National Park Service
U.S. Department of the Interior

Chesapeake & Ohio Canal National Historical Park
Potomac, MD

CHOH Civilian Conservation Corps (CCC) Structures — Historic Structures Report — SmithGroup • Gray & Pape • Silman • Building Conservation Associates

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National Park Service
U.S. Department of the Interior

Chesapeake and Ohio Canal National Historical Park
Potomac, MD

Chesapeake & Ohio Canal National Historical Park

Civilian Conservation Corps Structures Historic Structure Report • May 26, 2023

Final Submission

US Department of the Interior • National Park Service • National Capital Region • Resource Stewardship and Science • Washington, DC

This Historic Structure Report is available in two formats – a printed version for study at the park, the National Capital Area headquarters offices, and other repositories, and in electronic format (PDF) through the NPS Data Store and NPS Technical Information Center.

Front cover: Existing condition photos for Pivot Bridge Ruins, Boiler House, Comfort Station, Pump House, and Engineer's Garage (SmithGroup, 2020 & 2022)

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Historic Structure Report

Civilian Conservation Corps (CCC) Structures

Chesapeake & Ohio Canal National Historical Park (CHOH)

Potomac, MD

Pivot Bridge Ruins ❖ Boiler House ❖ Comfort Station ❖ Pump House ❖ Engineer's Garage

Prepared by:

SmithGroup
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US Department of the Interior • National Park Service • National Capital Region • Resource Stewardship and Science Washington, DC 2023

As the Nations's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under US administration.

US Department of the Interior
National Park Service
Resource Stewardship and Science
Washington, DC

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Forward

By the 1930's the Chesapeake and Ohio Canal, a once-vital transportation corridor, had faded into obsolete obscurity along the inconsistent shores of the Potomac River. President Franklin Roosevelt's New Deal programs transformed the canal, acquiring the land and planning for its modern potential as a public park. Great Falls, a tourist destination since the earliest moments of the canal's history, became a focus of recreational development and the federal government assigned two Civilian Conservation Corps (CCC) camps to Great Falls. These two camps, co-located at Carderock four miles south of Great Falls, were two of just three African-American CCC camps in the region. From 1938 to 1942, the men in these camps performed many, varied tasks along the canal. They repaired the damaged canal, fought area fires, and built four surviving structures: the Pivot Bridge Ruins, the Comfort Station, the Pump House and the Engineer's Garage. All four survive today, all remain in active use, and all serve as testament to the camps' contributions to the long history of the canal and the decisive period of the New Deal.

To further understand the important role these buildings play in the history of the Chesapeake and Ohio Canal, the National Park Service undertook this Historic Structures Report to research the history and document the conditions of each of these buildings. The report also includes the Boiler House, which was initially thought to be a CCC structure as well, but upon further research was discovered to have been built nearly a decade after the closing of the camps.

Many individuals contributed to the successful completion of this report, but we would particularly like to thank the following employees of the National Park Service; Joe Reed of the Chesapeake and Ohio Canal National Historical Park and Elizabeth Milnarik of the National Capital Regional Office. Susan Pommerer of SmithGroup and Katherine Watts of Gray & Pape played the most significant roles in shaping this document.

It is hoped this study will prove valuable to park management in its ongoing efforts to maintain these structures and to the park and public in understanding the contributions of the African American Civilian Conservation Corps to the transformation of the Chesapeake and Ohio Canal into a place to hike, bike, walk and enjoy nature. We are grateful for the cooperation of all those who helped make this document possible.

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Executive Summary

STATEMENT OF PURPOSES AND GOALS

The purpose of this Historic Structure Report (HSR) is to guide the preservation and continued maintenance of the historic structures built by the African American companies of the Civilian Conservation Corps (CCC) located near the Great Falls Tavern along the Chesapeake & Ohio (C&O) Canal.

This HSR of the CCC structures on the C&O Canal will enable the Park to develop comprehensive planning strategies to preserve and interpret these unique buildings. These efforts will complement "Our Only Alma Mater": the Civilian Conservation Corps and the C&O Canal, a 2017 *Special History Study* by Josh Howard on African American CCC camps on the C&O Canal and will aid the Park's efforts to develop educational programs that focus on the canal's restoration. The story of the African American CCC camps documents the role of their enrollees in restoring American treasures as well as the segregated history of the CCC during the late 1930s and early 1940s. The newly finished history of the CCC camps provided background information on the lives that the men led in the work camps. This HSR offers a critical piece of information on the nature of their work on the canal and the types of structures that they built.

INTRODUCTION

After the C&O Canal closed commercial operations in 1924, the Federal government acquired the property in 1938 as a Depression-era work relief project. Some resources in the Great Falls area were built by two African American companies of the CCC. The NPS and the CCC worked together as part of a national program that employed out-of-work youth from 1938 to 1942 to create a national recreation infrastructure. The NPS was also expanding at the time and across the country was increasing the documentation and interpretation of national historical parks in the 1930s. Critical to the restoration of the C&O Canal were the contributions of the African American men of the two CCC camps established along the canal. The goals of the CCC on the canal were to support ongoing visitation by restoring the canal and structures that were badly damaged during the storms of 1924 and 1936, and to work towards returning the canal to a condition where it could be rewatered. Camp NP-1-MD, Company No. 325, located near Carderock, was established on September 19, 1938 and existed until April 1, 1942. Camp NP-2- MD, Company No. 333, was established on October 5, 1938 and existed until October

15, 1941. Located about 4 miles south of Great Falls Tavern, the African American CCC enrollees constructed a Pivot Bridge to provide access across the canal from Camp NP-1-MD. A Boiler House was previously thought to be a CCC-era construction, but research for this report revealed it is more likely a later addition, built in 1951. Among the other CCC projects constructed near the Great Falls Tavern were the building of a Comfort Station, a two-story brick Pump House & water filtration plant, and an L-shaped Engineer's Garage on the hill above the tavern.

The period of significance for these resources is from 1938 to the 1950s, beginning when there was early Federal involvement in the area. The year 1938 reflects the year of acquisition and the onset of NPS recreational and transportation planning efforts for the once industrial and commercial landscape of the C&O Canal and the recreational history of the Great Falls Tavern. Under Roosevelt's Federal "New Deal" relief program, African American CCC enrollees were assigned to two camps working on the C&O Canal. They were two of only three segregated African American CCC camps in the greater Washington, DC area, and this history is an important part of the significance of the four CCC-built resources. The period of significance also encompasses pedestrian and vehicular circulatory patterns on the Great Falls Tavern site deriving from early planning efforts by NPS landscape architects and planners. The year 1942 is the last year in which African American CCC enrollees were involved at the site, however, after WWII and into the 1950s, NPS continued to transform the Great Falls area into the recreational hub it is today. The 2015 C&O Canal NRHP nomination update was incorrect about the construction date of the Boiler House, which is actually 1951, and it is not a CCC-built structure. The four CCC structures and the later Boiler House are listed as contributing features on the NPS's Cultural Resources Inventory System (CRIS). The CRIS is an evaluated inventory of all historic and prehistoric structures that have historical, architectural and/or engineering significance within parks of the NPS system.

The Pivot Bridge Ruins (mile 9.92), Boiler House (mile 14.27), Comfort Station (mile 14.28), Pump House (mile 14.29), and Engineer's Garage (mile 14.35) were listed as contributing structures to the Chesapeake and Ohio Canal National Historical Park Historic District (Additional Documentation and

Boundary Increase, 2015). The Boiler House was previously misidentified as a New Deal-era resource, but current research suggests it was built later, in 1951. It no longer derives its significance from its association with the African American CCC camps, but is still a part of the recreation and conservation movement associated with the canal. The district is significant nationally, statewide, and locally under Criteria A, C and D. The pivot bridge structure, and these four buildings are significant under Criterion A: New Deal Era Recreation & Conservation from Seneca to Georgetown: The CCC Program, New NPS Initiatives, & A Recreational Waterway, 1938-1950s.

RESEARCH CONDUCTED TO PRODUCE THE HSR

Gray & Pape Architectural Historians completed initial background research online and in person at the CHOH offices to identify available background source material on the history of the five resources associated with the CCC HSR. Historians reviewed a range of available documents either provided by the NPS or referenced in NPS-provided documents. These sources included Josh Howard's 2017 *Special History Study:* "Our Only Alma Mater" The Civilian Conservation Corps and the C&O Canal.

In addition, Gray & Pape historians reviewed online newspaper records, documents available online from the Maryland Historical Trust (Maryland State Historic Preservation Office), and the National Register of Historic Places (NRHP) Inventory Nomination form for the CHOH.

Howard's study provides a rich and fundamental context for understanding the history of the African American CCC camps in Maryland. As such, his study was crucial for addressing the requirements of Chapter 1: Historical Background and Context of the HSR. However, Howard provides only passing reference, and no substantive data, to document the construction or changes to the buildings and structures that are the subject of the HSR.

The project began in Fall 2020, and was suspended February 26, 2021, as a result of the Corona Virus Pandemic, causing closure of the Archives and other research venues. Work resumed on June 1, 2022. Following the reopening, Gray & Pape staff visited the National Archives and Records Administration (NARA)

in downtown Washington, DC and College Park, Maryland, specifically to look at record groups recommended by Howard's study:

- RG 35: Records of the Civilian Conservation Corps
- RG 79: Records of the National Park Service

Gray & Pape staff also looked at the below record group for its known association with the C&O Canal after 1938:

- RG 328: Records of the National Capital Planning Commission

The textual records, photos, and maps contained in these record groups were very helpful for Chapters 1 and 2 of the HSR.

SmithGroup made a trip to the CHOH offices, now located in Williamsport, in December 2022 to look at maintenance records and other archival materials.

ADDITIONAL PLANNED RESEARCH

After consultation with research staff at NARA in College Park, they suggested that the below record groups, while helpful for Howard's research, would likely be less fruitful for information on the CCC-built resources in the Great Falls Area:

- RG 77: Records of the Office of Chief of Engineers
- RG 407: Records of the Adjutant General's Office

Therefore, no further research is planned at this time.

HISTORIC DOCUMENTATION PROVIDED

The following records were provided by NPS in support of the research conducted for this HSR and the efforts to provide existing conditions drawings of each structure. The existing conditions drawings are provided in Part III: Documentation.

NPS Document No.	Date	Document Type	Title	Description
GENERAL OVERVIEW				
CHOH-412-80453	1941	Drawings	Great Falls Grading Plan	Site grading plans
N/A	1961	Report	CHOH The Bridges - Edwin Bearss	History and inventory of bridges across the C&O Canal by By Edwin C. Bearss.
N/A	1979	NR Nomination	NR Nomination 66000036 - C&O Canal National Historical Park	National Register Nomination for the Chesapeake and Ohio National Historical Park Historic District. The district is significant nationally, statewide and locally under Criteria A, C and D. The pivot bridge structure, and these three buildings are significant under Criterion A: New Deal era recreation and conservation from Seneca to Georgetown: The CCC Program, New NPS Initiatives, and a recreational waterway, 1938-1950's.
unknown	1985	Report	CCC Admin History 1933-1942	Administrative History of the Civilian Conservation Corps and the National Park Service by John C. Paige
CHOH-412-85165	1997	Drawings	Great Falls Utility Survey	Existing conditions topographic and utility survey.

NPS Document No.	Date	Document Type	Title	Description
N/A	1999	Report	Geology & Engineering Structures of the C&O Canal	An engineering geologist's descriptions and drawings of the masonry along the C&O Canal by William Davies
unknown	2007	Report	Historic Resource Study C&O Canal - Harlan Unrau	The purpose of this document is to present the biographies of the engineers who played a prominent role in the design and construction of the Chesapeake & Ohio Canal. By studying the back-ground of these men, one will gain a better understanding of the skills and experiences which they brought to the construction of the Chesapeake & Ohio. A look at the activities of these men after they left the canal will also enable one to place their services on the canal in the context of their professional engineering careers.
N/A	2011	Report	From Canal Boats to Canoes: The Transformation of the C&O Canal 1938-1942	Thesis submitted to the Eberly College of Arts and Sciences at West Virginia University by Angela Sirna.
CHOH-412-107131	2012	Drawings	Great Falls Utilities	Great Falls Utilities Location Plan As-Builts
N/A	2015	NR Nomination	NR Nomination 66000036 Update - C&O Canal National Historical Park	Update to the National Register Nomination for the C&O Canal to provide a boundary increase and additional documentation to include the Pivot Bridge Ruins (mile 9.92), Boiler House (mile 14.27), Comfort Station (mile 14.28), Pump House (mile 14.29), and Engineer's Garage (mile 14.35) as contributing structures to the Chesapeake and Ohio National Historical Park Historic District.
CHOH-412-120164	2015	Drawings	Great Falls Entrance Road	Paving and guardrail improvements to the Great Falls Entrance Road

NPS Document No.	Date	Document Type	Title	Description
N/A	2017	Report	Our Only Alma Mater	a 2017 Special History Study by Josh Howard on African American CCC camps on the C&O Canal.
N/A	2022	Excel Spreadsheet	FMSS Maintenance Records	"catalog of maintenance records from the Park Facility Management Division's Facility Management Software System (FMSS)"
N/A	2022	Email	FMSS Records CHOH 245010 A-A CCC Camp HSR - Pump House at Great Falls	"catalog of maintenance records from the Park Facility Management Division's Facility Management Software System (FMSS)"
N/A	2004	Report	Civilian Conservation Corps Activities in the National Capital Region of the National Park Service HABS No. DC-858	This overview history and a detailed site inventory were undertaken by the Historic American Buildings Survey program of the National Park Service (NPS), Paul Dolinsky, Chief (HABS) and John A. Burns, Acting Manager (HABS/HAER/HALS division).
N/A	1991	Report	C&O Canal: The Making of a Park	Administrative History of CHOH by Barry Mackintosh
N/A	various	Archival Box	Record Group 35-G, Records of the Civilian Conservation Corps	National Archives and Records Administration, College Park, MD, Still Photos Room. Miscellaneous photos in Box 41.
N/A	various	Archival Box	Record Group 35-GE, Records of the Civilian Conservation Corps	National Archives and Records Administration, College Park, MD, Still Photos Room. Miscellaneous photos in Box 1 of 4.
N/A	1933-1949	Archival Box	Record Group 79, Records of the National Park Service, Central Classified Files	National Archives and Records Administration, College Park, MD, Textual Records. Miscellaneous files in Boxes, 2809, 2823, 2836, and 2844.
N/A	various	Archival Box	Record Group 79, Records of the National Park Service	National Archives and Records Administration, College Park, MD, Cartographic Records. Miscellaneous files in Folder 412/3,000 and 412/80,205
N/A	various	Archival Box	Record Group 79-G, Records of the National Park Service	National Archives and Records Administration, College Park, MD, Still Photos Room. Miscellaneous photos in Box 2 of 40.

NPS Document No.	Date	Document Type	Title	Description
N/A	various	Archival Box	Series III: mm 0.55-3.13, Maintenance Files Collection, Chesapeake & Ohio Canal National Historical Park	Chesapeake & Ohio Canal National Historical Park, Williamsport, Maryland. Miscellaneous files in Box 03
N/A	various	Archival Box	Series V: mm 12.62-14.30, Maintenance Files Collection, Chesapeake & Ohio Canal National Historical Park	Chesapeake & Ohio Canal National Historical Park, Williamsport, Maryland. Miscellaneous files in Box 04 and 05
N/A	various	Archival Box	Series XIX: mm 108.91-110.10, Maintenance Files Collection, Chesapeake & Ohio Canal National Historical Park	Chesapeake & Ohio Canal National Historical Park, Williamsport, Maryland. Miscellaneous files in Box 01
N/A	undated	Drawings	Washington Aqueduct Data Book Great Falls Intake - Site Utility Plan	limited site utility plan
CHOH-412-80297	undated	Drawings	Site Plan	Undated site plan locating water lines. Likely dates after 1951 since the Boiler House is inlcuded on the plan.
PIVOT BRIDGE RUINS				
CHOH-412-80276	1941	Drawings	Rack Gear and Rail Assembly for Swing Bridge	details of rail, gears, and pivoting mechanisms for the pivot bridge
CHOH-412-80275	1941	Drawings	Swing Bridge Structure	structural drawings for the pivot bridge
CHOH-412-80277	1941	Drawings	Swing Bridge	construction drawings for a few bridges over the canal, including the Pivot Bridge at mile 9.92
N/A	2022	Photos	Existing Conditions Photos	Photos taken by NPS CHOH Staff and NPS HPTC Staff in December 2022
N/A	2022	Laser Scan Data	Laser Scan Data	Laser scan data taken by NPS Staff on December 14, 2022

NPS Document No.	Date	Document Type	Title	Description
BOILER HOUSE				
CHOH-412-80401	1951	Drawings	Boiler House for Tavern	construction documents for the construction of the Boiler House and upgrades to the systems in the Great Falls Tavern
CHOH-412-80474	1951	Drawings	Tavern & Boiler House	construction documents for the construction of the Boiler House and upgrades to the systems in the Great Falls Tavern
CHOH-412-41081	2006	Drawings	Great Falls Total Package	Civil, mechanical, and electrical upgrades at Great Falls to replace outdated equipment and infrastructure at the Boiler House and Pump House to provide updated services to the Great Falls Tavern and surrounding buildings.
N/A	2022	Photos	Existing Conditions Photos	Photos taken by NPS CHOH Staff and NPS HPTC Staff in December 2022
COMFORT STATION				
CHOH-412-80461	1941	Drawings	Great Falls Toilet	construction documents for the construction of the Comfort Station
CHOH-412-80400	1953	Drawings	Construction & Record Dwgs of Public Toilet Rooms Heating	details for the heating supply lines connecting the Boiler House to the Comfort Station
N/A	2022	Photos	Existing Conditions Photos	Photos taken by NPS CHOH Staff and NPS HPTC Staff in December 2022
PUMP HOUSE				
CHOH-412-80454	1941	Drawings	Great Falls Sewage Tank Lock 19	construction documents for the construction of the Pump House
CHOH-412-80465	1946	Drawings	Fence at Rear of Filtration Plant	Details for fence enclosure along east side of Pump House to conceal the coagulation basin.
N/A	2020	PMIS Statement	PMIS 245021 Pump House Roof Repairs	Project Management Information System (PMIS) information about recent roof replacement at the Pump House
N/A	2022	Photos	Existing Conditions Photos	Photos & Go-Pro Videos taken by NPS CHOH Staff and NPS HPTC Staff in December 2022

NPS Document No.	Date	Document Type	Title	Description
ENGINEER'S GARAGE				
CHOH-412-80459	1941	Drawings	Garage for U.S. Engineers	construction documents for the construction of the Engineer's Garage
N/A	2015	Contracts	Mule Barn Roof	Statement of Work; Notice of Award; Notice to Proceed & Contract Time; Contract Final Award; Firm Fixed Price Construction Clauses
N/A	2017	Drawings & Contracts	Mule Barn Garage Doors	Statement of Work; Notice of Award; Notice to Proceed & Contract Time; Contract Final Award; DOL Wage Determination
GREAT FALLS TAVERN				
CHOH-412-130788	1972	Drawings	Great Falls Tavern - Reference Drawings	reference drawings for Great Falls Tavern
CHOH-412-80012C	1975/ 1992	Drawings	Planting & Construction Plan - Revised 1992	site and planting plan for Great Falls Tavern
CHOH-412-80012B	1975	Drawings	Great Falls Tavern Planting & Construction Site Plan	site and planting plan for Great Falls Tavern
CHOH-412-85168	2001	Drawings	Great Falls Tavern Repairs	construction documents for repairs to the Great Falls Tavern
unknown	2009	Report	Great Falls Tavern Cultural Landscape Report	Cultural Landscape Report completed for the Great Falls Tavern
unknown	2021	Report	Great Falls Tavern HSR	Historic Structure Report for the Great Falls Tavern
CHOH-412-80403	undated	Drawings	Great Falls Tavern - Historic American Buildings Survey (HABS)	Partial set with notations

NPS Document No.	Date	Document Type	Title	Description
OTHER HISTORIC STRUCTURE REPORTS				
unknown	2021	Report	2021-1020 NPS Engineer's House HSR	Historic Structure Report for the Engineer's House located west of the Engineer's Garage, overlooking the Great Falls Tavern
U.S. ARMY CORPS OF ENGINEERS				
N/A	1940	Drawings	100.8-3.1 - Garage for U.S. Engineers - (1)	Garage for U.S. Engineer's; copy of construction documents
N/A	1941	Drawings	100.8-3.1 - Garage for U.S. Engineers - (2)	Garage for U.S. Engineer's; copy of construction documents
N/A	1941	Drawings	100.8-3.1 - Garage for U.S. Engineers - (3)	Garage for U.S. Engineer's; copy of construction documents
N/A	1941	Drawings	100.8-3.8 - Relocation of U.S. Engineers Unit	Relocation of U.S. Engineers Unit
N/A	1941	Drawings	100.8-3.9 - General Grading Plan	General Grading Plan
N/A	1961	Drawings	10.3-2.1 - Building Numbering for Real Estate Identification	Building Numbering for Real Estate Identification
N/A	1973/ 1977/ 1990	Drawings	10.3-2.2 - Building Numbering for Real Estate Identification	Building Numbering for Real Estate Identification

MAJOR RESEARCH FINDINGS

Perhaps the most important research finding was the CCC report compiled by Robert M. Coates an employee for the Office of Field Supervisor R.M. Schenck, on January 15, 1942, where CCC work completed at the C&O Canal and development in the Great Falls area was summarized. The report is titled "Inventory of Work Accomplished by CCC Camps Under the Jurisdiction of National Capital Parks, October 19, 1933 to January 1, 1942. National Park Service" and it also includes other parks in the National Capital Region, not just the C&O Canal. Several buildings and projects are described as being completed in the Great Falls area, which gives us certainty that the Engineer's Garage and associated road, parking, and service court, the Comfort Station and associated sewage system and pipes, and the Pump House were all finished by January 1942.

MAJOR ISSUES IDENTIFIED

One major issue that has been identified in our research and writing of the HSR is the Boiler House construction date. Multiple written sources suggest that it was completed by the CCC when the other utilitarian structures at Great Falls were completed. The drawings that we have from NPS of the Boiler House are dated 1951, and the set goes into great detail, including wall sections. Given that level of detail, the research team believes the Boiler House was built not by the CCC, but by the NPS in the 1950s, perhaps when repairs were made to the Great Falls Tavern. This would mean the Boiler House is at least 70 years old. In addition, a historic 1953 site plan noted as "Construction and Record Drawing of Public Toilet Rooms Heating" (NPS Document No. 412-80400) provides details of a connection from the Boiler House to provide heating to the Comfort Station. This may mean that from 1941–1953, the Comfort Station and other buildings were only open seasonally and closed during the winter months to prevent freezing of pipes. Further discussion is recommended with the Park to determine if the Boiler House should be removed as a contributing structure to the C&O Canal since it was likely not built by the African American enrollees of the CCC.

Administrative Data

Name and Location Data:	Pivot Bridge Ruins (mile 9.92) Boiler House (mile 14.27) Comfort Station (mile 14.28) Pump House (mile 14.29) Engineer's Garage (mile 14.35)
Preferred Structure(s) Name:	Pivot Bridge Ruins Boiler House Comfort Station Pump House Engineer's Garage
Other Historic Names Used:	**Pivot Bridge Ruins:** Carderock Swing Bridge **Comfort Station:** Great Falls Toilet **Pump House:** Filtration Plant **Engineer's Garage:** Garage for U.S. Engineers/ Mule Barn
Park:	Chesapeake and Ohio Canal National Historical Park (CHOH)
Structure State:	Maryland
NPS Region:	National Capital Region (NCR)
Administrative Unit:	Resources Stewardship and Sciences
FMSS Property Number:	Pivot Bridge Ruins: none Boiler House: 226488 Comfort Station: 7406 Pump House: 226487 Engineer's Garage: 7416
Historic Structure Cultural Resource Inventory System (HS-CRIS):	Pivot Bridge Ruins: none Boiler House: 046620 Comfort Station: 046622 Pump House: 046621 Engineer's Garage: 1073642

Square Feet (approximate):	Boiler House: 215 SF Comfort Station: 540 SF Pump House: 392 SF Engineer's Garage: 2,081 SF
National Register of Historic Places Status:	The Pivot Bridge Ruins (mile 9.92), the Boiler House (mile 14.27), Comfort Station (mile 14.28), Pump House (mile 14.29), and Engineer's Garage (mile 14.35) were listed as contributing structures to the Chesapeake and Ohio Canal National Historical Park Historic District (Additional Documentation and Boundary Increase, 2015). The district is significant nationally, statewide, and locally under Criteria A, C, and D. The four CCC-built resources and the Boiler House are significant under Criterion A: New Deal Era Recreation & Conservation from Seneca to Georgetown: The CCC Program, New NPS Initiatives, & A Recreational Waterway, 1938-1950s.
Date:	10/15/1966 & 02/03/2015 (Boundary Increase)
National Historic Landmark:	N/A
Significance:	Contributing
Period of Significance:	1938 - 1950s
National Register Information System No.:	66000036

RELATED STUDIES

- National Register Nomination No. 66000036 - C&O Canal National Historical Park, 1979
- National Register Nomination No. 66000036 - C&O Canal National Historical Park, 2015 Update
- Great Falls Tavern Cultural Landscape Report, 2009
- Great Falls Tavern Historic Structure Report, 2020
- Engineer's House Historic Structure Report, 2021

PERIOD OF SIGNIFICANCE

The period of significance is from 1938 to the 1950s, the period of time from the purchase of the canal by the government and when the CCC camps were established through the construction of the primary buildings near Great Falls, the four CCC buildings and then the Boiler House in 1951 (previously thought to have been constructed by the CCC). The CCC camps closed in 1942, and WWII and the flood of 1946 interrupted progress on the C&O Canal restoration, but NPS continued work into the 1950s on the recreational aspects of the canal. The Pivot Bridge Ruins (mile 9.92), the Boiler House (mile 14.27), Comfort Station (mile 14.28), Pump House (mile 14.29), and Engineer's Garage (mile 14.35) were listed as contributing structures to the Chesapeake and Ohio Canal National Historical Park Historic District (Additional Documentation and Boundary Increase, 2015). The district is significant nationally, statewide, and locally under Criteria A, C, and D. The four CCC-built resources and the Boiler House are significant under Criterion A: New Deal Era Recreation & Conservation from Seneca to Georgetown: The CCC Program, New NPS Initiatives, & A Recreational Waterway, 1938-1950s.

STATEMENT OF SIGNIFICANCE

The Federal government purchased the C&O Canal in 1938 and entrusted it to the care of the NPS, whose role was to transform its from a defunct industrial transportation canal into a recreational and historical park. In 1938, two CCC camps were established in the Great Falls Area, with two African American CCC companies, Company 325 and 333. These two companies established Camp NP-1-MD and Camp NP-2-MD. The camps are significant in their own right as two of three total African American CCC companies in the entire greater Washington, DC area. The African American CCC workers began working on the canal in 1938, constructing utilitarian structures like the Pump House and Engineer's Garage. According to CCC records, by January 1942, the

Pivot Bridge, the Pump House, the Engineer's Garage, and the Comfort Station were all completed. Camp NP-2-MD was closed on October 15, 1941. On April 1, 1942, Camp NP-1-MD was closed and transitioned into a defense camp, but it too was closed on July 29, 1942, as part of the mass closures of CCC camps due to the US involvement in World War II (WWII). After WWII, the 1946 flood of the canal, and the 1948 fire at Great Falls Tavern, the NPS continued its restoration work and transformation of the C&O Canal into a recreational park. This included construction of the Boiler House in 1951. All five of these structures are significant for their association with recreation and conservation of the C&O Canal.

PROPOSED TREATMENT OF STRUCTURES

Per the Scope of Services and discussions with the Park, the CCC structures are to remain in their current use and occupancy for the near-term. The goal of this HSR is to establish an understanding of the history and significance of the five CCC-associated structures built along the C&O Canal, provide detailed documentation of the existing conditions, and make recommendations to address repairs and deferred maintenance required to preserve and maintain these historic resources. Per the Secretary of the Interior's Standards for the Treatment of Historic Properties, Rehabilitation is recommended for the Boiler House, Comfort Station, and Engineer's Garage. Preservation is recommended for the Pivot Bridge Ruins and the Pump House.

List of Abbreviations

ABAAS	Architectural Barriers Act Accessibility Standard
B&O	Baltimore & Ohio Railroad
CCC	Civilian Conservation Corps
C&O	Chesapeake & Ohio Canal
CHOH	Chesapeake & Ohio Canal National Historical Park
CLR	Cultural Landscape Report
CRIS	Cultural Resources Inventory System
DC	District of Columbia
DOI	Department of Interior
FMSS	Facility Management Software System
HABS	Historic American Building Survey
HSR	Historic Structure Report
IBC	International Existing Building Code
LOC	Library of Congress
MD	Maryland
NARA	National Archives and Records Administration
NAACP	National Association for the Advancement of Colored People
NCP&PC	National Capital Park and Planning Commission
NFPA	National Fire Protection Association
NPS	National Park Service
NRHP	National Register of Historic Places
PWA	Public Works Administration
US	United States
USACE	US Army Corps of Engineers
WSSC	Washington Suburban Sanitary Commission
WWII	World War II

SELECT ARCHITECTURAL AND ENGINEERING TERMINOLOGY

CMU	Concrete Masonry Unit
EMT	Electrical Metal Tubing
FMC	Flexible Metal Conduit
MC	Metal Clad
VCP	Vitrified Clay Pipe

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Part I: Developmental History

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Part 1 Cover: Aerial View of CCC Camp NP-2 (NARA College Park, MD, Still Photos, Record Group 35-GE, Box 1 of 4)

Chapter 1: Historical Background and Content

INTRODUCTION

Chartered in 1825, the C&O Canal was originally envisioned and constructed to form a reliable trade route connecting the Potomac River to the Ohio River in Pennsylvania (**Figure 1**). The development of a canal connecting the Potomac River and the mountains was linked to many of the nation's early political and business leaders, including George Washington and John Quincy Adams. Washington, in particular, was enthusiastic about a future canal after he explored and surveyed the Potomac River region. He first dreamed of building a flowing water road across the Appalachian Mountains and into the west. Washington was a promoter, stockholder, and president of the Patowmack Company in 1785. At one point, Washington told the Virginia legislature "it would create an open highway to the sea for all time to every people."[1]

Figure 1. Logo of the Chesapeake & Ohio Canal Company, taken from the NPS Master Plan for the Chesapeake & Ohio Canal National Monument, June 1964. (NARA College Park, MD, Cartographic Room, Record Group 79, Folder 412/3,000)

The Patowmack Canal was built between 1785 and 1801 by clearing a river channel and building skirting canals around the turbulent parts of the river, and it fully opened to traffic in 1802. It struggled for many years and the company went bankrupt in 1828, transferring its charter to the C&O Canal Company, which had been chartered three years earlier.[2]

On July 4, 1828, the C&O Canal broke ground near Little Falls, although President John Quincy Adams hit rocks and roots in his first several attempts before finally succeeding. Prior to the start of the C&O Canal excavation, the route of the canal was surveyed by the US Board of Engineers, and the north side of the Potomac River was adopted for the route. In July and August of 1828, the 34 sections above Little Falls (just west of mile marker 5) were let to contractors. In late October 1828, another 50 sections were let from Seneca Creek (near mile marker 23) to Point of Rocks (near mile marker 47). The five miles between Little Falls and Georgetown were contracted in December, along with Dams 1 and 2. The proposed dimensions of the canal prism were to be 60 feet in width, where practicable, with the narrowest width 50 feet

1 "Nation's Famous 'Ghost Canal' to be built by Park Service." Newspaper article (undated/unattributed) filed in National Archives and Records Administration (NARA) College Park, MD, Textual Records, Record Group 79, Box 2809, February 19, 1939.

2 Beyer Blinder Belle Architects & Planners, et al., "Great Falls Tavern Historic Structure Report" (Washington, D.C.: National Park Service, 2021), 3-4.

at the top and 42 feet at the bottom, and six feet in depth, but not shallower than five feet. The proposed towpath was to be no less than twelve feet wide. The bank opposite the towpath was to be no less than eight feet wide. The embankments on either side of the canal were to be at least two feet above the water line.[3] The excavation of the C&O Canal was expensive, costing $11,071,075.21 total, or $59,618.61 per mile to build (in 1828 money).[4]

By the mid-nineteenth century, canal building in the US waned as railroads rose to dominate the transportation industry. Railroad use increased as trains transported freight and passengers ten to twenty miles per hour faster than canal boats, and the railroad infrastructure could be built faster than the canal. Canal success was primarily a less expensive means of transporting freight. The C&O Canal and the Baltimore & Ohio (B&O) Railroad engaged in legal disputes, including various injunctions against the other party, over land acquisitions beginning in 1828 and ending with an agreement for both transportation lines to have access through the narrow passes of the river between Point of Rocks and Harpers Ferry (approximately 50 miles from Great Falls) in 1833.[5] Despite the increased competition and delays caused by legal injunctions, the C&O Canal reached Harpers Ferry in November 1833. In 1834, the section of the canal between Dams Nos. 3 and 4 opened in April and the section between Dams Nos. 4 and 5 was completed the next year, in April 1835. Additional financial and labor problems and difficult terrain delayed the canal from reaching Dam No. 6 near Cacapon River until April 1839. Work on the canal was suspended in 1842 due to a lack of funding and the last 50-mile section to Cumberland was generally idle until November 1847. The C&O Canal was formally opened to Cumberland, Maryland on October 10, 1850.[6] Just two years later in 1852, the C&O Canal was heavily damaged by the highest flood in 60 years. The heaviest damaged area was the section between Seneca and Great Falls. The Chief Engineer estimated $80,000 in repairs and for future protection against similar floods. Waste weirs were constructed on all levels for overflow and masonry protection

3 Harlan D. Unrau, "Historic Structure Report: The Canal Prism, including towpath with canal berm and river revetments, Historical Data: Chesapeake and Ohio Canal National Historical Park" (Denver, CO: Denver Service Center, Historic Preservation Team, NPS 1974), 9-19.

4 Harlan D. Unrau, "Chesapeake & Ohio Canal Historic Resource Study" (Hagerstown, MD: United States Department of Interior, National Park Service, Chesapeake & Ohio Canal National Historical Park, August 2007), 105.

5 Unrau 2007, 637.

6 Unrau 2007, 638.

walls were installed for missing embankments. The total repair expenditure exceeded $100,000 (in 1850 money).[7]

In 1873, the C&O Canal had its greatest business year with an estimated 700 boats in operation which hauled 916,000 tons of coal.[8] In addition to coal, the canal boats hauled grain, lumber, whiskey, and other commodities, as well as passengers, between Georgetown and Cumberland. Two major floods in 1877 and 1889, in addition to three small floods in 1886, caused substantial damage to the banks of the canal; repairs were made following each of the flood episodes.[9] However, the 1889 flood caused over $1,000,000 (in 1889 money) in damage and the C&O Canal was forced into receivership while the B&O Railway purchased the majority of the canal's bonds. Another severe flood in the spring of 1924 created sufficient damage to close operations of the canal entirely. Small portions of the canal in Georgetown remained operable after 1924, as there were mills located there with leases from the Canal Company.[10] In addition to the flood damage, the canal suffered from the decline of coal in western Maryland and the transition to truck transportation throughout the US in the early twentieth century. The canal bed and the masonry structures were neglected, and decline was soon visible (**Figure 2**). While the majority of the canal was non-operational, the B&O claimed that the waterway

Figure 2. One of the seven locks above Cabin John, Maryland about halfway between Great Falls and Washington. Photo taken prior to NPS/CCC work commencing. (NARA College Park, MD, Still Photos, Record Group 79-G, Box 2 of 40)

7 Unrau 1974, 60.

8 "Nation's Famous 'Ghost Canal' to be built by Park Service." Newspaper article (undated/unattributed) filed in National Archives and Records Administration (NARA) College Park, MD, Textual Records, Record Group 79, Box 2809, February 19, 1939.

9 Unrau 1974, 65.

10 Reiff, Daniel D., *Historic American Buildings Survey: Chesapeake and Ohio Canal, Georgetown Section, HABS No. DC-147* (Washington, DC: NPS, 1967), 9.

was not abandoned and that it could be put into navigable condition if the carrying trade was offered to support the effort.[11]

Floods have been a constant part of the C&O Canal's history and in addition to the aforementioned floods, other notable floods occurred in 1936 (the St. Patrick's Day flood), 1942, 1947, 1972 (Hurricane Agnes), 1985, and 1996, among others. More information on these floods is available in Chapter 2.

Speculation regarding the potential sale of the waterway by the B&O arose. As early as 1935, NCP&PC Planner John Nolen, Jr., talked about preserving the canal as a recreational waterway.[12] Originally, the Federal government sought to acquire only the Georgetown end of the canal, from Rock Creek to Point of Rocks. Gradually, however, the government expanded the plan to acquire the entire canal as a national park. The B&O originally claimed that they would sell the canal for $2,500,000 to $3,000,000 with proceeds applied to their $80,000,000 debt to the Finance Corp.[13] In 1938, the C&O Canal (the entire 184.5-mile canal and towpath) was sold to the US government for $2,000,000, despite earlier estimates that it might cost the government as much as $3,800,000 (all in 1938 money).[14] The canal was put under the guidance and control of the National Park Service, which initiated and completed many projects on the canal and its ancillary buildings and resources in an effort to develop the canal for regional recreation. Many of these projects fell under the control and oversite of Depression-era work relief program, the CCC, whose focus by that time had shifted towards the promotion of recreational facilities in urban areas. The resources discussed below were constructed during the Depression and the pre-WWII era. Subsequent additions and alterations occurred in the 1950s and through the present day.[15]

Initial focus was on the rehabilitation of the canal waterway and towpath itself, and then on its conversion to a recreational park for picnicking, hiking, fishing, canoeing, etc. A 1939 proposed operating program put the Great Falls Tavern at the center of recreational activities. The program also

11 Unrau 1974, 67.
12 Quoted in Barry Mackintosh, *C&O Canal: The Making of a Park*. (Washington DC: History Division, NPS, Department of Interior, 1991), 12. Also, quoted in Davidson and Jacobs 2004, 62.
13 Unrau 1974, 67.
14 Memo to Secretary from NPS, March 21, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.
15 National Register of Historic Places Inventory Nomination Form, "Chesapeake & Ohio Canal National Historical Park." Updated 2015.

Figure 3. Sketch of the Canal Clipper at a mooring point between 31st Street NW and Thomas Jefferson Street in Georgetown by Helen Gatch Durston, as seen in the *Evening Star* newspaper September 16, 1944. (NARA College Park, MD, Textual Records, Record Group 79, Box 2837)

recommended restoring many of the original stone lockhouses for caretakers to live in them.[16] NPS operated once-weekly boat excursions on the canal in 1941 with the canopy-covered barge, the Canal Clipper, which was pulled by horses on the towpath, and ran from Chain Bridge to Carderock at first, and later extended to Seneca, Maryland (**Figure 3**). Damage to the canal by the 1942 flood stopped the excursions, but they resumed in 1943.[17] That flood, which stemmed from the Shenandoah River and impacted the Potomac River below Harper's Ferry damaged much of the work on the canal performed by the CCC.[18]

The development of the remainder of the canal from Seneca to Cumberland was discussed for years, as many saw it as virtually unmanageable as a parkland due to its abandoned and damaged condition. [19] In addition, while the lower portion of the canal was buffered on the land side by Federal lands from Georgetown to Great Falls, the upper portion of the canal lacked additional right-of-way. NPS owned only the 230-foot-wide right-of-way in the upper section, which did not extend much beyond the embankment of the towpath and a matching distance on the opposite side. Much of the land between the Potomac River and the canal was privately owned and used for homes, summer camps, and agriculture, which would require additional

16 Memo for the Associate Director from C. Marshall Finnan, Superintendent, February 10, 1939. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

17 "The Canal Clipper" Newspaper article from the *Evening Star* filed in NARA College Park, MD, Textual Records, Record Group 79, Box 2837, September 16, 1944.

18 Davidson and Jacobs 2004, 68.

19 Barry Mackintosh, *C&O Canal: The Making of a Park,* (Washington, DC: History Division, NPS, Department of Interior, 1991), 49.

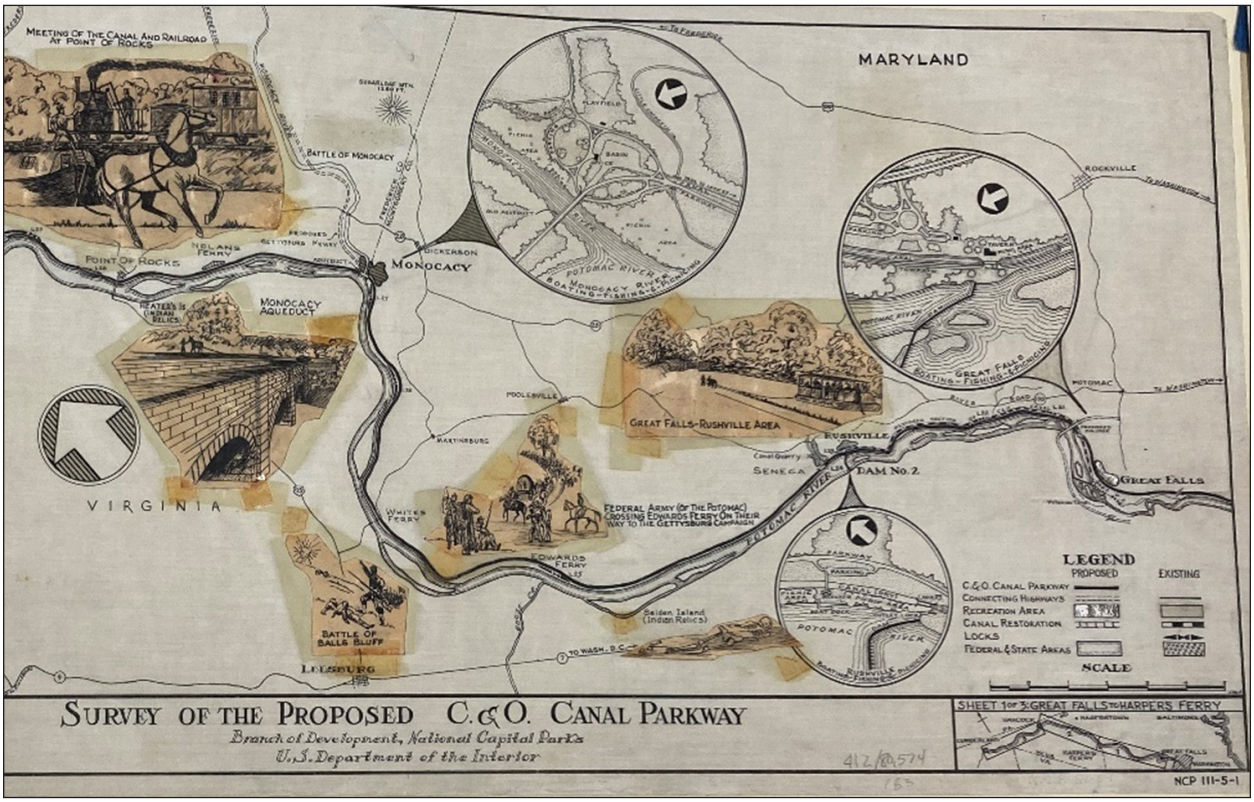
funds, time, and effort to acquire. Initial NPS planning for the acquisition of the C&O Canal intended for the land to become a parkway as far as Great Falls; however, landscape architects, Thomas C. Jeffers with the National Capital Park and Planning Commission (NCP&PC) and Malcolm Kirkpatrick with NPS, opposed the idea of a road alongside or on the canal. In a letter from Under Secretary of the Interior, Harry Slattery, to Senator Millard E. Tydings, Slattery said they did not consider a scenic highway, instead, the general plan was to preserve the area above Seneca for recreational use and the conservation of wildlife.[20] The plan to use the C&O Canal as a parkway began to lose favor with the public after 1942. The flood of 1942 and additional pressure from the city of Cumberland, Maryland began to change official (i.e., government) sentiment too. In 1941, the Maryland General Assembly requested that Congress and the Secretary of the Interior convey former canal company lands in Cumberland to the city for flood protection, highway construction, and "the elimination of conditions, within the canal basin, detrimental to the health and comfort of the citizens of said City."[21] The intended length of the parkway at this point was not clear in archival materials.

The idea of a C&O Canal parkway kept resurfacing, however. The cost to reconstruct the canal for recreational purposes was determined to be too costly in a letter from the Acting Secretary of the Interior, Oscar L. Chapman, to the House Public Lands Committee on March 29, 1948. Rather, Chapman recommended a scenic highway along the route of the old canal from Great Falls to Cumberland. A western Maryland Congressman, J. Glenn Beall introduced legislation for a feasibility study of the proposed canal parkway, which was passed in the House and Senate on June 10, 1948. The 1950 report declared that such a parkway would be both practical and advisable if Maryland would donate the additional land for the right-of-way. The estimated cost of the proposed parkway construction was $16,162,000 for the roadway and included rewatering three canal segments totaling 26 miles, restoring and repairing lockhouses and other historic buildings, and constructing new buildings and facilities, such as a headquarters and museum in Cumberland for a total of $17,107,700. Congressman Beall introduced another bill in order to gain the legal authority to accept the needed lands from Maryland and to authorize land exchanges, primarily for C&O Canal land to be swapped with B&O land in Cumberland, which

[20] Mackintosh, *C&O Canal: The Making of Park*, 1991, 54-55.
[21] Mackintosh 1991, 53.

was passed on September 22, 1950. However, by October 30, dissenters criticized the proposed parkway project as against the NPS's principle of conservation. A National Parks Association special committee reported in 1951 that the plan was inadequate in its attention to natural values, but the overall plan was not rejected. Divergent views and dissent caused NPS to modify the proposed parkway plan to a 60-mile parkway between Hancock and Cumberland. Another bill was passed through Congress to legalize the modified plan on August 1, 1953.[22] In 1954, the dissent peaked when Supreme Court Justice William O. Douglas, who lived near the canal, vehemently opposed the parkway. He invited journalists and conservationists to hike along the entire length of the canal with him, during which he showed off the canal's history and natural beauty. The success of the hike led the Washington Post to reverse its position on the parkway. The C&O Canal Association was formed in 1954 following Douglas's hike and the association was formally incorporated in 1957. The Association is an all-volunteer organization to help conserve the natural and historical environment of the Canal and Potomac River Basin. Today they work with the NPS and the C&O Canal Trust (the Trust). The Trust,

Figure 4. Detail from a Survey of the Proposed C&O Canal Parkway. (NARA College Park, MD, Cartographic Room, Record Group 79, Folder 412/80,205).



[22] Mackintosh 1991, 49-65.

formed in 2007, is the official partner of the park and has paid staff, unlike the association, which is independent, and comprised of all volunteers.[23] The Trust works with NPS and local communities "to raise funds to preserve the Park for future generations and to broaden support through programs that highlight the Park's historical, natural, and cultural heritage and recreational opportunities."[24]

In 1956, NPS abandoned the parkway idea in favor of a recreational trail.[25] A survey map of the proposed parkway from the Branch of Development, History Division, National Capital Parks, US Department of Interior and Bureau of Public Roads can be seen in **Figure 4**, with the Great Falls area highlighted at the top right for boating, fishing, and picnicking near the Tavern. In the legend to this survey map, both proposed and existing features were included: the C&O Canal Parkways are labeled, as are connecting highways, the canal restoration and locks, as well as Federal and state land areas. While it is not entirely clear, this survey map seems to be in support of both a parkway and recreational use of the canal.

THE CCC AND THE C&O CANAL

When the C&O Canal was purchased by the US government in September 1938, NPS planned to use the historic C&O Canal as a recreational waterway. In 1939, the canal was described in a newspaper article as a "brumbling, half-filled water ditch that painfully limps and twists for 185 miles."[26] The restoration work affected the roughly 22-mile section of the canal between Georgetown and Dam 2 in Seneca, Maryland.[27] The plans included restoring the canal bed by removing small trees and bushes, shaping and rebuilding the towpath, and excavating the accumulated silt, which would then be used to fill in sections of the towpath that had been washed out in previous floods.[28] In 1934, Frederick A. Delano, chairman of the NCP&PC and President

23 C&O Canal Association, "About." https://candocanal.org/about/, accessed September 22, 2022.

24 C&O Canal Trust, "About Us." https://www.canaltrust.org/about-us/about-the-trust/, accessed September 22, 2022.

25 National Park Service. Chesapeake & Ohio Canal, "Frequently Asked Questions." https://www.nps.gov/choh/learn/news/frequently-asked-questions.htm, accessed September 22, 2022.

26 "Nation's Famous 'Ghost Canal' to be built by Park Service." Newspaper article (undated/unattributed) filed in NARA College Park, MD, Textual Records, Record Group 79, Box 2809, February 19, 1939.

27 Josh Howard, "'Our Only Alma Mater': The Civilian Conservation Corps and the C&O Canal," *Special History Study*, final draft (16 December 2017), 1; Unrau 1974, 67.

28 "Restoring Old Canal as a Play Area." *The Berkshire Eagle* (Pittsfield, Massachusetts), 17 February 1939, 17.

Franklin Roosevelt's uncle, introduced the idea of using CCC labor on the C&O Canal properties to Secretary of Interior Harold Ickes.[29] The CCC was assigned to complete these renovations and two camps were established in Carderock, Maryland, four miles downstream from Great Falls. Just prior to the official purchase of the C&O Canal in 1938, officials requested the B&O Railroad Company to begin procedures to get a CCC camp approved for the rehabilitation project. In November 1938, NPS and NPC&PC staff met to discuss CCC and PWA projects related to the canal, the funding, and the idea of a C&O parkway.[30] CCC work began in February 1939. The anticipated cost of rehabilitating the roughly 22-mile section of the canal totaled $500,000, plus the work of the CCC, and the $2,000,000 paid for the initial purchase of the canal property (in 1939 dollars).[31]

Despite some leadership with integrationist tendencies, segregation was a standard practice across all the New Deal agencies. Secretary of Interior and previous president of the Chicago branch of the National Association for the Advancement of Colored People (NAACP), Harold Ickes, was a key figure in encouraging racial equality by hiring African Americans and resisting segregationist policies. He eventually mandated full desegregation of NPS facilities by the end of WWII. However, outside of the Washington, DC area, Ickes did not demand racial change, and he rarely enforced racial equality.[32] Oscar De Priest, Illinois House Republican and African American Congressman at the time, was also instrumental in including anti-discrimination practices by amending the legislation to include African Americans in the CCC, which was the only New Deal agency to have a policy rejecting segregation and discrimination based on "race, color, creed, or criminal records."[33] However, both Ickes and De Priest failed to enforce the integration of CCC camps and the majority of CCC camps were segregated in most places, including in the Washington, DC area, where African Americans were placed in separate camps from whites. Robert Fechner, CCC Director, established a policy in 1934 that African Americans could not comprise more than ten percent of the overall CCC, which according to Howard's report,

29 Howard 2017, 48–49.
30 Memo to Frederick A. Delano from John Nolen, Jr., November 10, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.
31 Martha Strayer, "Historic Canal to Live Again as Restoration Work Begins." Newspaper article (undated/unattributed) filed in NARA College Park, MD, Textual Records, Record Group 79, Box 2809.
32 Howard 2017, 18.
33 Holly Allen, *Forgotten Men and Fallen Women: The Cultural Politics of New Deal Narratives* (Ithaca, NY: Cornell University Press, 2015): 71-2; Howard 2017, 18.

was representative of the overall Black population in the US at the time.[34] Unfair treatment by white administrators was prevalent throughout CCC camps, including the dismissal of Eddie Simmons, an African American enrollee, after he refused to fan away flies from a white officer. By 1935, another new policy was enacted to restrict African Americans to only be enrolled to fill vacancies in existing Black companies and that the CCC would not create any new African American companies.

Complaints from African American leaders were led by W. Frank Persons, the main CCC administrator dealing with selection issues for African Americans. He questioned policies and spearheaded reforms that led to an increase in African American enrollment. While he was stymied by a lack of progress on the quota issue, in 1935, Persons decided to first tackle a single target, the education program. Persons realized that even though he could not significantly increase the enrollment of African Americans, he could improve the quality of life for the current enrollees. The goal was to ensure that segregated African American camps were led and directed by African American staffs to improve equity. Persons also sought improved educational programs in the segregated African American camps.[35] CCC educational advisors were tasked with organizing classes for enrollees on a variety of topics, which ranged from basic education to more technical skills.[36] While the idea of 100 percent African American camps met with resistance from Fechner, President Franklin D. Roosevelt, the US Commissioner of Education, and Secretary Ickes all personally approved the idea and in May 1935, fourteen Black educational advisors were appointed. In addition, by August 1936, 25 Black medical officers and chaplains entered the camps.[37] Approximately 140 African American camps with about 300,000 enrollees with 30,000 additional Black WWI veterans across 43 states were established throughout the CCC's existence. This contrasts with the 2,500 camps across the US housing 2,500,000 white men.

Two African American CCC camps were established in Maryland to assist with improving the C&O Canal and expanding its accessibility to the public: Camp NP-1-MD, established in September 1938, and Camp NP-2-MD, established in October 1938 (**Figure**s 5–7)[38]. Initially, local county

[34] Howard 2017, 19.
[35] Howard 2017, 22.
[36] Howard 2017, 5.
[37] Howard 2017, 22.
[38] Howard 2017, 33.

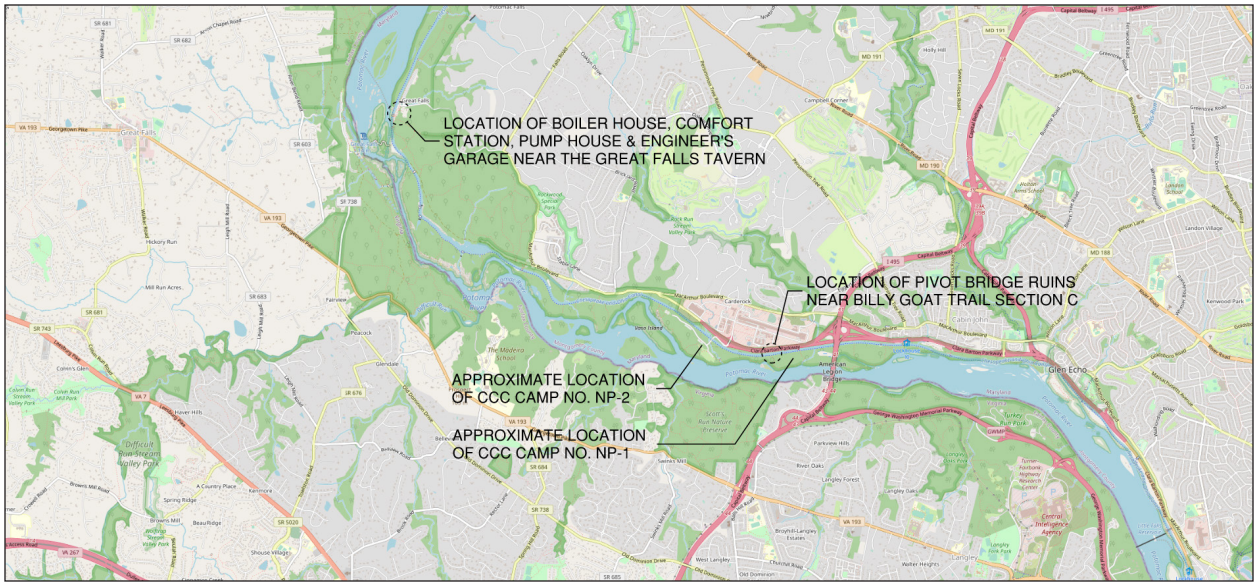


Figure 5. Map of the area showing approximate location of Camp NP-1-MD and Camp NP-2-MD in relation to the Pivot Bridge and the CCC-built buildings near the Great Falls Tavern

commissioners refused to approve the establishment of an African American CCC Camp near Carderock, but F. Bernard Welsh, county attorney, informed the commissioners they lacked the ability to block the camp. The Federal officials confirmed that the camp would proceed regardless of the commissioners' position.[39] The African American camp sites were isolated from residential areas. This may have made CCC leaders more confident about insisting on the African American camps in this location. It would be harder for the white residents around the camps to threaten or object; however, the research for this study did not include study of the race of local residents. The two Carderock camps and an earlier third camp established near the US National Arboretum were the only African American CCC camps established in the Washington, DC and Maryland area.[40] Company 333, an African American company at Camp MP-3 in Wilderness, Virginia was transferred to the canal project, potentially in order to make room for a white company to be placed at MP-3 in Wilderness. No definite explanation or justification for the transfer survives.[41] Company 333 was housed at Camp NP-2-MD. Each of the two African American CCC Camps in Maryland had approximately 180 men enrolled at the time of their establishment.[42]

While the men of Company 333 were transferred from Wilderness, Virginia to Carderock, Company 325 may have been similarly transferred from a camp at Indian Head, Maryland, or may have been an entirely new entity,

39 "CCC Camp Opposed." *The News (Frederick, Maryland)*, 15 June 1938: 1.
40 Howard 2017, 30.
41 Howard 2017, 50.
42 Angela Sirna, "From Canal Boats to Canoes: The Transformation of the C&O Canal, 1938-1942." Thesis submitted to Eberly College of Arts and Sciences, West Virginia University, 2011, 68.

simply organized under the previously used Company 325 designation. The Indian Head camp was terminated on May 31, 1938, but researchers failed to find transfer orders, or camp officer rosters, so it is difficult to determine the relationship between old and new Company 325. Researchers assume Company 325 was a new entity organized at Carderock.[43] Camp NP-1-MD housed Company 325 and was officially founded on September 18, 1938, with the structures completed on October 25. Edwin T. Arnold, First Lieutenant Calvary Reserves, was the assigned command of Company 325. He had been with the CCC for a year prior to the canal project.[44] There is some discrepancy in records, according to Howard, as some records indicate that enrollees began arriving in mid-June and mid-July 1938, three months before the camps were officially established. A temporary tent camp was set up for Company 325 by June 27, although its exact location is unknown. The official camp was established near Cabin John (near mile marker 7) and just upstream of the Seven Locks area (Locks 8-14) (between mile markers 8.3-9.5) on the south side of the Canal.[45] A June 3, 1939 letter between NPS administrators requested the transfer of Mr. Louis (or Lewis) G. Heider to serve as the

Figure 6. Undated aerial view of CCC Camp NP-1-MD (NARA College Park, MD, Still Photos, Record Group 35-GE, Box 1 of 4)

43 Howard 2017, 32; Sirna 2011, 70.
44 Sirna 2011, 67.
45 Lisa Pfueller Davidson and James A. Jacobs, *Historic American Buildings Survey: Civilian Conservation Corps Activities in the National Capital Region of the NPS, HABS No. DC-858,* (Washington DC, 2004), 64.

project superintendent of the new CCC camp to be established for the C&O Canal project.[46] Mr. Heider was assigned to Camp NP-1-MD.[47] Another letter, a week later (from June 11, 1938) recommended transferring Roger Hudson, Assistant Engineer, to Camp NP-1-MD to fill the role of senior foreman (engineer) at the camp, which may further verify that enrollees were already arriving in the summer of 1938.[48]

Engineer records show that Camp NP-1-MD contained typical portable CCC buildings, including a T-shaped mess hall/kitchen, four barracks, recreation hall, officers' quarters, technical services quarters, an educational building, two latrines for enrollees, office structures for the army commander and the technical services supervisor, a pump house, garages, and a blacksmith shop. The camp was partially wooded and the buildings were arranged in orderly lines (**Figure 6**). A well pumped water into a tank tower and the septic system had an outlet to the Potomac River. Garbage was collected by a local pig farmer or burned at the NP-2-MD camp's incinerator. Electricity was connected to the city electrical system.[49]

Camp NP-2-MD, housing Company 333, was officially founded on October 5, 1938, approximately three weeks after Camp NP-1-MD's official establishment. It is not clear from research how common it was in the CCC for two camps to be in such close proximity to one another. The men in Company 333 had gained experience at Wilderness in conservation-minded landscape work, which was relevant to the restoration of the canal bed and the towpath. The establishment of NP-2-MD was approved by Fechner on June 14, 1938; however, the local pressure and high cost of establishing a camp likely drove Fechner's indecision over the following weeks. Additional funds for completing NP-2-MD were submitted by the Adjutant General's office in September 1938. The delays and high cost led Fechner to wait until October 11 to officially request NP-2-MD.[50] By February 2, 1939, the structures of Camp NP-2-MD were completed. Company 333 was led by Captain E.D. Wilberger, who had nearly four years of work experience in the CCC prior to the canal project.

46 Letter to Mr. Cammerer from NPS Acting Associate Director, Hillory A. Tolson, June 3, 1939. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.
47 Howard 2017, 121.
48 Letter to Mrs. Maulding from NPS Associate Director, A.E. Demaray, June 11, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.
49 Davidson and Jacobs 2004, 63-64.
50 Howard 2017, 55.

Figure 7. Undated aerial view of CCC Camp NP-2-MD (NARA College Park, MD, Still Photos, Record Group 35-GE, Box 1 of 4)

The camp site for NP-2-MD was located upstream from Camp NP-1-MD and close to the present Carderock picnic facility on the south bank of the canal (near mile marker 10). The camp was between the canal and the Potomac River in a heavily wooded area (**Figure 7**). The completed Camp NP-2-MD contained portable frame buildings, similar to Camp NP-1-MD, and was planned for approximately 200 enrollees. The buildings included four barracks; a mess hall/kitchen; an educational building; a recreation building; technical service quarters with thirteen rooms; seven-room officers' quarters; a building designated for a hospital, headquarters offices, and supply room; garages; blacksmith shop; and a pump house. Similar to Camp NP-1-MD, Camp NP-2-MD also had access to city electricity, a sewage system, and a well with a storage tank. A garbage incinerator and a frame building were added in 1941 for garbage disposal.[51] The two camps, NP-1-MD and NP-2-MD often worked together on canal projects, which increased their efficiency and made project administration easier.[52]

Preliminary work on the C&O Canal began in October 1938 and included dredging, draining, and removing vegetation near Lock 14 (mile marker 9.5) and at Widewater (mile marker 13.8). Approximately 350 enrollees used steam

[51] Davidson and Jacobs 2004, 64-65.
[52] Memo to Fred T. Johnson from C. Marshall Finnan, Superintendent, November 25, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

dredge shovels and their own hands to complete the work. However, NPS staff instructed the camps to defer full reconstruction until after the best usage of the property could be determined. By January 1939, the two camps had grown to approximately 400 enrollees, who were reported to be hard at work restoring the canal. The restoration work was expected to take between three and five years to complete.[53] Besides restoring the canal bank and towpath, the Public Works Administration (PWA) and CCC workers assigned to the C&O Canal project worked on "landscaping, repair and restoration of historic buildings, lockhouses, lock shanties, lock bridges, etc.," in Great Falls, Carderock, and Georgetown (**Figure 8**). The reconstruction of the canal bed included approximately 50,700 cubic yards of "shaping canal channel and repairing flood damage along the towpath including breaks."[54] Approximately 9,835 square yards of stone rip rap was laid to protect the canal banks. An August 1939 progress report stated water was flowing in the canal from Lock 5 (near mile marker 5) to Georgetown and that the tow path and channel were repaired in a small area directly north of Lock 20 at Great Falls (near mile marker 14.3). Minor repairs, underbrush clearing, and removal of deposits in the Seven Locks area (Locks 8-14, which are located

Figure 8. Lock and Great Falls Tavern. Photo taken prior to NPS/CCC work commencing. (NARA College Park, MD, Still Photos, Record Group 79-G, Box 2 of 40)

53 "Canal Work is Started," *The Daily Mail* (Hagerstown, MD), 21 January 1939; *Cumberland Evening Times*, 20 January 1939 as cited in Howard 2017, 57.

54 Davidson and Jacobs 2004, 66.

between mile markers 8.3 and 9.5) was the focus of work for both CCC camps during October 1939.[55]

Often the CCC enrollees worked together with private contractors brought in with PWA funds to do more complex aspects of the project. This can make it difficult to distinguish the exact work of the CCC from the contractors, as it was a combined effort. Private contractors assisted with the work at Locks 15 and 16 (mile markers 13.4 and 13.6) in Spring 1940. PWA Federal Project (FP) No. 712 was issued in July 1939 and included the construction of concrete retaining walls, spillways, culverts, stone walls, a trestle, and earthen fill placement. The project specified work would occur in the vicinity of Widewater (near mile marker 13.8) between Cropley and Great Falls, north of the Carderock CCC camp area. The contract was awarded to Corson and Gruman of Washington, DC on September 8, 1939. The private contractor completed heavy construction work, including reconstruction of canal bypass flumes, intended to allow constant flow of water and more stable water levels. The reconstruction was done in concrete for better performance and stacked logs were placed on top of the concrete to mimic the original appearance. The private contractor was supported by enrollees at Camps NP-1-MD and NP-2-MD in this work.[56] Corson and Gruman was also the contractor for a reconditioning contract for the canal in April 1940 that was expected to be completed by July 1940 and allow the canal to be refilled with water.[57]

Both African American CCC Camps received fire protection training and they provided firefighting services for the canal from Seneca to Georgetown (approximately 22 miles). The CCC camps at Carderock were approximately 12 miles south of Seneca. The camps also stocked fish in the canal, sprayed for mosquitos, and removed snow in this section.[58]

In addition to clearing brush and debris, the camps reconstructed a six-room frame lockhouse and demolished several dilapidated buildings, including a five-room frame lockhouse. The exact locations and designations for these structures are not known.[59] Both PWA and CCC workers near Great Falls constructed several buildings, including minor canoe concessions, docks,

55 Davidson and Jacobs 2004, 66-67.
56 Davidson and Jacobs 2004, 67.
57 "Work on C.&O. Canal To Start Tomorrow," *Sunday Star*, 14 April 1940. Newspaper article filed at NARA College Park, MD, Textual Records, Record Group 79, Box 2809.
58 Davidson and Jacobs 2004, 67.
59 Davidson and Jacobs 2004, 67.

and facilities for portage around locks.[60] The two African American CCC camps constructed the buildings that are the subject of this study: the Pivot Bridge to cross the Canal prism near the Carderock site of the CCC camps (**Figure 11**); a board-and-batten latrine, or Comfort Station (**Figure 12**) and the associated septic and plumbing systems near the historic Great Falls Tavern building; a parking area for the Great Falls site; a two-storybrick Pump House accommodating a water filtration plant (**Figure 13**); and a wood-frame garage building for the US Army Corps of Engineers Washington Aqueduct maintenance yard next to Great Falls (**Figure 14**). Note that the Pivot Bridge is currently in ruins with only structural support piers on each bank and in the canal remaining.[61] These buildings and structures are discussed in further detail below.

SUMMARY OF THE CCC BUILDINGS AT GREAT FALLS

In a report compiled by Robert M. Coates, who worked in the Office of Field Supervisor R.M. Schenck, on January 15, 1942, CCC work completed at the C&O Canal and development in the Great Falls area was summarized. The report is titled "Inventory of Work Accomplished by CCC Camps Under the Jurisdiction of National Capital Parks, October 19, 1933 to January 1, 1942. National Park Service."[62] Several buildings and

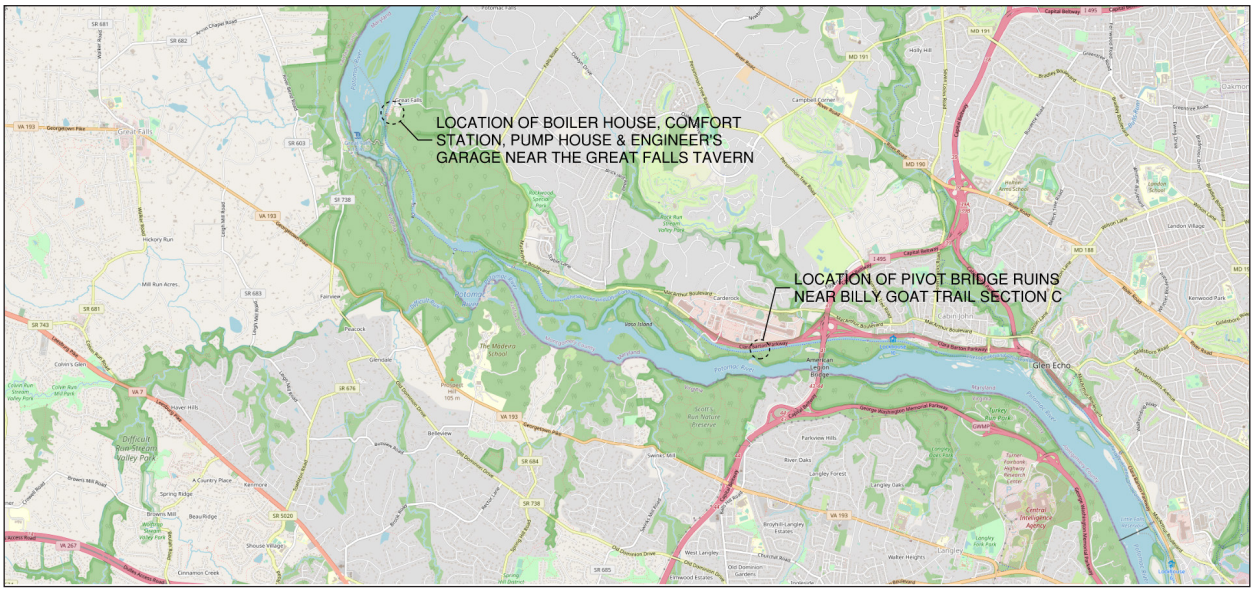


Figure 9. Map showing the location of the Pivot Bridge Ruins in relation to the buildings in the Great Falls area.

60 Howard 2017, 61-62.
61 Howard 2017, 113-114.
62 "Inventory of Work Accomplished by CCC Camps Under the Jurisdiction of National Capital Parks, October 19, 1933 to January 1, 1942. National Park Service," compiled by Robert M. Coates, January 15, 1942. NARA College Park, MD, Textual Records, Record Group 79, Box 2844.

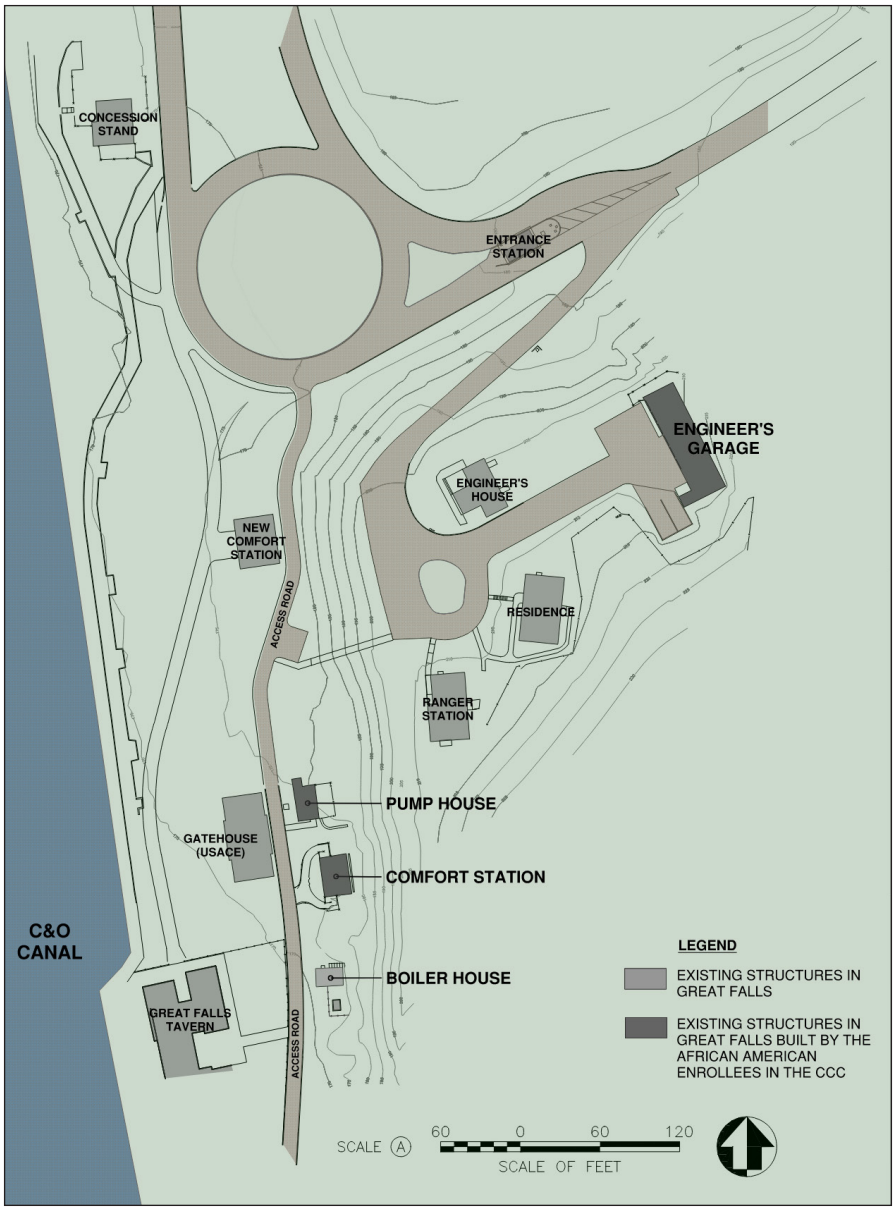


Figure 10. Site Map of buildings in Great Falls Area showing the CCC-built buildings, the Boiler House built in 1951, and other structures in the vicinity.

projects are described as completed in the Great Falls area in this report. Notably absent from this description was the Boiler House, which supports that the Boiler House may not have been constructed by the CCC and dates from 1951.[63] However, the Engineer's Garage and associated road, parking, and service court, the Comfort Station and associated sewage system and pipes, and the Pump House were all noted.

The 1942 report detailed the following work, which will serve as an introduction to the CCC buildings:

[63] Ibid.

In the Great Falls area, an equipment and supply storage house was built. The building was called the US Engineer's Garage, built of frame construction, 87'6" by 24' with an ell 13'4" by 10'4". The garage comprised 6 equipment stalls, a repair shop, bulk storage, and an office. A service court, parking area, and a road leading to the garage were also built by the CCC.

The Comfort Station was referred to as a latrine in the report and described as a 29'5" by 20' frame construction building with board-and-batten siding.

The Pump House was described as a filtration plant in the report. The two-story brick building was 25'4" by 15'10" and housed mechanical equipment, a reinforced concrete coagulating basin, a reinforced concrete clear well, and a 5000-gallon steel pressure tank. (This original equipment has been replaced over time.)

The CCC enrollees also laid terra cotta tile (i.e., ceramic) pipelines for the sewage system, installed cast iron pipeline for a water distribution system, and built a sewage and waste disposal system with a reinforced concrete septic tank.[64]

These CCC buildings and the Boiler House at Great Falls, along with the Pivot Bridge, can be seen on the two maps and are described in their current conditions below (**Figures 9 and 10**).

The summaries below provide a brief introduction to the current conditions of the specific structures and buildings constructed by the CCC in 1941 in addition to the Boiler House built in 1951. Each will be described in more detail in Chapter 3, including maintenance and repairs completed in more recent years. The first structure, the Pivot Bridge Ruins, was constructed near Carderock, a bit further south along the canal than the others. The Boiler House, Comfort Station, Pump House, and the Engineer's Garage are located in the vicinity of Great Falls Tavern.

PIVOT BRIDGE

The surviving remnants of the Pivot Bridge (**Figure 11**) are located at C&O Canal mile marker 9.92. The Pivot Bridge was originally constructed in 1938 by the CCC (Camps NP-1-MD and NP-2 MD) to provide vehicular access from the roads on the north side of the C&O Canal to the CCC

[64] Ibid.

Figure 11. Pivot Bridge Ruins.

camps south of the canal. The stone pier and abutments supported a steel bridge superstructure that is no longer extant. According to the original construction drawings, the center pier supported the bridge gears and rack assembly which controlled the operation of the bridge in a counterclockwise direction to allowed boats navigating the canal to pass.[65]

BOILER HOUSE

The Boiler House building is located at C&O Canal mile marker 14.27 (**Figure 12**).[66] The Boiler House had previously been thought to have been built between 1941 and 1942 by the CCC (Camps NP-1-MD and NP-2-MD), but given the detailed drawings and sections that exist from 1951, equipment

Figure 12. Boiler House.

[65] Howard 2017, 113-114.
[66] Howard 2017, 114.

installed in the 1950s (less than a decade after its supposed original construction and installation), and the lack of inclusion in the above-mentioned CCC report from January 15, 1942, it seems more likely that the Boiler House was not built until 1951.[67]

Following the fire at the Tavern in 1948 which spurred the renovations completed there in 1950–51, it is plausible that the Boiler House was constructed at this time to house a boiler and equipment to serve the Tavern and surrounding structures. The concrete block building with a stucco facade, featuring a painted brick chimney to serve the boiler exhaust, was designed in a style sympathetic to the adjacent Tavern and located just east of the Tavern across the access road. When built, the boiler was supported by a below grade fuel oil storage tank located south of the Boiler House. In 1953 the heating hot water lines were extended to serve the Comfort Station located just north of the Boiler House. In 2007, the equipment in the Boiler House was upgraded which included installation of a new fuel oil storage tank located above grade and east of the building. A new chiller was at grade on a concrete pad above the location of the original below grade fuel tank. At this time a wood stockade fence was constructed to the west and south of the chiller to conceal it from view.

COMFORT STATION

Built by the CCC (Camps NP-1-MD and NP-2-MD) in 1941, this wood-frame building is located at C&O Canal mile marker 14.28 along the east side of the access road behind the Great Falls Tavern and the Washington Aqueduct Gatehouse (**Figure 13**). In addition to the maintenance and other construction projects, the camps were responsible for associated septic and plumbing near the historic Great Falls Tavern. The Comfort Station is located just north of the Boiler House and south of the Pump House, described below.

Construction drawings from 1953 indicate the building was updated with radiant heat at this time. In 2008 a new comfort station was built north of the Washington Aqueduct Gatehouse. Originally constructed to accommodate men's and women's restrooms, in 2017 the interior of the historic restroom structure was altered to accommodate bicycle rental and

[67] United States Department of the Interior National Park Service, National Capital Parks, Engineering Division Office, "Boiler House for Tavern, Great Falls, Maryland, C&O Canal," drawings 110.5-75-M7A.

Figure 13. Comfort Station.

storage, including a workstation for bicycle repair.[68] This renovation included removal of most interior plumbing fixtures, creation of an opening in the interior demising wall to connect to former men's and women's restrooms, and removal of the south privacy screens at the exterior.

PUMP HOUSE

Constructed by the CCC (Camps NP-1-MD and NP-2-MD) in 1941-42, this one-and-a-half-story brick building is located at C&O Canal mile marker 14.29 just north of the Comfort Station and east of the Washington Aqueduct Gatehouse (**Figure 14**).[69] The Pump House was established to provide electrical service and water filtration, storage, and distribution for the surrounding structures building by the CCC in the 1940s. Raw water was brought into a raw water pump pit and sent through a process of filtration and treatment to provide potable water. The water from the pump pit moved to an exterior coagulation basin, located to the east of the building. Following coagulation and flocculation, the water was filtered through a sand and gravel filtration tank and stored in the clear well, a large holding tank located below the building, which extends past the south and west facades of the structure. For distribution, the water was sent to a below grade pressurized tank located east of the coagulation based before being send out to the surrounding structures. The raw water source changed from the Washington Aqueduct to well water between 1940 and the 1970s (exact date unknown). In the early 1980s a water line was brought to the site by the Washington Suburban

[68] Howard 2017, 114.
[69] Howard 2017, 114.

Figure 14. Pump House.

Sanitary Commission (WSSC) and the Pump House was taken out of service. The area's electrical service is still housed in this building, but the original 1940s electrical infrastructure was replaced and upgraded in 2007.

ENGINEER'S GARAGE

Constructed by the CCC (Camps NP-1-MD and NP-2-MD) in 1941 and 1942 at C&O Canal mile marker 14.35, the Engineer's Garage first appears as a project in CCC planning documents as early as August of 1941 (**Figure 15**).[70] The Engineer's Garage, located atop the bluff, is a bit further north and east of the Engineer's House. Away from the tourist-focused area below, the area at the Engineer's Garage and surrounding structures is limited to NPS access.

The building, a wood framed structure with a concrete masonry foundation and asphalt shingle roof, was constructed for use by the US Army Corps of Engineers Washington Aqueduct maintenance yard and originally included seven vehicle/ equipment bays, a repair shop area, an area dedicated to storage, and an office space at the south end. In 1967, the building was converted to accommodate stables and hay storage for mules when the NPS rewatered the canal for recreational boat rides.[71] In 1990, the Engineer's

[70] Howard 2017, 108.
[71] Howard 2017, 115.

Figure 15. Engineer's Garage.

Garage was included in a transfer of real estate from the Department of the Army to the National Park Service.[72]

[72] W.A. File No. 1503-03 Annual Report or Real Estate Holdings. Department of the Army. Washington Aqueduct Building Numbering for Real Estate Identification.

OTHER AFRICAN AMERICAN CCC ACTIVITIES

In " 'Our Only Alma Mater': The Civilian Conservation Corps and the C&O Canal," Howard provides some details related to other projects or activities the NPS directed the African American CCC camps undertake, including some projects beyond their work on the C&O Canal. The following list includes some projects that were completed and others that may not have been, since the camps were closed after the US joined WWII. The list does not always provide exact locations of the structures. Notably, the projects at Great Falls on this list that match up to extant or known resources include wells, drains, pipelines, the Pivot (Swing) Bridge, the latrine, the Engineer's Garage, and the Engineer's Garage access road. [73]

- Surveys, Jun. 1939
- Fire Presuppression, Oct. 1938
- Landscape Undiff. Clean Channel Supplemental, 35 Acres, Nov. 1938
- Prep. and Trans. Materials, May 1939
- Lockhouses, Dwellings, 4 total, Apr. 1939
- Excavation of Canal, 12481 cubic yards, Jun. 1939
- Minor Road, Navy Maint., 1.2 miles, Jul. 1939
- Riprap, 5006 sq. yards, Aug. 1939
- Public Picnic Grounds, New Approval

Figure 16. Photo from February 8, 1942. Enrollees from Camp NP-1-MD, Cabin John, Maryland are engaged in various activities of a national defense auto mechanics training class in a school building near Rockville, Maryland. Photo by W.J. Mead. (NARA College Park, MD, Still Photos, Record Group 35-G, Box 41).

[73] Howard 2017, 108.

Figure 17. Undated Photo (likely 1942) of CCC enrollees in Camp NP-1-MD, Cabin John, Maryland, engaged in woodworking. (NARA College Park, MD, Still Photos, Record Group 35-G, Box 41)

- Water Control Structure, Jan. 1940
- Access Road Maintenance, 1.5 miles, Nov. 1941
- Wells, Great Falls, May 1940
- Drains, Great Falls, 806 ln. ft., May 1940
- Sewage and Waste Disposal, Jan. 1941
- Pipe Lines, Great Falls, 255 ln. ft., May 1940
- Landscape Undiff. (Maint.), 144.9 Acres, Jun. 1940
- Water Control Structure Flumes, 11 total, Mar. 1941
- Swing Bridge, Carderock, Mar. 1941
- Latrine, Great Falls, May 1941
- Maintenance Water Level & Patrol C&O Canal, Nov. 1940
- Canoe Docks, 34 total, Dec. 1940
- Tennis Courts, 12 total, Apr. 1941
- Engineer's Garage, Great Falls, May 1941
- Engineer's Garage Access Road, Great Falls, May 1941[74]

Camp NP-2-MD was closed on October 15, 1941, prior to the closing of Camp NP-1-MD.[75] After Camp NP-2-MD closed, CCC administrators requested that the camp be dismantled, but the Superintendent of National Capital Parks, Irving Root, pushed back because there were remaining canal projects

[74] Ross Abare, "Work Project Report Supplement to Form 11: Camp NP-1," Mar. 3, 1941; CCC Camp Inspection Reports, Entry 115, RG 35, NACP. Ray Schenck, "Work Program Outline: Camp NP-1 & 2," Aug. 19, 1941; NPS Central Classified File, 1933-1949, Box 2844, Entry 10, RG 79, NACP as cited in Howard 2017, 108.

[75] Howard 2017, 104. Please note that Howard stated that Camp NP-2 was closed on October 15, 1941, and the report he cited was dated November 15, 1941. Davidson and Jacobs' HABS DC-858 2004 report stated that Camp NP-2 was closed on November 15, 1941, perhaps confusing the report date with the closure date.

and they hoped the camp would be reoccupied again in the future. The outbreak of war crushed those hopes. Four barracks buildings of Camp NP-2-MD were transferred to Bolling Field in Washington, DC as part of the war effort.[76]

In early 1942, Camp NP-1-MD was still operating, with 176 enrollees total, and 106 of them assigned to projects. In April 1942, Camp NP-1-MD was redesignated as NP(D)-3, and its purpose was shifted from conservation, preservation, and recreation work to military support training. The men were trained in automotive repair, welding, aviation mechanics, carpentry, and electrical work. **Figure 16 and Figure 17** show photos of the men of Camp NP-1-MD training in auto mechanics and carpentry/woodworking.[77]

[76] Howard 2017, 104-105.
[77] Howard 2017, 105-106.

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Chapter 2: Chronology of Development and Use

DEVELOPMENTAL TIMELINE

Below is a timeline of major events in the C&O Canal's early history, as well as events related to the US government's interest in acquiring the C&O Canal and subsequent management assignment of the canal by NPS to the present:

1785: George Washington and others chartered the Patowmack Company to improve navigation along the Potomac River.

1825: The C&O Canal was chartered.

1828: Patowmack Canal Company went bankrupt and transferred its charter to the C&O Canal.

1828: Construction began on the C&O Canal.

1852: A devastating flood in April caused damage to the C&O Canal from Georgetown to Dam 6, north of Williamsport, Maryland. Flooding is a constant part of the canal's history and has shaped the Potomac River for centuries. On average, a major flood overflows the banks of the Potomac River every 12–13 years.[1]

1889: The Great Flood of 1889 caused extensive damage to the C&O Canal and the B&O Railroad.

1924: C&O Canal ceased operations as a transportation system.

1935: NCP&PC Planner John Nolen, Jr. declared a unanimous agreement that the C&O Canal should be preserved as a recreational waterway with scenic and historic value in a 1935 report. In addition, he claimed that the restoration of the canal would be an ideal work relief project.[2]

1936: The St. Patrick's Day Flood, one of the greatest floods on record caused flooding throughout the Northeast.[3] The flood inflicted severe damage to the C&O Canal, including putting the income-producing Georgetown section out of commission. In addition, numerous summer camps and boathouses

1 National Park Service, Chesapeake & Ohio Canal, "Flooding." https://www.nps.gov/choh/learn/kidsyouth/flooding.htm, accessed September 22, 2022.

2 Quoted in Barry Mackintosh, *C&O Canal: The Making of a Park*. (Washington DC: History Division, NPS, Department of Interior, 1991), 12. Also, quoted in Davidson and Jacobs 2004, 62.

3 Davidson and Jacobs 2004, 66.

on the riverfront leased to the C&O Canal were swept away and the towpath was washed out in many places.[4] The B&O Railroad limited its repairs to the income generating areas of the canal, such as the rubble Dam No. 1 at Little Falls and the Georgetown section. The repairs cost $25,460 (1936 dollars); however, the remainder of the canal was not repaired.[5]

1938: On March 21, 1938, estimates for the C&O Canal purchase totaled $3,801,087 and included 1) Land value, from DC to Great Falls for $1,178,078; 2) Recreational value of canal from Rock Creek to Seneca for $500,000; 3) Land value, including Great Falls to Cumberland for $553,000; 4) Estimated water power rights in Georgetown for $450,000; and 5) Structural value of Monocacy Aqueduct for $120,000.[6] A revision memo was submitted to increase the land value of the canal from DC to Great Falls to an estimated $1,333,980.[7]

1938: On June 4, 1938, in a letter to B&O Railroad Assistant General Counsel, Daniel Willard, Jr., Esq., NPS Acting Director, A.E. Demaray described the partial justification for the purchase of the C&O Canal as an ideal fit for the CCC purposes of conservation, preservation, and recreation. Demaray asked B&O officials to request that CCC camps be assigned to the C&O project prior to the sale going through, to take advantage of the current labor availability.[8]

1938: A June 11, 1938 letter to Mrs. Maulding (the administrative assistant to E.K. Burlew, Senior Assistant to Secretary Ickes) from NPS Associate Director, A.E. Demaray mentions the establishment of NP-1-MD Camp and the need for a senior foreman (engineer) at the camp. Demaray recommended the immediate transfer of Mr. Roger Hudson, an Assistant Engineer with the Branch of Engineering, who was exceptionally well qualified for the position, with a salary of $2,600 annually. [9]

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4 Mackintosh 1991, 13.

5 Donald R. Shaffer, "'We are again in the midst of trouble': Flooding on the Potomac River and the Struggle for the Sustainability of the Chesapeake and Ohio Canal, 1828-1996." (Washington, D.C: The Chesapeake and Ohio River Canal Historical Park, National Park Service, 1997), 65.

6 Memo to Secretary from NPS, March 21, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

7 Memo to John Nolan, Jr., March 21, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

8 Letter to Daniel Willard, Jr., Esquire from NPS Acting Director, A.E. Demaray, June 4, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

9 Letter to Mrs. Maulding from NPS Associate Director, A.E. Demaray, June 11, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

1938: On September 19, 1938, Company No. 325 formally established Camp NP-1-MD, the first CCC camp dedicated to the restoration of the C&O Canal.[10]

1938: On September 28, 1938, the 184.5-mile long C&O Canal was purchased by the Federal government from the B&O Railroad and given to the NPS for management. The purchase of the C&O Canal by the US government was for a total of two million dollars ($2,000,000).[11]

1938: On October 5, 1938, Company No. 333 formally established Camp NP-2-MD, the second CCC camp assigned to the restoration work of the C&O Canal, about three weeks after Camp NP-1-MD was established.[12]

1938: In October 1938, there were approximately 350 CCC enrollees between the two camps.[13]

1938: On November 7, 1938, C. Marshall Finnan, Superintendent of the National Capital Parks, conducted a meeting on canal restoration and New Deal participation in the effort. Attendees included NPS staff and staff of the NCP&PC. John Nolen, Jr., NCP&PC Planning Director, asserted in a memorandum to Frederick A. Delano, chairman of the NCP&PC, that the section of the C&O Canal below Great Falls to Georgetown was part of the George Washington Memorial Highway. Nolen, Jr., suggested that in order to avoid delays, "that it was important in the realization of this plan that in the lower section where the Commission proposes to acquire adjoining land, not to encourage speculative activity particularly by undue publicity." The memo mentions that the schedule of operations would progress downstream from Great Falls and that undue publicity could cause delays.[14] Following this meeting and a November 10 memo from Nolen, two forms suggesting a change to the original WPA appropriation of $515,863.77 were filed. The first, an Allotment Advice form dated November 29, 1938 from NPS to National Capital Parks suggested a decrease of $2,600 for a new total of $513,263.77.[15] The second form, Advice of Change in Outline of Work 4525 (NPS), also

10 Davidson and Jacobs 2004, 63.
11 Deed of sale to US from C&O Canal Company receivers, September 23, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2823.
12 Davidson and Jacobs 2004, 63.
13 Davidson and Jacobs 2004, 64-65.
14 Memo to Frederick A. Delano from John Nolen, Jr., November 10, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.
15 Allotment advice, November 29, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

dated November 29, 1938, identified that the $2,600 decrease was to be taken from Federal Project 712, which included the acquisition of adjacent lands, construction work to a parkway, and the rehabilitation of the existing canal as a historic site.[16] The form cites a memorandum from Superintendent Finnan on November 8 as the reason for the decrease; however, the actual memo was not included in the Textual Records. The November 10 memo suggests two possible motivations for the decrease, such as the assignment of responsibility to the parkway for development or as a result of a change in the acquisition strategy of adjacent land.

1938: A memo dated November 25, 1938 from C. Marshall Finnan to Fred T. Johnson recommended combining NP-1-MD and NP-2-MD to operate to a certain extent as one unit on certain projects for efficiency and the orderly administration of the project. He recommended the revision of a few projects, Jobs # 400, 401, 402, and 404 to reflect this combination of NP-1-MD and NP-2-MD. In addition, work proposed on Jobs # 405 and 407 for the C&O Canal were not interpreted as reconstruction, but instead were seen as preparatory work required for the canal reconstruction.[17]

1939: In January 1939, the two camps had grown to approximately 400 enrollees.[18]

1939: The proposed operating program for the C&O Canal was submitted to the Associate Director from C. Marshall Finnan, Superintendent on February 10, 1939. In the proposed program, the portion of the original 184.5-mile C&O Canal from Georgetown to Seneca was to be developed as a recreational waterway and was to retain as much historical character as possible. The NPS did not propose any development above Seneca, leaving the 161.8 miles from Seneca to Cumberland unaltered and undeveloped. The center of recreational activity would be Great Falls and the historic tavern would be converted into a contact and administration building including lobbies, restrooms, and possibly a museum room. The general activities planned included boating, hiking, fishing, and picnicking. Canoe concessions would be located at Great Falls, at Carderock, four miles south of Great Falls, and at Key Bridge in Georgetown. The approximately 14-mile section between

16 Advice in Change of Outline of Work 4525, November 29, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

17 Memo to Fred T. Johnson from C. Marshall Finnan, Superintendent, November 25, 1938. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

18 Howard 2017, 57.

Georgetown and Great Falls was originally completed in 1831 and included twelve lockhouses, ten of which were still extant. The plan was to retain the original existing lockhouses and an additional two lockhouses above Great Falls, keeping the exteriors as close to original as possible, but adding modern conveniences to the interior, so that a custodian could live in each. Around 1870, frame lockhouses were added to each lock which originally had none. However, the 1870 houses were to be razed as they were architecturally and structurally poor with the exception of the houses at Lock 20 and Lock 23, which were more recent log cabin replacements. Only the houses at Locks 5 and 6 had complete installation of water, heat, and sanitary facilities. The water and power systems which served the villages of Glen Echo and Cabin John were identified as potentially able to supply the houses as far as Lock 11. Septic tanks would need to be separate installations. All the proposed retained original lockhouses were stone construction with a basement, two rooms on the first and second floors, and only one-and-a-half stories in height. The Carderock area housed the CCC camps in 1939, but the area was planned to be developed into a picnic area following the abandonment of the camps. The proposed picnic area was designed to include tables, fireplaces, and a canoe concession.[19]

1939: A June 3, 1939 letter to Mr. Arno Cammerer, NPS Director, from NPS Acting Associate Director Hillory A. Tolson requested the transfer of Mr. Louis (or Lewis) G. Heider as the project superintendent of the new CCC camp to be established for the C&O Canal project. The request for transfer was submitted on May 16 and recommended that Mr. Heider be hired at an annual salary of $2,900. The Secretary's order to transfer Mr. Heider was dated June 2 but had not been signed as of June 3.[20] Mr. Heider was assigned to Camp NP-1-MD.[21]

1940: A Press Release on April 14, 1940 in the *Sunday Star* stated that work on the $15,500 reconditioning contract of the C&O Canal was to start on April 15. Francis F. Gillen, the acting superintendent of National Capital Parks, announced that the contract was awarded to the Corson & Gruman Company of Washington, DC. Work was expected to be completed by July 1 and make the canal ready to be filled with water. The Corson and Gruman

19 Memo for the Associate Director from C. Marshall Finnan, Superintendent, February 10, 1939. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

20 Letter to Mr. Cammerer from NPS Acting Associate Director, Hillory A. Tolson, June 3, 1939. NARA College Park, MD, Textual Records, Record Group 79, Box 2836.

21 Howard 2017, 121.

Company was also responsible for a larger PWA contract ($101,117) that was nearing completion in the vicinity of Widewater between Cropley and Great Falls.[22]

1940: The Pump House was constructed per construction drawings approved in May 1940.

1941: The Pivot (Swing) Bridge was constructed per construction drawings approved in March 1941. Prior to construction of this bridge, temporary bridges provided access to the CCC camps.[23] The canal had reopened in 1940 and traffic necessitated the construction of this bridge.

1941: The Comfort Station (Great Falls Toilet) was constructed per construction drawings approved in April 1941.

1941: The Engineer's Garage (Garage for US Engineers) was constructed per construction drawings approved in May 1941.

1941: On October 15, 1941, the NP-2-MD camp was closed.[24]

1942: In early 1942, Camp NP-1-MD was still operating, with 176 enrollees total, and 106 of them assigned to projects.[25]

1942: On April 1, 1942, the NP-1-MD camp was closed and transitioned into a defense camp, NP (D) 3. The defense camp operated from the Carderock/ C&O Canal location from April 1 to July 29, 1942.

1942: In October 1942, the restored C&O Canal was again damaged by a flood, which stemmed from the Shenandoah River and impacted the Potomac River below Harpers Ferry. Much of the work done by the CCC enrollees was damaged.[26] Arthur E. Demaray, Associated Director of NPS, estimated that repairs would cost $250,000 for the area upstream to Great Falls. The B&O Railroad repaired the canal breach at Fletcher's Boathouse bordering its railroad tracks because it was likely affecting railroad operations. The flood had damaged the tracks and washed three freight cars into the river.

22 "Work on C.&O. Canal To Start Tomorrow," *Sunday Star*, 14 April 1940. Newspaper article filed at NARA College Park, MD, Textual Records, Record Group 79, Box 2809.
23 Howard 2017, 66.
24 Howard 2017, 104.
25 Howard 2017, 105-106.
26 Davidson and Jacobs 2004, 68.

At the time, the War Production Board regulated industrial production and prohibited Federal civilian construction projects over $10,000 during WWII. Demaray presented the repairs from Georgetown to Dam No. 1 (5.6 miles above Georgetown) as an alternative means to supply water to the Dalecarlia Reservoir in the event that the normal water conduits were bombed or sabotaged. The Dalecarlia Reservoir served as a settling basin for the Washington Aqueduct, supplying DC with water. The remainder of the canal was repaired from Georgetown to Seneca after WWII. While the Dam 1 work occurred during WWII, the rest of the repair work from Georgetown to Seneca was delayed until after the armistice.[27]

1947: A June 16, 1947 memo to the Secretary of Interior from A.E. Demaray, Associate Director of NPS, detailed several events of special interest, one of which was a summary of damage to the C&O Canal. The towpath of the C&O Canal was damaged on May 28 in the Georgetown level of the canal. The repairs were delayed due to the need to construct a 6-foot storm water sewer to traverse the bed of the canal at the point of the break by Washington, DC. The sewer construction contract had been awarded. Repairs to the canal were anticipated to be completed by August 1, at which point water would be reintroduced.[28]

1948: On February 25, 1948, "a bill to authorize the Secretary of Interior to have made by the Public Roads Administration and the National Park Service a joint reconnaissance survey of the C&O Canal between Great Falls, Maryland and Cumberland, Maryland and to report to the Congress upon the advisability and practicability of constructing thereon a parkway and for other purposes" was passed. An expenditure fund of $40,000 was authorized.[29]

1948: In 1948 a fire damaged the Great Falls Tavern and was the likely catalyst for renovations from 1950 to 1951.[30]

27 Shaffer 1997, 72-73.

28 Memo from A.E. Demaray, Associate Director, National Park Service, to the Secretary Re: Report of Special Events, National Capital Parks, June 16, 1947. NARA College Park, MD, Textual Records, Record Group 79, Box 2809.

29 Letter from C. Girard Davidson, Assistant Secretary of the Interior, to Honorable Mr. James E. Webb, Director, Bureau of the Budget, February 25, 1948. NARA College Park, MD, Textual Records, Record Group 79, Box 2809.

30 Beyer Blinder Belle Architects & Planners, et al., "Great Falls Tavern Historic Structure Report" (Washington, D.C.: National Park Service, 2021), 11.

1950: The reconnaissance survey/feasibility study of the C&O Canal between Great Falls and Cumberland, Maryland was completed by the Public Roads Administration and the NPS.[31]

1951: In March, NPS approved construction drawings for the Boiler House.

1953: The NPS approved construction drawings for the expansion of the radiator heating to the Comfort Station per construction and record drawings approved in December 1953. These drawings are noted as having been designed in August 1950, but were not approved and built until late 1953. The 1951 construction drawings for the Boiler House did not include distribution of the boiler lines to the Comfort Station.

Late 1940s/Early 1950s: Historic aerial photographs confirm the Pivot Bridge superstructure was removed by the mid-1950s. An aerial photograph confirms the superstructure was no longer extant by 1957.[32]

1954: On March 19, 1954, Supreme Court Justice William O. Douglas, reporters, and 32 others began their 8-day hike (185 miles in total) in an effort to save the canal from the parkway proposal.[33] Nine of the hikers completed the entire hike.[34]

1961: The C&O Canal was designated as a National Monument on January 18, 1961. [35]

1971: The C&O Canal was designated as a National Historical Park on January 8, 1971, the Chesapeake & Ohio Canal National Historical Park (CHOH), through the *Chesapeake and Ohio Canal National Historic Park Act*.[36]

1972: Flash flooding from the remnants of Hurricane Agnes in Virginia on June 21 and heavy rain was reported throughout the Mid-Atlantic as the storm moved north. The CHOH was declared a major disaster area in the

31 Ibid.
32 Nationwide Environmental Title Research, LLC 1949, 1957.
33 National Park Service. Chesapeake & Ohio Canal, "Frequently Asked Questions." https://www.nps.gov/choh/learn/news/frequently-asked-questions.htm, accessed September 22, 2022.
34 C&O Canal Association, "About." https://candocanal.org/about/, accessed September 22, 2022.
35 Davidson and Jacobs 2004, 68.
36 Ibid.

aftermath of the storm.[37] Damage included 66 miles of eroded and impassable towpath; a total of 26 breaks with seventeen downstream of Seneca and the worst break at Widewater, a 300-foot long, 330-foot deep gash in the towpath; a partially collapsed wingwall of the Monocacy Aqueduct; 86 damaged culverts; washed away bridges, including five steel footbridges installed in 1969 to provide access from the towpath below Lock 18 to Olmstead Island; damaged locks and lockhouses; heavily silted, damaged, or destroyed picnic and parking areas and access roads; numerous private cottages washing into park property; and over 200,000 uprooted trees.[38] The initial damage was estimated to be $7 million; however, on July 14, 1972, architect A.W. Frazen estimated that a total amount of $9,926,000 was actually needed to complete repairs. In September 1972, NPS revised the estimate again and requested a $34 million supplemental appropriation to repair damages, which was stalled in the Office of Management and Budget. The 1972 repairs were stopgap measures funded by the CHOH's 1973 maintenance budget and an additional $400,000, which was diverted from other parks. Repairs began in earnest in 1973 with $353,800 for repairs between Georgetown and Lock 5. An additional $1.8 million was received as part of the CHOH's 1974 budget. In September 1973, a C&O Canal Restoration Team was established as a special field unit to the National Capital Parks Team of the Denver Service Center to plan and oversee repair and restoration work on the canal. The unit was organized under Richard G. Huber and team members occupied park structures at Seneca and Williamsport. Additional funds were acquired from the bicentennial money in 1975. The bicentennial program included 27 projects to be completed before July 1976 at a total cost of $4,250,000 with 14 projects assigned to contractors and NPS park maintenance crews responsible for the remaining 13 projects.[39] The C&O Canal Restoration Team was suspended in 1977 following the end of the bicentennial program, but evolved into the Historic Preservation Training Center, which still exists as a construction entity within the NPS today.

1973: To reduce overcrowding, a picnic area at Great Falls was removed.[40]

37 Tom Horton, "Retrospective: The Damage Caused by Hurricane Agnes," *Washingtonian* (June 19, 2012); Silver Jackets, "50th Anniversary of Hurricane Agnes: Learn from the Past and Prepare for the Future." https://agnes50-noaa.hub.arcgis.com/, accessed January 11, 2023.

38 Shaffer 1997, 89; Mackintosh 1991, 159-161.

39 Mackintosh 1991, 162.

40 Mackintosh 1991, 167.

1974: The NPS remodeled the Comfort Station.[41]

1976: The Pivot Bridge Ruins were repointed, and vegetation was removed.

1979: The Chesapeake & Ohio Canal National Historical Park Historic District was listed in the National Register of Historic Places.

Early 1980s: The existing water supply prior to the early 1980s was located at mile marker 14.3 in a heavily visited area and consisted of only a deep well connected to a 40,000-gallon storage tank at the Pump House, which was deemed inadequate to supply the approximately 1 million visitors and the fire protection of the historic buildings.[42] A February 24, 1981 memo to John Longworth, Civil Engineer, National Capital Region from Dale B. Sipes, Chief of Maintenance discussed the proposed water hookup with the WSSC. The original proposal submitted in 1980 described a two-phase project to extend the water main from the WSSC line to the CHOH property line and then continue to extend the line from the property line to the Great Falls area. Water and sewage improvements were completed at Great Falls which included an 8" cast iron water main along Park Entrance Road routed to an existing 3" water line within a manhole north of the Pump House from an existing WSSC water main in Belmart Road. With water being supplied by WSSC, the Pump House and pressurized water tank located below grade east of the Pump House were taken out of service.

1985: A minor flood event caused less damage to the canal structure in November 1985; however, more than 140 miles of the towpath from Seneca (mile 22) to Oldtown, MD (mile 166) was scoured by water and suffered from debris deposits. NPS Director William Penn Mott, Jr., Superintendent Dick Stanton, and NPS staff organized a volunteer cleanup effort, which was endorsed by Secretary of Interior, Donald Paul Hodel as part of his "Take Pride in America" campaign. The cleanup effort opened on June 1, 1986 at the Potomac Fish & Game Club. By the end of August 1986, more than

41 "Individual Building Data: Comfort Station", NPS Form 10-768 (Rev. 8/64) prepared on September 30, 1975, filed at CHOH Maintenance Collection, Williamsport.

42 "Memorandum to John Longworth, Civil Engineer, National Capital Region from Dale B. Sipes, Chief of Maintenance, C&O Canal regarding the Proposed Hookup to WSSC – Great Falls," Memo dated February 24, 1981, filed at CHOH Maintenance Collection, Williamsport, MD, Series V: mm 12.62-14.30, Box 05, Folder 14.29 Pump House, 1975, 1995-1997; "Memorandum to Regional Director, National Capital Region from William B. Failor, Superintendent, C&O Canal regarding the FY-81 Maintenance Add-on," Memo dated December 15, 1980, filed at CHOH Maintenance Collection, Williamsport, MD, Series V: mm 12.62-14.30, Box 05, Folder 14.29 Pump House, 1975, 1995-1997.

7,000 Boy Scouts, Girl Scouts, and other volunteers had participated. NPS Superintendent Dick Stanton accepted a "Take Pride in America" award from President Ronald Reagan for the volunteer cleanup activity.[43]

1990: The Engineer's Garage, originally constructed as the US Army Corps of Engineers Washington Aqueduct maintenance yard, was included in a transfer of real estate from the Department of the Army to the National Park Service. This land and building real estate transfer included the Engineer's House, Residence, and Ranger's Station all located at the top of the bluff southwest of the Engineer's Garage.[44]

1995: Repairs completed at the Comfort Station in 1995 included wood shingle roof replacement in October and interior painting completed in March.[45]

1995: The Pump House roof was repaired and included the removal of vegetation, replacement of missing shingles, and review of the flashing at the chimney.[46]

1996: A flood in 1996 caused extensive damage to the C&O Canal. Portions of the towpath and many structures were rebuilt.

1997: The Pump House exterior was painted and some windows were re-glazed. The work was performed by the Montgomery County Conservation Corps.[47]

2007: The boiler and mechanical equipment in the Boiler House were replaced and/or upgraded to support new systems at Great Falls Tavern and

43 Mackintosh 1991, 168.

44 W.A. File No. 1503-03 Annual Report or Real Estate Holdings. Department of the Army. Washington Aqueduct Building Numbering for Real Estate Identification.

45 "Compliance Committee Checklist, Replace Roof – Great Falls Comfort Station, Project No. 94312", Compliance Completion Date 8/9/1994, form filed at CHOH Maintenance Collection, Williamsport; "Compliance Committee Checklist, Great Falls Comfort Station – Interior Painting, Project No. 95043", Compliance Completion Date 3/6/1995, form filed at CHOH Maintenance Collection, Williamsport.

46 "Job Order Request: Repair Roof at Pump House", NPS form 10-577 (March 1970) prepared on June 28, 1995, filed at CHOH Maintenance Collection, Williamsport, MD, Series V: mm 12.62-14.30, Box 05, Folder 14.29 Pump House, 1975, 1995-1997.

47 "Compliance Committee Checklist, Great Falls Pump House – Paint House, Project No. 97147", Compliance Completion August 28, 1997, filed at CHOH Maintenance Collection, Williamsport, MD, Series V: mm 12.62-14.30, Box 05, Folder 14.29 Pump House, 1975, 1995-1997.

the surrounding structures. Work included the replacement of the electrical service distribution board in the Pump House.

2008: A new accessible Comfort Station was built north of the Gatehouse in an area which had provided approximately 34 parking spaces. The parking area was removed to accommodate the new comfort station.

2010: The toilets and the water line at the historic Comfort Station were repaired.[48]

2015: The NPS undertook envelope repairs at the Engineer's Garage, including the replacement of the asphalt shingle roof, gutter installation, and wood siding repairs.

2016: An occupant fire alarm notification system was installed at the Engineer's Garage. [49]

2017: Work was completed at the historic Comfort Station, constructed in 1941, to modify it for temporary storage. Today the historic Comfort Station is used to support the bike share program. No specific information about this program was identified.

2017: Broken windows were replaced at the Pump House. Repairs were made at the Engineer's Garage including repairs to the wall unit heater in the office, light repairs, the removal of metal cabinets, the restoration of power, and the replacement of the garage doors.[50]

2018: The vegetation around the Pump House was trimmed and the roof was cleaned and repaired. Repairs to the Boiler House included repairs to the water meter, a leaking pipe, tank monitoring system, and the resetting and servicing of the boiler for the winter season.[51] Corrective actions were taken to address water infiltration at the Engineer's Garage which included excavations to install dampproofing and foundation drainage along the right side and behind the structure (assumed to be located along the southeast side).[52]

48 Summary of FMSS Maintenance Records pulled on September 28, 2022.
49 Ibid.
50 Ibid.
51 Ibid.
52 Ibid.

2019: Termite issues were mitigated and the mule paddocks were moved at the Engineer's Garage in 2019.[53]

2020: The deteriorating cedar shingle roof of the Pump House, which was covered with a tarp in 2019, was replaced in 2020. The scope of work also included roof framing reinforcement, select areas of new roof sheathing, and new flashing.[54]

2022: The NPS painted the Engineer's Garage and surrounding enclosure fence.[55]

53 Ibid.
54 Ibid.
55 Ibid.

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Chapter 3: Physical Description

GENERAL OVERVIEW

SmithGroup, Silman, and Gray & Pape (A/E Consulting Team) visited the project structures near Lock 20 on October 6, 2020 to assess the interior and exterior of the Boiler House (mile 14.27), the Comfort Station (mile 14.28), the Pump House (mile 14.29), and the Engineer's Garage (mile 14.35). On October 16, 2020 the A/E Consulting Team visited the Pivot Bridge Ruins (mile 9.92) near Carderock Recreation Area to document structural and masonry conditions. Following the project suspension due to COVID restrictions, SmithGroup returned to the site on June 22, 2022, September 27, 2022, and December 14, 2022 to evaluate any conditions that may have changed since the beginning of the project. These additional site visits were also conducted to document recent repair work completed at the Pump House and to conduct further investigations at the Pump House and Pivot Bridge with assistance from NPS staff.

The physical descriptions provided on the following pages are based on observations in the field supplemented by careful review of the original construction drawings provided by the NPS and archival resources identified at the C&O Canal archives located in Williamsport, MD. Some of these drawings and documents were difficult to decipher, but a moderate amount of information was gleaned to assist the A/E Consulting Team in developing a physical description.

SITING OF HISTORIC STRUCTURES

The structures built by the African American CCC enrollees, in addition to the Boiler House, are listed as contributing structures to the Chesapeake and Ohio National Historical Park Historic District and located along the 14th mile of the canal system, near the historic Great Falls Tavern (**Figure 18**). The one exception to this was the Pivot Bridge which was constructed at mile 9.92. The African American CCC enrollees worked on the first 22 miles of the C&O Canal as they built structures that developed the area for recreational purposes, as well as barracks, and other structures that facilitated their own work. The work they completed included the Comfort Station (mile 14.28), Pump House (mile 14.29), and Engineer's Garage (mile 14.35), all located within short walking distance to the Tavern (**Figure 19**). In 1951 the Boiler House (mile 14.27) was construction to support the heating and cooling needs of the Tavern.

- The Pivot Bridge Ruins, located several miles southeast along the Canal from the structures located near the Great Falls Tavern, was constructed in the early days of the CCC camp operations. The remains of the pivot bridge include the central pier and two abutments, which are clad in quartzitic schist. The north and south abutments feature several remaining steel bolts originally used to secure wood bumpers to the edges of the bridge to protect the boats and the steel bearing plates used to support the pivoting bridge mechanisms. The center pier includes the original rail, gears, and bearing plates of the bridge mechanisms and a stone inscribed on the south facade noting the date of construction.
- The Boiler House, located east of and across the access road from the Great Falls Tavern, is partially built into the sloped landscape east of the C&O Canal. The Boiler House was not built by the CCC, but was constructed later in 1951 to support the heating and cooling of the nearby Tavern. In 1953 the heat hot water was extended from the Boiler House to serve the Comfort Station. The structure maintains most of its original architectural details, but the equipment and operations have been updated, most recently in 2007. The original

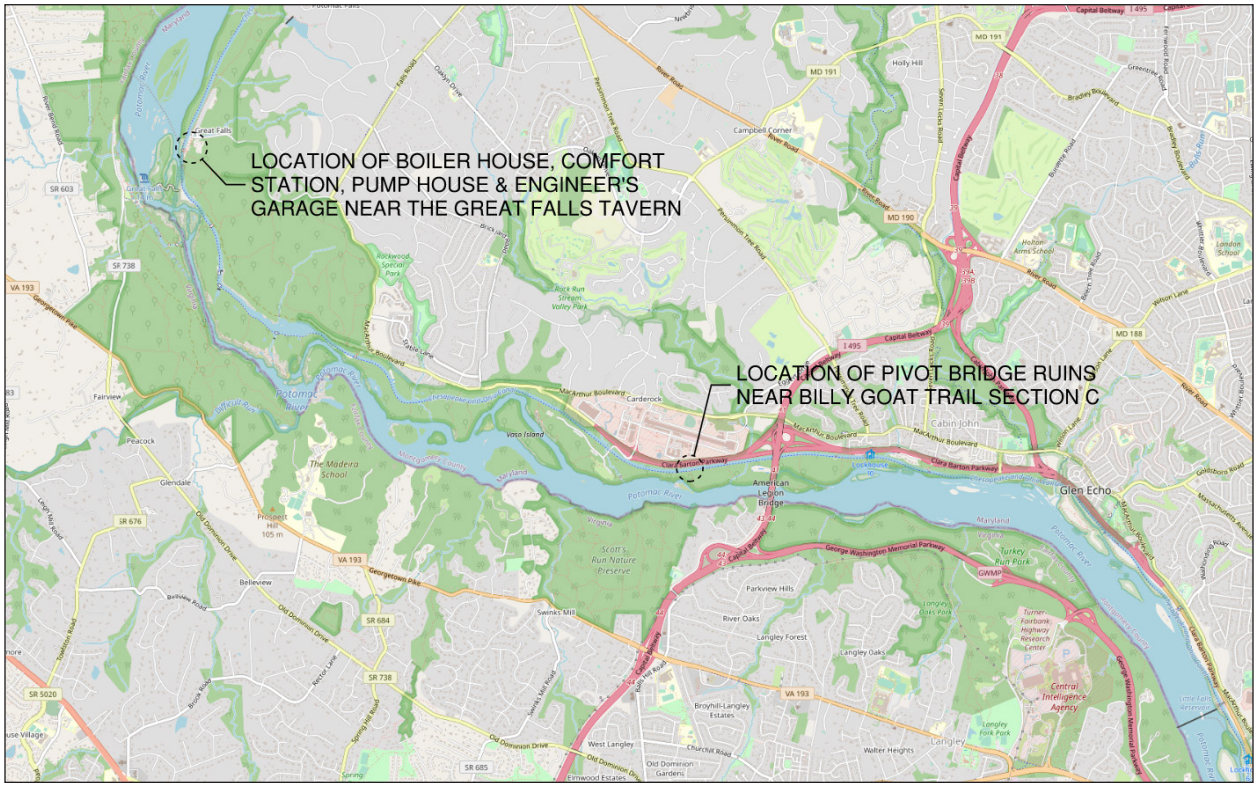

Figure 18. Site Map locating the structures adjacent to the Great Falls Tavern (Boiler House, Comfort Station, Pump House, & Engineer's Garage) and the Pivot Bridge Ruins located near the Carderock Picnic Pavilion and the Billy Goat Trail at mile marker 9.92.

below grade fuel oil tank has been replaced and relocated above grade east of the building and the interior equipment replaced and upgraded. The existing documentation from the 2007 upgrades mentions the original below grade fuel oil tank located south of the building, but did not indicate whether it was removed. A chiller installed in 2007 is located south of the building on a concrete slab on grade and concealed from view on the south and west sides by a painted fence. The location of this chiller presents challenges to confirming the presence of the original below grade fuel oil storage tank at this time.

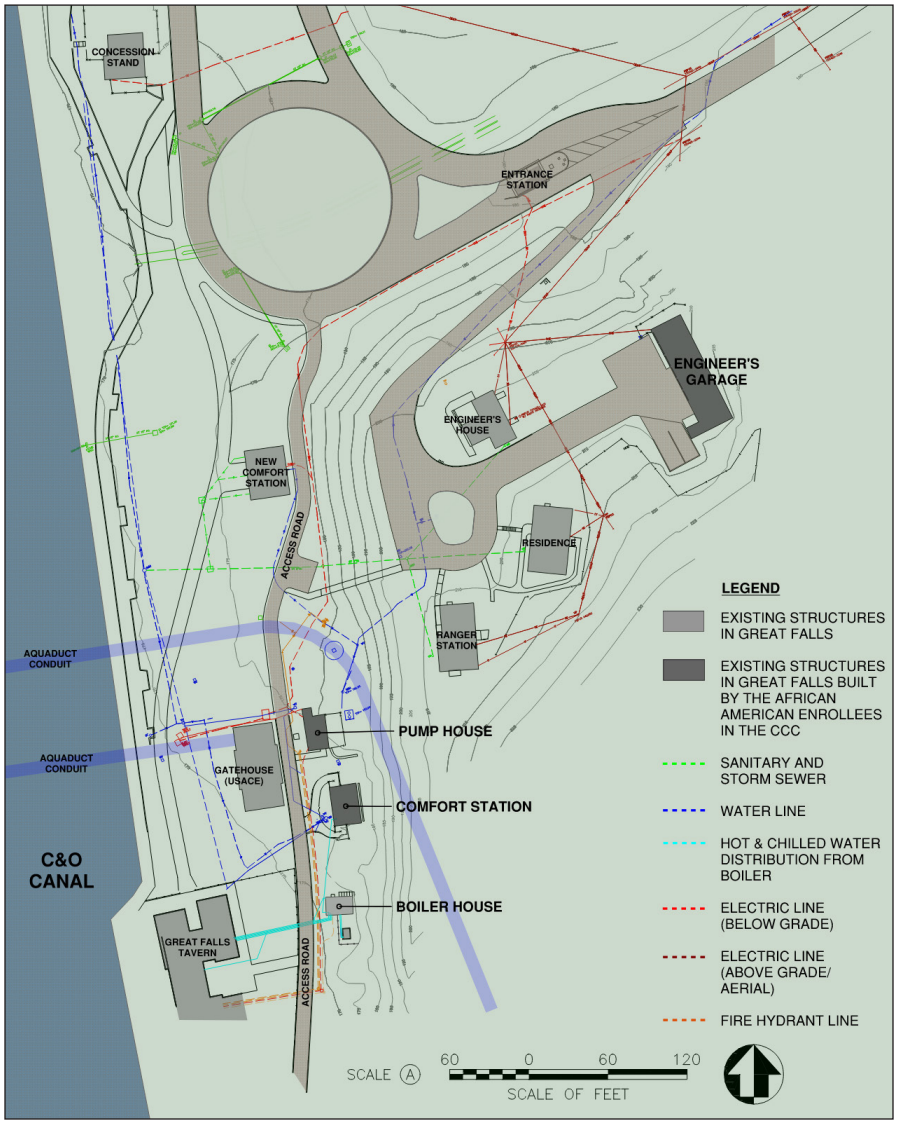

Figure 19. Site map of structures in vicinity of Great Falls Tavern with an approximation of the utilities throughout the site. Utility survey data obtained from the 2012 site survey work provided by NPS.

- The Comfort Station was constructed just north of the Boiler House on a more level portion of the terrain between the Boiler House and the Pump House. A low retaining wall to the east holds back the rising grade, but access to the east facade is limited by this change in grade and adjacent vegetation. The Comfort Station currently functions as a storage facility for the Bike Share Program operated by NPS staff and does not contain any operating plumbing fixtures or other accessories from its original use. The exterior enclosure remains intact, except for the privacy screen that shielded the door to the women's room on the south side of the building which has been removed.
- The Pump House, located just north of the Comfort Station, is built into the rising grade east of the C&O Canal similar to the Boiler House. The Pump House served as a water filtration facility with a water storage clear well and subsurface pressurized tank to provide potable water to the nearby structures beginning in the early 1940s. The clear well, located within the basement of the structure, provided a holding chamber larger than the footprint of the Pump House above. The clear well was the final storage chamber in the system, following filtration and disinfection. From the clear well, the water was briefly contained in the subsurface pressurized tank east of the Pump House before distribution.

  The incoming raw water source to this building changed over time, first from a line directly from the aqueduct, then modified to pull water from an adjacent well, until the early 1980s when the Pump House was taken out of service and water was provided to the site by WSSC. Much of the historic piping, valves, and meters remain intact but have not operated for decades.

  The Pump House also housed primary electrical service and distribution panels for the surrounding structures, including the Comfort Station, Boiler House, and Great Falls Tavern. The electrical service was upgraded in 2007, but many of the original electrical boxes and circuit enclosures remain abandoned in-place.
- The Engineer’s Garage, located atop the bluff, is a bit further north and east of the Engineer’s House. Away from the tourist-focused area below, the area at the Engineer’s Garage and surrounding structures is limited to NPS access and is located away from the Boiler House, Comfort Station, and Pump House. The Engineer's Garage is a stable

for mules and a barn for hay and equipment storage. The existing drawings provided for this structure included early undated design drawings that are noted as being superceded by later design drawings also provided by NPS. The later design drawings are dated to 1941 and more closely align with the current condition. The superceded design included a 6-bay garage, instead of the 7-bay garage that exists today, with an earth and cinder floor a modified design for a shop and storage at the south end of the structure.

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PIVOT BRIDGE RUINS

ARCHITECTURE & STRUCTURE

The Pivot Bridge Ruin is a stone and concrete remnant of a cast-steel pivot bridge (**Figure 20**). The remaining structure includes stone and concrete abutments built into the banks of the canal measuring approximately 12' wide with side walls splaying out to approximately 24' at the embankment and a square central abutment measuring approximately 12' x 12' in plan built upon a concrete foundation (**Figure 21**). The abutments ramp up towards the center of the canal to provide the ledge to support the ends of the original bridge superstructure. The bridge superstructure is no longer extant and is believed to have been removed sometime in the late 1940s or early 1950s based upon aerial photographs from this time period.

Figure 20. Pivot Bridge Ruins: View of the Center and South Abutments, from northwest looking towards the Chesapeake and Ohio Canal Towpath.

Per review of the original construction drawings provided by NPS, the abutments are built upon a concrete foundation approximately 18” thick. The core structure of the center pier is noted as being constructed of cyclopean concrete. Though the cyclopean method is only noted for the center pier in the original construction drawings, it is likely a similar method was used to construct the abutments. Beyond the mention of this type of concrete, no details were given regarding construction methods. Cyclopean concrete derives its name from an ancient method of forming massed concrete in which stones are placed as the concrete is poured. This concrete base is noted in the historic drawings to have 4" x 4" #4 mesh reinforcing with a 2" cover and 1/2" diameter dowels at 12" on center anchored to the concrete foundation below. The upper portion of the pier is faced with 8” to 12” of quartzitic schist facing stones, noted to be anchored approximately 2’-0" on center both ways. The vertical face of each side of the pier is noted as being battered approximately 1/8" per 12" in vertical elevation.

The two (2) side abutments built into the banks of the canal are also built upon concrete foundations and are assembled of concrete retaining

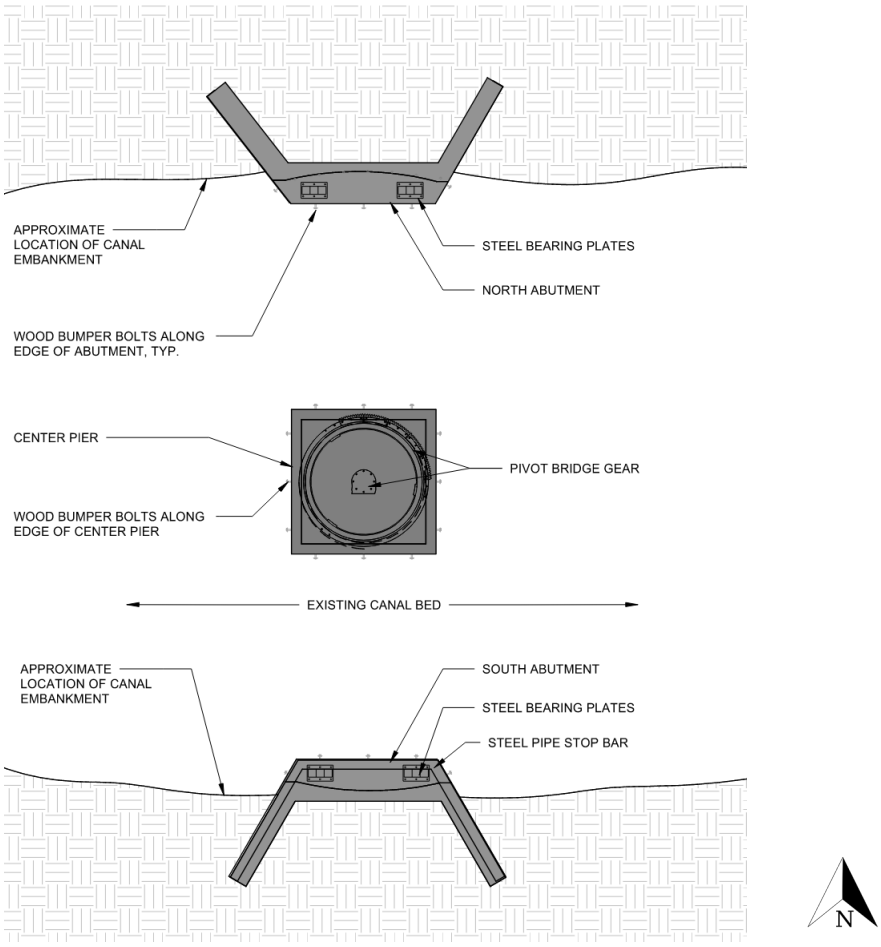


Figure 21. (Left) Pivot Bridge Ruins: Key Plan. (See Part III Documentation for more detailed drawings.)

structures clad in 8" to 12" of quartzitic schist facing at the upper 6'-0" of the elevation (**Figure 22-31**). The quartzitic schist cladding is also noted to be anchored approximately 2'-0" on center both ways.

The central pier features the original steel channel, gears, bearing plates and bolts from the historic bridge central pivoting mechanism. The original historic drawings provided by NPS included details of these steel components and the original bridge structure (**Figures 32-33**). Select remaining elements were uncovered by NPS in December 2022 allowing the A/E Consultant Team to obtain better photographic documentation (**Figures 34-43**). Unfortunately the bridge ruins do not include any of the original bridge components.

The ridged gear along the northeast quadrant of the pivot bridge gear confirms the direction of rotation of the bridge superstructure. The bridge

Figure 22. (Top) Pivot Bridge Ruins: North abutment, west face.
Figure 23. (Middle) Pivot Bridge Ruins: North abutment, south face.
Figure 24. (Bottom) Pivot Bridge Ruins: North abutment, east face.

Figure 25. Pivot Bridge Ruins: Central pier, north face.

Figure 26. Pivot Bridge Ruins: Central pier, east face.

Figure 27. Pivot Bridge Ruins: Central pier, south face.

Figure 28. Pivot Bridge Ruins: Central pier, west face.

Figure 29. (Top) Pivot Bridge Ruins: South abutment, east face.
Figure 30. (Middle) Pivot Bridge Ruins: South abutment, north face.
Figure 31. (Bottom) Pivot Bridge Ruins: South abutment, west face.

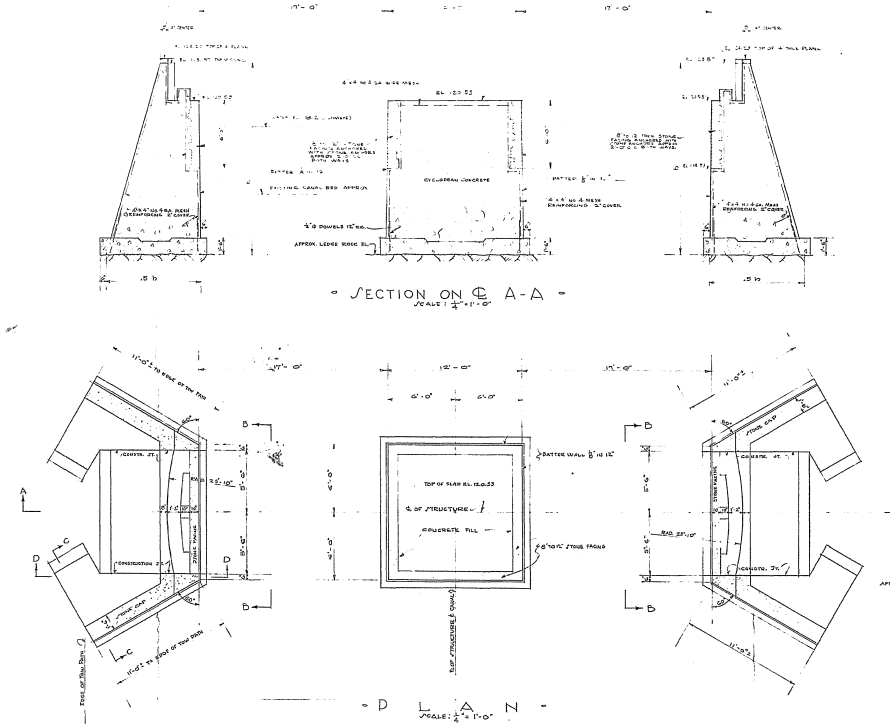
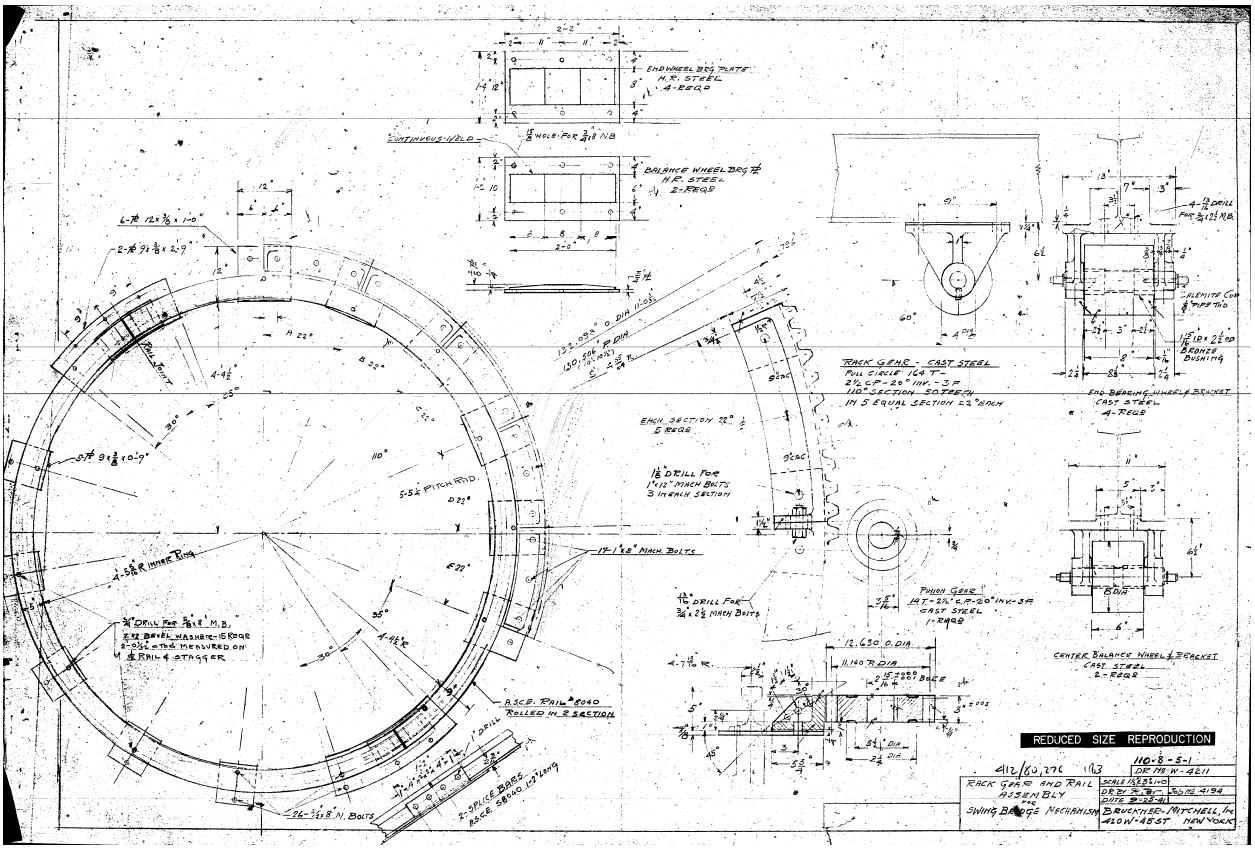


Figure 32. (Top) Pivot Bridge Ruins: Portion of original 1941 construction drawing showing plan of Pivot Bridge (NPS Document No. 412-80277).
Figure 33. (Bottom) Pivot Bridge Ruins: Portion of original 1941 construction drawing showing details of bridge rail, gears, and bearing plates (NPS Document No. 412-80276).



superstructure rotated 90 degrees in a counterclockwise direction to allow boats to pass. A steel pipe used to stop the rotation of the bridge is still extant at the east corner of the south abutment. There was no evidence uncovered that detailed motor operation of the bridge.

A series of steel rods and with threaded ends and bolts were found at the upper portion of each abutment. Each held a square steel plate and were spaced approximately 4’-0" on center. These bolts were used to secure wood bumpers to the bridge abutments to protect the boats navigating the Canal. Select other steel elements were documented including a section of slotted strut channel. Evidence of various prior stabilization and repointing campaigns were observed along with significant efflorescence and mineral crusts.

Figure 34. (Top) Pivot Bridge Ruins: Central pier, pivot bridge rail, gears, and bearing plate.
Figure 35. (Bottom Left) Pivot Bridge Ruins: Central pier, pivot bridge bearing plate.
Figure 36. (Bottom Right) Pivot Bridge Ruins: Central pier, pivot bridge rail and gears.

Figure 37. (Left) Pivot Bridge Ruins: Central pier with remains of original pivot bridge machinery.
Figure 38. (Right) Pivot Bridge Ruins: Bridge rail with bolted plate.

Figure 39. (Left) Pivot Bridge Ruins: Steel gears at top of central pier.
Figure 40. (Right) Pivot Bridge Ruins: Bridge rail with bolted plate.

Figure 41. (Left) Pivot Bridge Ruins: Central pier with encrusted efflorescence.
Figure 42. (Right) Pivot Bridge Ruins: Central pier with lichen growth.

Figure 43. (Left) Pivot Bridge Ruins: Inscription on south face of central pier.

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BOILER HOUSE

ARCHITECTURE

The Boiler House is a small, concrete masonry unit structure with a cement plaster exterior finish and a tall brick chimney along the east facade (**Figures 65-66**). Adjacent to the south facade is an exterior fenced in equipment pad to conceal an chiller installed in 2007 (**Figure 46**). Adjacent to the east facade is a large diesel fuel oil storage tank set on concrete footers above grade. The structure measures 13’-9" x 20’-0", providing approximately 219 net square feet (nsf) of interior space. The interior floor is a concrete slab-on-grade and the roof framing consists of wood rafters and joists. There are wood ceiling joists, however no finished ceiling is present.

Per review of historic drawings, the building is assumed to have been constructed c. 1951. These historic 1951 construction drawings identify a reinforced concrete shingle roof and 3/4" cement plaster finish on the concrete masonry unit exterior walls. This exterior finish is compatible with the surrounding structures, including the Tavern (**Figure 47**). The original concrete shingle roof was replaced sometime after 1975 with a wood shingle roof. The original drawings did not include gutters and downspouts which are not present on the structure currently.

The painted brick chimney extends to a height 30'-0" from the top of concrete floor slab. The original construction drawings identify the chimney was constructed of a 12” thick masonry construction to house a 18" x 18"

Figure 44. Boiler House: View from northwest.

fire-glazed brick flue which is still in use by the existing boiler. A chimney and flue inspection was not completed as part of this scope of services, but is recommended.

The north facade features a flush wood entry door, which is a new door replacing the original 6-panel door as seen in the 1951 construction drawings. The small structure originally featured four (4) double hung wood windows with wood shutters. Two (2) of the double-hung windows (windows

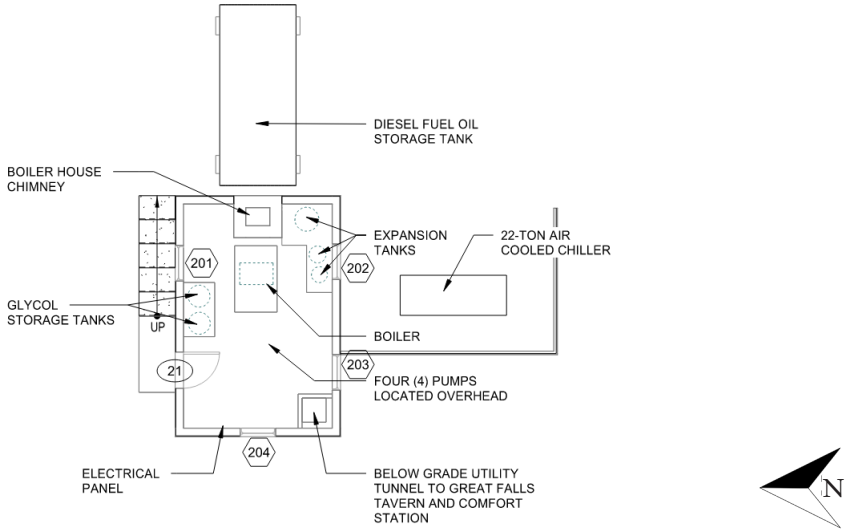

Figure 45. (Left) Boiler House: Key Plan. (See Part III Documentation for more detailed drawings.)

Figure 46. (Left) Boiler House: View from southwest.

201 and 203) were replaced with louvers during a 2007 upgrade to the interior equipment of the Boiler House to serve the Tavern and Comfort Station. Based on a photograph from the 1990s when the wood shutters were still featured on the exterior facade, it is assumed the wood shutters were removed during the 2007 rehabilitation project and never reinstalled. It was noted that a number of painted wood shutters are currently stored in the Pump House, some of which may be original to the Boiler House.

Located south of the Boiler House is a concrete equipment pad at grade measuring approximately 48" x 96" to support a chiller that was installed in 2007 (**Figure 48**). Prior to the installation of the chiller, a below grade fuel oil storage tank was located in the area. This original fuel oil storage tank, later replaced and relocated in 2007, was indicated in the original construction drawings (**Figure 49**). These drawings indicate a 42" diameter, 1,000 gallon tank located 8 feet from the south wall of the Boiler House. The orientation of this below grade tank is indicated to be 90 degrees to the existing chiller

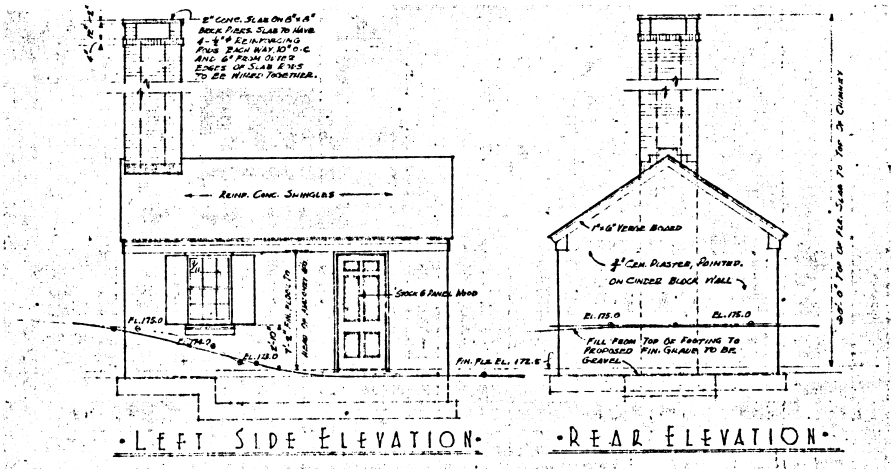

Figure 47. Boiler House: Portion of original 1951 construction drawing elevations (NPS Document No. 412-80401).

Figure 48. (Left) Boiler House: Figure Carrier 22-ton Aquasnap air cooled chiller located south of the Pump House.
Figure 49. (Right) Boiler House: Fuel oil storage tank located east of Boiler House.

currently located in this area (**Figure 50**). The top of the tank was noted at elevation 170', about 3'-6" below the approximate grade noted at this area of 173.5'.

Documentation was not found to confirm any regrading of this area in 2007 and based upon existing conditions any regrading required would have been minimal. The original construction drawings did not include a fence surrounding the below grade storage tank, which was likely unnecessary since the tank was buried below grade. No documentation was provided for the construction of the fence, but it was likely installed with the 2007 relocation of the boiler and addition of the chiller.

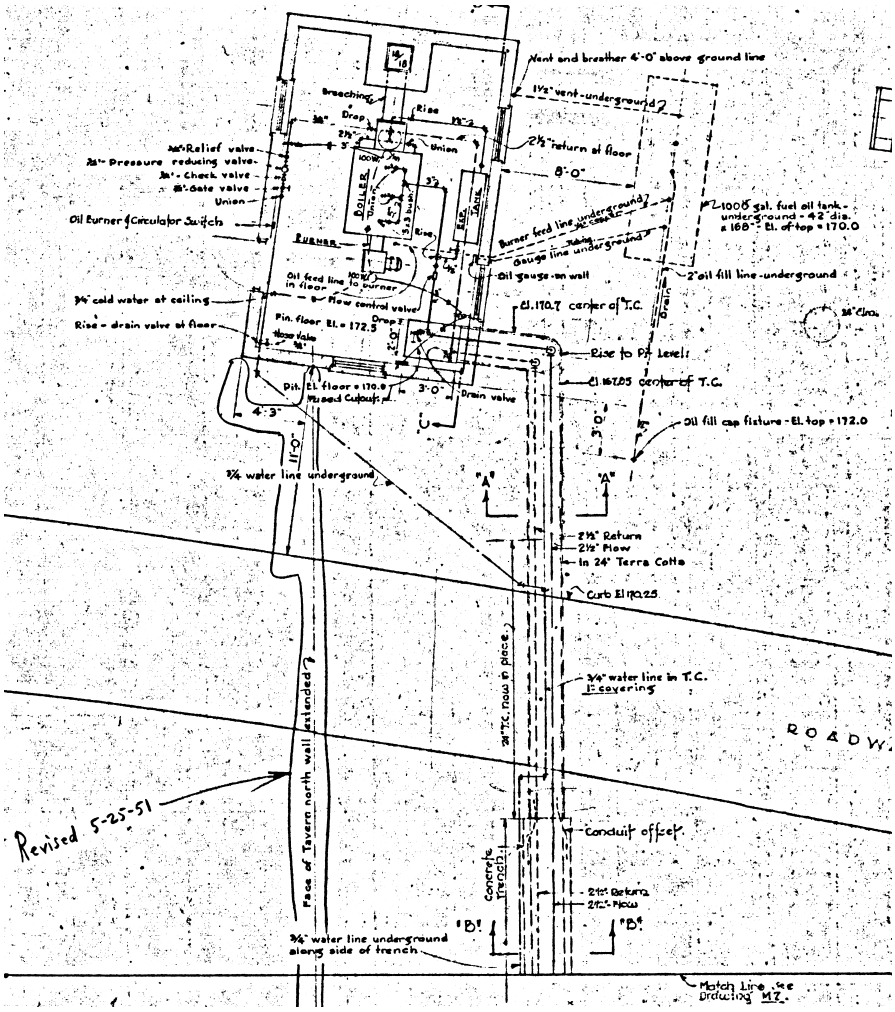

Figure 50. Portion of original 1951 construction drawing site plan locating a 1000 gallon fuel oil tank below grade south of the Boiler House (NPS Document No. 412-80401).

STRUCTURE

According to the original 1951 construction drawings, the foundation and exterior enclosure of the Boiler House are shallow concrete spread footings with 8” CMU exterior walls and brick window sills (**Figures 51 and 54**). Existing drawings show a 4" foundation drain tile around the perimeter of the structure which terminates thru the existing curb of the access road, however no outlet was observed. It is possible this below grade drainage line was connected to the storm drainage system during the 2007 mechanical and electrical upgrades.

The structure is built into the rising grades at the east side. Per the 1951 construction drawings, the interior floor is a 5” slab-on-grade reinforced with welded wire mesh. The concrete masonry is finished with cement plaster at the exterior and is exposed on the interior. Shallow concrete equipment pads have also been added inside the structure to support tanks and equipment.

Roof framing of the Boiler House is 2x6 (actual) joists at approximately 16” on-center. The roof rafters are tied with 2x6 (actual) joists at 16” on-center forming a ceiling level. These ceiling joists currently support mechanical

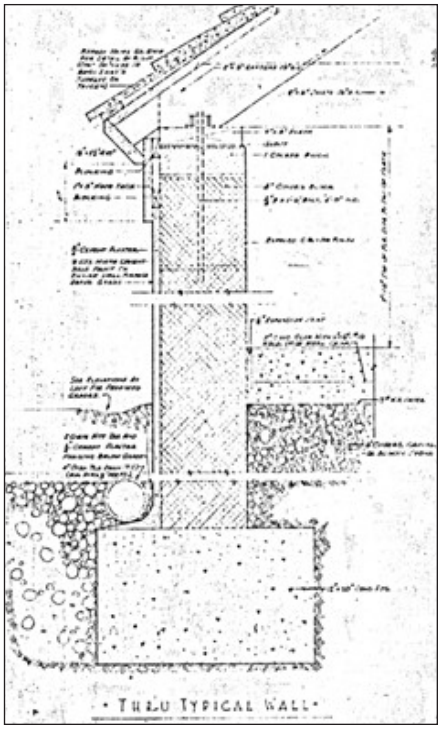

Figure 51. (Left) Boiler House: Wall Section excerpt from the 1951 Construction Drawings.
Figure 52. (Right) Boiler House: Interior view of ceiling and roof framing at Boiler House, including LVL beams laid across ceiling ties.

equipment and piping. Two 5-1/4" x 8" engineered laminated veneer lumber (LVL) beams have been laid perpendicular across the ceiling joists, presumably as load distributing members supporting suspended mechanical equipment (**Figure 52**). Suspended equipment is supported directly from the ceiling joists and slotted strut channel framing is supported on the joists and LVL beams. The engineered LVL beams stop short of the exterior walls and do not appear to be positively attached to the ceiling joists. In addition, select portions of the roof sheathing have been replaced (**Figures 55-56**).

The Boiler House has a tall, slender brick chimney along the east elevation. Per 1951 construction drawings, the chimney measures 2'-8" square and extends to a height 30'-0" from the top of the interior concrete floor slab. A large mechanical enclosure surrounded by a wood stockade fence is located south of the Boiler House and features a concrete slab on grade to support the existing chiller (**Figure 53**). The large fuel tank on the east side of the structure is supported on two concrete rectangular piers. Both foundations are surrounded by vegetation.

Figure 53. Boiler House: Exterior view of Boiler House, looking from the south; chiller located in the foreground.

INVENTORY OF PHYSICAL FEATURES

BOILER HOUSE		
Building Element/ Feature	Material Description	Dimensions
Floor	4" concrete slab-on-grade with 1" topping slab	5"
Walls - Exterior	8" concrete masonry units with exterior 3/4" cement plaster finish	8"
Ceiling	N/A	exposed wood rafters and ceiling joists
Door 21	flush wood	3'-0" x 7'-0"
Windows 201 & 203	wood double hung; 6/6 lites	2'-9" x 4'-4" masonry opening
Windows 202 & 204	louvers installed within original masonry opening in place of double hung windows	2'-9" x 4'-4" masonry opening
Ceiling Joists	wood joists	2x6 joists @ 16" o.c. Two (2) engineered lumber beams (~5.25" d. x 8" w.) added above ceiling joists for hanging equipment.
Roof Rafters	wood framing	2x6 wood framing at 16" o.c
Roofing	wood sheathing and wood shingles	N/A
Chimney	brick masonry chimney along east facade	Per the 1951 construction drawings, the chimney measures approximately 2'-8" square in plan and 28'-6" height above grade

Figure 54. (Left) Boiler House: Existing window, missing shutters.
Figure 55. (Center) Boiler House: Roof and eave/rake; no gutters or downspouts present.
Figure 56. (Right) Boiler House: Existing brick chimney and cedar shingle roof.

MECHANICAL & PLUMBING

The Boiler House contains heating and cooling equipment to provide heating hot water and chilled water that is pumped to adjacent site buildings, including the Great Falls Tavern and Comfort Station. Historic construction drawings for the Boiler House and Tavern from 1951 indicate a below grade utility tunnel connecting this equipment to the Great Falls Tavern located just west of the Boiler House. Additional documentation from 1953 references heating lines to serve the radiators at the Comfort Station, however the resolution of this file is poor and details could not be confirmed. In 2007, the mechanical and electrical equipment and services at the Boiler House and Pump House were updated. The systems described here all date to this upgrade project.

Chilled water is produced by a 22-ton air cooled chiller (ACC-1, Carrier Model 30RAN022, Serial Number 2707Q03325). ACC-1 sits south of the Boiler House behind a wooden fence and chilled water is piped from the chiller to the Boiler House. Two (2) redundant inline chilled water pumps (P-1 and P-2 as labeled on-site) are located in the Boiler House. The chilled water pumps have a combination motor starter and disconnect switch located

Figure 57. Boiler House: Smith diesel hot water boiler at the interior of the Boiler House.

on the wall within the Boiler House. The chilled water system also contains a chilled water buffer tank, expansion tank, glycol injection feed pump, chemical treatment tanks, temperature and pressure gauges, and an air separator.

Hot water is produced by a diesel fired hot water boiler (**Figure 57**). A 1500 gallon diesel fuel oil storage tank is located above grade east of the Boiler House. A fuel oil monitoring system monitors fuel oil levels. The boiler flue gas is ducted and exhausted from the Boiler House through the chimney located along the east side the building (**Figure 56**).

Two (2) Bell and Gosset inline hot water pumps (P-3 and P-4 as labeled on-site) are used to pump the hot water throughout the site. The hot water pumps have a combination motor starter and disconnect switch located in the Boiler House (**Figures 58-59**). The hot water system also contains a hot water expansion tank, glycol injection feed pump, chemical treatment tanks, temperature and pressure gauges, and an air separator (**Figures 60-**

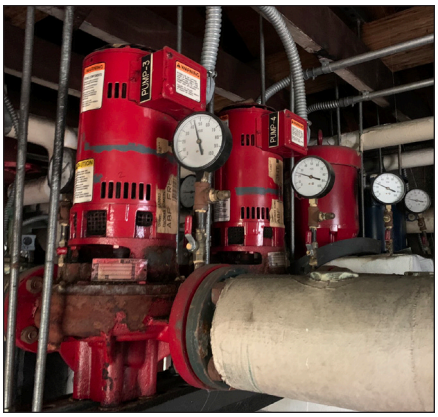

Figure 58. (Left) Boiler House: Four inline Bell and Gossett pumps are installed in the Boiler House. Pumps 1 and 2 (P-1 and P-2) serve the chilled water system and pumps 3 and 4 (P-3 and P-4) serve the hot water system.
Figure 59. (Right) Boiler House: Each pump has a wall mounted combination motor started and disconnect switch.

Figure 60. (Left) Boiler House: Cemline chilled water buffer tank and Bell and Gossett expansion tanks for the hot water and chilled water systems.
Figure 61. (Right) Boiler House: Glycol feed systems are installed to pump glycol to both the hot water and chilled water systems to avoid pipes from freezing.

Figure 62. (Left) Boiler House: The boiler flue gas is ducted and exhausted up through the chimney.
Figure 63. (Center) Boiler House: The boiler house is ventilated by an exhaust fan and an outdoor air intake louver. The outside air intake louver also provides combustion air for the diesel boiler outside.
Figure 64. (Right) Boiler House: Hot water unit heater was installed to heat the boiler house. Heating hot water and chilled water distribution piping enters a pit and is distributed underground.

61). Both the hot water piping and the chilled water piping are distributed underground to the Comfort Station and Great Falls Tavern (**Figure 64**).

The Boiler House is ventilated and cooled by an inline direct drive exhaust fan and an outside air intake louver located on the opposite wall (**Figure 63**). These louvers were installed in original masonry openings and the original double-hung wood windows removed. A hot water unit heater is also provided in the Boiler House.

ELECTRICAL

In 2007, the electrical equipment and services at the Boiler House and Pump House were updated. The systems described here all date to this upgrade project. The equipment in the Boiler House is served by 208Y/120V, 200A main circuit breaker (MCB) panel named 'RPBH'. This panel serves pumps, an air-cooled chiller, and other accessory mechanical equipment (**Figure 65**). 'RPBH' appears to have been upgraded in 2007. 'RPBH' is served by the main distribution panel, 'DP1', located in the Pump House. All the pumps within the Boiler House have enclosed motor starters with indicator lights (**Figure 66**). Most of the conduit within the space is rigid metal conduit (RMC) with the last couple feet of conduit transitioning to flexible metal conduit (FMC) to any vibrating mechanical equipment.

Figure 65. (left) Boiler House: Flexible Metal Conduit used in the Boiler House.
Figure 66. (Right) Boiler House: Panelboard with wall-mounted combination motor started and disconnect switch for each pump.

FIRE PROTECTION/LIFE SAFETY/ SECURITY

The Boiler House does not contain any security or fire protection systems (fire alarm or fire suppression) as the building is a normally, non-occupied utility (Use Group "U" per IBC) building. Neither an automatic sprinkler system nor an addressable fire alarm system are required by the building code for this building based on occupancy classification and size of building; however, other DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

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COMFORT STATION

ARCHITECTURE

The Comfort Station, accessed by original concrete pathways from the access road to the west, is a wood framed structure with vertical board and batten siding and a gable roof with cedar shingles (**Figures 67-68**). The existing structure is consistent with the original 1941 construction drawings absent the removal of plumbing fixtures and the privacy screen walls at the south entry. The structure measures 20’-0" x 29'-5", providing approximately 533 net square feet (nsf) of interior space (**Figure 70**). A low retaining wall is located along the east side of the Comfort Station to retain the adjacent grade.

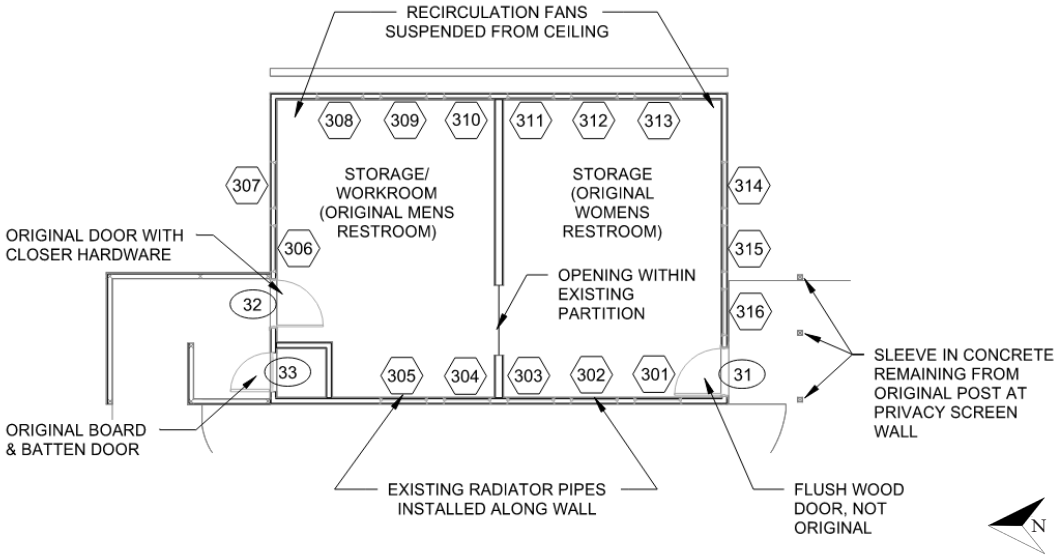
The original 1941 construction drawings, though difficult to decipher, indicate wood framed exterior walls with vertical siding boards and battens and an interior finished with 3/4" painted cement plaster on metal lath. Original drawing details identify a 4” slab-on-grade with a 1” topping slab which transitions to a cove base at the perimeter of the former men’s and women’s restrooms. The existing plaster on metal lath finished ceiling is located 9'-0" above the finish floor. The womens restroom included seven (7) water closets along the center demising wall. There were four (4) lavatories and two (2) additional water closets along the south wall. The mens restroom included five (5) water closets along the center demising wall, five (5) urinals along the west wall, and four (4) lavatories along the north wall. The original "built-in" urinals are still intact behind a partition at the workbench along the west wall.

Figure 67. Comfort Station: Southwest view of Comfort Station from the access road.

Figure 68. Comfort Station: West facade

Figure 69. (Right) Comfort Station: View of Comfort Station from northeast. Great Falls Tavern is seen in the background.

Figure 70. (Below) Comfort Station: Key Plan. (See Part III Documentation for more detailed drawings.)



The original entry doors are not detailed in the original 1941 construction drawings, but the solid wood 5-paneled north entry door into the former mens restroom, typical of the period and purpose of construction, is likely original. The exterior door at the north utility room, directly to the right of the north door leading into the former mens room, is presumed to be original due to its vertical board and batten design which matches the exterior cladding (**Figure 71**). The south entry door into the former womens restroom has been replaced with a flush wood door (**Figure 72**).

Figure 71. (left) Comfort Station: North entry door.
Figure 72. (right) Comfort Station: South entry door.

Figure 73. (Left) Comfort Station: Original vertical board and batten door at utility closet.
Figure 74. (Right) Comfort Station: Original vertical board and batten door at utility closet.

Figure 75. (Left) Comfort Station: Interior view of historic wood hopper window, typical.
Figure 76. (Right) Comfort Station: Exterior fixed aluminum storm window installed at exterior of historic wood hopper window, typical.

The hopper windows as shown in the original 1941 construction drawings remain with locking hardware and sash chains (**Figure 75**). Each window has been retrofitted with a fixed aluminum storm window at the exterior (**Figure 76**) and one original sash is missing at window 312. There are two (2) hopper windows located along the north facade, six (6) along the east facade, three (3) along the south facade, and five (5) along the west facade.

The 1975 Individual Building Data sheet notes the Comfort Station was remodeled in 1974 but does not provide any additional detail. Work completed in 1995 to replace the cedar shingle roof included removal and replacement of rotten and deteriorated cedar shingles and the installation 1x6 wood furring over the sheathing to provide ventilation for the wood shingle roof above. Additional work in 1995 included interior power washing, scraping, sanding, and removal of paint from walls, windows, and ceilings, and priming and repainting of walls and wood trim. This work does not specifically mention the gutter and downspout along the east eave. The original drawings did not include gutters and downspouts, however a gutter and downspout have been installed along the east edge of the roof.

Work completed in 2017 at the historic Comfort Station included wood shingle roof replacement, door and window repair, and extensive interior work to convert the building from toilet rooms to storage (**Figures 77-78**). That work included the removal of toilets, sinks and the toilet partitions (which were installed in 2004), the covering of the built-in urinals, the sealing off of floor drains, sealing the concrete floor slab with epoxy coating, and the removal of the water supply, while maintaining the existing heating system. In addition, a below grade drainage system was installed and connected to the existing downspout.

Figure 77. (Left) Comfort Station: Storage of bicycles and workbenches in former men's restroom.
Figure 78. (Right) Comfort Station: Storage of bicycles in former women's restroom.

The demising partition between the mens and womens restrooms remains intact, but was opened at the west end to provide a connection between each space. The Comfort Station is currently used as storage for the NPS Bike Share Program, but no reference to this program was found in the archives. In addition, the original utility room at the northwest corner remains, but the sink has been removed. It is assumed the sink was removed when the other plumbing fixtures were removed in 2017. In lieu of the sink, a hose bib is located in the corner and two (2) electrical panels are located along the west wall. In addition, the historic urinals remain intact along the west wall, concealed by the wall assembly below the workbench.

In 2011, park managment requested the removal of the historic screen walls from the building entrances, as people continued to assume the building served as a Comfort Station. In 2017, the screen wall was only removed from the south, womens room side, and remains in place on the north. Review of the dimensional clearance at the north screen walls confirm accessible clearances are in incompliance with ABAAS 403.5.2 "Clear Width at Turn" requirements.

INVENTORY OF PHYSICAL FEATURES

COMFORT STATION		
Building Element/ Feature	Material Description	Dimensions
Floor	4" concrete slab-on-grade with 1" topping slab	5"
Walls - Exterior	wood framing with sheathing; vertical siding; vertical battens; and interior finish of cement plaster on metal lath (assumed)	2x4 wood framing with 3/4" sheathing; 1" vertical siding; 1/2" vertical battens; and interior finish of 3/4" cement plaster on metal lath (assumed)
Walls - Interior	wood framing with finish cement plaster finish on metal lath each side	2x6 wood framing with finish of 3/4" cement plaster on metal lath each side
Ceiling	plaster on metal lath	9'-0" above finish floor
Door 31	flush wood door	3'-0" x 7'-0"
Door 32	5-panel solid wood	3'-0" x 7'-0"
Door 33	wood board and batten	2'-6" x 6'-4"

Figure 79. Comfort Station: View of wood roof rafters above Comfort Station.

STRUCTURE

The structure of the Comfort Station is comprised of shallow concrete spread footings, a short concrete foundation wall, wood stud walls, and a wood roof structure.

Per original 1941 construction drawings, the interior floor is a 4" slab on grade reinforced with welded wire mesh. The walls of the Comfort Station are wood stud walls covered with cement plaster on metal lath at the building interior and vertical board and batten siding at the exterior. Originally, the building was divided into two separate rooms (mens and womens restrooms) with a central dividing wood stud wall covered on both sides with cement plaster on metal lath. Original drawings show the central dividing wall is also supported on a short concrete foundation wall. Based on the drawings, it is assumed that the exterior walls are 2x4 wood stud walls and the interior wall is a 2x6 wood stud wall. Because finishes are intact and in relatively good condition, framing sizes could not be confirmed in the field. A large opening was cut through the center dividing wall in 2017 when the Comfort Station was renovated for use as storage facility.

Per the original drawings and confirmed in the field, the roof framing is 2x8 rafters at 16" on-center. There are 2x10 ceiling ties at each pair of roof rafters (**Figure 79**). The ceiling ties support a plaster on metal lath ceiling.

The north entrance to the building also includes a concrete walkway and a wood screening fence. Per the original 1941 construction drawings, the privacy screen is supported on isolated concrete piers with an embedded 4" galvanized pipe to receive 4x4 wood posts. The south entrance originally had a privacy screen, but it has since been removed and only a concrete walkway remains. Sidewalks and a concrete slab on grade connect the Comfort Station's doors at the north and south elevations to the main concrete access road.

MECHANICAL & PLUMBING

All original plumbing fixtures were disconnected and removed from the Comfort Station in 2017 when the building was modified to be used for temporary storage and the new accessible comfort station was constructed to the north. Historic radiant heating piping can be seen installed along the west wall in both the former mens and womens restroom (**Figure 80**). Based on historic documents it is understood this radiant heat was installed in 1953 shortly after the Boiler House was constructed to the south in 1951. More recently, recirculation fans have been installed and are controlled by a manual on/off switch. Though not operating when survey was completed, NPS staff confirmed the radiant heating system is operational. It appears that the fans are in working condition.

Figure 80. Comfort Station: Radiator piping along west wall of former men's restroom. Original built-in urinals concealed behind wall built below workbench when restroom was re-purposed for storage in 2007.

ELECTRICAL

The electrical service from the Pump House to the Comfort Station is provided through the load center located in the utility closet at the Comfort Station. The extent of existing electrical infrastructure within this structure includes overhead surface mounted fluorescent 2'x4' light fixtures, exterior wall mounted lighting fixtures at each of the two entries to the structure, toggle light switches, convenience receptacles, and two (2) wall mounted recirculation fans. The original 1941 construction drawings include a reflected ceiling plan which makes reference to ceiling mounted fixtures and exterior sconces, however, no details were provided. The current 2'x4'

Figure 81. Comfort Station: Access panel in ceiling of former men's restoom at the Comfort Station.

Figure 82. (Left) Comfort Station: Original exterior wall mounted sconce.
Figure 83. (Right) Comfort Station: Original exterior wall mounted sconce

fixtures are modern, replacements for earlier fixtures, but the exterior wall-mounted sconces are possibly original (**Figures 82-83**).

There are no automatic controls such as occupancy sensors within these spaces. Most of the branch circuits within the Comfort Station are concealed behind ceilings and walls (**Figure 81**).

FIRE PROTECTION/ LIFE SAFETY / SECURITY

The Comfort Station does not contain any security or fire protection systems (fire alarm or fire suppression) as this storage space serves as a Low-hazard Storage Occupancy (S-2 per the IBC) and these systems are not required. However, other DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

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PUMP HOUSE

ARCHITECTURE

The Pump House is a 1-1/2 story brick building housing water filtration and distribution equipment established to support the Boiler House, Comfort Station, and Engineer's Garage. The Pump House structure is comprised of concrete foundations, a concrete slab-on-grade floor, double-wythe brick masonry exterior walls, an interior-framed concrete mezzanine floor (historically referenced as the Operating Gallery) and a wood-framed roof structure finished with cedar shingles. The building measures approximately 15'-10" x 32'-2" on the exterior, providing approximately 340 sf interior space at the ground level. The Operating Gallery is approximately 172 sf.

The historic masonry facade includes ten (10) double hung wood windows. The south and west facades include three (3) double hung wood windows at each elevation (**Figure 84**). Two (2) double hung wood windows are located along the north facade, at the upper level of the Operating Gallery, and still feature painted wood shutters (**Figure 85**). The east facade features two (2) small double hung wood windows at the level of the Operating Gallery overlooking the coagulating basin (**Figure 86**).

Figure 84. Pump House: Southwest view of Pump House from the access road. Electrical raceway and wireway present along west facade.

The original solid wood 5-paneled entry door at the south facade remains, as well as the original solid wood 5-paneled entry door connecting the Operating Gallery to the platform access to the coagulation basin.

The original drawings did not include gutters and downspouts, and they are not present on the structure currently. The brick chimney along the south facade extends from grade to approximately 3 feet above the roof ridge. The historic use of the chimney is unclear, but the historic construction drawings locate a 6” terra cotta thimble for an exhaust pipe to run into the flue approximately 12' from the finished floor. The drawings also indicate an 8" flue inside the chimney. It is assumed there must have been a heat source

Figure 85. Pump House: Northwest view of Pump House from the access road.

Figure 86. Pump House: East view of Pump House from the decking installed over the coagulation basin.

present at the Pump House to keep pipes from freezing as evident from the chimney collar and flue for exhaust; however, few details are known.

The Pump House was originally constructed to support the water filtration and treatment required to supply the site and surrounding structures with potable water and house the primary electrical feeders and service to support these surrounding structures. The water filtration and treatment operations began in 1940 and continued in varying capacities until the early 1980s when the site was connect to a new incoming water line from WSSC. The electrical service is still housed in this building, but the original 1940s electrical infrastructure was replaced and upgraded in 2007. The details of this water and electrical infrastructure are described in greater detail in the following sections of the report.

As described more thoroughly in the mechanical & plumbing descriptions of the Pump House, this structure was established to provide water filtration, storage, and distribution for the surrounding structures in the 1940s. Raw water was brought in at the raw water pump pit and and through a process of filtration and treatment to provide potable water. The water processed from the pump pit to a coagulation basin located to the east of the building. Following a process of coagulation and flocculation, the water was filtered through a sand and gravel filtration tank to be stored in the clear well, a large holding tank located below the building and extending out past the south and west elevations of the structure. For distribution, the water was sent to a below grade pressurized tank located east of the coagulation basin, before being distributed to the surrounding structures. The mechanical & plumbing narrative describes the changes to the raw water source between 1940 and the early 1980s and outlines the sequence of operations to understand all historic filtration and pump equipment extant in the Pump House today.

INVENTORY OF PHYSICAL FEATURES

PUMP HOUSE		
Building Element/ Feature	Material Description	Dimensions
Floor	4" concrete slab-on-grade with 1" topping slab	5"
Mezzanine Floor	concrete slab	5” concrete slab with 6” deep beam along the edge with the railing There is also a deeper tapered concrete slab near stair ladder. At the ladder edge, the slab is 9” deep (slab inclusive) and it tapers to 17” depth the interior wall.
Walls - Exterior	brick masonry, painted	8” (2-wythe)
Ceiling	N/A	exposed wood rafters
Door 41	5-panel solid wood	3'-0" x 7'-0"
Door 42	5-panel solid wood	3'-0" x 7'-0"
Windows 301-316	wood double hung; 6/6 lites	2'-9" x 4'-4" masonry opening
Roof Rafters	wood framing	2x6 wood framing at 24" o.c.
Roofing	wood sheathing and wood shingles	N/A

STRUCTURE

The structure of the Pump House is comprised of a concrete basement mat slab, concrete framed first floor and operating gallery, brick masonry above grade walls, and a wood-framed roof (**Figures 87-88**). Per the existing drawings the basement level extends beyond the footprint of the above grade structure on the north, south, and west sides and served as the clear well. The basement foundation is made up of a concrete reinforced mat slab with existing drawings showing both wire mesh and rebar reinforcing. The foundation walls are concrete and, per the original 1941 construction drawings, are 8" thick. At the north end the mat extends out to form the base of the raw water pump pit. This pit extends up past the first floor with 8" concrete walls below grade. The walls switch to brick above grade until they terminate around the operating gallery floor. Access to the basement is provided only at an access panel located in the first-floor slab outside of the footprint of the above grade structure.

The first-floor slab is a reinforced concrete slab supported by concrete beams and columns. There are four columns measuring 12"x12", which support a grid of beams that measure 12"x12" in the east-west direction and 12"x21" (width x depth) in the north south direction. There are several penetrations in the first-floor slab, which allow piping to extend into the clear well (**Figures 90 and 93**). Where the basement extends beyond the above grade building footprint on the west side, the first-floor slab appears to have a topping slab applied, which is exposed.

Figure 87. (left) Pump House: Sistering of roof framing and roof sheathing replacement completed in 2022.
Figure 88. (Right, top) Pump House: Concrete bridge and step connecting Operating Gallery to coagulation basin.
Figure 89. (Right, bottom) Pump House: Concrete platform supporting the motor for the agitation chambers.

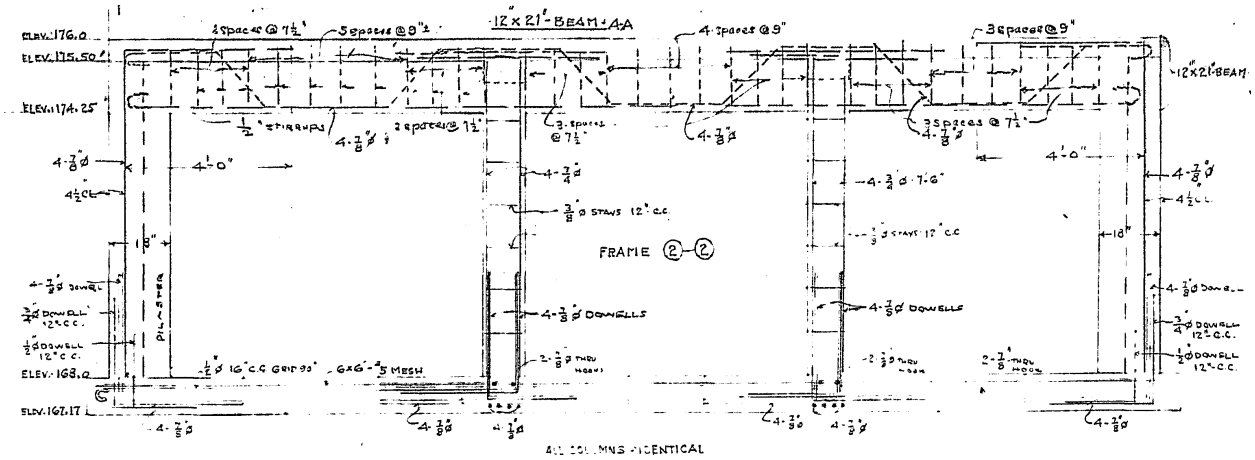


Figure 90. Pump House: Structural section through clear well indicating rebar placement. (Drawing detail taken from NPS Document No. 412-80454)

The interior walls at the pump house are cast in place concrete. The exterior walls are two wythes of brick, totaling 8" thick, with headers tying them together. At the northeast corner of the structure, 8" concrete walls span from the first through the second floor to frame out the wash trough structure. The Operating Gallery is accessible from an interior wood and metal ships ladder. There is a brick chimney at the south gable wall. Based on existing drawings the chimney does not appear to continue below grade. Window openings in the masonry walls across the building are supported with steel lintels.

The Operating Gallery level concrete slab is 5" in depth. The slab is supported on the brick masonry walls at the north, east, and west masonry walls, and is bounded by a 6" deep beam at the exposed south edge. A thicker slab is present near the ships ladder. Near the ladder, the slab is 9" deep and increases to 17" at the interior wall enclosing the sand and gravel filtration.

The roof structure is 2x6 rafters at 24" on-center with wood decking (**Figure 87**). Rafters at the center of the building also feature a collar tie.In June 2020, the roof sheathing and wood shingle roofing were replaced and bolted sister reinforcement was installed at rafters east of the roof ridge.

A large concrete coagulating basin is located to the east of the main structure (**Figure 91**). The basin is approximately 11'-6" deep and extends just below the first-floor level. The foundation of the basin is an 8" wire mesh reinforced slab, and the walls are 8" reinforced concrete walls. Towards the south end of the basin, there is an 8" brick stilling wall that extends the full height of the

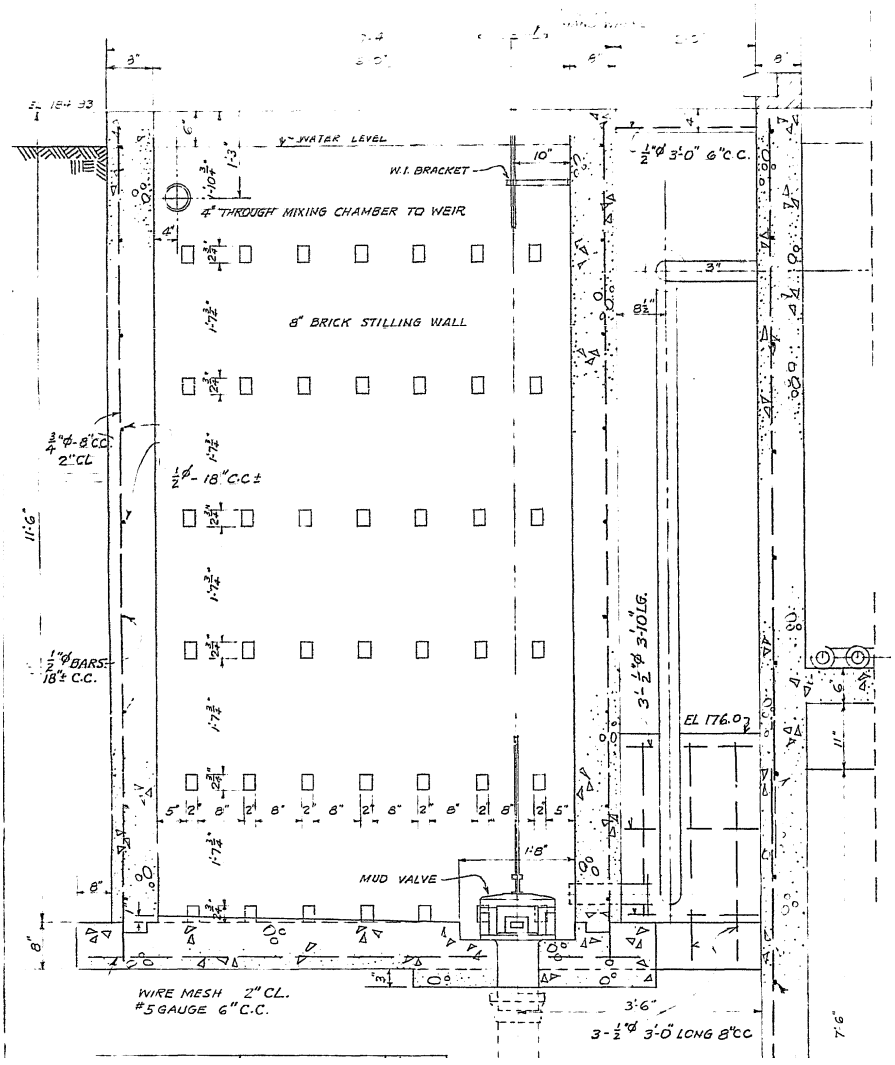


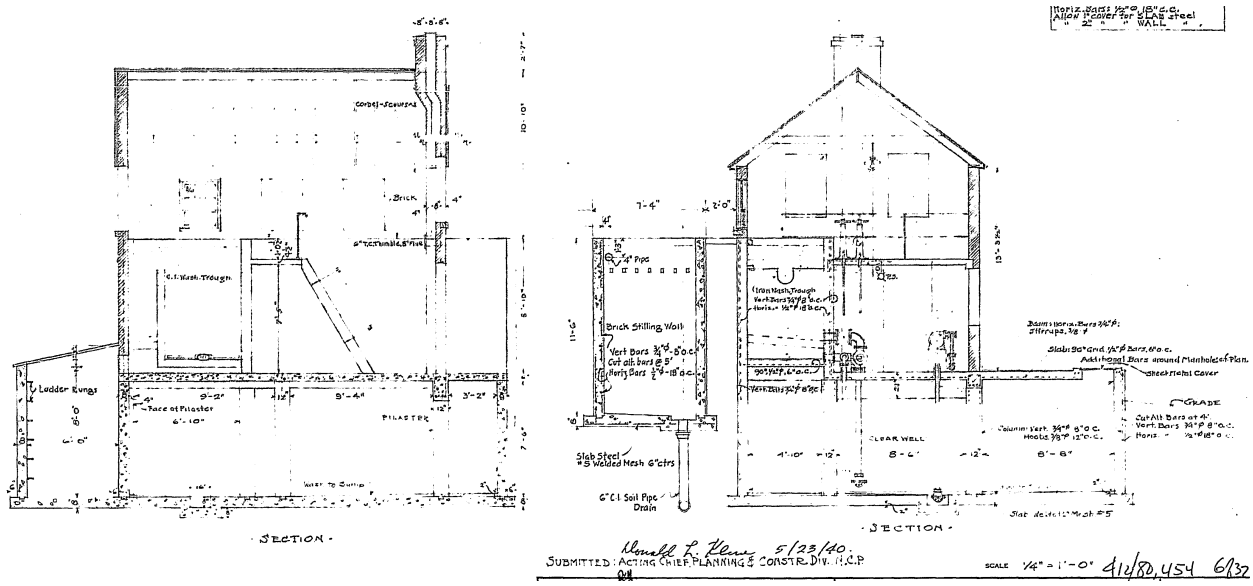
Figure 91. Pump House: Section through coagulation basin featuring the brick stilling wall at the south end and the mud valve at the bottom. (Drawing detail taken from NPS Document No. 412-80454)

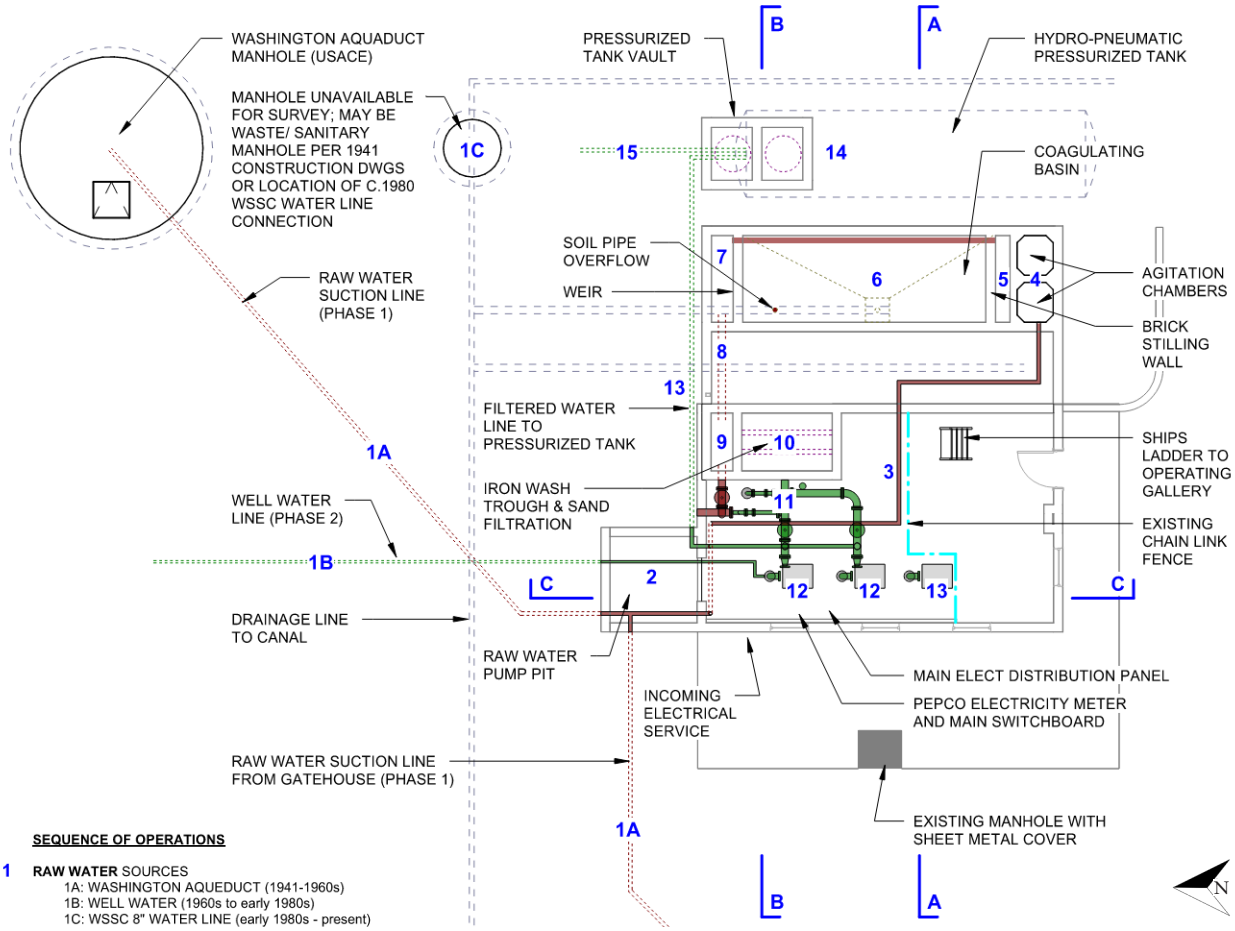
basin. The coagulation basin is connected to Operating Gallery by a concrete walkway and stair that currently spans between the upper level of the pump house to the concrete retention structure. The basin is currently topped with a 1-1/2" wood deck supported by 4"x8" wood beams spanning from the east to west walls. A fence, built along the edge of the coagulation basin walls, surrounds the basin on the north, east, and south. It is possible the coagulation basin was originally designed with a cover; however, the historic drawing documentation did not reference any cover enclosure.

A low, curved stone masonry retaining wall is present south of the Pump House (**Figure 92**). This low retaining wall maintains the grade which conceals the pressurized storage tank located below grade east of the Pump House.

Figure 92. (Right) Pump House: Low curved retaining wall located south of the agitation chamber and coagulation basin.

Figure 93. (Bottom) Pump House: Portion of original 1941 construction drawing sections indicating extent of clear well below grade (NPS Document No. 412-80454).





SEQUENCE OF OPERATIONS

1 **RAW WATER** SOURCES
- 1A: WASHINGTON AQUEDUCT (1941-1960s)
- 1B: WELL WATER (1960s to early 1980s)
- 1C: WSSC 8" WATER LINE (early 1980s - present)

2 RAW WATER ENTERS VIA THE **PUMP PIT**

3 WATER IS PUMPED UP TO THE **OPERATING GALLERY** AND THROUGH A **WATER METER** (NOT EXTANT) BEFORE BEING ROUTED TO THE AGITATION CHAMBERS

4 WATER ENTERS THE **AGITATION CHAMBERS** AND MIXED WITH CHEMICALS TO AID IN COAGULATION AND FLOCCULATION

5 WATER FILTERS THROUGH **BRICK STILLING WALL** TO SLOW DOWN FLOW

6 WATER COMBINED WITH FLOCCULANT IN **COAGULATION BASIN;** COLLOIDAL PARTICLES COME OUT OF SUSPENSION TO SEDIMENT IN THE FORM OF FLOC OR FLAKE

7 WATER DRAINED THROUGH **WIER**

8 WATER ROUTED BACK INTO PUMP HOUSE

9 **HOLDING CHAMBER** COLLECTS WATER

10 WATER FLOWS OVER THE **IRON WASH TROUGH** AND FILTERS THROUGH SAND AND GRAVEL FILTER

11 AT BASE OF SAND FILTRATION WATER ENTERS THE **CLEAR WELL** BELOW THE BUILDING

12 WHEN NEEDED WATER IS PUMPED FROM THE CLEAR WALL

13 WATER ROUTED ALONG THE NORTH WALL OF THE PUMP HOUSE BELOW GRADE

14 WATER IS HELD IN THE BELOW GRADE **PRESSURIZED WATER TANK**

15 PRESSURIZED WATER TANK DISTRIBUTED WATER THROUGHOUT THE NEARBY STRUCTURES

Figure 94. (Top) Pump House: First Floor Key Plan. (See Part III Documentation for more detailed drawings.)

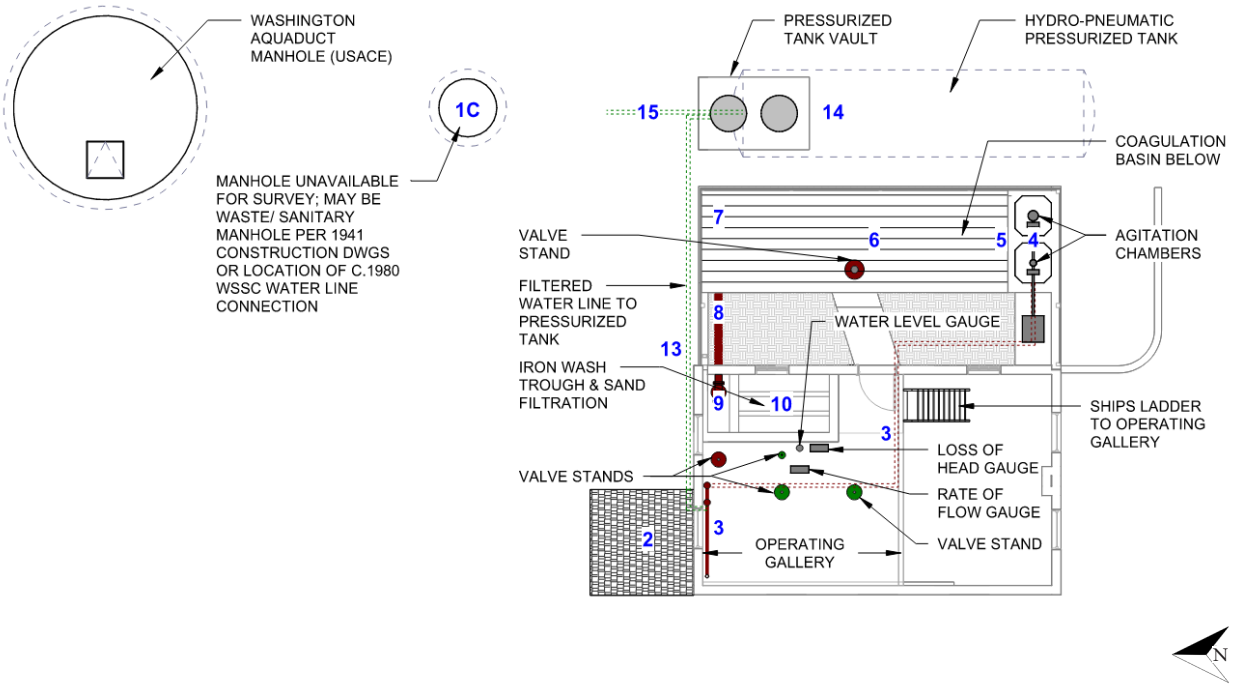


Figure 95. (Bottom) Pump House: Operating Gallery Key Plan. (See Part III Documentation for more detailed drawings.)

SEQUENCE OF OPERATIONS

1 **RAW WATER** SOURCES
- 1A: WASHINGTON AQUEDUCT (1941-1960s)
- 1B: WELL WATER (1960s to early 1980s)
- 1C: WSSC 8" WATER LINE (early 1980s - present)

2 RAW WATER ENTERS VIA THE **PUMP PIT**

3 WATER IS PUMPED UP TO THE **OPERATING GALLERY** AND THROUGH A **WATER METER** (NOT EXTANT) BEFORE BEING ROUTED TO THE AGITATION CHAMBERS

4 WATER ENTERS THE **AGITATION CHAMBERS** AND MIXED WITH CHEMICALS TO AID IN COAGULATION AND FLOCCULATION

5 WATER FILTERS THROUGH **BRICK STILLING WALL** TO SLOW DOWN FLOW

6 WATER COMBINED WITH FLOCCULANT IN **COAGULATION BASIN;** COLLOIDAL PARTICLES COME OUT OF SUSPENSION TO SEDIMENT IN THE FORM OF FLOC OR FLAKE

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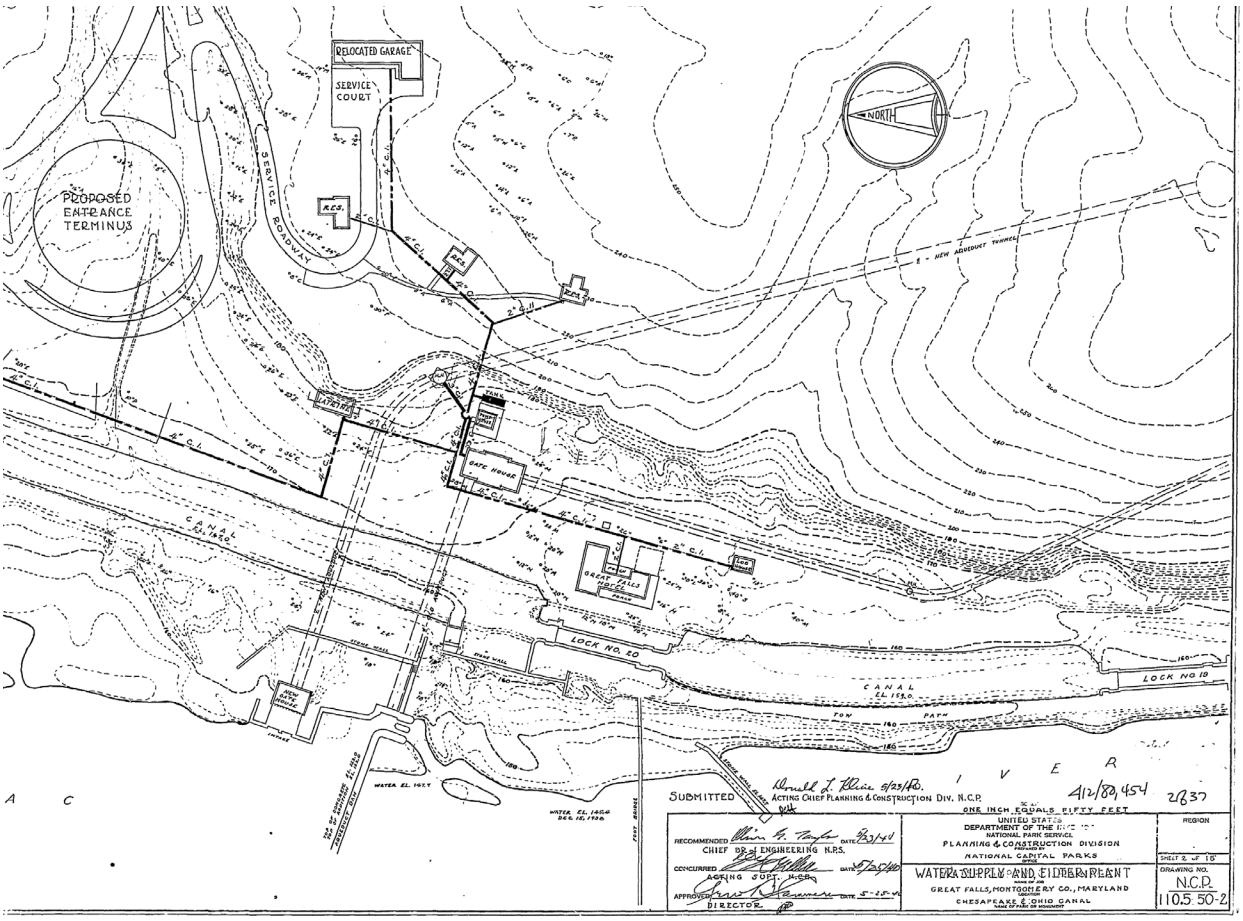
14 WATER IS HELD IN THE BELOW GRADE **PRESSURIZED WATER TANK**

15 PRESSURIZED WATER TANK DISTRIBUTED WATER THROUGHOUT THE NEARBY STRUCTURES

MECHANICAL & PLUMBING

Built by the CCC in the early 1940's, the Pump House filtered, stored and distributed water for the buildings at Great Falls. Historically, the raw water supplied to the Pump House was sourced from the Potomac River through the Washington Aqueduct (**Figures 94-95**). The original filtration, water storage, and distribution systems were taken out of service in the early 1980s when water was supplied to the site from WSSC. The historic piping and distribution lines, pumps, valces, valve stands, water meters, pressure gauges, and floor meters survive in the building (**Figure 96**). The original water meters and gauges were manufactured by Builder's Iron Foundry in Providence, RI and are not currently in service. The remnants of compressed air piping and meters for a compressor (not extant) are still evident at the lower level.

Figure 96. Pump House: Site plan locating a portion of 1940 Water Supply and Filter Plant. As originally designed, the Pump House received raw water from the Washington Aqueduct as identified in this site plan. (NPS Document # 412-80454)



The Pump House is currently heated with a new electric unit heater likely installed with the 2007 mechanical and electrical upgrades. It is assumed there must have been an original heat source present at the Pump House to keep pipes from freezing as evident from the chimney collar and flue for exhaust; however, few details are known. No cooling is provided in the Pump House, but operable windows are present.

WATER FILTRATION & DISTRIBUTION SYSTEMS

Understanding the equipment and sequence of operations inside the Pump House are critical in understanding the relationship of the Pump House to the surrounding buildings and below grade infrastructure. The following outlines a sequence of operations and explains the various spaces, holding tanks, and equipment present at the Pump House (**Figures 94-96**). These systems are no longer operational, but the description below outlines how these systems operated between the early 1940s and the early 1980s.

Figure 97. (Left) Pump House: Raw water pump pit; pump and drain seen at bottom of pit; well water line (green) seen on the right.
Figure 98. (Right) Pump House: Washington Aqueduct manhole (managed by the USACE); Pump House and historic Gatehouse seen in background.

Figure 99. (Left) Pump House: Water well located north of the Pump House; Pump House seen in the background.
Figure 100. (Left) Pump House: Location of original water meter (no longer extant) along raw water line at the Operating Gallery level.

Beginning in 1940 the raw water lines drew water from the Washington Gatehouse and aqueduct, located just west and north of the Pump House, into the pipes and pump within the raw water pit (**Figure 97**). The 3" cast iron suction line entering from the west originated at the historic Gatehouse located west of the Pump House. The 3" cast iron suction line entering from the north originated from the 14 ft diameter manhole (**Figure 98**) located along the 10 ft Aqueduct conduit installed c.1940. The incoming pipe lines were painted red to distinguish the raw water from the filtered and treated water in the pipes painted green. The raw water pump pit included a drain at the bottom connected to a common waste drainage line routed to the C&O Canal.

Figure 101. (Left) Pump House: Raw water line carrying water to the agitation chambers.
Figure 102. (Right) Pump House: motor and gears above agitation chambers.

Figure 103. Pump House: Gears above agitation chambers.

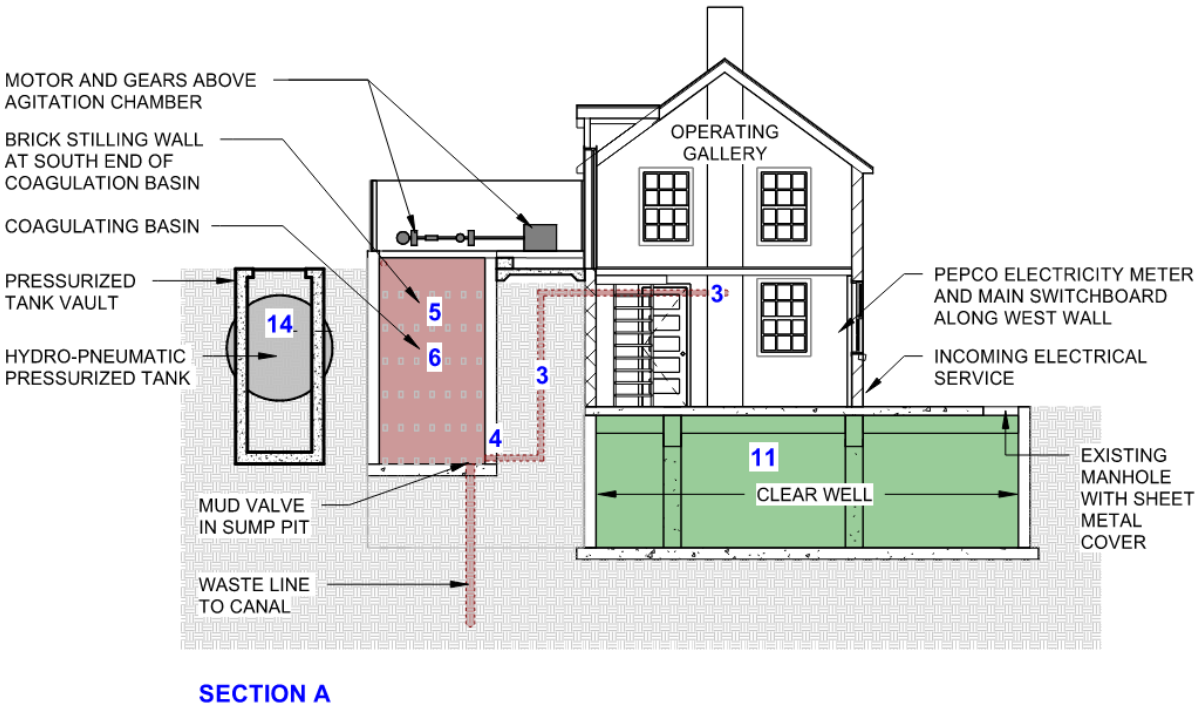
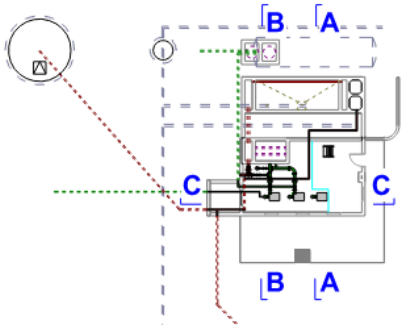


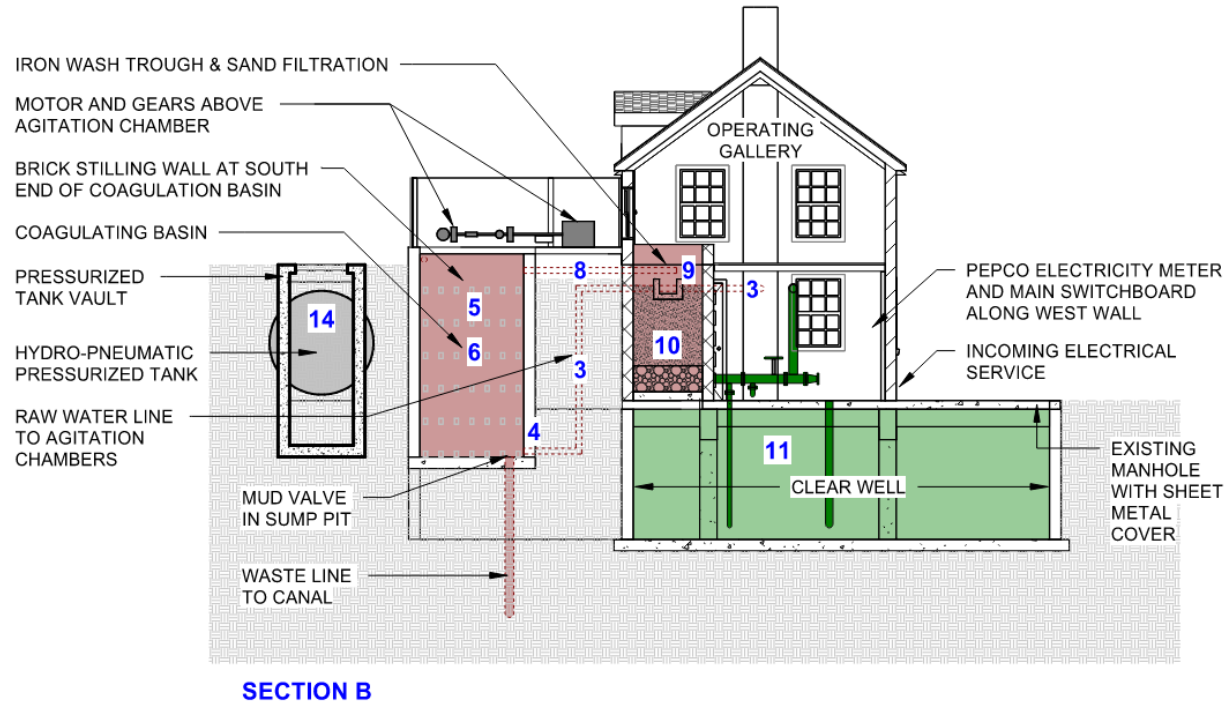
Figure 104. (Top) Pump House: East/west section diagram of Pump House through pressurized tank, coagulation basin, iron trough & sand filtration, and clear well. (See Part III Documentation for more detailed drawings.)

SEQUENCE OF OPERATIONS

1. **RAW WATER** SOURCES
   - 1A: WASHINGTON AQUEDUCT (1941-1960s)
   - 1B: WELL WATER (1960s to early 1980s)
   - 1C: WSSC 8" WATER LINE (early 1980s - present)
2. RAW WATER ENTERS VIA THE **PUMP PIT**
3. WATER IS PUMPED UP TO THE **OPERATING GALLERY** AND THROUGH A **WATER METER** (NOT EXTANT) BEFORE BEING ROUTED TO THE AGITATION CHAMBERS
4. WATER ENTERS THE **AGITATION CHAMBERS** AND MIXED WITH CHEMICALS TO AID IN COAGULATION AND FLOCCULATION
5. WATER FILTERS THROUGH **BRICK STILLING WALL** TO SLOW DOWN FLOW
6. WATER COMBINED WITH FLOCCULANT IN **COAGULATION BASIN;** COLLOIDAL PARTICLES COME OUT OF SUSPENSION TO SEDIMENT IN THE FORM OF FLOC OR FLAKE
7. WATER DRAINED THROUGH **WIER**
8. WATER ROUTED BACK INTO PUMP HOUSE
9. **HOLDING CHAMBER** COLLECTS WATER
10. WATER FLOWS OVER THE **IRON WASH TROUGH** AND FILTERS THROUGH SAND AND GRAVEL FILTER
11. AT BASE OF SAND FILTRATION WATER ENTERS THE **CLEAR WELL** BELOW THE BUILDING
12. WHEN NEEDED WATER IS PUMPED FROM THE CLEAR WALL
13. WATER ROUTED ALONG THE NORTH WALL OF THE PUMP HOUSE BELOW GRADE
14. WATER IS HELD IN THE BELOW GRADE **PRESSURIZED WATER TANK**
15. PRESSURIZED WATER TANK DISTRIBUTED WATER THROUGHOUT THE NEARBY STRUCTURES



PUMP HOUSE KEYPLAN



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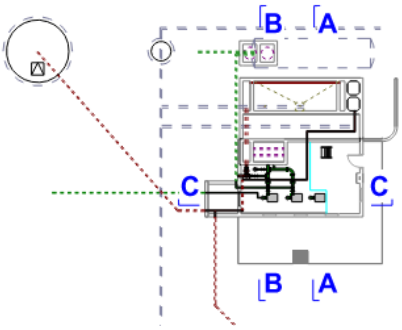

PUMP HOUSE KEYPLAN

SEQUENCE OF OPERATIONS

1 **RAW WATER** SOURCES
1A: WASHINGTON AQUEDUCT (1941-1960s)
1B: WELL WATER (1960s to early 1980s)
1C: WSSC 8" WATER LINE (early 1980s - present)

2 RAW WATER ENTERS VIA THE **PUMP PIT**

3 WATER IS PUMPED UP TO THE **OPERATING GALLERY** AND THROUGH A **WATER METER** (NOT EXTANT) BEFORE BEING ROUTED TO THE AGITATION CHAMBERS

4 WATER ENTERS THE **AGITATION CHAMBERS** AND MIXED WITH CHEMICALS TO AID IN COAGULATION AND FLOCCULATION

5 WATER FILTERS THROUGH **BRICK STILLING WALL** TO SLOW DOWN FLOW

6 WATER COMBINED WITH FLOCCULANT IN **COAGULATION BASIN;** COLLOIDAL PARTICLES COME OUT OF SUSPENSION TO SEDIMENT IN THE FORM OF FLOC OR FLAKE

7 WATER DRAINED THROUGH **WIER**

8 WATER ROUTED BACK INTO PUMP HOUSE

9 **HOLDING CHAMBER** COLLECTS WATER

10 WATER FLOWS OVER THE **IRON WASH TROUGH** AND FILTERS THROUGH SAND AND GRAVEL FILTER

11 AT BASE OF SAND FILTRATION WATER ENTERS THE **CLEAR WELL** BELOW THE BUILDING

12 WHEN NEEDED WATER IS PUMPED FROM THE CLEAR WALL

13 WATER ROUTED ALONG THE NORTH WALL OF THE PUMP HOUSE BELOW GRADE

14 WATER IS HELD IN THE BELOW GRADE **PRESSURIZED WATER TANK**

15 PRESSURIZED WATER TANK DISTRIBUTED WATER THROUGHOUT THE NEARBY STRUCTURES

Figure 105. (Middle) Pump House: East/west section diagram of Pump House through pressurized tank, coagulation basin, and clear well. (See Part III Documentation for more detailed drawings.)

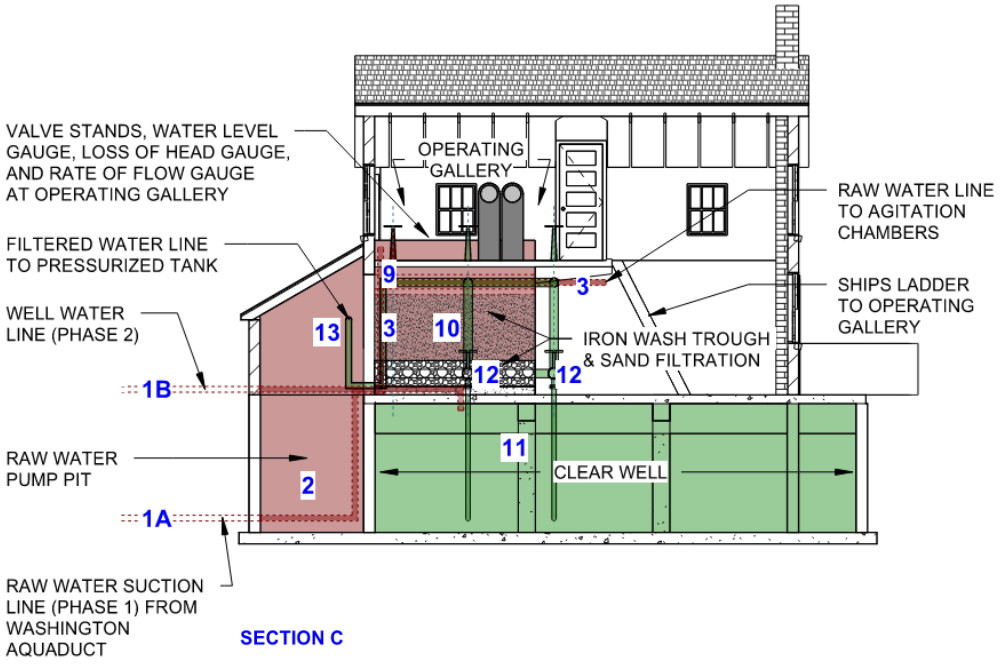

Figure 106. (Bottom) Pump House: North/ south section diagram of Pump House through raw water pump pit, iron trough & sand filtration, and clear well. (See Part III Documentation for more detailed drawings.)

SEQUENCE OF OPERATIONS

1 **RAW WATER** SOURCES
- 1A: WASHINGTON AQUEDUCT (1941-1960s)
- 1B: WELL WATER (1960s to early 1980s)
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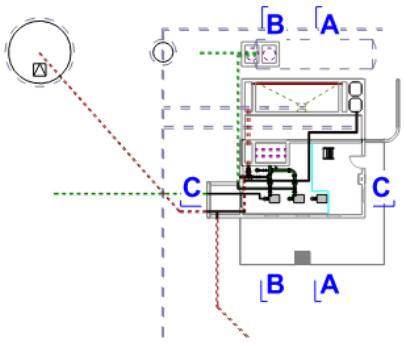

PUMP HOUSE KEYPLAN

Figure 107. (Left) Pump House: View of agitation chamber.
Figure 108. (Right) Pump House: View looking down into the coagulation basin; brick stilling wall seen at the top of the image.

Sometime between the 1940s and the 1980s (exact date unknown), the water source for the Pump House was modified to connect a nearby well (**Figure 99**) located just to the north of the raw water pump pit. This incoming well water line, naturally filtered through the soil unlike the turbid Potomac, was directed to the clear well, circumventing the Pump House water treatment and filtration process. In the early 1980s, a new waterline was provided via a

Figure 109. (Left) Pump House: Cast iron overflow drain pipe at the coagulation basin.
Figure 110. (Top, Right) Pump House: Weir located at the north end of the coagulation basin; cast iron overflow drain located at the far east end.
Figure 111. (Bottom, Right) Pump House: Iron grate to strain water running from the weir to the holding tank for the iron wash trough and sand filtration chamber.

connection made by WSSC following complaints that the water contained in the clear well of the Pump House did not meet potable requirements.

From the raw water pump pit, the water was pumped up to the Operating Gallery of the Pump House to a water meter (not extant, **Figure 100**). From the water meter, the painted red cast iron pipe was routed back down below the Operating Gallery reinforced concrete floor slab (**Figure 89**) to the two (2) agitation chambers (**Figure 107**) located at the southeast corner of the Pump House. The agitation chambers, octagonal in plan and measuring approximately 12 ft deep were operated by two (2) agitation motors and gears attached to a motoreducer (**Figure 103**). Based on observation of the motor and gears at the top of the agitation adjacent chamber, the chamber on the west provided a faster agitation than the one on the east. Though not observed on site, and possibly concealed by debris accumulated at the base of the chambers, the two chambers were likely connected at the bottom to allow water to flow between the chambers. Following the addition of chemical treatment in the agitation chambers, the water was released into a narrow cavity along the south side of the coagulation

Figure 112. Pump House: Iron raw water line carrying water running from the weir to the holding tank for the iron wash trough and sand filtration chamber.
Figure 113. Pump House: Pump House: Iron wash trough and sand filtration chamber.

Figure 114. Pump House: Raw water waste line from holding tank north of the iron wash trough and sand filtration chamber.

basin. This narrow cavity, approximately 12 inches wide and 12 ft deep regulated the flow of water entering the coagulation basin by the use of an 8" brick stilling wall (**Figure 108**). The water flowed from the base of the agitation chambers through a pipe at the base when a 4" shear gate was lifted.

The coagulation basin (**Figure 108**) is a 1,200 cubic ft cast-in-place concrete chamber, located outside of the Pump House along the east facade. This basin was used to contain the raw water during the coagulation and flocculation phases to collect suspended solids into flocculent which would settle to the bottom of the basin. The chamber contained a 4" soil overflow pipe and sump at a mud valve to drain the flocculent to a waste line.

The treated water from the coagulation basin spilt over the edge of the weir located along the north edge of the coagulation basin (**Figure 110**). A 4" cast iron overflow pipe captured excess water from the east end of the weir and directed it back to the agitation chambers.

Figure 115. (left) Pump House: Raw (red) and filtered (green) cast iron water lines used to distribute water through the Pump House; view looking towards iron wash trough and sand filtration chamber.
Figure 116. (right) Pump House: Raw (red) and filtered (green) cast iron water lines used to distribute water through the Pump House; view looking towards incoming electrical service and distribution panels located along the west wall of the Pump House.

From the weir, the water was filtered through a metal grate (**Figure 111**) into a cast iron pipe to a holding chamber adjacent to the iron wash trough and the sand and gravel filtration chamber.

At the top of the iron wash trough holding chamber, water flowed into a concrete wash trough (**Figure 115**) located above the sand filtration. As the water spilt over the top edge of the iron wash trough, the water was filtered

Figure 117. (Left) Pump House: Water level gauge at Operating Gallery.
Figure 118. (Right) Pump House: Gauge abandoned in place from an air compressor (no longer extant).

Figure 119. (Left) Pump House: Loss of head gauge at Operating Gallery.
Figure 120. (Right) Pump House: Piping and controls abandoned in place from an air compressor (no longer extant).

Figure 121. (Left) Pump House: Piping and controls abandoned in place from an air compressor (no longer extant).

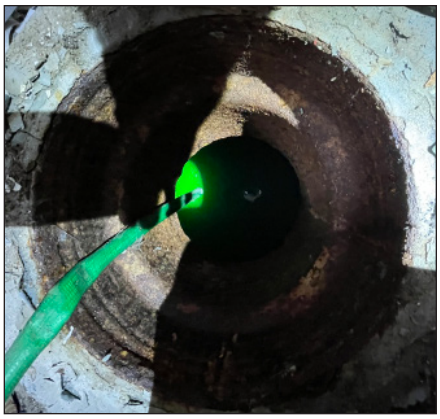

Figure 122. (Left) Pump House: View into clear well.
Figure 123. (Right) Pump House: View into clear well. Well water line seen routed directly into the clear well.

through a system of fine sands supported by graded gravels as indicated in the original construction drawings. At the base of the filtration chamber, a manifold directed the water through the west wall of the chamber to a cast iron pipe connected to the clear well and the waste drainage line (**Figure 116**).

On the first floor of the Pump House, atop the below grade clear well water storage tank, a series of cast iron water lines, valves, and pumps controlled and managed the water distribution process throughout Great Falls (**Figures 117-121**). There were many connections and valves to control the process, but the system also provided overrides that allowed operators to circumvent

Figure 124. (Left) Pump House: Vault manhole openings above pressurized tank.
Figure 125. (Right) Pump House: Water supply and valves at west end of the pressurized tank located below grade east of the coagulation basin.

certain steps of the process if the water quality was determined unacceptable. If necessary, all water could be drained back to the C&O Canal through the waste drainage line.

The clear well located below the Pump House provided a below grade holding chamber for the treated water supply. This space was not accessible for survey as the steel access plate locate at grade just west of the Pump House was not operable. However, limited observation could be made from the first floor of the Pump House where several floor sleeves allowed pipes to be routed down into the clear well to pump the water to the pressurized tank located east of the Pump House (**Figures 122-123**) as needed. Visual observation completed in December 2022 found that the clear well contains standing water that has been mixed with a bright green substance emitting a chemical odor. The quality and condition of this water is unknown and should be further evaluated to assess any hazardous conditions.

If the current substance in the well is corrosive, it may be expediting the deterioration of any exposed reinforcing. It is recommended that the clear well be emptied to prevent any additional deterioration of the reinforced concrete. The well should be drained slowly and observations of the structure should be made as it is draining to detect any areas that may have suffered significant deterioration which would necessitate shoring. Analysis was performed to determine if the well walls are structurally stable in the empty condition using the existing drawings, and they were found to be adequate assuming no unknown deterioration has occured. After the clear well is emptied it is recommended that a conditions assessment be done of the well structure to identify any deteriorated areas and that require repaired to ensure the longevity of the structure.

Included in the equipment and controls located on the first floor of the Pump House were two (2) filtered water pumps to draw the water from the clear well to the hydro-pneumatic pressurized storage tank located below grade, east of the Pump House. This pressurized steel storage tank was supported by the air compressor (not extant) which was located at the first floor of the Pump House. A concrete vault with two (2) manhole covers provided access to the piping and valves entering the north side of the tank and access to an opening in the top of the steel tank (**Figure 124**). From this pressurized tank, filtered water was distributed to the nearby structures including the Comfort Station, Boiler House, Engineer's Garage (**Figure 125**) and the Tavern.

ELECTRICAL

The Pump House contains the main electrical service for the adjacent structures and distributes power to the Pump House, Boiler House, Great Falls Tavern, and the Comfort Station. The original electrical service was installed at the Pump House when the building was constructed in 1941 and was upgraded in 2007 (**Figure 126**). The upgraded site-wide electrical service installed in 2007 also provided power to the new comfort station located north of the Gatehouse.

According to the 2007 drawing to "Repair/ Rehabilitate Visitor Center" (NPS Document 412-41081) the electrical service to the site originates at a utility pole near the entrance road and runs in a direct buried conduit as the primary service feeder to the PEPCO transformer located between the Gate House, New Comfort Station, and Pump House. From the transformer, service is provided through a 2-way direct buried duct bank for secondary feeders from the transformer to the New Comfort Station. A 4-way duct bank continues from the transformer to the Pump House. A 3-way duct bank provides service from the Pump House to the Boiler House and Tavern. No plan reference is made to the power supplying the Comfort Station, but the elevation on sheet E1.2 maps out an existing to remain electrical service to the Comfort Station Load Center, located in the utility closet at the Comfort Station.

Figure 126. (Left) Pump House: Electrical transformer located north of the historic Gatehouse, across the access road from the Pump House.
Figure 127. (Right) Pump House: Exterior wireway proving incoming electrical service conductors to to the main distribution electrical panel located inside the Pump House; located at northwest corner of Pump House.

Figure 128. (Left) Pump House: Electrical main distribution panel located along west wall of Pump House.
Figure 129. (Right) Pump House: Original, abandoned electrical panel located along west wall of Pump House.

Figure 130. (Left) Pump House: Exterior wireway distributing electrical service from Pump House to nearby structures; located at west facade of Pump House.
Figure 131. (Right) Pump House: Exterior wireway distributing electrical service from Pump House to nearby structures; located at west facade and southeast of Pump House.

The PEPCO electricity meter and the main switchboard located within the Pump House are served off an interior-mounted wireway. The 208Y/120V main distribution panel, 'DP1', is wall mounted and contains a 600A main circuit breaker (MCB) and was installed in 2007 (**Figures 128, 130-131**). To distribute power to the adjacent structures, an additional exterior wire way serves as a pathway for the feeders to these accessory buildings and transitions to underground conduit.

The Pump House contains an older, abandoned lighting distribution panelboard and load center enclosure which appear to have been repurposed as junction boxes (**Figure 129**). Many of the electrical devices in the building

Figure 132. (Left) Pump House: Historic light switches manufactured by Benjamin Electric Co.
Figure 133. (Right) Pump House: Historic light socket with threaded cover plate manufactured by Benjamin Electric Co. located along the walls at the Operating Gallery.

are abandoned, or no longer in use, some of which are original to the building. During survey it was noted that the existing light switches adjacent to the entry door were made by Benjamin Electric Co. and are likely original to the 1941 construction. These light switches have pull levers to operate the lights. The lighting fixtures are E26 medium socket base light fixtures with screw-in incandescent lamps. Most branch circuiting within the space is surface mounted electrical metallic tubing (EMT) type conduit throughout, however there is some metal clad (MC) cable. This space does not feature any automatic controls including occupancy sensors.

FIRE PROTECTION/ LIFE SAFETY/ SECURITY

The Pump House does not contain any security or fire protection systems (fire alarm or fire suppression) as this building is normally non-occupied and is a Use Group "U" occupancy building. No fire protection systems are required for this building based on its use; however, other DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

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ENGINEER'S GARAGE

ARCHITECTURE

The Engineer's Garage, located atop the bluff, is a bit further north and east of the Engineer's House. Away from the tourist-focused area below, the area at the Engineer's Garage and surrounding structures is limited to NPS access.

The Engineer's Garage is a wood framed structure on a concrete masonry foundation (**Figure 140**). The concrete slab on grade is noted in the historic 1941 construction drawings as a 4" concrete floor slab over a minimum 6" cinder base (**Figure 137**). This slab on grade was topped with a 1" topping slab. The floor elevation is noted in these drawings as sloping down 4" from east to west to allow drainage out through the garage door openings along the west facade.

The exterior walls are built of 8" concrete blocks set on concrete foundations below grade. At varying elevations that increase with the surrounding elevation along the east facade, this concrete block supports 2x4 wood framed construction to support the roof structure. Fifteen (15) wood double-hung windows punctuate the exterior wood-framed wall assembly, with two (2) on the north facade, nine (9) on the east, three (3) on the south, and one

Figure 134. Engineer's Garage: West elevation of Garage.

Figure 135. (Left) Engineer's Garage: View of north facade of Garage.
Figure 136. (Right) Engineer's Garage: Equipment storage in the Garage.

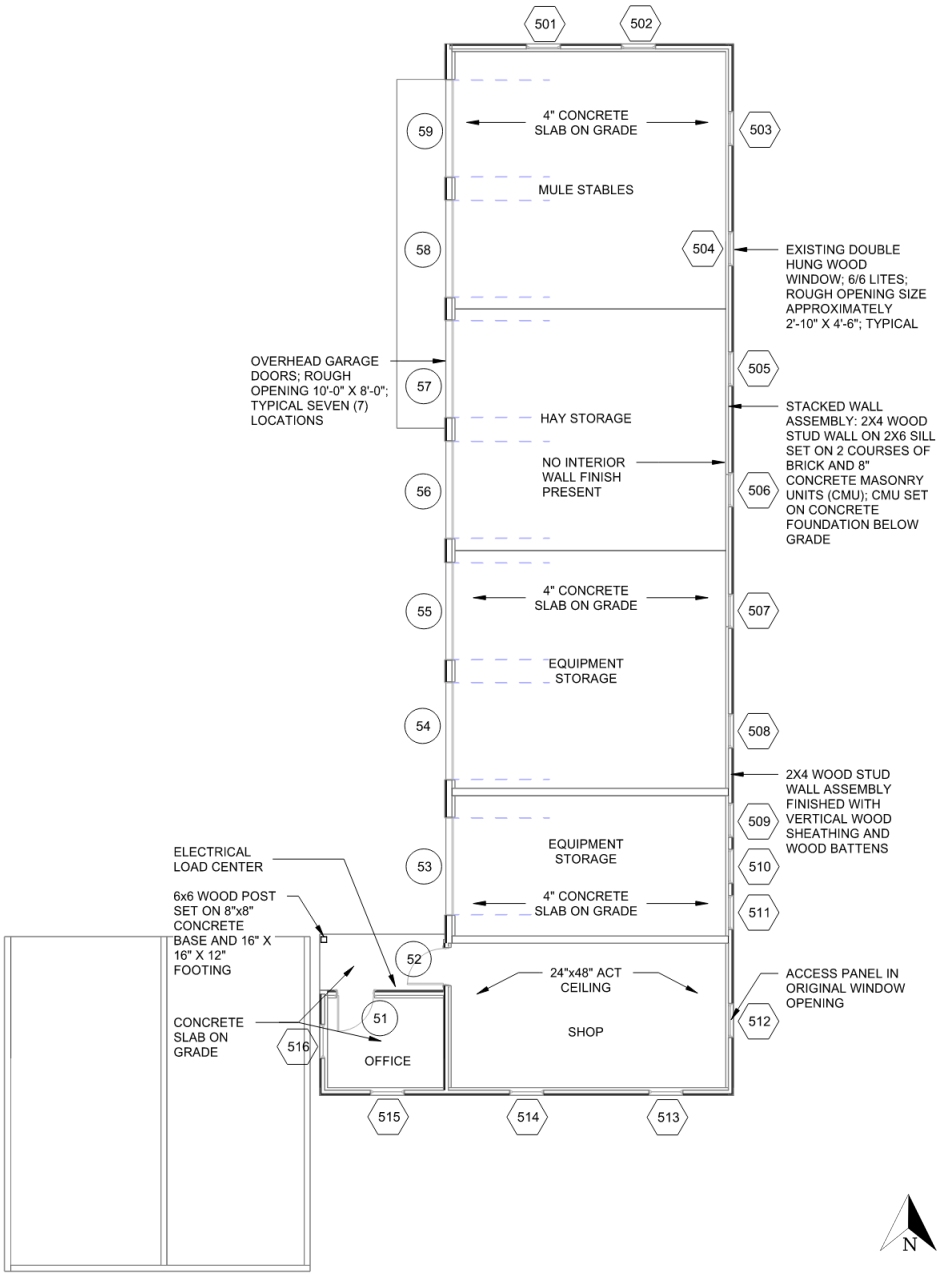

Figure 137. Engineer's Garage: Key Plan. (See Part III Documentation for more detailed drawings.)

(1) on the west. Seven (7) manually-operated garage doors occupy the west facade (**Figure 134**). Originally, the Engineer's Garage had just two man-doors, one on the north facade leading into the office, and one at the southern end of the west facade, accessing the shop (**Figure 135**). At some point, however, the southernmost window on the south facade, window 512, was replaced with an access panel with interior wood stairs. The garage doors are 16 panel doors with the top four panels featuring clear glazing. These garage doors were installed in 2017 and replaced the original doors installed in 1941. The original garage doors were 24-paneled with the top 6 panels featuring

clear glazing. The replacement garage doors are similar but do not match the historic design. The entry doors into the Office and Shop are solid wood paneled doors with 3 panels at the lower portion of the doors and divided lite glazing on the upper portion.

The structure is largely used for equipment storage at the southern end, with the northern half providing stables for mules and storage for their supplies and equipment, including hay storage (**Figures 136 and 138-139**). The original 1941 construction drawings indicate the southern spaces were to be used as a shop and office, but current conditions indicate that storage dominates the space leaving little area for these original functions. The interior portion of the structure used for mules, hay storage, and equipment storage remains unfinished with exposed wall and roof framing. The office and storage room located at the south end of the structure have interior plaster finishes and fiberboard ceiling panels attached to the underside of the roof rafter framing. The floor throughout is an unfinished concrete slab on grade.

Figure 138. (Left) Engineer's Garage: Garage storage at the south end, equipment hanging from structure
Figure 139. (Right) Engineer's Garage: Garage mules stable at the north end.

Figure 140. (Left) Engineer's Garage: Concrete and masonry base and wood stud wall construction above
Figure 141. (Right) Engineer's Garage: Wood roof rafters

The roof structure is assembled from wood framed king post trusses (**Figure 141**). The wood sheathing is clad with modern asphalt shingle roofing which was installed in 2015. The historic 1941 construction drawings indicate the roof finish was asphalt shingles. The gutters are modern k-style aluminum gutters with rectangular downspouts.

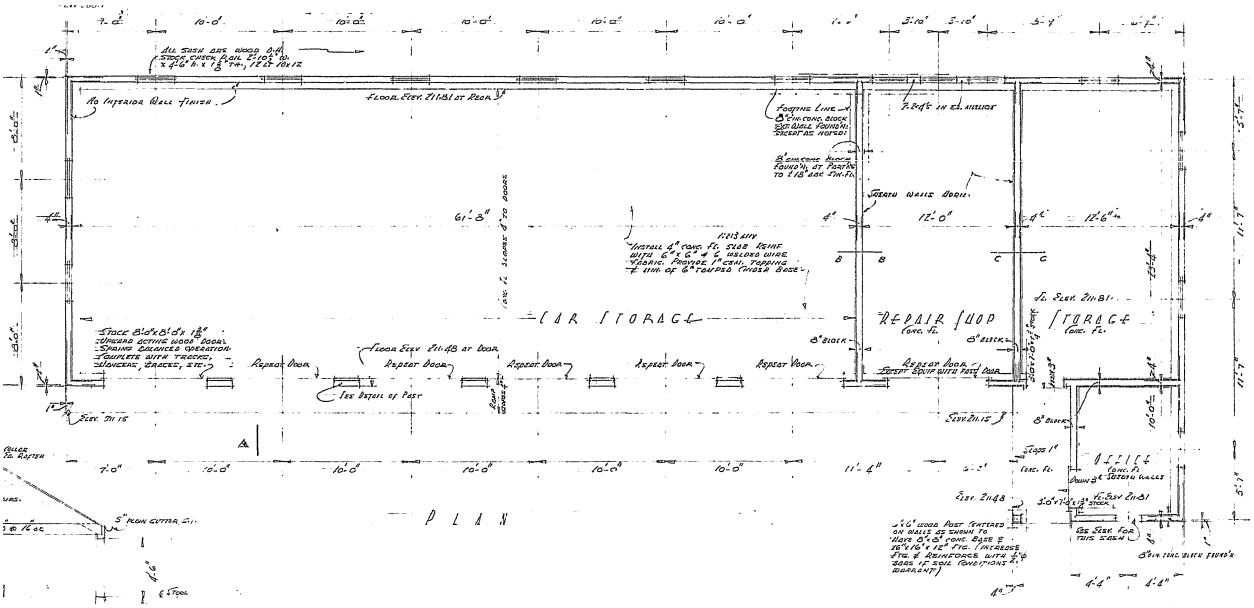

Figure 142. Engineer's Garage: Historic floor plan from 1941 construction drawings (NPS Document No. 412-80459).

STRUCTURE

The Engineer's Garage is an L-shaped structure primarily constructed of wood (**Figure 142**). Per the historic 1941 construction drawings the footings are reinforced concrete strip footings with 8" CMU foundation walls extending above grade (**Figure 143**). The footings and CMU walls step along the changing grade elevations. Two courses of brick were built on top of the CMU walls and noted in the original drawings as a "termite stop". The exterior and interior walls are wood stud walls. Original drawings indicate the exterior walls are 2x4s at 16" on-center. The floors in the main garage area are 6" cinder slab-on-grade with wire mesh reinforcing.

The roof structure of the Engineer's Garage is constructed of wood trusses spaced about 16" on-center (**Figure 144**). Wood truss members include 2x8 roof rafters, a 2x6 center king post, 2x10 ceiling ties, and 2x6 horizontal collar ties. The 2x10 ceiling ties are spliced with bolts at their midspan, and the high horizontal collar ties are fastened to the rafters and central king post. A 2x10 ridge member also spans perpendicular to the truss framing. Some of the roof members are painted, but many are not, suggesting the roof framing was completely painted at one point in the building's history, and unpainted

Figure 143. Engineer's Garage: Base wall/ foundation detail at southwest corner.

elements are replacements. While the existing drawing showed 5/8" plywood sheathing, wood sheathing boards were observed in the field.

The structure of the L-shaped wing could not be viewed due to the presence of finishes, but the structure is assumed to be similar based on the original historic drawings. The entrance here also includes a raised concrete porch and roof framing is supported on a corner 6x6 nominal wood post.

There are low concrete retaining walls at the south side of the Engineer's Garage.

Figure 144. Engineer's Garage: Wood roof rafters above the mule stables in the Garage.

INVENTORY OF PHYSICAL FEATURES

ENGINEER'S GARAGE		
Building Element/ Feature	Material Description	Dimensions
Floor	4" concrete slab-on-grade with 1" topping slab	5"
Walls - Exterior	stacked wall assembly: 2x4 wood stud wall on 2x6 sill set on 2 courses of brick and 8" concrete masonry units (cmu); cmu set on concrete foundation below grade	number of CMU courses varies
Walls - Interior	wood framed partitions	
Ceiling	N/A	exposed wood rafters
Door 51	3-panel solid wood with 4-light window at top	3'-0" x 7'-0"
Door 52	3-panel solid wood with 4-light window at top	3'-0" x 7'-0"
Access Panel 53	flush wood access panel installed in original window opening	2'-9" x 4'-4" masonry opening, formerly window 512
Windows 501-511, & 513-516	wood double hung; 6/6 lites	2'-9" x 4'-4" masonry opening
Garage Doors 53 - 59	4-panel garage door	10'-0" x 8'-0" rough opening
Garage Door Posts and Header	5-1/2" square posts with 8" d. header beam	
Ceiling Joists/ Bottom Chord of Trusses	2x10s @ 16" o.c. ((2)2x10s bolted together at center of span)	
King Post	2x8s, nailed to bottom chord and bolted to the horizontal tie at roof ridge	
Roof Rafters	2x8 wood framing at 16" o.c.	
Roof Ridge	2x8 wood framing	Small horizontal ties at roof ridge: assumed to be 2x8
Roofing	wood sheathing and asphalt shingles	

MECHANICAL & PLUMBING

The Engineer's Garage does not utilize any centralized heating, cooling, or ventilation equipment. A small electric wall heater warms the office and circulation fans vent the unfinished stables and garage space (**Figures 145-146**). The garage also contains a wall exhaust fan in the portion of the garage used for hay storage. No incoming water service was located at the Engineer's Garage.

Figure 145. (Left) Engineer's Garage: Electric wall heater at Engineer's Garage office
Figure 146. (Right) Engineer's Garage: Wall exhaust fan at mules stable

ELECTRICAL

The Engineer's Garage has an exterior mounted load center in an exterior enclosure, located on the west exterior wall outside of the office (**Figure 147**). This load center appears to primarily serve lighting, a general-purpose power, exhaust fan, and electric heater loads within the interior office at the south end of the garage structure. The branch circuits appear to be Romex type NM cable directly out of this load center. The incoming electrical service at the Engineer's Garage is not directly connected to the electrical service at the Pump House per 2007 site utility plans provided by NPS.

Figure 147. Engineer's Garage: Exterior electrical load center located outside the north wall of the office.

FIRE PROTECTION/ LIFE SAFETY/ SECURITY

The Engineer's Garage is a combination of a livestock shelter with stables and storage for material and equipment. This type of use directly relates to occupancy classification of Utility and Miscellaneous Group "U" per the IBC. The building does not have any type of fire suppression system, however, the building is provided with heat detectors in each bay of the shelter/garage (**Figure 148**). The heat detectors report back to a central, combination burglary/ fire alarm system which is typical for small buildings. The security control panel (model Z1100 manufactured by Moose) is located in the locked office on the south end of the building (**Figure 149**). The DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

Figure 148. (Left) Engineer's Garage: Heat detector within rafters
Figure 149. (Right) Engineer's Garage: Security control panel at the Engineer's Garage office at the south end of the building

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Chapter 4: Character Defining Features & Assessment of Integrity

Each historic structure built by the CCC African American enrollees and the Boiler House at the C&O Canal is unique, with its own purpose, identity, and distinctive character. Character refers to all those visual aspects and physical features that comprise the appearance of every historic building. Character-defining elements include the overall shape of the building, its materials, craftsmanship, decorative details, interior spaces and features, as well as the various aspects of its site and environment.

The National Register defines integrity as the ability of a property to convey its significance. One way to better understand the way buildings, structures, or properties convey integrity is to consider their completeness and authenticity in expressing their character defining features. To be listed in the National Register of Historic Places, a building, structure, or property must not only be shown to be significant under the National Register criteria, but it also must have integrity. Only after significance is fully established can you proceed to the issue of integrity.

CHARACTER DEFINING FEATURES

The period of significance is from 1938 to the 1950s, the period of time from the purchase of the canal by the government and when the CCC camps were established through the construction of the primary buildings near Great Falls, the four CCC buildings and then the Boiler House in 1951 (previously thought to have been constructed by the CCC). The CCC camps closed in 1942, and WWII and the flood of 1946 interrupted progress on the C&O Canal restoration, but NPS continued work into the 1950s on the recreational aspects of the canal. The Pivot Bridge Ruins (mile 9.92), the Boiler House (mile 14.27), Comfort Station (mile 14.28), Pump House (mile 14.29), and Engineer's Garage (mile 14.35) were listed as contributing structures to the Chesapeake and Ohio Canal National Historical Park Historic District (Additional Documentation and Boundary Increase, 2015). The district is significant nationally, statewide, and locally under Criteria A, C, and D. The four CCC-built resources and the Boiler House are significant under Criterion A: New Deal Era Recreation & Conservation from Seneca to Georgetown: The CCC Program, New NPS Initiatives, & A Recreational Waterway, 1938-1950s.

The Federal government purchased the C&O Canal in 1938 and entrusted it to the care of the NPS, whose role was to transform it from a defunct industrial transportation canal into a recreational and historical park. In 1938, two CCC camps were established in the Great Falls Area, with two African American CCC companies, Company 325 and 333. These two companies built Camp NP-1-MD and Camp NP-2-MD. The camps are significant in their own right as two of three total African American CCC companies in the entire greater Washington, DC area.

One important step in assessing integrity is to define the essential character defining elements and features that must be present for a property to represent its significance. The character defining features below are significant based on their completeness and representation of original construction materials and methods at each structure. While some historic features have been modified or have been removed over time, many of the character-defining features dating to the Period of Significance (1938-1950s) still exist at the buildings and structures.

PIVOT BRIDGE RUINS (MILE 9.92)

- Quarzitic schist cladding on central pier & abutments
- Steel rail, gears, bearing plates, and bolts

BOILER HOUSE (MILE 14.27)

- Exterior masonry enclosure with painted cement plaster exterior finish
- Painted brick masonry chimney
- Size and location of fenestration (entry door and windows)
- Two (2) remaining double hung wood windows
- Exposed industrial equipment, pipes, conduit, etc.

COMFORT STATION (MILE 14.28)

- Cedar shingle roofing
- Wood framed exterior enclosure with painted vertical board & batten siding
- North privacy screen
- Painted 5-panel solid wood north entry door
- Painted board and batten utility closet door
- Wood hopper clerestory windows

- Original urinals concealed behind wall at workbench
- Interior concrete slab on grade floor
- Interior plaster wall and ceiling finishes

PUMP HOUSE (MILE 14.29)

- Cedar shingle roofing
- Painted brick and cast-in-place concrete exterior enclosure
- Painted 5-panel solid wood entry doors
- Double hung wood windows
- Historic piping and distribution lines, pumps, valves, valve stands, water meters, pressure gauges, and flow meters
- Agitation Chambers
- Coagulating Basin
- Weir
- Iron Wash Trough & Sand Filtration chamber
- Clear Well
- Pressurized Tank

ENGINEER'S GARAGE (MILE 14.35)

- Asphalt shingle roof
- Exterior masonry knee walls supporting the wood framed exterior enclosure with painted vertical board & batten siding
- Size, location, and type of fenestration (entry door and windows)
- Size and location of original garage doors

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ASSESSMENT OF INTEGRITY

The NPS outlines seven aspects or factors which must be evaluated to determine the integrity of a building or structure. These include location, setting, design, materials, workmanship, feeling, and association. Integrity is also based on significance: why, where, and when a property is important. To retain historic integrity a building, structure, or property will always possess several, and usually most, of the aspects. Each of the CCC structures and the Boiler House are evaluated below against these aspects in support of determining their significance and identifying the character defining features outlined above.

Location is the place where the historic property was constructed or the place where the historic event occurred.

Setting is the physical environment of a historic property. Whereas location refers to the specific place where a property was built or an event occurred, setting refers to the character of the place in which the property played its historical role.

Design is the combination of elements that create the form, plan, space, structure, and style of a property.

Materials are the physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property.

Workmanship is the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory.

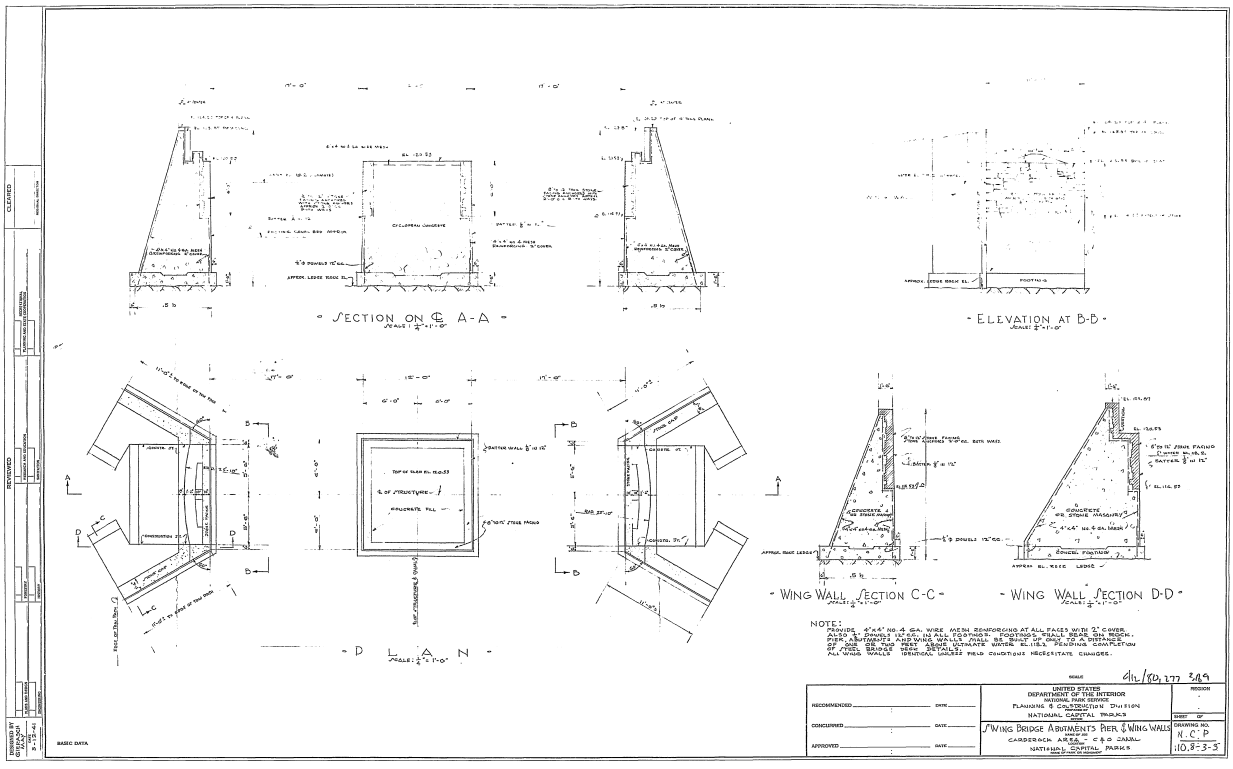
Feeling is a property's expression of the aesthetic or historic sense of a particular period of time.

Association is the direct link between an important historic event or person and a historic property.

The structures at Great Falls constructed by the CCC and the Boiler House remain in their original locations. The original designs implemented by the NPS were based on recreational or facility infrastructure needs and much of the original historic fabric and materials are evident in many of the extant

structures with a moderate degree of integrity. The integrity of the original designs has been somewhat compromised due to the need to accommodate NPS and visitor needs and address ongoing maintenance.

Figure 150. Pivot Bridge Ruins: Original 1941 construction drawing (NPS Document No. 412-80276).



PIVOT BRIDGE RUINS (MILE 9.92)

LOCATION & SETTING

The location of the historic Pivot Bridge Ruins remains intact where the CCC camp enrollees would cross the canal. The setting and surrounding context of the historic Pivot Bridge Ruins have changed in notable ways. The bridge assembly is not extant and the concrete and masonry central pier and abutments remain as artifacts in the landscape, no longer providing a connection across the Canal.

DESIGN

The plan and configuration of the historic Pivot Bridge Ruins has remained constant since the original construction of the bridge (**Figure 150**). The historic concrete and masonry piers have remained intact, but the steel framing and bridge assembly were removed at an unknown date.

The central pier located at the center of the Canal measures approximately 12' x 12' in plan and stands approximately 8.5' tall at the bottom of the Canal bed. The north and south abutments project from the banks of the Canal and maintain their relationship to the central pier to establish the bearing points for the pivot bridge.

MATERIALS

The historic concrete clad in quarzitic schist remains stable but features significant lichen growth and efflorescence. A select portion of the historic steel bearing plates, pivot rails, gears, and bolts (**Figure 151**) remain with minor corrosion and damage.

WORKMANSHIP, FEELING, & ASSOCIATION

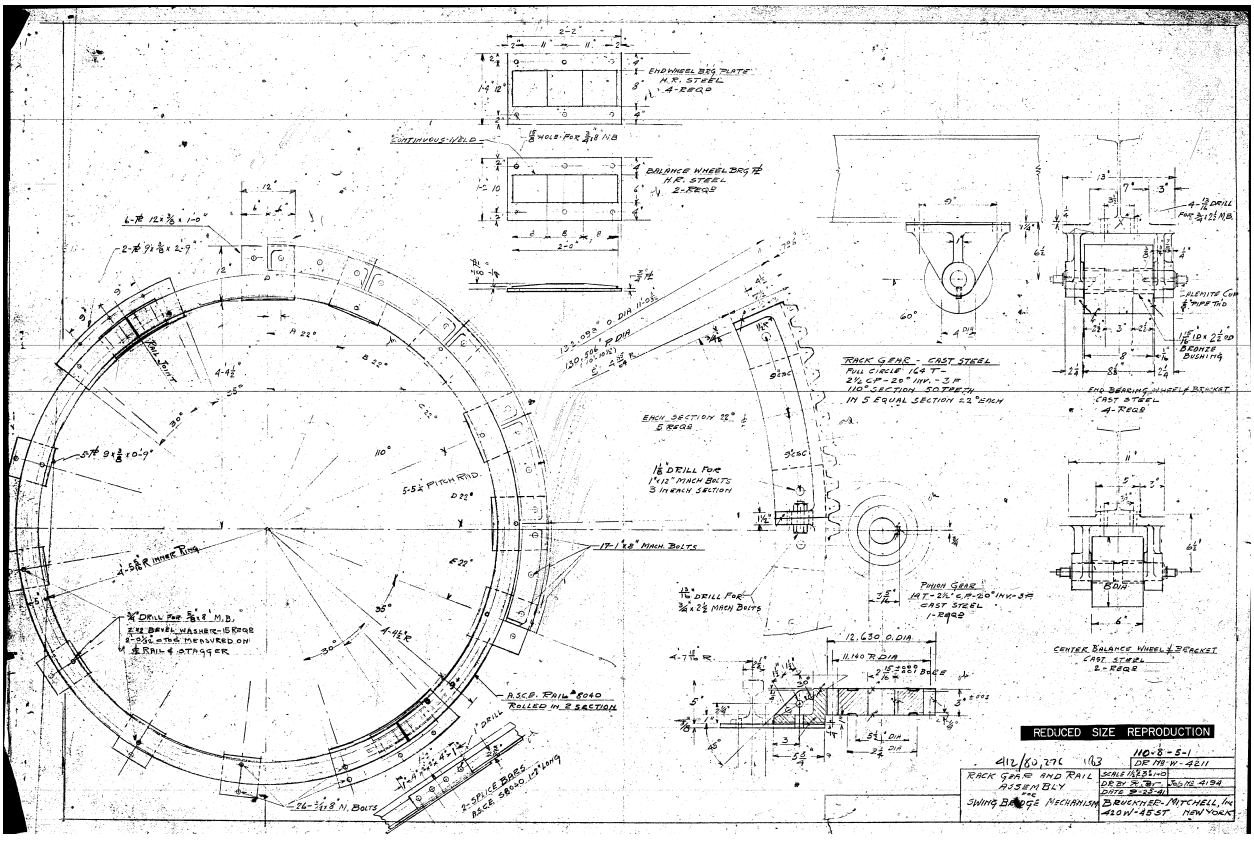
The workmanship of the hand-assembled cyclopean pier and stone abutments communicate the rough process of hand-wrought construction characteristic of the CCC. Today, the feeling and association of the pier and abutments, without the bridge superstructure, are best described as a ruin, rather than a clear contributor to the canal system.

The concrete construction clad in quarzitic schist is notable for its use of cyclopean concrete (**Figure 150**). Though the cyclopean method is only noted for the center pier in the original construction drawings, it is likely a similar method was used to construct the abutments.

The feeling surrounding the Pivot Bridge design is not distinctive of any particular architectural style, but it does respond to the landscape by integrating regional materials to clad the structural concrete.

A strong association of the Pivot Bridge to the historic work of the CCC camps does not remain at this site. The camps were discontinued in the 1940s and in the decade following the superstructure of the bridge was dismantled. When visiting the site, the bridge ruins remain in the canal bed, however the canal does not operate as it did historically.

Figure 151. Pivot Bridge Ruins: Original 1941 construction drawing showing details of bridge rail, gears, and bearing plates (NPS Document No. 412-80276).



BOILER HOUSE (MILE 14.27)

LOCATION & SETTING

The location of the Boiler House remains unchanged along the edge of the access road to the east of Great Falls Tavern. This supporting structure was designed and built in 1951 to support the Tavern and provide necessary services to NPS Staff and visitors to the site. The location was selected to allow the structures to serve as a backdrop to the historic context of the Tavern along the edges of the steeply sloped landscape to the east. The sloped landscape allows for the structure to be partially buried below grade, minimizing visual impact and concealing necessary infrastructure. The trees and vegetation to the east were maintained to preserve the natural landscape and setting.

DESIGN

The plan and configuration of the historic Boiler House has remained constant since the original construction in 1951 (**Figure 152**). The equipment and systems inside and adjacent to the Boiler House have been modified and upgraded over time, most recently in 2007. The surrounding site was also modified in 2007 to relocate the fuel oil tank and install an exterior chiller behind a perimeter fence. The masonry construction of the historic Boiler House with the tall brick masonry chimney at the east end has remained intact.

MATERIALS

Roof

Per review of historic drawings, the building is assumed to have been constructed c. 1951. These historic 1951 construction drawings identify a reinforced concrete shingle roof supported on wood roof rafters. This original concrete shingle roof was replaced sometime after 1975 with a wood cedar shingle roof, however, the original wood rafters remain. Though the cedar shingle roof is not accurate to the original design, it is compatible with the roofing at the nearby structures.

Exterior Envelope

The original painted cement plaster exterior finish on the masonry structure remains intact with minor cracking and peeling paint. The historic brick chimney displays signs of paint and mortar loss, but the original design remains.

Doors

The historic 6-paneled door along the north facade has been replaced with a flush wood door, presumably in 2007 when the mechanical and electrical systems were upgraded.

Windows

The historic window masonry openings have remained intact, however, two (2) of the original double-hung wood windows were removed in 2007 to install needed louvers to support new mechanical and ventilation equipment. The original wood shutters have been removed, leaving only the shutter hinges anchored into the adjacent masonry. It is possible the original shutters are included in the stockpile of wood shutters currently stored in the Pump House.

Equipment

The original heating equipment installed in and adjacent to the Boiler House has been replaced, most recently in 2007, to continue operations and serve the needs of the nearby structures.

Fence

The wood stockade fence was constructed in 2007, after the Period of Significance.

WORKMANSHIP, FEELING, & ASSOCIATION

Built c. 1951, the Boiler House's workmanship and feeling are defined by mid-century materials and construction methods used to project a historic, secondary appearance. The building is associated with the Great Falls Tavern, accommodating systems equipment for the much older structure.

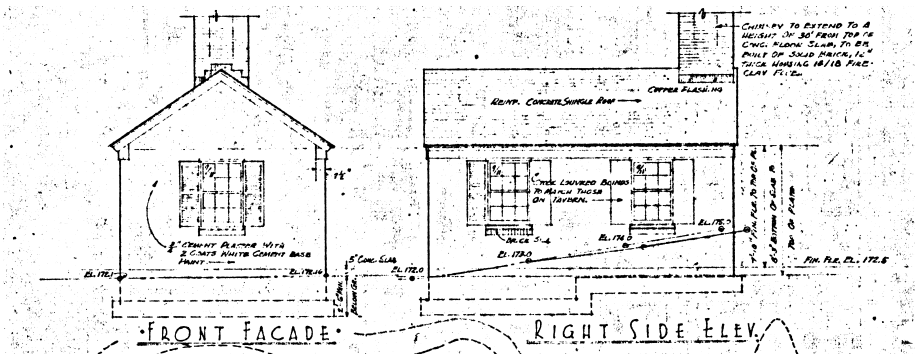


Figure 152. Boiler House: Portion of original 1951 construction drawing elevations (NPS Document No. 412-80401).

COMFORT STATION (MILE 14.28)

LOCATION & SETTING

The location of the Comfort Station remains unchanged along the edge of the access road to the northeast of Great Falls Tavern and directly across from the historic aqueduct Gatehouse. This supporting structure among others was designed to support the Tavern and provide necessary services to NPS staff and visitors to the site. The location was selected to allow the structures to serve as a backdrop to the historic context of the Tavern along the edges of the steeply sloped landscape to the east. The trees and vegetation to the east were maintained to preserve the natural landscape and setting.

DESIGN

The plan and configuration of the historic Comfort Station has been modified since its original construction in 1941 (**Figure 153**). In 2017 the Comfort Station was modified to be used for temporary storage when the new accessible comfort station was constructed to the north. This work in 2017 included roof replacement, door and window repair, toilet removal, sink removal, toilet partition removal, covering of built-in urinals, sealing off drains and turning off water supply, and maintaining existing HVAC.

The demising partition between the men's and women's restrooms remains intact, but was opened at the west end to provide a connection between each space. The Comfort Station currently serves as storage and workspace for the CHOH Bike Share Program, but the archival documents do not mention that as the intended use, so it is not possible to determine when, exactly, the Bike Share Program moved into the building. It is assumed the sink was removed when the other plumbing fixtures were removed in 2017.

In 2011, the Park management team requested that the historic wing walls/ privacy screens be removed from the building entrances citing ongoing confusion of visitors assuming this building still operated as a comfort station. The south side privacy screen was removed, but the north walls remain in place.

The wood framed construction and massing of the historic Comfort Station has remained intact since the original construction in 1941, absent removal of the wing walls/ privacy screens at the south entry.

MATERIALS

Roof

The historic 1941 construction drawings indicate the original design included a cedar shingle roof. The cedar shingle roof was most recently replaced in 2017 in a manner sympathetic to the original.

Exterior Envelope

The original wood framed exterior enclosure with painted vertical board & batten siding remains intact.

Doors

The original entry door at the north facade and the door to the utility closet remain intact. The south entry door, however, was replaced with a flush wood door that is not sympathetic to the historic character of the structure.

Windows

The hopper windows as shown in the original 1941 construction drawings remain with locking hardware and sash chains. Each window has been retrofitted with an aluminum storm window at the exterior and one original wood sash is missing at window 312.

Plumbing Fixtures

The reprogramming and reuse of the structure in 2017 as a temporary storage facility included toilet removal, sink removal, toilet partition removal (noted to

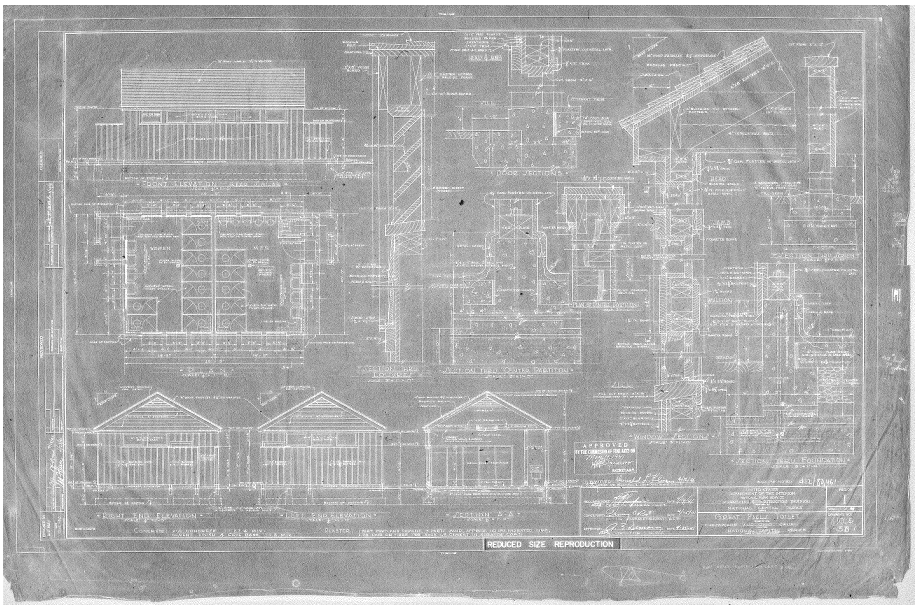


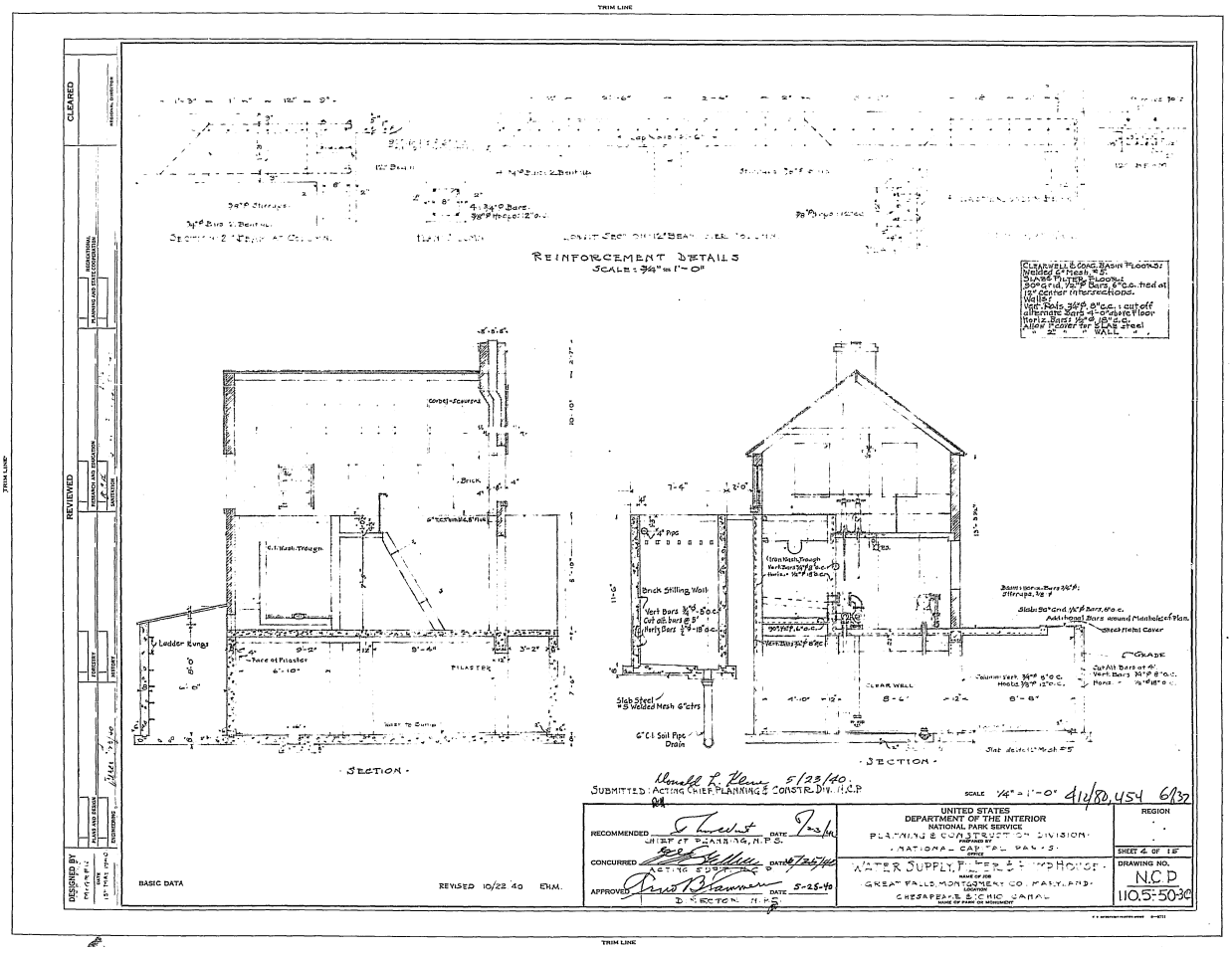
Figure 153. Comfort Station: Original 1941 construction drawing (NPS Document No. 412-80461).

have been installed in 2004), covering of built-in urinals, sealing off drains and turning off water supply.

WORKMANSHIP, FEELING, & ASSOCIATION

The comfort station's workmanship and feeling are distinguished by the simplicity of the wood framing and board and batten sheathing, originally hand-rendered by the CCC crew. Initially serving as toilets, the building remains associated with the public, now offering bikes for rides along the canal.

Figure 154. Pump House: Original 1941 construction drawing sections indicating extent of clear well below grade (NPS Document No. 412-80454).



PUMP HOUSE (MILE 14.29)

LOCATION & SETTING

The location of the Pump House remains unchanged along the edge of the access road to the northeast of Great Falls Tavern and directly across from the historic aqueduct Gatehouse. This supporting structure among others was designed to support the Tavern and surrounding buildings and provide necessary services to NPS Staff and visitors to the site. The location was selected to allow the structures to serve as a backdrop to the historic context of the Tavern along the edges of the steeply sloped landscape to the east. The sloped landscape allows for the structure to be partially buried below grade, minimizing visual impact and concealing necessary infrastructure. The trees and vegetation to the east were maintained to preserve the natural landscape and setting.

DESIGN

The plan and configuration of the historic Pump House has remained largely untouched since its original construction in 1941 (**Figure 154**). In the early 1980s, the Pump House was taken out of service when incoming water service was provided to the site by the WSSC. The original filtration equipment and holding chambers remain, with select components having been removed, such as the pumps and the compression tank.

The masonry construction of the historic Pump House with the brick masonry chimney at the south end has remained intact. Significant portions of the concrete enclosure and water storage tanks remain below grade. This includes the clear well located below the ground floor level and extending towards the access road and the agitation chamber and coagulating basin located east of the primary building enclosure.

MATERIALS

Roof

The historic 1941 construction drawings indicate the original design included a cedar shingle roof. The cedar shingle roof was most recently replaced in 2021 in a manner sympathetic to the original.

Doors

The historic 5-paneled doors at the south facade entry and east facade providing access to the coagulating basin from the Operating Gallery remain intact.

Windows

The historic wood double hung windows remain intact. However, the original wood shutters have been removed, leaving only the shutter hinges anchored into the adjacent masonry.

Water Filtration Equipment

The Pump House was established to provide water filtration, water storage, and distribution for the surrounding structures built by the CCC in the 1940s. The existing filtration, water storage, and distribution systems were taken out of service in the early 1980s when water was suppled to the site from the WSSC. Still present inside the building are the historic piping and distribution lines, pumps, valves, valve stands, water meters, pressure gauges, and flow meters that were original to the building in the 1940s. The original water meters and gauges were manufactured by Builder's Iron Foundry in Providence, RI and are not currently in service. The remnants of compressed air piping and meters for a compressor (not extant) are still evident at the lower level.

Fence

The wood stockade fence was constructed in 1946, within the Period of Significance.

WORKMANSHIP, FEELING, & ASSOCIATION

The Pump House is composed of a custom-built, manufactured filtration system, fitted inside a secondary structure in the landscape -- simple, but referentially historic, defining the workmanship and feeling of the building. Initially associated with water filtration and distribution, the Pump House underwent changes over time, but was eventually decommissioned, and is no longer associated with water use at Great Falls Tavern.

ENGINEER'S GARAGE (MILE 14.35)

LOCATION & SETTING

The location of the Engineer's Garage remains unchanged at the upper elevations of Great Falls. The Engineer's Garage was constructed east of the Engineer's House and originally provided space for vehicle storage, a repair shop, storage and an office. This supporting structure among others was designed to support the Tavern and surrounding buildings and provide necessary services to NPS Staff and visitors to the site.

DESIGN

The plan and L-shaped configuration of the historic Engineer's Garage has remained largely untouched since its original construction in 1941, however the use and functions have been modified (**Figure 155**). The Engineer's Garage was constructed east of the Engineer's House and originally provided space for vehicle storage, repair shop, storage and office. The area historically used for vehicle storage has been re-purposed for mule stables and hay storage. The other remaining spaces to the south are currently used for equipment and supply storage.

The wood framed construction and massing of the historic Engineer's Garage have remained intact since the original construction in 1941.

MATERIALS

Roof

The original asphalt shingle roof was recently replaced in 2015.

Doors

The historic solid wood paneled entry doors with glazing remain intact and provide access to the storage areas - the areas historically used for storage and an office. Window 512 was removed and a plywood access panel installed in the framed opening with interior wood stairs to allow materials and supplies to be accessed from the east facade adjacent to the steeply sloped landscape.

Garage Doors

The size and location of the seven (7) historic garage doors remains intact, however, the garage doors were recently replaced in 2017 in a style that does not match the original, but is stylistically sympathetic.

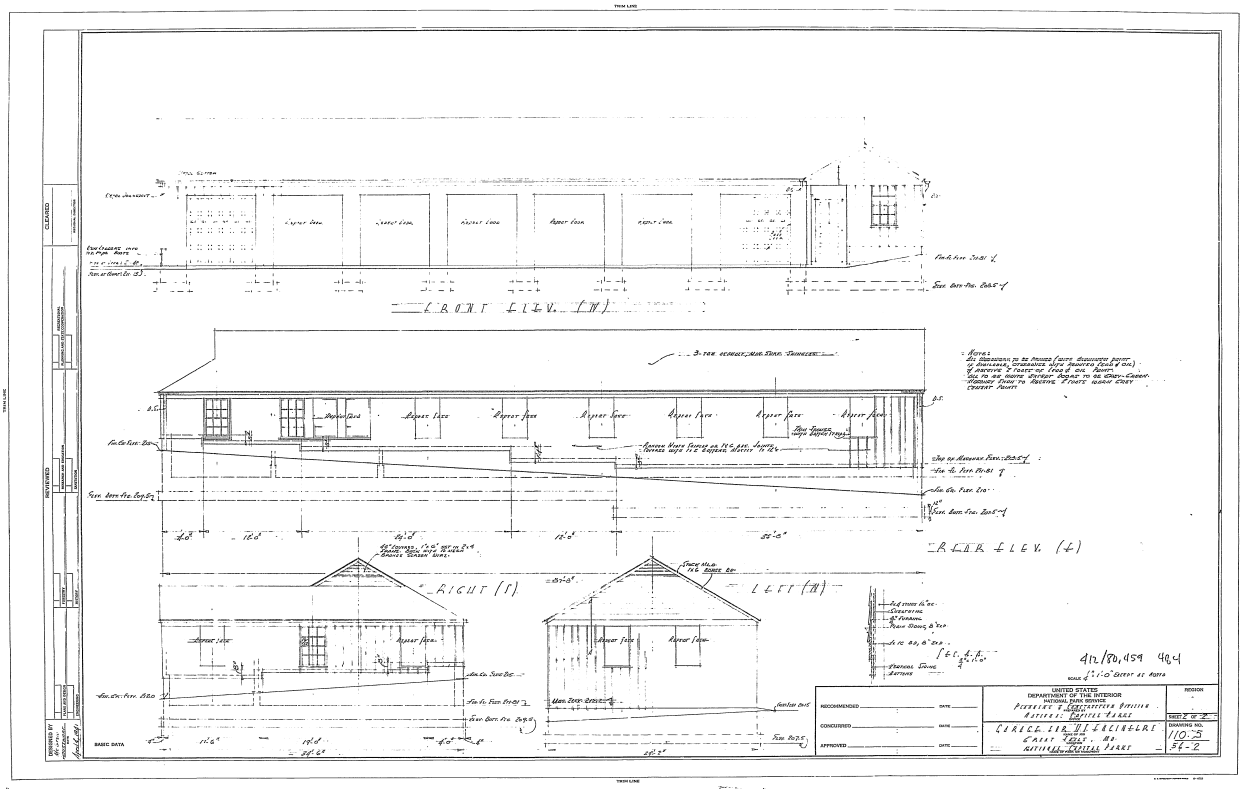
Windows

The historic wood double hung windows remain intact.

WORKMANSHIP, FEELING, & ASSOCIATION

The workmanship and feeling of the roughly constructed, lightly built Engineer's Garage reflect the CCC's typical approach, the building's original secondary function, and the distance from the areas of the park open to the public. Now commonly called the Mule Barn, with stalls a bit too small for contemporary vehicles, the building continues to serve as needed storage and a workshop for those who maintain and support the facilities at Great Falls Tavern, largely retaining the historic association of the building.

Figure 155. Engineer's Garage: Historic elevations from 1941 construction drawings (NPS Document No. 412-80459).



Chapter 5: Conditions Assessment

GENERAL OVERVIEW

SmithGroup, Silman, and Gray & Pape (A/E Consulting Team) visited the project structures near Lock 20 on October 6, 2020 to assess the interior and exterior of the Boiler House (mile 14.27), the Comfort Station (mile 14.28), the Pump House (mile 14.29), and the Engineer's Garage (mile 14.35). On October 16, 2020 the A/E Consulting Team visited the Pivot Bridge Ruins (mile 9.92) near Carderock Recreation Area to document structural and masonry conditions. Following the project suspension due to COVID restrictions, SmithGroup returned to the site on June 22, 2022, September 27, 2022, and December 14, 2022 to evaluate any conditions that may have changed and document recent repair work completed at the Pump House.

The following is a summary of initial observations. The following descriptions are not meant to be comprehensive, but instead highlight conditions and deficiencies where present and provide a broad assessment of each structure.

QUALITATIVE CONDITION RATINGS

GOOD

- Routine maintenance should be sufficient to maintain the current condition; and/ or a cyclic maintenance or repair/rehabilitation project is not specifically required to maintain the current condition or correct deficiencies.
- The feature is intact, structurally sound and performing its intended purpose. The feature needs no repair or rehabilitation, but only routine or preventative maintenance

FAIR

- The feature generally provides an adequate level of service to operations, but the feature requires more than routine maintenance, and cyclic maintenance or repair/rehabilitation work may be required in the future.
- The feature is in fair condition if either of the following conditions is present:
    - There are early signs of wear, failure, or deterioration though the feature is generally structurally sound and performing its intended purpose, or
    - There is failure of a portion of the feature.

POOR

- Feature requires immediate attention
- Routine maintenance is needed at higher level of effort to meet significant safety and legal requirements
- Cyclic maintenance should be scheduled for the current year
- A special repair/rehabilitation project should be requested consistent with park requirements, priorities, and long- term management objectives
- The feature is in poor condition if any of the following conditions is present:
    - The feature is no longer performing its intended purpose, or
    - Significant elements of the feature are missing, or
    - Deterioration or damage affects more than 25% of the feature, or
    - The feature shows signs of imminent failure or breakdown.

MAINTENANCE DEFICIENCY PRIORITY RATINGS

(10-year rating period)

MINOR - Short Term/Long-Term Priority

- This rating indicates standard preventative maintenance priorities and preservation methods have not been followed
- There is reduced life expectancy of affected adjacent or related materials and/or systems within 5 to 10 years and beyond;
- There is condition with long-term impact within 5 to 10 years and beyond

SERIOUS - Immediate/Short-Term Priority

- This rating defines a deteriorated condition that if not corrected within 1 to 5 years will result in the failure of the feature
- A threat to the health and/ or safety of the user may occur within 1 to 5 years if the ongoing deterioration is not corrected
- There is ongoing deterioration of adjacent or related materials and/or features as a result of the feature's deficiency

CRITICAL - Immediate Priority

- This rating defines an advanced state of deterioration which has resulted in the failure of a feature or will result in the failure of a feature if not corrected within 1 year
- There is accelerated deterioration of adjacent or related materials or systems as a result of the feature's deficiencies if not corrected within 1 year
- There is immediate threat to the health and safety of the user
- There is failure to meet a legislated requirement

NOT RATED

- The feature was not rated as it was not extant at the time of the report or is non- contributing, removed, and is not planned to be replaced.

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SUMMARY OF CONDITIONS: PIVOT BRIDGE RUINS

The following chart provides an inventory of existing conditions with qualitative ratings and maintenance priorities identified for components and features of the Pivot Bridge Ruins. These are explained in more detail on the following pages. The Pivot Bridge Ruins are overall in GOOD condition.

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
A Substructure	A10 Foundations	A1010 Standard Foundations	A1011 Wall Foundations	Reinforced concrete abutments	Good	Minor
B Shell	B20 Exterior Enclosure	B1010 Exterior Walls	B2011 Exterior Wall Construction	Quartzitic schist cladding on existing concrete abutments	Fair	Minor
B Shell	B20 Exterior Enclosure	B1010 Exterior Walls	B2011 Exterior Wall Construction	Remnants of steel gears and existing embedded iron bars and plate washers.	Fair	Critical
G Building Sitework	G10 Site Preparation	G1010 Site Clearing	G1011 Clearing & Grubbing	Vegetation and lichen growth on existing masonry and from within existing mortar joints	Good	Minor
G Building Sitework	G10 Site Preparation	G1010 Site Clearing	G1012 Tree Removal & Thinning	Vegetation and trees growing directly adjacent to abutments and retaining structures	Good	Minor

Major Group Element
A Substructure

Group Elements
A10 Foundations

Individual Elements
A1010 Standard Foundations

Sub-Elements
A1011 Wall Foundations

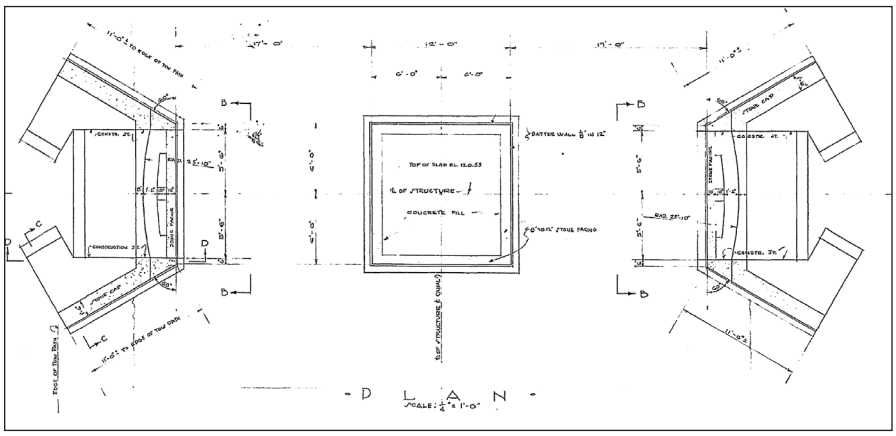
Material/ Equipment
Reinforced concrete abutments

Qualitative Condition Rating
Good

Maintenance Deficiency Priority
Minor

A10 - SUBSTRUCTURE

Per the historic 1941 construction drawings provided, the existing foundations are reinforced concrete abutments on concrete footers (**Figures 156-157**). These foundations and footers were not accessible for observation, but there was no evidence of failure or settlement. Beyond the vegetation, the structure and concrete foundations are in fair to good condition.



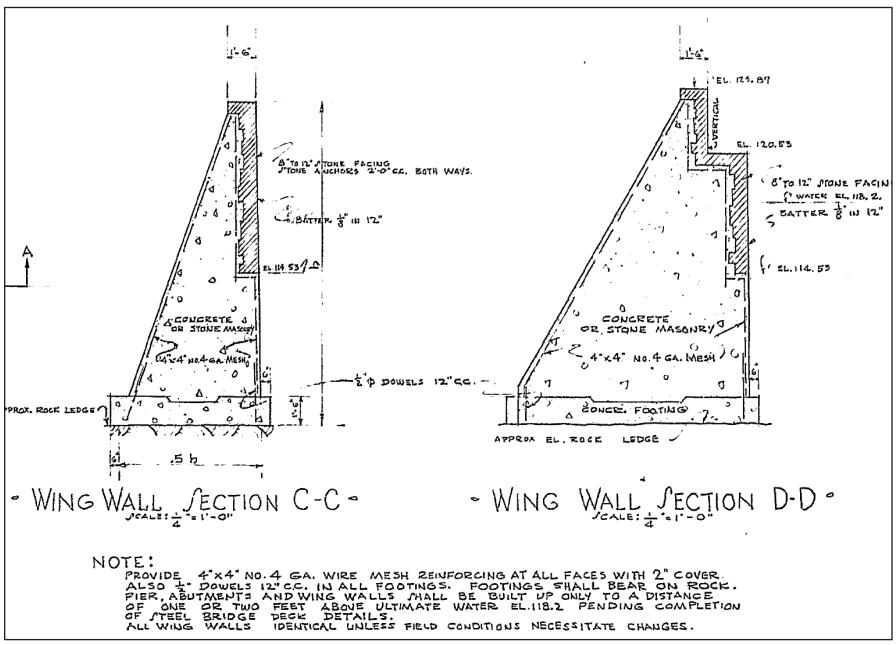


Figure 156. (Top) Detailed plan for Swing (Pivot) Bridge, 1941.
Figure 157. (Bottom) Detailed section for Swing (Pivot) Bridge, 1941.

B20 - EXTERIOR ENCLOSURE

Major Group Element
B Shell

Group Elements
B20 Exterior Enclosure

Individual Elements
B1010 Exterior Walls

Sub-Elements
A2011 Exterior Wall Construction

Material/ Equipment
Quartzitic schist cladding on existing concrete abutments

Remnants of steel gears and existing embedded iron bars and plate washers.

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Critical

The existing concrete abutments are clad in quartzitic schist. The masonry of the central pier is stable without evidence of significant voids or mortar loss. The abutment appears to have been repointed multiple times with mixes of varying compositions. In some areas hard, incompatible mortars have been used to fill in large gaps in the masonry and locations of previous spalls (**Figure 158**). Some cracking through mortar joints was noted, which may have been caused by the installation of incompatible repair mortars. Select areas require repointing and a select number of coping stones need to be reset.

Water migration into the concrete abutment from open and skyward facing mortar joints has caused leaching of excessive salts from the concrete and the accumulation of efflorescence on the quartzitic schist cladding and heavy lichen growth. Heavy efflorescence was noted on the central pier, but the masonry is stable without evidence of significant voids or mortar loss. The masonry surfaces should be cleaned and efflorescence removed with care being taken to avoid additional damage to the masonry.

Remnants of steel rails, gears, and embedded iron bars and plate washers remain in the quartzitic schist cladding. Many of the features are detailed in the original 1941 construction drawings of the swing/ pivot bridge rack gear and rail assembly. The historic and original embedded metal materials should be cleaned of any corrosion, and appropriate corrosion inhibiting coatings should be considered. Other light gage metal elements and non-historic ferrous elements should be removed, such as the slotted steel strut channel on the west face of the south abutment. The channel is a miscellaneous metal attachment that has no historic significance.

Figure 158. South abutment of Pivot Bridge Ruins, west face; slotted strut channel can be seen at the west face.

Major Group Element
G Building Sitework

Group Elements
G10 Site Preparation

Individual Elements
G1010 Site Clearing

Sub-Elements
G1011 Clearing & Grubbing

G1012 Tree Removal & Thinning

Material/ Equipment
Vegetation and lichen growth on existing masonry and from within existing mortar joints

Vegetation and trees growing directly adjacent to abutments and retaining structures

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Critical

G10 - SITE PREPARATION

There is a lot of overgrowth of surrounding vegetation, and some has taken root in the open mortar joints of the masonry cladding (**Figures 159-161**). Vegetation should be removed and carefully cleared from the existing structure. Routine maintenance and the use of select biocides should be used to manage the seasonal vegetation growth.

Several moderate to large sized trees are growing in close vicinity of the north concrete and masonry abutment. Remove existing trees and vegetation growing within ten feet of the north abutment per the CHOH standard operating practices. In December 2022, NPS staff cleared much of the vegetation and cleared several trees from the vicinity of the north abutment.

Figure 159. Pivot Bridge Ruins: pivot bridge rail, gears, and bearing plates at top of central pier.

Figure 160. (Left) Pivot Bridge Ruins: Center pier, pivot bridge rail, gears, and bearing plate.
Figure 161. (Right) Pivot Bridge Ruins: Center pier, pivot bridge bearing plate.

SUMMARY OF CONDITIONS: BOILER HOUSE

The following chart provides an inventory of existing conditions with qualitative ratings and maintenance priorities identified for components and features of the Boiler House. These are explained in more detail on the following pages. The Boiler House is overall in FAIR condition.

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
A Substructure	A10 Foundations	A1010 Standard Foundations	A1011 Wall Foundations	Continuous Concrete Footer	Good	Minor
A Substructure	A10 Foundations	A1010 Standard Foundations	A1011 Foundations	Concrete Footers at Fuel Storage Tank	Good	Minor
A Substructure	A10 Foundations	A1030 Slab on Grade	A1032 Structural Slab on Grade	Cast-in-Place Slab, Painted	Good	Minor
B Shell	B10 Superstructure	B1020 Roof Construction	B1022 Pitched Roof Construction	Wood Framing	Fair	Minor
B Shell	B10 Superstructure	B1020 Roof Construction	B1022 Interior Ceiling and Mechanical Support Framing	Wood Framing	Fair	Serious
B Shell	B20 Exterior Enclosure	B2010 Exterior Walls	B2011 Exterior Wall Construction	Concrete Masonry Units	Good	Minor
B Shell	B20 Exterior Enclosure	B2010 Exterior Walls	B2011 Exterior Wall Finish	Cement Plaster	Good	Minor
B Shell	B20 Exterior Enclosure	B2010 Exterior Walls	B2011 Chimney	Brick Masonry	Fair	Critical
B Shell	B20 Exterior Enclosure	B2020 Exterior Windows	B2021 Windows	Wood, Double Hung	Fair	Minor

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
B Shell	B20 Exterior Enclosure	B2020 Exterior Windows	B2021 Window Shutters	Wood, Painted	Not Extant/ Missing	Minor
B Shell	B20 Exterior Enclosure	B2030 Exterior Doors	B2032 Solid Exterior Doors	Wood, Flush	Fair	Minor
B Shell	B30 Roofing	B3010 Roof Coverings	B3011 Roof Finishes	Wood Shingle	Fair	Minor
B Shell	B30 Roofing	B3010 Roof Coverings	B3014 Flashing & Trim	Metal flashing and wood trim at eave	Fair	Minor
B Shell	B30 Roofing	B3010 Roof Coverings	B3016 Gutters & Downspouts	[None]	N/A	N/A
D Services	D20 Plumbing	D2020 Domestic Water Distribution	D2021 Cold Water Service	Domestic Cold Water Piping	Fair	Minor
D Services	D20 Plumbing	D2030 Sanitary Waste	D2031 Waste Piping	Sanitary Waste Piping	Fair	Serious
D Services	D20 Plumbing	D2030 Sanitary Waste	D2033 Floor Drains	Floor Drains	Fair	Minor
D Services	D30 HVAC	D3020 Heat Generating Systems	D3021 Boilers	400 MBH Fuel Oil Hot Water Boiler	Fair	Serious
D Services	D30 HVAC	D3020 Heat Generating Systems	D3023 Auxiliary Equipment	50 gallon Glycol Make up feeders	Fair	Serious
D Services	D30 HVAC	D3020 Heat Generating Systems	D3023 Auxiliary Equipment	1000 Gal Fuel Oil Storage Tank	Fair	Critical
D Services	D30 HVAC	D3050 Terminal & Packaged Units	D3052 Package Units	Vertical Hot Water Unit Heater	Fair	Minor

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
D Services	D30 HVAC	D3040 Distribution Systems	D3044 Hot Water Distribution	Heating Hot Water Piping	Fair	Serious
D Services	D30 HVAC	D3040 Distribution Systems	D3045 Chilled Water Distribution	Chilled Water Piping	Fair	Serious
D Services	D30 HVAC	D3040 Distribution Systems	D3042 Exhaust Ventilation Systems	500 CFM Centrifugal Exhaust Fan	Fair	Serious
D Services	D30 HVAC	D3040 Distribution Systems	D3045 Chilled Water Distribution	60 Gallon Chilled Water Buffer Tank	Fair	Minor
D Services	D30 HVAC	D3040 Distribution Systems	D3032 Direct Expansion Systems	Hot and chilled water expansion Tanks	Fair	Serious
D Services	D30 HVAC	D3040 Distribution Systems	D3044 Hot Water Distribution	5 HP Hot Water inline pumps	Fair	Serious
D Services	D30 HVAC	D3040 Distribution Systems	D3045 Chilled Water Distribution	5 HP Chilled Water inline pumps	Fair	Serious
D Services	D30 HVAC	D3030 Cooling Generating Systems	D3031 Chilled Water Systems	22 Ton Air cooled chiller	Fair	Serious
D Services	D30 HVAC	D3060 Controls & Imstrument.	D3061 HVAC Controls	HVAC Controls	Poor	Serious
D Services	D40 Fire Protection	D4030 Fire Protection Specialities	D4031 Fire Extinguishers	Wall mounted	Good	Minor
D Services	D50 Electrical	D5010 Electrical Service & Distribution	xxxx Electrical Incoming Service		Fair	Minor

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
D Services	D50 Electrical	D5020 Lighting and Branch Wiring	D5021 Branch wiring devices	Lighting fixtures, wiring, conduit, raceways, and wiring troughs, junction boxes, light switches	Poor	Critical
D Services	D50 Electrical	D5020 Lighting & Branch Wiring	D5020 Interior Lighting	Utility lighting	Poor	Critical
D Services	D50 Electrical	D5030 Commun & Security	D5038 Security & Detection Systems	No system present	N/A	N/A
G Building Sitework	G20 Site Improvements	G2030 - Pedestrian Paving	G2031 Paving & Surfacing	Concrete sidewalk and landing at entry	Poor	Serious
			G2033 Exterior Steps	Concrete	Fair	Critical

A10 - FOUNDATIONS

The existing wall foundations and structural concrete slab on grade appear to be in good condition (**Figure 162**). Though the wall foundations could not be visually observed, there was no evidence of failure or settlement. The concrete footers supporting the fuel storage tank are in good condition. The concrete pads supporting mechanical equipment are in good condition.

The base of the building around the foundation should be kept clear of vegetation to reduce sustained moisture (**Figure 163**). The outlet of the foundation drain should be located and regularly maintained to minimize the potential for water infiltration into the building.

Major Group Element
A Substructure

Group Elements
A10 - Foundations

Individual Elements
A1010 - Standard Foundations

A1030 - Slab on Grade

Material/ Equipment
Continuous Concrete Footer

Concrete Footers at Fuel Storage Tank

Cast-in-Place Slab, Painted

Qualitative Condition Rating
Good

Maintenance Deficiency Priority
Minor

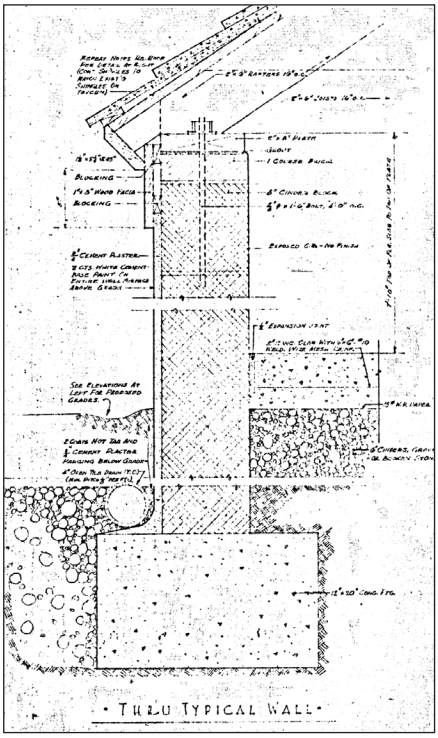


Figure 162. (Left) Boiler House: Foundation details from 1951 construction drawings.
Figure 163. (Right) Boiler House: Detail of footer below fuel tank.

Major Group Element
B Shell

Group Elements
B10 - Superstructure

Individual Elements
B1020 - Roof Construction

Material/ Equipment
Wood Framing

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Serious

B10 - SUPERSTRUCTURE

The existing pitched roof framing is in good condition. There is no interior finished ceiling, however there are ceiling joists that span above the existing mechanical equipment. These ceiling joists support an engineered wood beam which supports some mechanical equipment below (**Figure 164**). Large splits were observed in the ceiling joists, suggesting that the weight of the hanging equipment exceeds the capacity of the framing. It is unknown whether the engineered lumber beams were added before or after the damage to the joists. Two ceiling joists in the center of the building are failing and require replacement (**Figure 165**). Until they are replaced, the split joists should be shored with metal or wood shoring posts. As a permanent solution, unused mechanical equipment should be removed and the existing ad-hoc mechanical supports should be replaced with a designed solution. Further design and coordination with a mechanical engineer and the Park is recommended to understand whether more robust supports for active mechanical equipment is needed at the Boiler House ceiling.

While no immediate need for repair of roof framing was observed, it is recommended that any re-roofing projects include an allowance for approximately 16 linear feet of repair of the 2x6 members (approximately two rafters) to account for localized water damage through the existing decking and any wood rot of the rafters. Based on the good condition of the existing roof surface, this condition and repair estimate should be considered minor.

Figure 164. (Left) Boiler House: Interior view of ceiling and roof framing at Boiler House, including LVL beams laid across ceiling ties.
Figure 165. (Right) Boiler House: Interior view of ceiling and roof framing at Boiler House, including LVL beams laid across ceiling ties. One of two ceiling joists must be replaced in the immediate future as seen in this image.

B20 - EXTERIOR ENCLOSURE, WALLS

The existing exterior wall is constructed of concrete masonry units finished on the exterior in painted cement plaster. It is assumed the existing stucco finish is original to the 1951 construction of the Boiler House as no records were found indicating replacement. There are select areas of settlement cracks, soiling, and lichen growth on the exterior cement plaster finish (**Figure 166**). Hairline cracking was observed surrounding windows and horizontally at the south face of the building.

Hairline cracking at the exterior can be addressed by removing stucco, repointing the existing masonry, and re-applying the stucco coating. For budgeting it should be assumed that 10% of the stucco finish will require patching and repair prior to repainting. Repairs will be focused on areas around window and door openings and at the base of the exterior wall near grade.

Major Group Element
B Shell

Group Elements
B20 - Exterior Enclosure

Individual Elements
B2010 - Exterior Walls

Material/ Equipment
Concrete Masonry Units

Cement Plaster

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

Figure 166. North wall of Boiler House; biological growth and cracking in cement plaster finish.

Major Group Element
B Shell

Group Elements
B20 - Exterior Enclosure

Individual Elements
B2010 - Exterior Walls

Material/ Equipment
Brick Masonry

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

B20 - EXTERIOR ENCLOSURE, CHIMNEY

Mortar loss was observed near the top of the tall slender chimney (**Figure 167**). Previous paint and mortar has washed away, leaving the brick units exposed. This is particularly evident at the topmost five courses and at the brick corner piers supporting the chimney vent.

Due to its aspect ratio, the chimney may also be vulnerable in seismic events and not compliant with current seismic provisions of the building code. The NPS should have an engineer evaluate the chimney as a slender masonry element, using ASCE 41-17 Seismic Evaluation and Retrofit of Existing Buildings. This analysis is recommended because the height-to-width ratio of the chimney exceeds three. Three is the limit outlined in ASCE 41-17 seismic performance checklists and is the threshold beyond which seismic assessment of chimneys is recommended. Analysis will predict the chimney's behavior in a seismic event.

Figure 167. (Left) Boiler House: View of original brick chimney; paint and mortar loss evident.

B20 - EXTERIOR ENCLOSURE, WINDOWS & DOORS

Major Group Element
B Shell

Group Elements
B20 - Exterior Enclosure

Individual Elements
B2020 - Exterior Windows

B2030 - Exterior Doors

Material/ Equipment
Double hung wood windows

Aluminum louvers

Window shutters

Flush wood exterior doors

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

The two (2) existing double hung wood windows (202 and 204) are in fair condition with intact frames, sashes, and trim (**Figures 168-169**). Each window features minor areas of wood rot at sills and broken or missing glazing. The sashes require new glazing putty, cleaning, and repainting. The frames should be cleaned and select areas of wood rot at sills replaced prior to being repainted. Window 202 has a louver installed within one pane of the upper sash which needs to be accommodated.

The original double hung windows 201 and 203 were removed during the 2007 mechanical and electrical upgrades project to accommodate louvers in the existing masonry openings. It should be noted the wood windows and doors, and all painted surfaces, have likely been finished in lead-based paint in the past.

The original shutters are missing, but the hinges remain intact. Based on a photograph from the 1990s when the wood shutters were still featured on the exterior facade, it is assumed the wood shutters were removed during the 2007 rehabilitation project and never reinstalled. It was noted that a number of painted wood shutters are currently stored in the Pump House, some of which may be original to the Boiler House. It is advised that NPS consider reinstallation of the wood shutters, particularly to conceal the mechanical louvers installed in two (2) of the historic window openings. Further evaluation is required to confirm that the free area and required air flow

Figure 168. (Left) Boiler House: Figure Window 204 located along the west facade.
Figure 169. (Right) Boiler House: Original double hung wood window 203 removed in 2007 to install mechanical louver.

is maintained if the historic shutters are reinstalled and held in the closed position to conceal the louvers.

The original solid wood 6-paneled exterior door noted in the 1951 construction drawings has been replaced by a modern flush wood door (**Figure 170**). The door is in good condition but is not sympathetic to the historic character of the structure. The existing flush wood door should be replaced with a new 6-panel wood door, with hardware and locks compliant with NPS standards.

Figure 170. North wall of Boiler House; Historic entry door has been replaced with flush wood door.

B30 - ROOFING

The existing cedar wood shingle roof appears to be in fair condition with a moderate amount of lichen growth present (**Figures 171-172**). Though not as severely deteriorated as the roof over the Pump House which was recently replaced, the roof at the Boiler House should be replaced in the near future, to include new flashing at the chimney. Though no records were found, it is possible the roof was replaced in 1995 when the roof at the Comfort Station was replaced. As this building is not insulated, future replacement of the shingles should be installed over skip sheathing. If installed properly and maintained regularly, a cedar shingle roof could last from 20-40 years.

It is also notable that the original roof was concrete shingles as noted in the historic 1951 construction drawings. Replacement of the existing cedar shingles with concrete shingles should be considered to restore the historic character.

Major Group Element
B Shell

Group Elements
B30 - Roofing

Individual Elements
B3010 - Roof Coverings

Material/ Equipment
Wood shingles

Flashing & Trim

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

The original drawings did not include gutters and downspouts and are not present on the structure currently. Gutters and downspouts should be considered as a reversible measure to manage stormwater.

Figure 171. Boiler House: Detail of eave; no gutters or downspouts present.

Figure 172. Boiler House: Detail of existing wood shingle roof.

D20 - PLUMBING/ D30 - HVAC

Major Group Element
D Services

Group Elements
D20 - Plumbing

D30 - HVAC

Individual Elements
D2020 - Domestic Water Distribution

D2030 - Sanitary Waste

D3020 - Heat Generating Systems

D3050 - Terminal & Packaged Units

D3040 - Distribution Systems

D3030 - Cooling Generating Systems

D3060 - Controls and Instrumentation

Material/ Equipment

Domestic Cold Water Piping; Sanitary Waste Piping; Floor Drains; 400 MBH Fuel Oil Hot Water Boiler; 50 gallon Glycol Make up feeders; 1000 Gal Fuel Oil Storage Tank; Vertical Hot Water Unit Heater; Heating Hot Water Piping; Chilled Water Piping; 500 CFM Centrifugal Exhaust Fan; 60 Gallon Chilled Water Buffer Tank; Hot and chilled water expansion Tanks; 5 HP Hot Water inline pumps; 5 HP Chilled Water inline pumps; 22 Ton Air cooled chiller; HVAC Controls

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Serious

The mechanical systems and distribution piping throughout the Boiler House and to the nearby buildings, including the Great Falls Tavern, were replaced in 2007. All above ground domestic cold water piping is in fair condition. All below ground domestic cold water piping is assumed to be in good condition knowing it was replaced in 2007, approximately 15 years ago.

All above ground sanitary and vent piping should be cleaned. It is also assumed that all underground sanitary piping is in fair condition as it was also replaced in 2007. It is recommended to clean all floor drains to ensure proper operation.

The boiler and burner were installed with the mechanical and infrastructure upgrades implemented in 2007 (**Figure 173**). Routine maintenance should be performed and equipment replaced at the recommended intervals outlined below based on standard expected useful service life. It is also recommended to evaluate if the oil boiler could be replaced with an electric boiler for higher efficiencies. The electrical infrastructure will need to be evaluated to determine if it can support increased electrical demand if an electrical boiler is used.

The flue exhausts through the chimney at the east side of the Boiler House. A chimney inspection is recommended to verify conditions and manage risks.

Figure 173. (Left) Boiler House: Smith diesel hot water boiler at the interior of the Boiler House.
Figure 174. (Right, top) Boiler House: Glycol feed systems are installed to pump glycol to both the hot water and chilled water systems to avoid pipes from freezing.
Figure 175. (Right, bottom) Boiler House: Fuel oil storage tank located east of Boiler House.

The glycol make up feeders are approaching the end of their useful life (**Figure 174**). It is recommended to replace both hot water and chilled water glycol make up units, pumps, and controls to ensure proper operation and prevention of pipe freezing.

The fuel tank appears to be in good condition; however, it is recommended to replace the fuel oil pumps, the valves, the low level control system and the relief vents to ensure proper operation and safety of the heating equipment (**Figure 175**).

The hot water unit heater is approaching the end of its useful service and should be replaced in kind with an electronically commutated motor to include a temperature and time controller from the manufacturer (**Figure 176**). Replacement should include the manufacturer temperature controller and the two way modulating control valve.

The exhaust fan is approaching the end of its useful service life and should be replaced in kind with an electronically commutated motor to include temperature and time controller from manufacturer.

The expansion tanks are approaching the end of their useful service life and should be replaced with a 45 gallon hot water expansion tank and a 25 gallon chilled water expansion tank (**Figure 177**).

The chilled water and hot water inline pumps are past their useful service life with rust and corrosion visible on the pumps. These should be replaced in kind (**Figures 178**).

The piping is in fair condition and typically has a service life of 50+ years. However, it is recommended to replace damaged or displaced piping insulation to increase the useful service life of the piping system and energy efficiency. One location was noted where the insulation needed to be re-secured to the piping and equipment.

Figure 176. Boiler House: Hot water unit heater was installed to heat the boiler house. Heating hot water and chilled water distribution piping enters a pit and is distributed underground.

In 2007, the mechanical and electrical equipment and services at the Boiler House were updated. The systems described here all date to this upgrade project. To understand expected service life of each type of equipment the following chart has been provided.

Excerpts from ASHRAE Equipment Life Expectancy Chart

Equipment Type	Expected Service Life in Years
Fuel Oil Hot Water Boiler	25
Glycol Make up Feeder	20
Gal Fuel Oil Storage Tank	30
Hot Water Unit Heater	20
Centrifugal Exhaust Fan	25
Chilled Water Buffer Tank	35
Hot and Chilled Water Expansion Tanks	20
Hot Water Inline pumps	10
Chilled Water Inline pumps	10
Air cooled chiller	23
HVAC Controls	15

Figure 177. (Left) Boiler House: Cemline chilled water buffer tank and Bell and Gossett expansion tanks for the hot water and chilled water systems.
Figure 178. (Right, top) Boiler House: Four inline Bell and Gossett pumps are installed in the Boiler House. Pumps 1 and 2 (P-1 and P-2) serve the chilled water system and pumps 3 and 4 (P-3 and P-4) serve the hot water system.
Figure 179. (Right, bottom) Boiler House: Figure Carrier 22-ton Aquasnap air cooled chiller located south of the Pump House.

D40 - FIRE PROTECTION/ D50 - ELECTRICAL

Per OSHA [29 CFR 1910.157(e)(2), NPS should provide a visual inspection of portable fire extinguishers at least once per month. A full maintenance check on existing portable fire extinguishers should be conducted once per year, according to OSHA 29 CFR 1910.157(e)(3). "Maintenance" means a thorough examination and repair, as needed, of all your facility's portable fire extinguishers, as covered in NFPA 10(98), Sec. 4-4.

The Boiler House does not contain any security or fire protection systems (fire alarm or fire suppression) as the building is a normally, non-occupied utility (Use Group "U" per IBC) building. Neither an automatic sprinkler system nor an addressable fire alarm system are required by the building code for this building based on occupancy classification and size of building. However, DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

The electrical distribution board was replaced in 2007 and remains in acceptable working condition. Replacement is not recommended in the near term. However, metal clad (MC) cable is used for motors and should be replaced with liquidtight flexible metal conduit (LFMC).

Major Group Element
D Services

Group Elements
D40 - Fire Protection

D50 - Electrical

Individual Elements
D4030 - Fire Protection Specialities

D5010 - Electrical Service & Distribution

D5020 - Lighting and Branch Wiring

D5020 - Lighting & Branch Wiring

D5030 - Communications & Security

Material/ Equipment
Wall mounted fire extinguisher; Distribution Panelboard; Lighting fixtures, wiring, conduit, raceways, and wiring troughs, junction boxes, light switches

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

Figure 180. Boiler House: Panelboard with wall-mounted combination motor started and disconnect switch for each pump.

Lighting equipment and fixtures are older and it is not clear if they comply with current safety standards. It is advised that NPS provide new utility lighting per code. International Energy Conservation Code (IECC) falls under the family of codes under IBC. Per section C405 of the IECC, there are requirements to implement forms of automatic control for lighting for energy reduction measures in spaces including storage rooms and rooms 300 sf or less that are enclosed by floor to ceiling height partitions. If a substantial renovation or rehabilitation is planned for the structure, compliance with the IECC will likely require upgrades to address light levels, automatic controls, emergency egress lighting, and energy efficient lamping.

G20 - SITE IMPROVEMENTS

The existing concrete paving and landing at the building entry is cracked and displaced (**Figure 181**). This concrete landing should be replaced and a pathway provided to connect the entry to the nearby service road to the west of the Boiler House.

The existing masonry steps providing access to the fuel storage tank behind the Boiler House need to be cleared of debris. According to Chapter 12 of the 2018 IBC, a handrail is not required for this existing stair condition because the building is less than 3,000 sf. For maintenance access to serve the fuel oil tank a level landing should be considered, but is it not a code requirement for this existing conditions.

Major Group Element
G Building Sitework

Group Elements
G20 - Site Improvements

Individual Elements
G2030 - Pedestrian Paving

Material/ Equipment
Concrete sidewalk and landing at entry

Concrete steps

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Serious

Figure 181. Boiler House: View of Boiler House from access road, northwest.

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SUMMARY OF CONDITIONS: COMFORT STATION

The following chart provides an inventory of existing conditions with qualitative ratings and maintenance priorities identified for components and features of the Comfort Station. These are explained in more detail on the following pages. The Comfort Station is overall in FAIR condition.

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
A Substructure	A10 Foundations	A1010 Standard Foundations	A1011 Wall Foundations	Reinforced concrete abutments	Good	Minor
A Substructure	A10 Foundations	A1030 Slab on Grade	A1032 Structural Slab on Grade	Cast-in-Place Slab, Painted	Good	Minor
B Shell	B10 Superstructure	B1020 Roof Construction	B1022 Pitched Roof Construction	Wood Framing	Fair	Minor
B Shell	B20 - Exterior Enclosure	B2010 Exterior Walls	B2011 Exterior Wall Construction	Wood Frame with Vertical Board & Batten Siding	Good	Minor
B Shell	B20 - Exterior Enclosure	B2020 xterior Windows	B2021 Windows	Wood, Hopper	Fair	Critical
B Shell	B20 - Exterior Enclosure	B2030 Exterior Doors	B2032 Solid Exterior Doors	5-Panel Wood, Painted	Fair	Critical
B Shell	B20 - Exterior Enclosure	B2030 Exterior Doors	B2032	Flush Wood, Painted	Fair	Critical
B Shell	B20 - Exterior Enclosure	B2030 Exterior Doors	B2032	Board & Batten Exterior Door	Fair	Critical
B Shell	B30 - Roofing	B3010 Roof Coverings	B3011 Roof Finishes	Wood Shingle	Poor	Serious

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
B Shell	B30 - Roofing	B3010 Roof Coverings	B3016 Gutters & Downspouts	Painted 6" half-round metal gutter and downspout along east roof eave	Poor	Serious
C Interiors	C30 Interior Finishes	C3010 Wall Finishes	C3011 Wall Finishes to Inside Exterior Wall	Cement Plaster on Metal Lath	Good	Minor
C Interiors	C30 Interior Finishes	C3020 Floor Finishes	C3021 Floor Toppings	Concrete topping slab, painted	Good	Minor
C Interiors	C30 Interior Finishes	C3030 Ceiling Finishes	C3031 Ceiling Finishes	Cement Plaster on Metal Lath	Fair	Critical
D Services	D20 Plumbing	D2020 Domestic Water Distribution	D2021 Cold Water Service	Hose bibb in exterior closet	Fair	Minor
D Services	D20 Plumbing	D2030 Sanitary Waste	D2033 Floor Drains	Two (2) interior floor drains located within former restrooms	Fair	Minor
D Services	D30 HVAC	D3040 Distibution Systems	D3044 Hot Water Distrubution	Hot Water Radiator Piping located along west wall of Comfort Station	Fair	Minor
D Services	D30 HVAC	D3040 Distibution Systems	D3042 Exhaust Ventilation Systems	Air Circulator Fan	Fair	Minor
D Services	D40 Fire Protection	D4030 Fire Protection Specialities	D4031 Fire Extinguishers	Wall mounted fire extinguisher.	Good	Minor

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
D Services	D50 Electrical	D5020 Lighting & Branch Wiring	D5022 Interior Lighting	1x4 florescent lighting	Poor	Serious
D Services	D50 Electrical	D5020 Lighting & Branch Wiring	D5022 Exterior Lighting	Exterior sconce with guard	Poor	Serious
D Services	D50 Electrical	D5030 Commun. & Security	D5038 Security & Detection Systems	None.	N/A	N/A
G Building Sitework	G20 Site Improve.	G2030 Pedestrian Paving	G2031 Paving & Surfacing	Concrete sidewalk and landing at entry	Poor	Serious
G Building Sitework	G20 Site Improve.	G2040 Site Development	G2041 Exteior Screen Walls	Wood posts and wood board and batten panels	Poor	Serious
G Building Sitework	G20 Site Improve.	G2040 Site Development	G2042 Retaining Walls	Low height CMU retaining wall located parallel to east façade	Poor	Serious

Major Group Element
A Substructure

Group Elements
A10 Foundations

Individual Elements
A1010 - Standard Foundations

A1030 - Slab on Grade

Material/ Equipment
Continuous Concrete Footer with Knee Wall

Cast-in-Place Slab, Painted

Qualitative Condition Rating
Good

Maintenance Deficiency Priority
Minor

A10 - FOUNDATIONS

The structure of the Comfort Station is in fair to good condition. Some minor hairline cracking was observed at the exposed concrete foundation wall, but this is to be expected for a foundation wall of this age (**Figures 182-183**). The concrete foundation walls should be patched in areas of hairline cracking with a crack injection product or repair mortar. Or, if preferred, tell-tale crack monitors can be installed to monitor if cracks are stable or widening and may become unstable.

Though not accessible for field survey and verification, the original construction drawings for the Comfort Station from 1941 include typical details for the structural foundations.

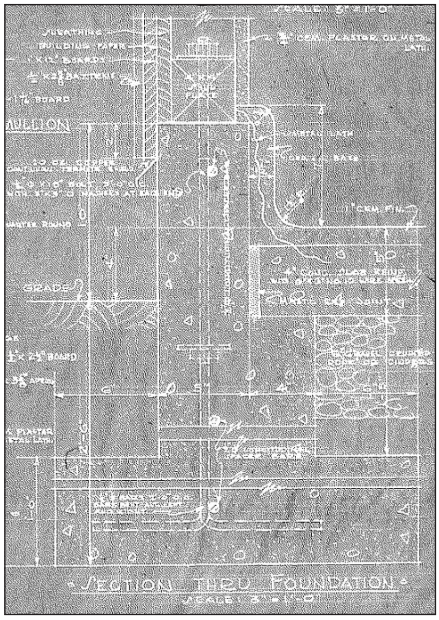

Figure 182. (Left) Comfort Station: Foundation detail from original 1941 construction drawings.
Figure 183. (Right) Cracking evident in exterior concrete foundation wall.

B10 - SUPERSTRUCTURE

The interior cement plaster ceiling finish conceals the roof and ceiling framing. However, the structural framing and the roof sheathing were accessed for observation through an access panel in the ceiling. The condition of the ceiling framing and rafters is fair (**Figure 184**). There are limited locations where the rafters were noted to be sistered and where individual sheathing boards were replaced. Some minimal areas of sheathing deterioration were noted, and it is recommended that the sheathing and rafters be further evaluated the next time the roof is replaced.

Major Group Element
B Shell

Group Elements
B10 Superstructure

Individual Elements
B1020 - Roof Construction

Material/ Equipment
Wood Framing

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Minor

Figure 184. Comfort Station: View of wood roof rafters above Comfort Station.

Major Group Element
B Shell

Group Elements
B20 - Exterior Enclosure

Individual Elements
B2010 - Exterior Walls

Material/ Equipment
Wood Frame with Vertical Board & Batten Siding

Qualitative Condition Rating
Good

Maintenance Deficiency Priority
Minor

B20 - EXTERIOR ENCLOSURE, WALLS

The exterior wood framed wall assembly supported by the CMU knee walls is in fair condition with very limited areas of wood rot and paint loss in the exterior vertical board and batten siding (**Figures 185-187**). The exterior siding should be repaired in select areas to replace any areas of wood rot and repainted. Areas of rot and wood deterioration were noted at the base of the wood cladding along the east facade, above the windows at each gable end, and above the north door 32.

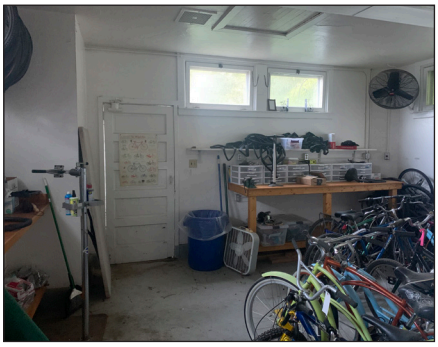

Figure 185. (Left Top) Comfort Station: Vertical board and batten siding along south facade.
Figure 186. (Right) Comfort Station: Vertical board and batten siding and hopper windows along west facade.
Figure 187. (Left, Bottom) Comfort Station: Storage of bicycles and workbenches in former men's restroom.

B20 - EXTERIOR ENCLOSURE, WINDOWS, & DOORS

The majority of existing wood hopper windows and wood doors are in fair condition with intact frames, sashes, and trim. A few windows showed minor areas of wood rot at sills. The existing window sashes and frames display paint loss, select areas of missing or failing glazing putty, broken glass, and missing or damaged hardware (**Figures 188-189**). Each window has been retrofitted with a fixed aluminum storm window at the exterior and one original sash is missing at window 312.

Remove loose and flaking paint from wood window frames, sashes, and trim. Repair and restore windows to replace missing and broken glazing, repair damage from wear and vandalism, replace missing hardware, repaint, and remove exterior storm windows. The window sash at window 312 needs to be replaced. It should be noted the wood windows and doors, and all painted surfaces, have likely been finished in lead-based paint in the past.

Major Group Element
B Shell

Group Elements
B20 Exterior Enclosure

Individual Elements
B2020 - Exterior Windows

B2030 - Exterior Doors

Material/ Equipment
Wood hopper windows

Wood 5-paneled door, flush door, and board & batten door

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

Figure 188. Comfort Station: Exterior aluminum storm window installed at exterior of historic wood hopper window, typical.

Figure 189. Comfort Station: Interior view of historic wood hopper window, typical.

The original entry doors are not detailed in the original 1941 construction drawings, but the north entry door into the former men's restroom is likely the original (**Figure 191**). The south entry door into the former women's restroom has been replaced with a flush wood door (**Figure 190**). The door is in good condition, but is not sympathetic to the historic character of the structure. The exterior door at the north utility room is presumed to be original due to its vertical board and batten design which matches the exterior cladding (**Figure 192**).

The existing flush door 31 should be replaced with a new 5-panel door with new hardware, and NPS-compliant locks. The existing 5-panel door 32 at the north entry and the board and batten door 33 at the utility closet should be cleaned, repaired, repainted and equipped with new hardware and a NPS-compliant lock.

Figure 190. Comfort Station: South entry door into Comfort Station

Figure 191. (Left) Comfort Station: North entry door.
Figure 192. (Right) Comfort Station: Original vertical board and batten door at utility closet.

B30 - ROOFING

The existing cedar shingle roof has significant biological and lichen growth which indicates the wood shingles have remained saturated (**Figure 193**). Archival records indicate this roof was last replaced in 2007 when the Comfort Station was re-purposed for use as a temporary storage facility. Though not as severely deteriorated as the roof over the Pump House which was recently replaced, the roof at the Comfort Station should be replaced in the near future. As this building is not insulated, future replacement of the shingles should be installed over skip sheathing. If installed properly and maintained regularly, a cedar shingle roof could last from 20-40 years; however, the overhanging tree branches present challenges to the roof drying out.

Major Group Element
B Shell

Group Elements
B20 - Exterior Enclosure

Individual Elements
B3010 - Roof Coverings

Material/ Equipment
Wood Shingle

Painted 6" half-round metal gutter and downspout along east roof eave

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Serious

The 1941 construction drawings do not show gutters and downspouts, but a gutter and downspout have been installed along the east eave of the roof. This gutter should be maintained and a gutter considered for the west eave. During a site visit it was observed that the downspout located at the northeast corner of the Comfort Station was clogged with debris. This was resulting in poor stormwater management and may be contributing to the erosion and undermining of the north end of the low CMU retaining wall.

Figure 193. Comfort Station: Existing cedar shingle roofing with excess lichen growth.

Major Group Element
C Interiors

Group Elements
C30 - Interior Finishes

Individual Elements
C3010 - Wall Finishes

C3020 - Floor Finishes

C3030 - Ceiling Finishes

Material/ Equipment
Cement Plaster on Metal Lath

Concrete topping slab, painted

Cement Plaster on Metal Lath

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

C30 - INTERIOR FINISHES

The existing interior cement plaster finish along the walls is in fair condition. The plaster ceiling finish displays signs of cracking and delamination (**Figure 194**). The cracks in the ceiling finish are likely due to deflection in the ceiling joists above. There is no equipment located in the attic, so there is no issue of overloading of the ceiling structure. The peeling and cracking paint is likely due to poor surface preparation prior to earlier repainting campaigns. The work recommendations include repairing of minor cracks and repainting the interior walls and ceiling surfaces. Care should be taken as lead-based paints and coatings are likely present at the Comfort Station.

Figure 194. Comfort Station: Cracking evident in cement plaster ceiling.

D20 - PLUMBING/ D30 - HVAC/ D40 - FIRE PROTECTION/ D50 - ELECTRICAL

Existing floor drains appear new and free of debris (**Figure 195**). Existing radiators and manually-operated air recirculation fans are operational (**Figure 196**).

Per OSHA [29 CFR 1910.157(e)(2), NPS should provide a visual inspection of portable fire extinguishers at least once per month. A full maintenance check on existing portable fire extinguishers should be conducted once per year, according to OSHA 29 CFR 1910.157(e)(3). "Maintenance" means a thorough examination and repair, as needed, of all your facility's portable fire extinguishers, as covered in NFPA 10(98), Sec. 4-4.

Unfortunately, the historic 1941 construction drawings include a lighting layout, but do not specify fixture types. The interior lighting, though operational, consists of modern 1x4 flush mounted fluorescent light fixtures which are not original and should be replaced with historically sympathetic lighting (**Figures 197-198**). The exterior lighting may be original, but needs to be upgraded and equipped with new automatic control devices (OS Sensors) to comply with current energy code. IECC falls under the family of codes under IBC. Per section C405 of the IECC, there are requirements to implement forms of automatic control for lighting for energy reduction

Major Group Element
D Services

Group Elements
D20 - Plumbing

D30 - HVAC

D40 - Fire Protection

D50 - Electrical

Individual Elements
D2020 - Domestic Water Distribution

D2030 - Sanitary Waste

D3040 - Distibution Systems

D4030 - Fire Protection Specialities

D5020 - Lighting & Branch Wiring

D5030 - Communications & Security

Material/ Equipment
Hose bibb in exterior closet

Two (2) interior floor drains located within former restrooms

Hot Water Radiator Piping located along west wall of Comfort Station

Air Circulator Fan

Wall mounted fire extinguisher.

Interior 1x4 florescent lighting

Exterior sconce lighting

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

Figure 195. (Left, Top) Comfort Station: Existing interior floor drain, typical.
Figure 196. (Right, top) Comfort Station: Radiator piping along west wall of former men's restroom. Original built-in urinals concealed behind wall built below workbench when restroom was re-purposed for storage in 2007.
Figure 197. (Left, Bottem) Comfort Station: Original exterior wall mounted sconce.
Figure 198. (Right, Bottom) Comfort Station: surface mounted florescent lighting and exhaust vent in ceiling.

measures in spaces including storage rooms and rooms 300 sf or less that are enclosed by floor to ceiling height partitions. If a substantial renovation or rehabilitation is planned for the structure, compliance with the IECC will likely require upgrades to address light levels, automatic controls, emergency egress lighting, and energy efficient lamping.

The Comfort Station does not contain any security or fire protection systems (fire alarm or fire suppression) as this storage space serves as a Low-hazard Storage Occupancy (S-2 per the IBC) and these systems are not required. However, DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

G20 - SITE IMPROVEMENTS

The Comfort Station is accessed by the original concrete pathways adjacent to the access road. The concrete paving surrounding the Comfort Station is in poor condition (**Figures 199-201**). The slab has cracked and heaved in many locations, and walking surfaces are uneven. Where the screen wall was originally located on the south side of the building and the south entry, multiple fence posts have been removed by cutting the metal pipe at the concrete surface. The embedded post elements have corroded, exacerbating the cracking at the concrete slab. Where the screen wall is extant at the north entrance, the post bases display signs of wood rot and section loss. The wood posts at the north exterior screen wall should be replaced with pressure treated wood where they are in contact with the concrete slab. An appropriate bearing detail with a galvanized post base should be used. Repairs should be made to the site concrete where it has cracked and heaved.

A low retaining wall is located along the east side of the Comfort Station to retain the adjacent grade. The northern portion of this low retaining was is being undermined by poor site drainage. The failing portion of the retaining wall must be selectively rebuilt with improved drainage to move water away from the foundation of the building.

Major Group Element
G Building Sitework

Group Elements
G20 - Site Improvements

Individual Elements
G2030 - Pedestrian Paving

G2040 - Site Development

Material/ Equipment
Concrete sidewalk and landing at entry

Low CMU retaining wall located parallel to east façade

Wood posts and wood board and batten panels

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Serious

Figure 199. (Left) Comfort Station: Broken and displaced concrete landing and walkway outside south entry door
Figure 200. (Right) Comfort Station: Low CMU retaining wall east of Comfort Station; north section being undermined by poor site drainage.

Figure 201. Comfort Station: Existing concrete walkway providing access to Comfort Station from access road to the west.

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SUMMARY OF CONDITIONS: PUMP HOUSE

The following chart provides an inventory of existing conditions with qualitative ratings and maintenance priorities identified for components and features of the Pump House. These are explained in more detail on the following pages. The Pump House is overall in FAIR condition.

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
A Substructure	A10 Foundations	A1010 Standard Foundations	A1011 Wall Foundations	Continuous Concrete Footer	Good	Minor
A Substructure	A10 Foundations	A1030 Slab on Grade	A1032 Structural Slab on Grade	Cast-in-Place Slab, Painted	Good	Minor
B Shell	B10 Superstructure	B1010 Floor Construction	B1012 Upper Floors Construction	Cast-in-Place Slab, Painted	Fair	Critical
B Shell	B10 Superstructure	B1020 Roof Construction	B1022 Pitched Roof Construction	Wood Framing	Poor	Critical
B Shell	B10 Superstructure	B1020 Roof Construction	B1022 Pitched Roof Construction	Wood Roof Sheathing	Poor	Critical
B Shell	B20 Exterior Enclosure	B2010 Exterior Walls	B2011 Exterior Wall Construction	Brick Masonry, Painted	Fair	Critical
B Shell	B20 Exterior Enclosure	B2020 Exterior Windows	B2021 Windows	Wood, Double Hung	Fair	Minor
B Shell	B20 Exterior Enclosure	B2030 Exterior Doors	B2032 Solid Exterior Doors	5-Panel Wood, Painted (First Floor)	Fair	Minor
B Shell	B20 Exterior Enclosure	B2030 Exterior Doors	B2032 Solid Exterior Doors	5-Panel Wood, Painted (Second Floor)	Poor	Serious
B Shell	B30 Roofing	B3010 Roof Coverings	B3011 Roof Finishes	Wood Shingle	Good	Minor

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
B Shell	B30 Roofing	B3010 Roof Coverings	B3014 Flashing & Trim	Glav. Metal Flashing	Good	Minor
B Shell	B30 Roofing	B3010 Roof Coverings	B3016 Gutters & Downspouts	None	N/A	N/A
C Interiors	C20 Stairs	C2010 Stair Construction	C2011 Regular Stairs (Ships Ladder)	Wood ships ladder with galv. Metal tub railing	Poor	Serious
C Interiors	C30 Interior Finishes	C3020 Floor Finishes	C3021 Floor Toppings	Concrete topping slab, painted	Fair	Critical
D Services	D20 Plumbing	D2030 Sanitary Waste	D2034 Sanitary Waste Equipment	Steel Pressure Tank	Not Rated	Not Rated
D Services	D20 Plumbing	D2020 Domestic Water Distribution	D2023 Domestic Water Supply Equipment	Domestic Water Backflow Preventor, Manual isolation valves, pressure regulator, water meter, and water level.	Not Rated	Not Rated
D Services	D20 Plumbing	D2030 Sanitary Waste	D2034 Sanitary Waste Equipment	Sump Pump	Poor	Critical
D Services	D20 Plumbing	D2030 Sanitary Waste	D2031 Waste Piping	Sanitary Waste piping	Poor	Critical
D Services	D20 Plumbing	D2030 Sanitary Waste	D2033 Floor Drains	Floor Drains	Poor	Critical
D Services	D30 HVAC	D3020 Heat Generating Systems	D3050 Package Units	5K Electric Unit Heater	Fair	Minor
D Services	D40 Fire Protection	D4030 Fire Protection Specialities	D4031 Fire Extinguisher	Wall mounted fire extinguisher	Good	Minor

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
D Services	D50 Electrical	D5010 Electrical Service & Distribution	D5012 Electrical Incoming Service	Distribution Panelboard	Fair	Minor
D Services	D50 Electrical	D5020 Lighting & Branch Wiring	D5022 Lighting Equipment & Interior Lighting	Lighting fixtures, wiring, conduit, raceways, and wiring troughs, junction boxes, light switches	Poor	Serious
D Services	D50 Electrical	D5020 Lighting & Branch Wiring	D5022 Exterior Lighting	Exterior sconce with guard	Poor	Serious
D Services	D50 Electrical	D5030 - Commun. & Security	D5038 Security & Detection Systems	None.	N/A	N/A
G Building Sitework	G20 Site Improve.	G2030 - Pedestrian Paving	G2031 Paving & Surfacing	Concrete sidewalk and landing at entry	Poor	Serious
G Building Sitework	G20 Site Improve.	G2040 - Site Development	G2042 Retaining Walls	Concrete retaining walls to cistern located east of Pump House.	Unknown	Unkown
G Building Sitework	G20 Site Improve.	G2040 - Site Development	Retaining Structures	Concrete slab and retaining structure at grade at west elevation	Poor	Serious

Major Group Element
A Superstructure

Group Elements
A10 Foundations

Individual Elements
A1010 - Standard Foundations

A1030 - Slab on Grade

Material/ Equipment
Concrete cast-in-place retaining walls

Concrete vault below grade

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

A10 - FOUNDATIONS

The historic 1941 construction drawings of the Pump House offer a lot of information about the design and functions of the Pump House. Per the historic drawings, there is a mat foundation and concrete-framed basement below grade, accommodating the clear well for filtered water storage. Not intended for regular human occupancy, a steel plate-covered access panel west of the building is the only way to access the basement (**Figure 202**). Concrete cast-in-place walls form the subsurface walls of the clear well. Unfortunately, the clear well is currently filled with fouled water and it was impossible to survey the condition of these walls. Observations of below grade conditions were limited to the raw water pump pit in the shed-roofed structure at the northwest corner of the building, where the lower level walls appeared to be in good condition.

The structural concrete slab is spalling and cracking. Select repairs are needed to stabilize the concrete enclosure, and further survey is needed to understand all existing conditions. Analysis was performed to determine if the well walls are structurally stable in the empty condition using the existing drawings, and they were found to be adequate.

If the current substance in the well is corrosive, it may be expediting the deterioration of any exposed reinforcing. Silman recommends emptying the clear well to prevent any additional deterioration of the reinforced concrete. The clear well should be drained in phases and the walls should be observed as feasible (by camera or personnel with proper safety gear) at discrete

Figure 202. Pump House: View of mat slab and deteriorated topping slab west of the Pump House, over the clear well. The steel cover plate provide access to the clear well below, but was not removable during site survey.

integrals during draining, such as 25% of the clear well, then to 50%, then to 75%. At each interval, the visible portion of the walls can be checked for any large cracks or spalls that suggest structural damage might be present. As soon as the area is fully drained, an engineer should survey and evaluate the walls to identify any deterioration. In addition to the phased observation, NPS should close off the adjacent area during the draining process and have a contingency plan in place in case any poor conditions are uncovered, such as re-filling the clear well or installing temporary shoring if needed.

East of the Pump House, concrete cast-in-place walls form the coagulation basin on the north, east and south, with the wall of the Pump House enclosing it on the west (**Figure 203**). The concrete walls of the coagulation basin appeared in fair condition with some cracking noted on the east and west walls (**Figure 204**). A crack at the mid-span of the east wall of the basin runs the full height of the basin and is recommended to be repaired. Additionally, some spalling and cracking was noted around a pipe penetration at the north end of the west wall (**Figure 205**). It is recommended that this be repaired. None of the cracking noted at the basin walls impacts the structural integrity of the basin. They are recommended

Figure 203. (Right) Pump House: Fence enclosure around the coagulation basin..

to be repaired to prevent the cracks from growing and to reduce the risk of corrosion to the reinforcing. Analysis of the walls was performed using the existing drawings and they were determined to be adequately designed when the basin is empty.

A low, curved stone masonry retaining wall is located adjacent to the south facade (**Figure 206**). Select repointing is required along this wall.

Figure 204. (Left) Pump House: Crack in east concrete wall of coagulation basin.
Figure 205. (Right) Pump House: Spalling and cracking noted at pipe penetration at north end of west wall of coagulating basin.

Figure 206. (Left) Pump House: Low curved retaining wall located south of the agitation chamber and coagulation basin.

B10 - SUPERSTRUCTURE

Major Group Element
B Shell

Group Elements
B10 - Superstructure

Individual Elements
B1010 - Floor Construction

B1020 - Roof Construction

B1020 - Roof Construction

Material/ Equipment
Cast-in-place concrete slab

Wood framing

Wood roof sheathing

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

At the interior, the concrete framed structure is in fair condition, except for one large spall at the center of the bounding edge beam at the operating gallery floor slab (**Figures 207-209**). Although the exact cause is unknown, the damage may have been caused by impact when heavy equipment was moved to or from the upper level. An allowance should be made for localized patching and replacement of the slab on grade if mechanical equipment is removed. Silman recommends repair of the large concrete spall at the upper level of the pump house. At this location the deteriorated concrete should be chipped out, new reinforcement should be spliced in, and the area should be patched.

At the time of this report, the roof sheathing has recently been locally replaced and the east side rafters have been sistered. The top plate at the east wall has also been replaced and new roofing has been installed.

Based upon the lack of wall displacement, the roof thrust is currently resolved through an unconventional load path. While this is not of immediate concern, due to the unbraced height and width of the Pump House walls it is recommended that either additional investigation be done to determine the load path, or modifications be made to the roof structure to ensure that the roof thrust is resolved. Modifications may include new rafter ties installed at each pair of rafters to resolve the thrust imparted at the top of the walls. If the addition of ties is not architecturally desirable, other interventions would need to be developed through design, such as developing moment frames or the horizontal distribution of thrust forces.

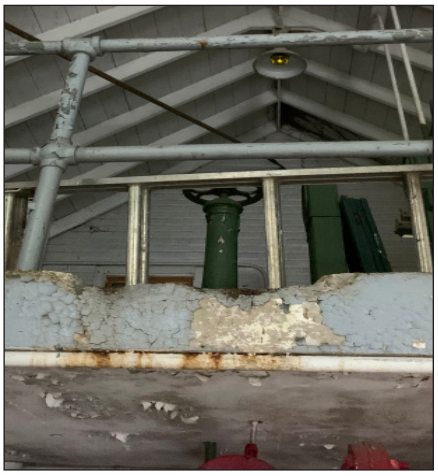

Figure 207. (Left) Pump House: Pump House interior with view of the operating gallery.
Figure 208. (Right) Pump House: Detail of spalled concrete beam along edge of operating gallery.

Figure 209. (Left) Pump House: Sistering of roof framing and roof sheathing replacement completed in 2022.
Figure 210. (Right) Pump House: Sistering of roof framing and roof sheathing replacement completed in 2022.

B20 - EXTERIOR ENCLOSURE, WALLS

Repointing of the existing brick masonry walls is required in areas of water infiltration, particularly along the east wall where the significant roof failure occurred, as the brick has become saturated resulting in select mortar loss and peeling paint (**Figure 212 and 213**). The selection of paints and coatings must consider the condition of the underlying masonry and mortar, which needs to breathe.

At the exterior, corrosion was observed at a steel window lintel, causing spalling and displacement of a brick unit (**Figure 211**). Two lintels over the windows 403 and 404 on the west elevation should be replaced with angles.

Repointing is required at the chimney where mortar loss was also observed at the top of the brick chimney along the south facade (**Figure 214**).

Major Group Element
B-Shell

Group Elements
B20 Exterior Enclosure

Individual Elements
B2010 - Exterior Walls

B2020 - Exterior Windows

Material/ Equipment
Brick Masonry Walls

Brick Masonry Chimney

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

Figure 211. (Top Left) Pump House: Corrosion of steel lintel above window has caused cracking and displacement in adjacent brick.
Figure 212. (Top Right) Pump House: Painted brick chimney at south gable end wall; paint and mortar loss evident.
Figure 213. (Bottom Left) Pump House: Paint and mortar loss evident along east wall of Pump House.
Figure 214. (Bottom Right) Pump House: Top corbelled brick courses at the chimney along the south wall of the Pump House..

Major Group Element
B Shell

Group Elements
B20 Exterior Enclosure

Individual Elements
B2020 - Exterior Windows

B2030 - Exterior Doors

Material/ Equipment
Double hung wood windows

Wood 5-paneled door

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

B20 - EXTERIOR ENCLOSURE, WINDOWS & DOORS

The existing double hung wood windows and paneled wood doors are in poor condition with areas of wood rot at sills and broken glazing (**Figures 215-216**). The existing window sashes and frames display wood rot, paint loss, select areas of missing or failing glazing putty, broken or missing glazing, and missing or damaged hardware. The existing doors are in poor condition with areas of wood rot and paint loss.

Repair and restore windows to replace rotten elements and missing and broken glass. Repair damage from wear and vandalism. Restore the operation of the counterweights were applicable, and replace missing hardware. Clean, repair, and repaint the existing 5-panel entry door (41) and the door at the Operating Gallery (42) providing access to the Coagulating Basin, including hardware and locking devices. It should be noted the wood windows and doors, and all painted surfaces, have likely been finished in lead-based paint in the past.

The original window shutters are missing, but the hinges remain intact. It is assumed the wood shutters were removed during the 2007 rehabilitation project and were never reinstalled. It was noted that a number of painted wood shutters are currently stored in the Operating Gallery, some of which may be original to the Pump House.

Figure 215. (Left) Pump House: Existing wood double hung window along west facade of Pump House.
Figure 216. (Right) Pump House: Original 5-paneled wood entry door at the south facade of the Pump House.

B30 - ROOFING

The Park recently replaced the cedar shingle roofing at the Pump House. When surveys were first conducted in 2020, the existing roof was in a state of extreme deterioration and failure of the roof sheathing and roof framing had occurred. When additional site survey was conducted in June 2022, the roofing had been replaced in-kind and associated repairs to the roof framing and wood sheathing were completed. (**Figres 217-218**).

Original documents do not show gutters and downspouts at the Pump House, and none are currently present on the structure. Gutters and downspouts should be considered as a reversible measure to manage stormwater.

Major Group Element
B Shell

Group Elements
B30 Roofing

Individual Elements
B3010 - Roof Coverings

Material/ Equipment
Wood Shingle

Glav. Metal Flashing

Qualitative Condition Rating
Good

Maintenance Deficiency Priority
Minor

Figure 217. Pump House: Northwest view of Pump House from the access road.

Figure 218. Pump House: East view of Pump House from the decking installed over the coagulation basin..

Major Group Element
C Interiors

Group Elements
C20 Stairs

Individual Elements
C2010 - Stair Construction

Material/ Equipment
Wood ships ladder with galv. metal railing

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Serious

C20 - STAIRS

The operating gallery of the Pump House is accessed from a steel frame ship's ladder with wood treads. The existing wood treads have signs of significant wood rot and one (1) tread has failed at the base of the ladder (**Figures 219-221**). The railing at the operating gallery does not comply with code requirements per IBC Chapter 10 which requires that guards not less than 42" be installed along open sided walking surfaces that are located more than 30" measured vertically to the floor below.

Replace the wood treads of the ladder to provide safe conditions to access the operating gallery. If public access is being proposed, it should be evaluated if a code compliant railing should be installed for safety. There are pipe and tube railings with ball fittings available on the market which would allow modification of the existing while preserving the historic design and complying with code requirements.

Figure 219. Pump House: Ships ladder with wood treads providing access to the Operating Gallery.

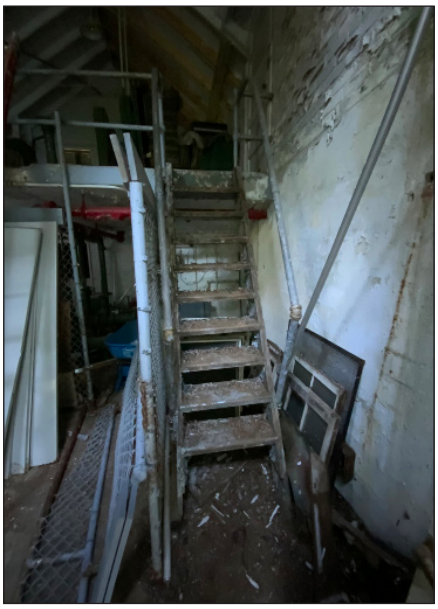

Figure 220. (Left) Pump House: Ships ladder with wood treads providing access to the Operating Gallery.
Figure 221. (Left) Pump House: Ships ladder with wood treads providing access to the Operating Gallery.

D20 - PLUMBING

Water service has been disconnected and the Pump House is no longer in service as a water filtration facility, but the original filtration equipment remains intact (**Figures 222-224**). The abandoned incoming domestic water and associated domestic water accessories including, but not limited to, manual valves, a water level gauge, a loss of head gauge, and a rate of flow gauge are original to the building and are no longer in use.

No system repairs are required since the system is not in operation. However, it was noted that the cast iron water line which carried water from the clear well to the pressurized tank is exposed above grade due to erosion.

In addition to a hazardous materials survey to assess the building materials, it is highly recommended that NPS test the water held in the clear wall of the Pump House for contamination. Though the clear well was not accessible for survey, observation was made from floor openings above where the original pumps had been removed. Water containing a foul smelling green substance was observed which needs to be evaluated as soon as possible to protect the health, safety, and welfare of NPS staff and any visitors to the building. Until this is further evaluated, access to the building should be strictly limited.

Major Group Element
D Services

Group Elements
D20 Plumbing

Individual Elements
D2030 - Sanitary Waste

D2020 - Domestic Water Distribution

D2030 - Sanitary Waste

Material/ Equipment
Steel Pressure Tank

Domestic Water manual valves, water level gauge, loss of head gauge, and rate of flow gauge

Sanitary Waste piping

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Critical

Figure 222. (Left) Pump House: Raw (red) and filtered (green) cast iron water lines used to distribute water through the Pump House.
Figure 223. (Right, top) Pump House: Filtered water line connecting clear well to pressurized tank located east of the coagulating basin.
Figure 224. (Right, bottom) Pump House: Raw water pump pit; pump and drain seen at bottom of pit; well water line (green) seen on the right.

Major Group Element
D Services

Group Elements
D30 - HVAC

D40 - Fire Protection

D50 - Electrical

Individual Elements
D3020 - Heat Generating Systems

D4030 - Fire Protection Specialities

D5010 - Electrical Service & Distribution

D5020 - Lighting & Branch Wiring

D5030 - Communications & Security

Material/ Equipment
Wall mounted fire extinguisher.

Distribution Panelboard

Lighting fixtures, wiring, conduit, raceways, and wiring troughs, junction boxes, light switches

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

D30 - HVAC/ D40 - FIRE PROTECTION/ D50 ELECTRICAL

The Pump House is currently heated with a new electric unit heater. The operation of the heater should be routinely monitored to assure it continues to function.

Per OSHA [29 CFR 1910.157(e)(2), NPS should provide a visual inspection of portable fire extinguishers at least once per month. A full maintenance check on existing portable fire extinguishers should be conducted once per year, according to OSHA 29 CFR 1910.157(e)(3). "Maintenance" means a thorough examination and repair, as needed, of all your facility's portable fire extinguishers, as covered in NFPA 10(98), Sec. 4-4.

The Pump House does not contain any security or fire protection systems (fire alarm or fire suppression) as this building is normally non-occupied and is a Use Group “U” occupancy building. No fire protection systems are required for this building based on its use; however, other DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

The electrical service entrance distribution board was replaced in 2007. It appears to be in acceptable working condition and is not recommended for replacement in the near term. The exterior wireways along the west facade of the Pump House bring the electrical service to the main switch board inside the Pump House and carry the feeders to nearby structures, including the Comfort Station, Boiler House, and Great Falls Tavern. The exterior wireways could be relocated inside the Pump House, but the effort with be costly, and the space needed may necessitate the removal of some historic equipment.

Lighting equipment and fixtures are older and it is not clear if they comply with current safety standards. New lighting should be provided per code in a style that is compatible with the historic character of the structure. IECC falls under the family of codes under IBC. Per section C405 of the IECC, there are requirements to implement forms of automatic control for lighting for energy reduction measures in spaces including storage rooms and rooms 300 sf or less that are enclosed by floor to ceiling height partitions.

Figure 225. Pump House: Historic main electrical distribution panel along west wall of Pump House.
Figure 226. Pump House: Historic (abandoned) light distribution panel along west wall of Pump House.

Major Group Element
G Building Sitework

Group Elements
G20 Site Improvement

Individual Elements
G2030 - Pedestrian Paving

G2040 - Site Development

Material/ Equipment
Flagstone walkway

Stone retaining wall

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

G20 - SITE IMPROVEMENTS

Access to the entry of the Pump House is provided via a flagstone pathway which displays signs of settlement and displacement (**Figure 227**). The paved pathway requires repair to provide a safe pathway to access the entry of the Pump House.

A low, curved stone masonry retaining wall is located adjacent to the south facade. Select repointing is required along this wall. Routine maintenance is also required to manage vegetation growth along and above this retaining wall.

Figure 227. Pump House: Uneven flagstone paving at south entry door

SUMMARY OF CONDITIONS: ENGINEER'S GARAGE

The following chart provides an inventory of existing conditions with qualitative ratings and maintenance priorities identified for components and features of the Engineer's Garage. These are explained in more detail on the following pages. The Engineer's Garage is overall in FAIR condition.

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
A Substructure	A10 Foundations	A1010 Standard Foundations	A1011 Wall Foundations	Continuous Concrete Footer	Good	Minor
A Substructure	A10 Foundations	A1030 Slab on Grade	A1032 Structural Slab on Grade	Cast-in-Place Slab, Painted	Good	Minor
B Shell	B10 Superstructure	B1020 Roof Construction	B1022 Pitched Roof	Wood Framing	Fair	Critical
B Shell	B10 Superstructure	B1020 Roof Construction	B1022 Pitched Roof	Wood Roof Sheathing	Fair	Critical
B Shell	B20 Exterior Enclosure	B2010 Exterior Walls	B1022 Pitched Roof	Wood Frame with Vertical Board & Batten Siding	Fair	Critical
B Shell	B20 Exterior Enclosure	B2020 Exterior Windows	B2021 Windows	Wood, Double Hung	Fair	Critical
B Shell	B20 Exterior Enclosure	B2030 Exterior Doors	B2032 Solid Exterior Doors	Existing 4-lite, 3-paneled solid wood doors	Fair	Critical
B Shell	B20 Exterior Enclosure	B2030 Exterior Doors	B2032 Sectional Garage Doors	Wood, paneled garage doors	Fair	Critical
B Shell	B30 Roofing	B3010 Roof Coverings	B3011 Roof Finishes	Asphalt Shingle	Good	Minor

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
B Shell	B30 Roofing	B3010 Roof Coverings	B3016 Gutters & Downspouts	Painted "k-style" metal gutter and downspout along east roof eave	Good	Minor
D Services	D30 HVAC	D3050 Terminal & Packaged Units	D3052 Packaged Units	Recessed wall mounted Electric unit heater located in front office/ storage.	Fair	Minor
D Services	D30 HVAC	D3040 Distibution Systems	D3042 Exhaust Ventilation Systems	Air Circulator Fan	Fair	Minor
D Services	D40 Fire Protection	D4030 Fire Protection Specialities	D4031	Wall mounted	Fair	Minor
D Services	D50 Electrical	D5020 Lighting & Branch Wiring	D5022 Interior Lighting	Industrial sconces with guards and 1x4 florescent fixtures	Fair	Minor
D Services	D50 Electrical	D5020 Lighting & Branch Wiring	D5022 Exterior Lighting	None.	Poor	Critical
D Services	D50 Electrical	D5020 Lighting & Branch Wiring	D5022 Branch circuit wiring devices	Branch circuit wiring devices	Poor	Critical
D Services	D50 Electrical	D5030 Commun. & Security	D5037 Fire Alarm/ Security & Detection Systems	No system present.	Poor	Critical
D Services	D70 Electronic Safety & Security	D7050 Fire Detection & Alarm	Smoke Detection Sensors	Existing smoke detectors	Poor	Critical

Major Group Element	Group Elements	Individual Elements	Sub-Elements	Material/ Equipment	Qualitative Condition Rating	Maintenance Deficiency Priority
G Building Sitework	G20 Site Improvements	G2030 Pedestrian Paving	G2031 Paving & Surfacing	Asphalt and concrete sidewalk and landing at entry	Fair	Minor
G Building Sitework	G20 Site Improvements	G2040 Site Development	G2042 Retaining Walls	Concrete site and retaining walls	Fair	Minor

Major Group Element
A Substructure

Group Elements
A10 Foundations

Individual Elements
A1010 Standard Foundations

A1030 Slab-on-Grade

Material/ Equipment
Continuous concrete footer and concrete masonry knee wall.

Cast-in-place concrete slab

Qualitative Condition Rating
Good

Maintenance Deficiency Priority
Minor

A10 - FOUNDATIONS

Hairline to 1/8" cracking was noted in localized areas at the CMU foundation wall and some hairline cracking exists at the slab on grade (**Figures 228-229**). Hairline cracking in the exterior CMU walls should be infilled with a patching mortar or crack injection product. The walls should be repointed around the cracked area or crack gauges can be installed at the wall face to monitor whether cracks are actively moving or stable.

Repair and maintenance campaigns should include an allowance for approximately 50 square feet of concrete patching, including localized replacement of slab on grade and application of repair mortars in areas of cracking and spalling. This repair allowance is for localized, minor cracking, and impact damage.

Figure 228. (Left) Engineer's Garage: Concrete and masonry base and wood stud wall construction above
Figure 229. (Right) Engineer's Garage: Example of cracking in CMU and brick exterior wall base.

B10 - SUPERSTRUCTURE

Localized previous moisture infiltration was noted through the roof sheathing, however, it is assumed repairs have been made and remaining evidence is superficial since the roof at the Engineer's Garage was replaced in 2015. Generally, the roof framing is in fair condition (**Figure 230**).

At the south entry porch, the wood post has been cut back and replaced with steel places and a threaded rod, presumably to address past wood rot at the base (**Figure 231**). The post should be replaced in kind, in its entirety. To increase durability, the post should be set on a galvanized post base. This galvanized post base can be hidden within a decorative element that mimics the appearance of the original post base.

Major Group Element
B Shell

Group Elements
B10 Superstructure

Individual Elements
B1020 Roof Construction

Material/ Equipment
Wood framing and wood roof sheathing

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Minor

Figure 230. (Left) Engineer's Garage: Wood roof rafters above the mule stables in the Garage.
Figure 231. (Right) Engineer's Garage: Original wood post at south porch supported by steel threaded rod and plates.

Major Group Element
B Shell

Group Elements
B20 Exterior Enclosure

Individual Elements
Exterior Walls

Material/ Equipment
Wood Frame with Vertical Board & Batten Siding

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

B20 - EXTERIOR ENCLOSURE, WALLS

The exterior wood framed wall assembly supported by the CMU knee walls is in fair condition with very limited areas of wood rot, paint loss, and missing trim in the exterior vertical board and batten siding (**Figures 232-234**). Windows 513 and 515 display signs of rot in the sills and missing wood cladding below the window sills. In addition, there is significant rot at the base of the wood siding at the southeast corner where steep grades likely result in increased runoff towards this corner of the structure. FMSS maintenance records indicate that water infiltration at the Engineer's Garage resulted in excavations, damp-proofing, and foundation drainage along the south and east side of the structure in 2018. The extent of this work should be verified as the wood rot at the base of the siding may have been a result of this prior water infiltration which has been addressed. The exterior siding should be repaired in select areas to replace any missing portions, replace rotten wood elements, and repainted. These repairs will be focused at the base of the wood cladding, just above the masonry foundations.

Figure 232. (Left, top) Engineer's Garage: View of entry doors into historic office and shop at south end of Garage; both spaces currently used for storage.
Figure 233. (Left, bottom) Engineer's Garage: View of north facade of Garage.
Figure 234. (Right) Engineer's Garage: View of southeast corner of Garage from hill to the east; significant site drainage is directed to this southeast corner of the Garage.

B20 - EXTERIOR ENCLOSURE, WINDOWS & DOORS

The sixteen (16) existing double hung wood windows are in fair condition (**Figures 235-236**). The existing window sashes and frames display paint loss, areas of missing glazing putty, broken or missing glazing, and missing or damaged hardware. Repair and restore existing windows to replace rotten wood components (sills and frames), missing and broken glazing, repair damage from wear and vandalism, restore operability, repaint, and replace missing hardware.

The existing solid wood paneled doors at the Office and Shop are in fair condition. These doors should be cleaned, repainted, and fitted with new hardware and locking devices. It should be noted the wood windows and doors, and all painted surfaces, have likely been finished in lead-based paint in the past.

The manually operated garage doors are in good condition. According to archival records, the garage doors were replaced in 2017 in a style that resembles, but does not replicate the original design. No immediate repairs are required.

Window 512 has been removed and replaced with a plywood access panel within the existing wood frame. No repairs were identified at this location if the use of the access door and interior wood steps are still required.

Major Group Element
B Shell

Group Elements
B20 Exterior Enclosure

Individual Elements
B2020 Exterior Windows

B2030 Exterior Doors

Material/ Equipment
Double-hung wood windows

Existing 4-lite, 3-paneled solid wood doors

Wood, paneled garage doors

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Critical

Figure 235. (Left) Engineer's Garage: Typical double hung wood window.
Figure 236. (Right) Engineer's Garage: View of entry door into historic shop at south end of Garage.

Major Group Element
B Shell

Group Elements
B30 Roofing

Individual Elements
B3010 Roof Coverings

Material/ Equipment
Asphalt Shingle

Painted "k-style" metal gutter and downspout along east roof eave

Qualitative Condition Rating
Good

Maintenance Deficiency Priority
Minor

B30 - ROOFING

According to archival records, the existing roof sheathing was repaired and the asphalt shingle roof, aluminum gutters, and downspouts were replaced in 2015 (**Figure 237**).

No repair recommendations have been identified.

Figure 237. Engineer's Garage: View of double hung windows along north facade of Garage; asphalt shingle roof replaced in 2015; window 512 replaced with access door into storage space.

D30 - HVAC/ D40 - FIRE PROTECTION/ D50 ELECTRICAL

The small electric wall heater and the manually operated recirculation fans are operational and do not require immediate replacement (**Figures 238-239**).

The Engineer's Garage is a combination of a livestock shelter with stables and storage for material and equipment. This type of use directly related to occupancy classification of Utility and Miscellaneous Group "U" per the IBC. The building does not have any type of fire suppression system, however, the building is provided with heat detectors in each bay of the shelter/garage. The heat detectors report back to a central, combination burglary/ fire alarm system which is typical for small buildings. The security control panel (model Z1100 manufactured by Moose) is located in the locked office on the south end of the building, however, a date of installation was not able to be determined (**Figure 240**). The DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be

Major Group Element
D Services

Group Elements
D30 HVAC

D40 Fire Protection

D50 Electrical

Individual Elements
D3050 - Terminal & Packaged Units

D3040 - Distibution Systems

D4030 - Fire Protection Specialities

D5020 - Lighting & Branch Wiring

D5030 - Communications & Security

D7050 - Fire Detection & Alarm

Material/ Equipment
Recessed wall mounted electric unit heater

Air circulator fan

Wall mounted fire extinguisher

Smoke detection sensors

Qualitative Condition Rating
Fair

Maintenance Deficiency Priority
Minor

Figure 238. (Left) Engineer's Garage: Electric wall heater at Engineer's Garage office
Figure 239. (Right) Engineer's Garage: Wall exhaust fan at mules stable

Figure 240. (Left) Engineer's Garage: Security control panel located in the office at the south end of the Engineer's Garage.
Figure 241. (Right) Engineer's Garage: Typical 1x4 florescent light fixture in storage space adjacent to heat detector.

evaluated when considering the feasibility of installing a fire suppression system during future design phases.

One concern is that the garage and stables are not heated. Based on the technical data of the burglary/fire alarm system, the operating temperature for the systems is between 32 degrees to 122 degrees Fahrenheit. In the climate the building is in, temperatures in the winter months routinely dip below 32 degrees. Continued exposure to these extreme temperatures will reduce the expected useful life of the system and will require a replacement earlier than normally expected.

An alternate type of system could be considered such as spot type detection devices with linear heat detection. The temperature range of this type of system should fully cover any concerns given the unconditioned state of the Engineer's Garage. The only issue with this product is that it requires flame and heat to activate unlike smoke detectors; however, under the circumstances this is recommended over the premature failure of smoke detectors placed in an incorrect environment.

The exterior mounted electrical load center is contained within an exterior enclosure outside the north wall of the office (**Figures 242-243**). The branch circuits appear to be Romex non-metallic (NM) type cable directly out of this load center. NM cable is not permitted to be installed in wet or damp locations (i.e. exterior locations) per the National Electrical Code (NEC 334.12 (B) (4)). Acceptable raceway methods would be electrical metallic tubing (EMT) or rigid metal conduit (RMC). Replace any exposed wiring not complying with wiring methods outlined the National Electrical Code.

Figure 242. (Left) Engineer's Garage: Exterior electrical load center.
Figure 243. (Right) Engineer's Garage: Incoming electrical service lines at the north facade.

G20 - SITE IMPROVEMENTS

The slope of the grade along the east and south facades is very steep with the potential for increased surface runoff to drain towards the foundation walls (**Figure 244**). The site drainage needs to be evaluated and managed to direct stormwater and run-off away from the building foundations.

The concrete site walls surrounding the hay storage area at the southwest side of the engineer's garage are in fair condition with areas of biological growth and poor consolidation. Depending on this area's intended use, the concrete can be repaired with surface patching repairs.

A wood stair which provides access to the upper grade is in poor condition with risers and handrails which do not provide stable and safe conditions to access the upper portion of the landscape (**Figure 245**). According to Chapter 12 of the 2018 IBC, a handrail is not required for this existing stair condition because the building is less than 3,000 sf, however it is strongly advised that this existing stair be replaced to provide safe access for NPS staff to this upper area of the landscape. This stair is not original historic fabric and a stair could be installed that does not compromise the historic integrity of the Engineer's Garage.

Major Group Element
G Building Sitework

Group Elements
G20 Site Improvements

Individual Elements
G2030 Pedestrian Paving

G2040 Site Development

Material/ Equipment
Concrete site and retaining walls

Exterior wood stair at retaining wall

Qualitative Condition Rating
Poor

Maintenance Deficiency Priority
Critical

Figure 244. (Left) Engineer's Garage: Base wall/ foundation detail at southwest corner.
Figure 245. (Right) Engineer's Garage: Wood stair providing access to upper levels of the landscape adjacent to the southwest corner of the Garage.

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Part II: Ultimate Treatment & Use

Chapter 6: Treatment Recommendations
Chapter 7: Cost Estimates
Chapter 8: Requirements for Treatment Recommendations

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Part III Cover: Aerial View of CCC Camp NP-1 (NARA College Park, MD, Still Photos, Record Group 35-GE, Box 1 of 4)

Chapter 6: Treatment Recommendations

Actively used to support visitor services along the C&O Canal, these buildings are intended to remain in their current use and function. This will require a scope of work for repair and deferred maintenance in lieu of an evaluation for alternate uses.

THE SECRETARY OF THE INTERIOR'S STANDARDS FOR THE TREATMENT OF HISTORIC PROPERTIES

The Secretary of the Interior has established standards and guidelines for the appropriate treatment of historic properties. These standards identify two approaches recommended for treatment and use of the Pivot Bridge Ruins, Boiler House, Comfort Station, Pump House, and Engineer's Garage - Preservation and Rehabilitation. Restoration and Reconstruction are not considered applicable treatment approaches for these structures.

PRESERVATION

Preservation is defined as "the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project." Under preservation, the structures would be maintained in more or less their present state, with minimal maintenance necessary to continue in their current conditions. Preservation is the recommended approach to treatment for the Pivot Bridge Ruins.

REHABILITATION

Rehabilitation is defined as "the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values." A rehabilitation approach to treatment will provide the most flexibility in the use of the Boiler House, Comfort Station, Pump House, and Engineer's Garage. This approach emphasizes the retention and repair of historic materials, but provides more latitude for replacement to address deferred maintenance. Like those for preservation, the standards for

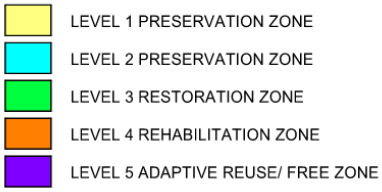
rehabilitation focus attention on the preservation of those materials, features, finishes, spaces, and spatial relationships that, together, give a property its historic character. Therefore, rehabilitation is the recommended approach to treatment for the Boiler House, Comfort Station, Pump House, and Engineer's Garage.

PRESERVATION ZONES

To aid in future planning and work, the spaces of the CCC structures and the Boiler House have been classified into preservation zones. Zones are defined as follows:

LEVEL 1 - PRESERVATION ZONE

Areas, in both plan and elevation, that exhibit unique or distinctive



qualities, original materials or elements; or representing examples of skilled craftsmanship; or work of a known architect or builder; or associated with a person or event or pre-eminent importance. Level 1 areas may be distinguished from Level 2 areas by concentrations of details or "richness" of finish material and detail.

Treatment Guideline – The character and qualities of this zone should be maintained and preserved as the highest priority.

LEVEL 2 – PRESERVATION ZONE

Areas exhibiting distinguishing qualities or original materials and or features; or representing examples of skilled craftsmanship.

Treatment Guideline – Every effort should be made to maintain and preserve the character and qualities of this zone.

LEVEL 3 – RESTORATION ZONE

Work focuses on the retention of materials from the most significant time in a property's history, while permitting the removal of materials from other periods.

Treatment Guideline – Every effort should be made to maintain and preserve the character and qualities of the established Period of Significance while allowing removal of features that were later

additions. Recreation of historic elements to restore the features of a specific period are allowed.

LEVEL 4 – REHABILITATION ZONE

Areas that are modest in nature, void of highly significant character defining features, materials, or conditions, but which may be original and maintained at an acceptable level.

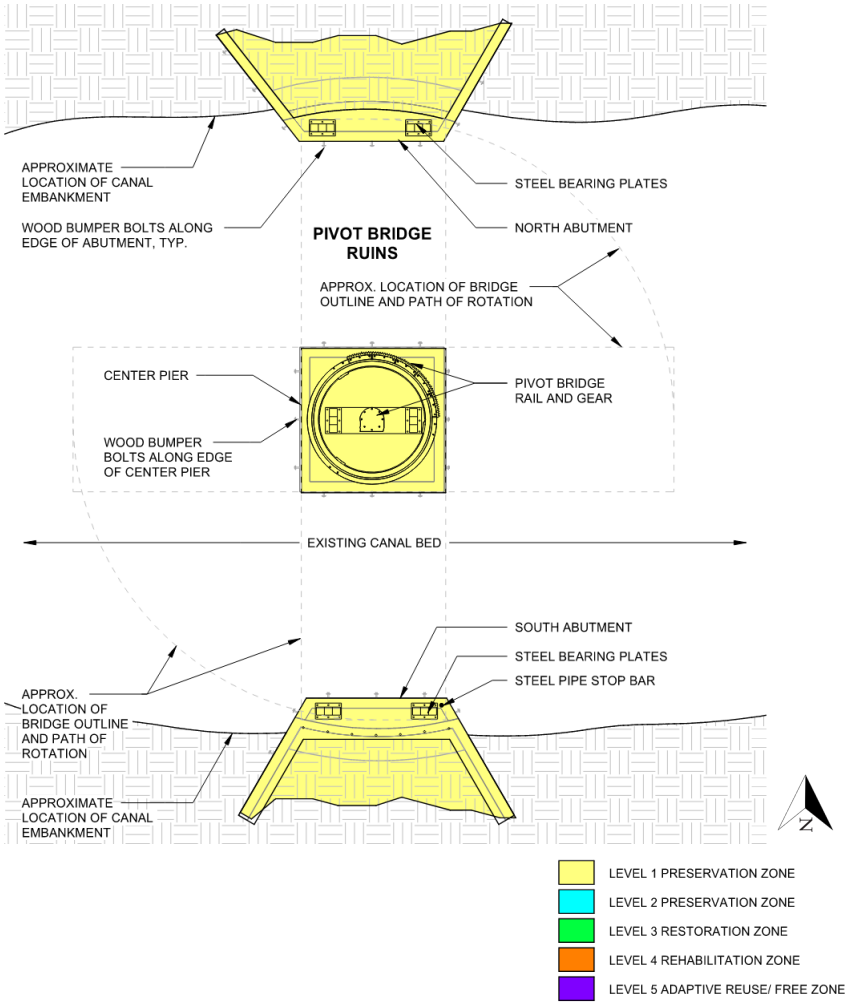
Treatment Guideline – Undertake all work in this zone as sensitively as possible, however, contemporary methods, materials and designs may be selectively incorporated.

LEVEL 5 – ADAPTIVE REUSE ZONE

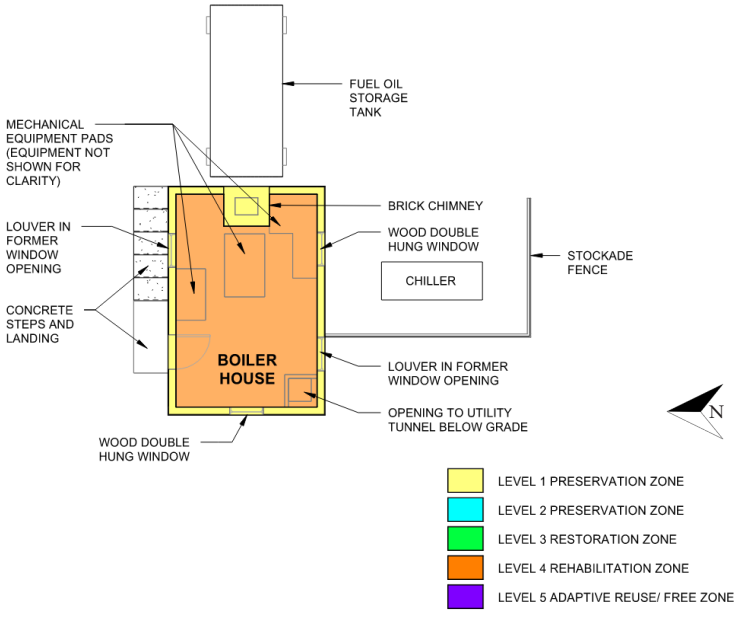
Areas not subject to the above three categories and whose modification would not represent loss of character, code violation or intrusion to an otherwise historically significant structure.

Treatment Guideline – Treatments in this zone, while sympathetic to the historic qualities and character of the building, may incorporate extensive changes of total replacement through the introduction of contemporary methods, materials, and designs.

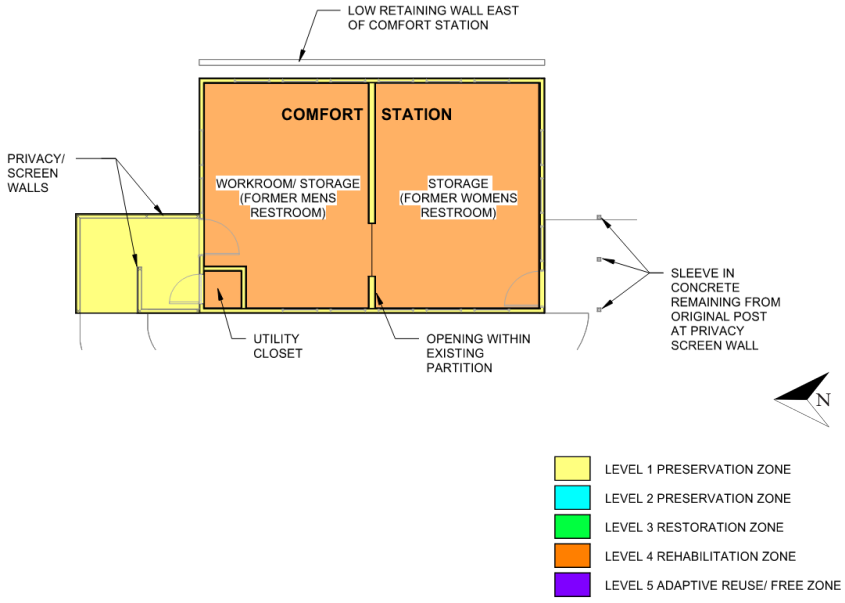
PIVOT BRIDGE RUINS - PRESERVATION ZONES



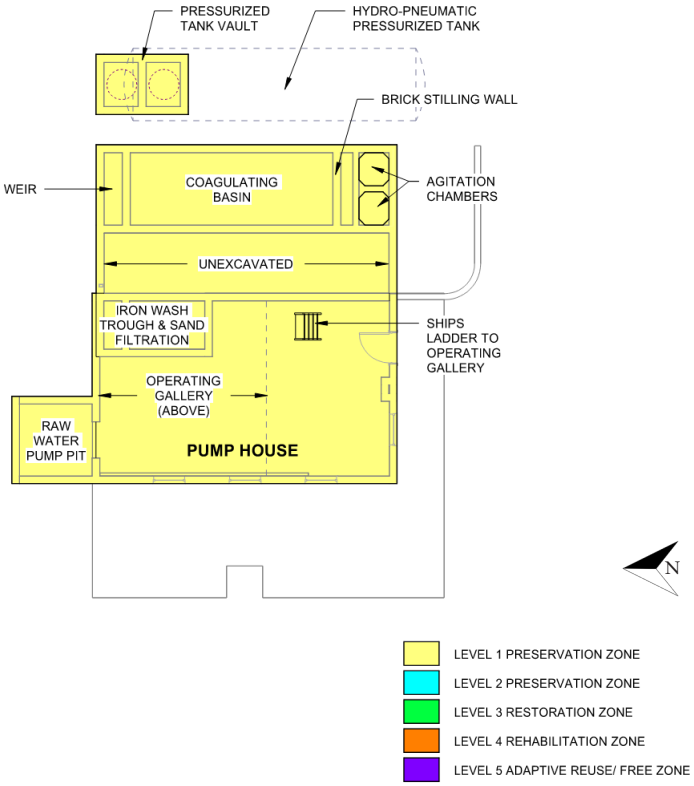
BOILER HOUSE - PRESERVATION ZONES



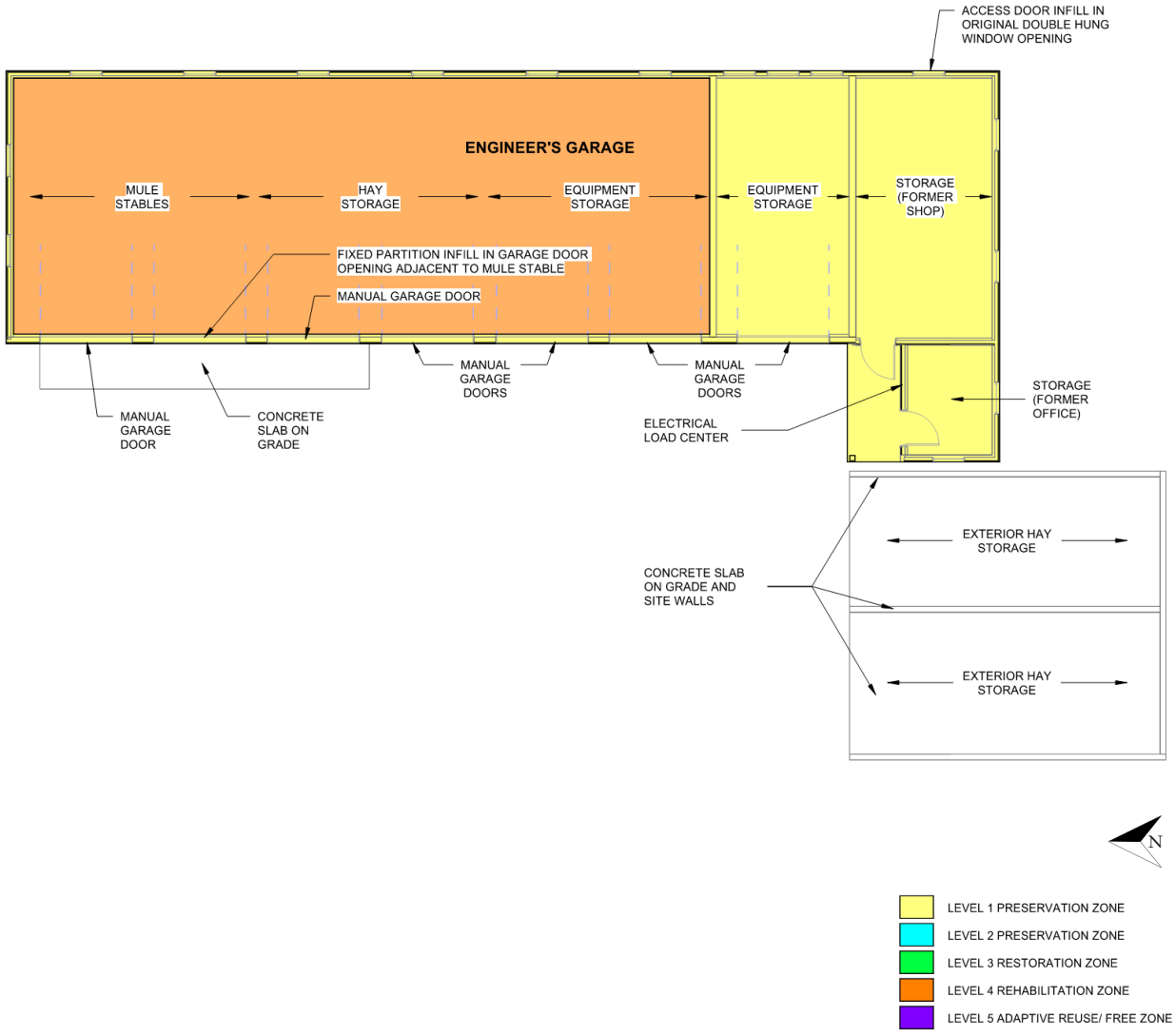
COMFORT STATION - PRESERVATION ZONES



PUMP HOUSE - PRESERVATION ZONES



ENGINEER'S HOUSE - PRESERVATION ZONES



Chapter 7: Cost Estimates

WORK RECOMMENDATIONS & CLASS C COST ESTIMATES

Work recommendations have been provided to align with the Conditions Assessment provided in Part 1, Chapter 5 of this Historic Structure Report. These work recommendations have been reviewed by the cost estimator and included in the development of a Class C Cost Estimate for each of the five (5) structures. ***The cost data for each estimate is provided under a separate cover.***

A summary of these work recommendations per UniFormat is provided below with a Class C Cost Estimate. These estimates include the following markups:

Cost Estimating Mark-up Factor	Percentage
Published Location Factor	-9.80%
Remoteness Factor	5.00%
Federal Wage Rate Factor - on 60% of Direct Cost	0.00%
State & Local Taxes - on 40% of Direct Cost	6.00%
Design Contingency	20.00%
Standard General Conditions	30.00%
Government General Conditions	5.00%
Historic Preservation Factor	10.00%
Overhead	15.00%
Profit	25.00%
Bonds & Permits	2.00%
Contracting Method Adjustment	15.00%
Inflation Escalation	11 month @ 7%

The Class C Cost Estimates to address repairs and deferred maintenance for each of the CCC structures is as follows:

CCC Structure	Class C Cost
Pivot Bridge Ruins	
Boiler House	
Comfort Station	
Pump House	
Engineer's Garage	

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PIVOT BRIDGE RUINS

The Class C Cost for the work outlined in the matrix below is $---.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
A1011	Wall Foundations	Reinforced concrete abutments	Existing concrete abutments in good to fair condition. No immediate work recommendations are required.
B2011	Exterior Wall Construction	Quartzitic schist cladding on existing concrete abutments	Re-pointing: Repoint existing quartzitic schist cladding per recommendations in 2021 Material Analysis completed by Building Conservation Associates, Inc. Assume 20% of quartzitic schist cladding requires repointing.
B2011	Exterior Wall Construction	Quartzitic schist cladding on existing concrete abutments	Reset Coping Stones: Provide allowance to rest approximately 20 coping stones.
B2011	Exterior Wall Construction	Biological growth/ lichen on existing quartzitic schist cladding	Biological Growth: The lichen growth does not pose a risk to the historic masonry or mortar. If it is removed for aesthetic reasons the following process should be implemented: Remove superficial vegetation and lichen grown manually, followed by biocide treatment to prevent future growth.
B2011	Exterior Wall Construction	Efflorescence on existing quartzitic schist cladding	Efflorescence: The efflorescence does not pose a risk to the hard stone and mortar, however, if removal is desired for aesthetic reasons the following process should be implemented: Remove calcified salts and efflorescence, first by careful mechanical means via chisel (with caution taken to not damage stone) followed by microabrasive cleaners. To reduce the formation of efflorescence, the skyward facing joints of the center pier and abutments should be repointed. Seasonal variations in the water level of the canal are difficult to control and will continue to result in the lower courses of stone to remain saturated.
B2011	Exterior Wall Construction	Remnants of steel gears and existing embedded iron bars and plate washers.	Ferrous Metal Anchors: Clean and treat existing steel gears, bearing plates, and bolts with rust inhibiting paint to prevent deterioration resulting in corrosion. Though the steel shows no sign of section loss due to corrosion and the surrounding masonry remains intact, the rust inhibitor is recommended from a preservation perspective.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
B2011	Exterior Wall Construction	Remanants of slotted strut channel.	Remove slotted strut channel.
G1011	Clearing & Grubbing	Vegetation and lichen growth on existing masonry and from within existing mortar joints	Shrubs/ Vegetation: Clear vegetation and growth within joints of masonry to prevent further delamination and spalling of quartzitic schist cladding.
G1012	Tree Removal & Thinning	Vegetation and trees growing directly adjacent to abutments and retaining structures	Trees: Remove existing trees and vegetation growing within 10' of north abutment. Periodic maintenance will be required to control vegetation growth. (Trees and vegetation in this area were removed in December 2022 during the course of this contract.)

BOILER HOUSE

The Class C Cost for the work outlined in the matrix below is $---.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
A1011	Wall Foundations	Continuous Concrete Footer	No immediate repair needs identified. Keep base of building clear of vegetation and dried leaves.
A1011	Foundations	Concrete Footers at Fuel Storage Tank	No immediate repair needs identified.
A1032	Structural Slab on Grade	Cast-in-Place Slab, Painted	No immediate repair needs identified.
B1022	Pitched Roof Construction	Wood Framing	No immediate repair needs identified. Allowance included for localized framing repair by sistering of roof framing.
B1022	Interior Ceiling and Mechanical Support Framing	Wood Framing	Replace and/or reinforce ceiling framing which supports mechanical equipment when it is repaired or replaced. Assume replacement of ceiling joists. Remove unused mechanical equipment or shore joists until repairs or replacement is made. Assume 4 shoring posts minimum.
B2011	Exterior Wall Construction	Concrete Masonry Units	Remove cement plaster in areas and repoint walls. Patch cement plaster in areas of hairline cracking.
B2011	Exterior Wall Finish	Cement Plaster	Clean existing cement plaster finish to remove soil and lichen growth. Repaint exterior façade.
B2011	Chimney	Brick Masonry	Clean, repair, and repoint existing brick chimney. Repaint existing chimney. Assess seismic performance of chimney and develop reinforcement details if necessary.
B2021	Windows	Wood, Double Hung	Clean, repair, and restore two (2) existing wood double hung windows. Maintain existing louver with insect/ bird screen in former window openings, one located along north façade and another at the south façade. Each window masonry opening measures 36" x 55".
B2021	Window Shutters	Wood, Painted	Install wood shutters at four (4) existing windows. Each measures approx. 18" x 26".
B2032	Solid Exterior Doors	Wood, Flush	Replace existing flush wood door with solid wood six-paneled door as shown in the 1951 construction drawings. Include hardware and locking device.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
B3011	Roof Finishes	Wood Shingle	Replace cedar shingle roof due to significant lichen growth which indicates the wood shingles have remained saturated. New cedar shingle roof to be installed over skip-sheathing. Seal the cedar shingles for protection.
B3014	Flashing & Trim	Metal flashing at Chimney	Replace chimney flashing.
B3016	Gutters & Downspouts	[None]	Gutters and downspouts were not shown in the historic drawings and are not present at the structure. Gutters and downspouts should be considered as a reversible measure to manage stormwater. Costs to assume 40 LF of gutter with two (2) downspouts.
D2021	Cold Water Service	Domestic Cold Water Piping	All above ground domestic cold water piping appears to be in fair condition. The below ground domestic cold water piping was replaced in 2007. No work recommendations.
D2031	Waste Piping	Sanitary Waste Piping	All above ground sanitary and vent piping should be cleaned. All underground sanitary piping was replaced in 2007. No work recommendations.
D2033	Floor Drains	Floor Drains	It is recommended to clean all floor drains to ensure proper operation.
D3021	Boilers	400 MBH Fuel Oil Hot Water Boiler	The boiler and burner is approaching the end of its useful service life. It is recommended to replace in kind. It is also recommended to evaluate if oil boiler could be replaced with electric boiler for higher efficiencies and reduction in greenhouse emissions.
D3023	Auxiliary Equipment	50 gallon Glycol Make up feeders	The glycol make up feeders are approaching the end of their useful life. It is recommended to replace both hot water and chilled water glycol make up units, pumps, and controls to ensure proper operation and prevention of pipe freezing.
D3023	Auxiliary Equipment	1000 Gal Fuel Oil Storage Tank	The tank appears to be in good condition, however, it is recommended to replace the fuel oil pumps, valves, low level control system, and relief vents to ensure proper operation and the safety of the heating equipment.
D3052	Package Units	Vertical Hot Water Unit Heater	The hot water unit heater is approaching the end of its useful service. Replace unit heater in kind. Include manufactuerer temperature controller and two way modulating control valve.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
D3044	Hot Water Distribution	Heating Hot Water Piping	The underground piping connecting the boiler house to the tavern was replaced in 2007. No work recommendations.
D3045	Chilled Water Distribution	Chilled Water Piping	The underground piping connecting the boiler house to the tavern was replaced in 2007. No work recommendations.
D3042	Exhaust Ventilation Systems	500 CFM Centrifugal Exhaust Fan	The exhaust fan is approaching the end of its useful service life. Replace exhaust fan in kind with ECM motor. Include temperature and time controller from manufacturer.
D3045	Chilled Water Distribution	60 Gallon Chilled Water Buffer Tank	No immediate repair identified.
D3032	Direct Expansion Systems	Hot and chilled water expansion Tanks	The expansion tanks are approaching the end of their useful service life. Replace 45 gallon hot water expansion tank and replace 25 gallon chilled water expansion tank.
D3044	Hot Water Distribution	5 HP Hot Water inline pumps	The pumps are approaching the end of their useful service life. Replace pumps with new 5 HP in kind pumps. Include new VFDs and electrical disconnects per energy code.
D3045	Chilled Water Distribution	5 HP Chilled Water inline pumps	The pumps are approaching the end of their useful service life. Replace pumps with new 5 HP in kind pumps. Include new VFDs and electrical disconnects per energy code.
D3031	Chilled Water Systems	22 Ton Air cooled chiller	The chiller is approaching the end of its useful service life and the chiller should be replaced in kind with a new high efficient 22 ton chiller. Include on board controller from manufacturer.
D3061	HVAC Controls	HVAC Controls	The HVAC controls are approaching the end of their useful service life. Replace all temperature sensors, pressure gauges, differential pressure sensors and control valves with new DDC controls. Provide modulating 2-way control valves.
D4031	Fire Extinguishers	Wall mounted fire extinguisher.	Per OSHA [29 CFR 1910.157(e)(2), provide a visual inspection on portable fire extinguishers at least once per month. Provide full maintenance check on existing portable fire extinguishers once per year, according to OSHA 29 CFR 1910.157(e)(3). "Maintenance" means a thorough examination and repair, as needed, of all your facility's portable fire extinguishers, as covered in NFPA 10(98), Sec. 4-4.
D4031	Fire Suppression	Fire Suppression System	Provide a new fire suppression system to protect the structure (total building area approximately 280 SF).

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
D5012	Electrical Incoming Service	Distribution Panelboard	The Distribution Board appears to have been replaced in 2007. It appears to be in acceptable working condition and is not recommended for replacement in the near term.
D5021	Branch wiring devices	Lighting fixtures, wiring, conduit, raceways, and wiring troughs, junction boxes, light switches	Lighting equipment and fixtures are older and it is not clear if they comply with current safety standards. MC cable is used for motors and should be replaced with LFMC.
D5022	Interior Lighting	Linear florescent light fixtures	Provide new utility lighting per code. Assume cost per SF of building (total building area approximately 220 SF).
D5038	Security & Detection Systems	None.	Install new security system per NPS standards.
F2010	Hazardous Materials Abatement	Asbestos containing materials; lead-containing materials, PCBs, mercury	Conduct a complete hazardous material survey and testing for the Comfort Station
G2031	Paving & Surfacing	Concrete sidewalk and landing at entry	Replace concrete paving and landing at entry. Extend to the service road located along the west façade of the building.
G2033	Exterior Steps	Concrete	Clean and repair existing concrete steps (30" wide) along north façade.
G2033	Exterior Fence	6'-0" tall stockade fence	Existing wood fence in good condition. Mid-term maintenance plan should plan for repainting and minor repairs.

COMFORT STATION

The Class C Cost for the work outlined in the matrix below is $---.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
A1011	Wall Foundations	Continuous Concrete Footer with Knee Wall	No immediate repair needs identified. Patch surface of concrete foundation walls in areas of hairline cracking.
A1032	Structural Slab on Grade	Cast-in-Place Slab, Painted	No immediate repair needs identified.
B1022	Pitched Roof Construction	Wood Framing	No immediate repair needs identified.
B2011	Exterior Wall Construction	Wood Frame with Vertical Board & Batten Siding	No immediate repair needs identified.
B2021	Windows	Wood, Hopper	Clean, repair, and restore sixteen (16) existing wood hopper windows. Each window framed opening measures 38" x 25". One new replacement window needed.
B2032	Solid Exterior Doors	5-Panel Wood, Painted	Clean, repair, and repaint existing 5-panel door. Include hardware and locking device.
B2032	Solid Exterior Doors	Flush Wood, Painted	Replace existing flush door with new 5-panel wood door, painted. Include hardware and locking device.
B2032	Solid Exterior Doors	Board & Batten Exterior Door	Clean, repair, and repaint existing board & batten door at exterior utility/ maintenance closet. Include hardware and locking device.
B3011	Roof Finishes	Wood Shingle	Replace cedar shingle roof due to significant lichen growth which indicates the wood shingles have remained saturated. New cedar shingle roof to be installed over skip-sheathing. Seal the cedar shingles for protection.
B3016	Gutters & Downspouts	Painted 6" half-round metal gutter and downspout along east roof eave	Gutters and downspouts were not shown in the historic drawings and are not present at the structure. Provide new gutters and downspouts along the west eaves of the roof as a reversible measure to manage stormwater. Costs to assume 80 LF of gutter with two (2) downspouts.
C3011	Wall Finishes to Inside Exterior Wall	Cement Plaster on Metal Lath	Repair minor cracks and repaint interior wall surface. Assume 20% of interior wall surface. Assume total Interior wall surface is approximately 1000 sf.
C3021	Floor Toppings	Concrete topping slab, painted	No immediate repair needs identified.
C3031	Ceiling Finishes	Cement Plaster on Metal Lath	Repair cracks in cement plaster finish and repaint. Total ceiling is 600 sf. Include 200 lf of crack repair

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
D2021	Cold Water Service	Hose bib in exterior closet	No work recommendations.
D2033	Floor Drains	Two (2) interior floor drains located within former restrooms	Existing floor drains appear new and free of debris.
D3044	Hot Water Distribution	Hot Water Radiator Piping located along west wall of Comfort Station	No work recommendations.
D3042	Exhaust Ventilation Systems	Air Circulator Fan	No work recommendations. Manual operated air recirculation fans are operational.
D4031	Fire Extinguishers	Wall mounted fire extinguisher.	Per OSHA [29 CFR 1910.157(e)(2), provide a visual inspection on portable fire extinguishers at least once per month. Provide full maintenance check on existing portable fire extinguishers once per year, according to OSHA 29 CFR 1910.157(e)(3). "Maintenance" means a thorough examination and repair, as needed, of all your facility's portable fire extinguishers, as covered in NFPA 10(98), Sec. 4-4.
D4031	Fire Suppression	Fire Suppression System	Provide a new fire suppression system to protect the structure (total building area approximately 600 SF).
D5022	Interior Lighting	Linear florescent light fixtures	Provide new lighting per code. Assume cost per SF of building (total building area approximately 600 SF). Provide new automatic control devices (OS Sensors) to comply with current energy code. Lighting design to be sympathetic to the historic character of the structure.
D5022	Exterior Lighting	Exterior sconce with guard	Provide new utility lighting per code. Select LED fixtures which replicate historic styles. Lighting design to be sympathetic to the historic character of the structure.
D5038	Security & Detection Systems		Install new security system per NPS standards.
F2010	Hazardous Materials Abatement	Asbestos containing materials; lead-containing materials, PCBs, mercury	Conduct a complete hazardous material survey and testing for the Comfort Station
G2031	Paving & Surfacing	Concrete sidewalk and landing at entry	Replace concrete paving and landing at entry
G2042	Retaining Walls	Low CMU retaining wall located parallel to east façade	Repair or replace the bottom course of the retaining wall where it has deteriorated.
G2041	Exterior Screen Walls	Wood posts and wood board and batten panels	Replace wood posts with pressure treated material where in contact with the concrete slab with appropriate bearing detail using galvanized post base set apart from concrete.

PUMP HOUSE

The Class C Cost for the work outlined in the matrix below is $---.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
A1011	Wall Foundations	Continuous Concrete Footer	No immediate repair needs identified
A1011	Below Grade Concrete Foundations Walls	Cast-in-Place Concrete Walls	The concrete spall at the pipe penetration at the west wall of the coagulating basin should be patched and repaired. Following the hazardous materials abatement outlined in item F2010, a structural survey and assessment should be conducted of the below grade clear well to evaluate conditions of the structural concrete retaining walls, columns, and slab.
A1032	Structural Slab on Grade	Cast-in-Place Slab, Painted	No immediate repair needs identified. Allowance included for localized patching and replacement of slab on grade associated with mechanical equipment.
B1012	Upper Floors Construction	Cast-in-Place Slab, Painted	Repair damage/ spall at concrete slab edge adjacent to ships ladder. Chip back deteriorated concrete, splice in new reinforcement and repair concrete edge. Additional allowance included for localized concrete patching.
B1012	Exterior Decking	1-1/2" x 11" (actual) wood decking on 4" x 8" (actual) wood joists	Replace wood decking above coagulation basin. Wood joists below are stable, but the wood decking is showing signs of rot. This should be addressed in the near-term to provide safe conditions for occupants to walk over the coagulation basin.
B1022	Pitched Roof Construction	Wood Framing	Roof joists have been sistered and a new sill plate has been installed. Provide 2x8 rafter ties to all rafters.
B1022	Pitched Roof Construction	Wood Roof Sheathing	Wood sheathing has been replaced. No immediate repair needs identified.
B2011	Exterior Wall Construction	Brick Masonry, Painted	Clean, repair, and repoint existing brick exterior walls, interior and exterior. Repaint existing walls, interior and exterior. Replace lintels over windows at two exterior windows at west elevation.
B2021	Windows	Wood, Double Hung	Clean, repair, and restore ten (10) existing wood double hung windows. Each window masonry opening measures 34" x 57".
B2032	Solid Exterior Doors	5-Panel Wood, Painted (First Floor)	Clean, repair, and repaint existing 5-panel door. Include hardware and locking device.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
B2032	Solid Exterior Doors	5-Panel Wood, Painted (Second Floor)	Replace existing 5-panel door in-kind. Include hardware and locking device.
B3011	Roof Finishes	Wood Shingle	Cedar shingle roof replaced in 2022.
B3014	Flashing & Trim	Glav. Metal Flashing	Galvanized metal flashing replaced with roofing replacement in 2022.
B3016	Gutters & Downspouts	None.	Gutters and downspouts were not shown in the historic drawings and are not present at the structure. Gutters and downspouts should be considered as a reversible measure to manage stormwater. Costs to assume 52 LF of gutter with two (2) downspouts.
C2011	Regular Stairs (Ships Ladder)	Wood ships ladder with galv. Metal tub railing	Replace unstable wood ships ladder treads in-kind. The railing height does not comply with code. If public access is being proposed, a code compliant railing should be installed for safety. There are pipe and tube railings with ball fittings available on the market which would allow the modification of the existing handrail, without impacting the integrity of the interior.
C3021	Floor Toppings	Concrete topping slab, painted	Clean and repaint the existing concrete floor at each level.
D2034	Sanitary Waste Equipment	Hydro-Pneumatic Steel Pressure Tank	Undergound tank appears is original to the building; however, is no longer in use. Tank should remain in place.
D2023	Domestic Water Supply Equipment	Manual isolation valves, pressure regulator, water meter, and water level.	Incoming raw water and associated water treatment and filtration accessories including but not limited to pumps, manual isolation valves, motorized agitator, water level gauge, loss of head gauge, and rate of flow gauge are orginal to the building and no longer in use. Incoming water service was terminated to the Pump House in the 1980s when water was provided to the site by WSSC. No work recommendations.
D3050	Package Units	5K Electric Unit Heater	The 5KW electric heater is in good condition. No work required.
D4031	Fire Extinguishers	Wall mounted fire extinguisher	Per OSHA [29 CFR 1910.157(e)(2), provide a visual inspection on portable fire extinguishers at least once per month. Provide full maintenance check on existing portable fire extinguishers once per year, according to OSHA 29 CFR 1910.157(e)(3). "Maintenance" means a thorough examination and repair, as needed, of all your facility's portable fire extinguishers, as covered in NFPA 10(98), Sec. 4-4.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
D4031	Fire Suppression	Fire Suppression System	Provide a new fire suppression system to protect the structure (total building area approximately 500 SF).
D5012	Electrical Incoming Service	Distribution Panelboard	The Service Entrance Distribution Board appears to have been replaced in 2007. It appears to be in acceptable working condition and is not recommended for replacement in the near term.
D5022	Lighting Equipment & Interior Lighting	Lighting fixtures, wiring, conduit, raceways, and wiring troughs, junction boxes, light switches	Lighting equipment and fixtures are older and it is not clear if they comply with current safety standards. Provide new utility lighting per code. Assume cost per SF of building (total building area approximately 500 SF).
D5022	Exterior Lighting	Exterior sconce with guard	Provide new utility lighting per code. Select LED fixtures which replicate historic styles.
D5038	Security & Detection Systems	None.	Install new security system per NPS standards.
F2010	Hazardous Materials Abatement	Asbestos containing materials; lead-containing materials, PCBs, mercury	Conduct a complete hazardous material survey and testing for the Pump House. Testing to include evaluation of contaminated water found in the Clear Well. Work to assume all water contained in the clear well needs to be pumped out and disposed of properly.
G2031	Paving & Surfacing	Concrete sidewalk and landing at entry	Replace concrete paving and landing at entry
G2033	Exteior Fence	6'-0" tall stockade fence	The existing wood fence is in good condition. A mid-term maintenance plan should plan for repainting and minor repairs.
G2042	Retaining Walls	Concrete retaining walls to cistern located east of Pump House.	Repair minor cracks along the east and west walls of the coagulating basin. Repair deteriorated concrete at pipe at north end of west wall.
G2042	Retaining Structures	Concrete slab and retaining structure at grade at west elevation	Replace concrete slab/lid of assumed below grade concrete structure.

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ENGINEER'S GARAGE

The Class C Cost for the work outlined in the matrix below is $---.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
A1011	Wall Foundations	Continuous Concrete Footer and concrete masonry knee wall.	Repair hairline cracking at the exterior CMU walls by repointing and infilling cracks.
A1032	Structural Slab on Grade	Cast-in-Place Slab	No immediate repair needs identified.
B1022	Pitched Roof Construction	Wood Framing	No immediate repair needs identified. Allowance included for localized wood framing repair with 2x8 rafter sisters
B1022	Pitched Roof Construction	Wood Roof Sheathing	No immediate repair needs identified. Allowance included for localized roof sheathing replacement with new boards.
B2011	Exterior Wall Construction	Wood Frame with Vertical Board & Batten Siding	Repair and repaint exterior siding. Replace missing portions below windows along south façade. Replace the exterior 6x6 post with appropriate base detail.
B2021	Windows	Wood, Double Hung	Clean, repair, and restore sixteen (16) existing wood double-hung windows. Each window framed opening measures 34" x 54". One (1) window along the east façade requires full replacement since a temporary access door has been installed in this location.
B2032	Solid Exterior Doors	Existing 4-lite, 3-paneled solid wood doors	Clean, repair, and repaint two (2) existing wood doors. Include hardware and locking devices.
B2032	Sectional Garage Doors	Wood, paneled garage doors	Clean, repair, and restore seven (7) existing segmented garage doors and repaint. Include hardware and locking devices.
B3011	Roof Finishes	Asphalt Shingle	The asphalt shingle roof appears to be in good condition and recently replaced. No work required.
B3016	Gutters & Downspouts	Painted "k-style" metal gutter and downspout along east roof eave	Clean the gutters and downspouts. Verify slopes and anchor attachments to the roof eave and facade.
D3052	Packaged Units	Recessed wall mounted Electric unit heater located in front office/storage.	The 5KW electric heater is in good condition. No work required.
D3042	Exhaust Ventilation Systems	Air Circulator Fan	No work recommendations. Two (2) manual operated air recirculation fans are operational.

Uniformat Level 4	Individual Sub-Elements Categories	Materials	Work Recommendation
D4031	Fire Extinguishers	Wall mounted fire extinguisher.	Per OSHA [29 CFR 1910.157(e)(2), provide a visual inspection on portable fire extinguishers at least once per month. Provide full maintenance check on existing portable fire extinguishers once per year, according to OSHA 29 CFR 1910.157(e)(3). "Maintenance" means a thorough examination and repair, as needed, of all your facility's portable fire extinguishers, as covered in NFPA 10(98), Sec. 4-4.
D4031	Fire Suppression	Fire Suppression System	Provide a new fire suppression system to protect the structure (total building area approximately 2200 SF).
D5022	Interior Lighting	Exterior sconce with guard	Provide new utility lighting per code. Assume cost per SF of building (total building area approximately 2100 SF). Lighting design to be sympathetic to the historic character of the structure.
D5022	Exterior Lighting	None.	Provide new utility lighting per code. Select LED fixtures which replicate historic styles. Lighting design to be sympathetic to the historic character of the structure.
D5022	Branch circuit wiring devices.	Exposed electrical wiring	Replace any exposed wiring not complying with wiring methods outlined the National Electrical Code.
D5037	Fire Alarm/ Security & Detection Systems	None.	Upgrade/ replace existing burglary/ fire alarm system per NPS standards.
D5037	Heat Detection Sensors	Heat detectors	Replace heat detectors, which are connected to the combined burglary/ fire alarm.
F2010	Hazardous Materials Abatement	Asbestos containing materials; lead-containing materials, PCBs, mercury	Conduct a complete hazardous material survey and testing for the Engineer's Garage
G2031	Paving & Surfacing	Asphalt and concrete sidewalk and landing at entry	Patch and repair the asphalt paving to the west of the Garage and the concrete paving at the building entrances.
G2042	Site Walls	Concrete site and retaining walls	No immediate repair needs identified. Allowance included for localized concrete patching.

Chapter 8: Requirements for Treatment Recommendations

APPLICABLE LAWS & REGULATIONS

A number of laws, regulations, and functional requirements delineate treatment and use of the historic structures in National Parks. The treatment and use of the historic structures in this report must be considered within a framework of applicable laws, agreements and policies. These mandates govern a wide range of management issues beyond the preservation, protection, and interpretation of the cultural resources, and extend to issues of visitor and staff use, safety, universal accessibility, and resiliency to natural hazards, among others. Some of these requirements may contradict or be at cross purposes with one another if they are rigidly interpreted. Any treatment must be carefully considered to ensure the historic fabric of the structure is preserved.

AUTHORIZING LEGISLATION

- The Antiquities Act of 1906
- Historic Sites, Buildings, and Antiquities Act of 1935
- National Historic Preservation Act of 1966, as amended (16 USC 470)
- Archaeological Resources Protection Act of 1979
- Executive Order 11593, "Protection and Enhancement of the Cultural Environment"
- "Curation of Federally-Owned and Administered Archaeological Collections" (36 CFR 79)
- "Protection of Historic Properties" (36 CFR 800)
- NPS Management Policies 2006 (Chapter 5)
- Director's Order 28: Cultural Resource Management (1998)
- Director's Order 28A: Archeology (2004)

SECTION 106 OF THE NATIONAL HISTORIC PRESERVATION ACT OF 1966

Section 106 of the National Historic Preservation Act (NHPA) mandates that federal agencies, such as the NPS, consider the effects of their actions on properties listed or eligible for listing on the National Register of Historic Places and allow the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment.[1] The Pivot Bridge Ruins (mile 9.92), Boiler House (mile 14.27), Comfort Station (mile 14.28), Pump House (mile 14.29), and Engineer's Garage (mile 14.35) were listed as contributing

[1] The NHPA of 1966 was last amended in 2006. A downloadable copy is located at (http://www.achp.gov/nhpa.html).

structures to the Chesapeake and Ohio National Historical Park Historic District (Additional Documentation and Boundary Increase, 2015). The district is significant nationally, statewide and locally under Criteria A, C and D. The pivot bridge structure, and these four buildings are significant under Criterion A: New Deal era recreation and conservation from Seneca to Georgetown: The CCC Program, New NPS Initiatives, and a recreational waterway, 1938-1950's. Any undertakings involving the expenditure of federal funds will be reviewed in accordance with NPS policy and federal historic preservation laws including the service-wide Programmatic Agreement Among the National Park Service (U.S. Department of the Interior), the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers for Compliance with Section 106 of the National Historic Preservation Act (2008).[2] To satisfy the requirements of Section 106, regulations have been published (36 CFR Part 800, "Protection of Historic Properties") that require, among other things, consultation with local governments, State Historic Preservation Officers, and Indian tribal representatives. They also establish criteria under which the Advisory Council may comment, but as a practical matter, the vast majority of Federal undertakings do not involve review by the Advisory Council. The point of Section 106 review is to ensure that all interested parties have a voice in the treatment of the nation's cultural heritage.

SECTION 110 OF THE NATIONAL HISTORIC PRESERVATION ACT OF 1966

Section 110 of the NHPA clarifies the broad historic preservation responsibilities of federal agencies with the intention of ensuring that historic preservation is fully integrated into the ongoing programs of all federal agencies by identifying, protecting, and avoiding unnecessary damage to historic properties. Additionally, each agency is required to use historic properties available to it and when managing these properties, must consider preservation of their historic, archaeological, architectural, and cultural values.[3]

EXECUTIVE ORDER 11593

Executive Order 11593: Protection and Enhancement of the Cultural Environment (1971) mandates that "the Federal Government shall provide leadership in preserving, restoring, and maintaining the historic and cultural environment of the Nation."[4] Responsibilities of federal agencies include:

2 A copy of this agreement can be found on the NPS's website at (http://www.nps.gov/policy/106agreement.pdf).
3 More information on Section 110 can be found on the NPS's website at (http://www.nps.gov/hps/fapa_110.htm).
4 A copy of this E.O. can be found on the NPS's website at (http://www. nps.gov/history/history/online_books/anps/anps_7b.htm).

- Nominating "...to the Secretary of the Interior all sites, buildings, districts, and objects under their jurisdiction of the control that appear to qualify for listing on the National Register of Historic Places."

- Exert caution "...during the interim period until inventories and evaluation...are completed to assure that any federally owned property that might qualify for nomination is not inadvertently transferred, sold, demolished, or substantially altered."

- "Initiate measures to assure that where as a result of Federal action or assistance a property listed on the National Register of Historic Places is to be substantially altered or demolished, timely steps be taken to make or have made records, including measured drawings, photographs, and maps, of the property, and that copy of such records then be deposited in the Library of Congress as part of the Historic American Buildings Survey or Historic American Engineering Record for future use and reference."

- "Initiate measures and procedures to provide for the maintenance, through preservation, rehabilitation, or restoration, of federally owned and registered sites professional standards prescribed by the Secretary of the Interior."

EXECUTIVE ORDER 13006

Executive Order 13006: Locating Federal Facilities on Historic Properties (1996) mandates that "the Federal Government shall utilize and maintain, wherever operationally appropriate and economically prudent, historic properties and districts...". Furthermore, "any rehabilitation or construction that is undertaken pursuant to this order must be architecturally compatible with the character of the surrounding historic district or properties."

THE SECRETARY OF THE INTERIOR'S STANDARDS FOR THE TREATMENT OF HISTORIC PROPERTIES

The Secretary of the Interior's Standards for the Treatment of Historic Properties (Standards) provide a philosophy to underpin historic preservation that is widely understood and almost universally accepted in the United States. By separate regulation, the Secretary has required the application of the Standards in certain programs that the Secretary administers through the National Park Service. They have also been widely adopted by state and local governments and the private sector, and are intended to be applied to a wide variety of resource types, including

buildings, sites, structures, objects, and districts. The Standards, revised in 1992, are codified as 36 CFR Part 68 in the 12 July 1995 Federal Register (Vol. 60, No. 133). The revision replaced the 1978 and 1983 versions of 36 CFR 68 entitled "The Secretary of the Interior's Standards for the Treatment of Historic Properties". The Standards are neither technical nor prescriptive, but are intended to promote responsible preservation practices that help protect the nation's irreplaceable cultural resources. For example, they cannot, in and of themselves, be used to make essential decisions about which features of the historic building should be saved and which can be changed. But once a treatment is selected, the Standards provide philosophical consistency to the work.

The Standards describe four broad approaches to the treatment and use of historic properties. These are, in hierarchical order:

- **Preservation**, which places a high premium on the retention of all historic fabric through conservation, maintenance, and repair. It reflects a building's continuum over time, through successive occupancies, and the respectful changes and alterations that are made.

- **Rehabilitation**, which emphasizes the retention and repair of historic materials, but provides more latitude for replacement because it is assumed the property is more deteriorated prior to work. (Both Preservation and Rehabilitation standards focus attention on the preservation of those materials, features, finishes, a property its historic character.)

- **Restoration**, which focuses on the retention of materials from the most significant time in a property's history, while permitting the removal of materials from other periods.

- **Reconstruction**, which establishes limited opportunities to re-create a non-surviving site, landscape, building, structure, or object in all new materials.

Regardless of treatment approach, the Standards put a high priority on the preservation of existing historic materials and not just the architectural form and style. The Standards also require that any alterations, additions, or other modifications be reversible. For example, additions must be designed and constructed in such a way that they can be removed or reversed in the future

without the loss of existing historic materials, features, or character. As noted previously, rehabilitation has been identified as the most appropriate overall approach to the treatment of the Boiler House, Comfort Station, Pump House,and Engineer's Garage. Preservation is the recommended approach to the treatment of the Pivot Bridge Ruins.

DIRECTOR'S ORDER 28

Also circumscribing treatment and use of historic properties in the National Park Service is Director's Order 28 (DO-28), Cultural Resource Management Guideline. It requires that the NPS plan for the protection of cultural resources and reinforces the requirement to use existing buildings for NPS purposes. In Chapter 8, "Management of Historic and Prehistoric Structures," observes that "the primary preservation issue…is the compatibility of the use with the structure." DO-28 also requires that no historic structure be rehabilitated or restored without an appropriate historic structure report.

DO-28 Cultural Resource Management Guideline is intended to guide the National Park Service through successful cultural resource management through three steps:

- Research: "identify, evaluate, document, register, and establish other basic information about cultural resources;"

- Planning: "ensure that this information is well integrated into management processes for making decisions and setting priorities;" and

- Stewardship: "planning decisions are carried out and resources are preserved, protected, and interpreted to the public."

Through the development of this HSR, the research and planning (for treatment and use) of this historic building is addressed. The general preservation philosophy integrated into this HSR is best represented by the following: "Better to preserve than to repair, better repair than restore, better restore than [re]construct. It is ordinarily better to retain genuine old work of several periods, rather than arbitrarily to 'restore' the whole, by new work, to its aspect at a single period."

The demolition of a structure listed or eligible for listing on the National Register is allowable "only when all alternatives have been determined infeasible in the planning process."

Decisions for the future stewardship of the Pivot Bridge Ruins, Boiler House, Comfort Station, Pump House, and Engineer's Garage are under the purview of CHOH. As part of DO-28, stewardship focuses on five major activities:

- Control of treatment and use,
- Monitoring conditions of deterioration and structural failure,
- Protecting from human and environmental threats,
- Retaining or delegating responsibility for structures, and
- Developing the skills, knowledge, and attitudes needed to support the program.

DO-28 provides standards for each of the SOI's Standards. Preservation sustains the existing form, integrity, and materials of a historic property. Work generally focuses the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. Sensitive upgrading of systems to ensure the long-term functionality and code-compliance of a property is appropriate within a preservation project. The following standards based on the Secretary's Standards apply:

- A property will be used as it was historically, or be given a new use that maximizes the retention of distinctive materials, features, spaces and spatial relationships. Where a treatment and use have not been identified, a property will be protected and, if necessary, stabilized until additional work may be under-taken.
- The historic character of a property will be retained and preserved. The replacement of intact or repairable historic materials or alteration of features, spaces and spatial relationships that characterize a property will be avoided.
- Each property will be recognized as a physical record of its time, place and use. Work needed to stabilize, consolidate and conserve existing historic materials and features will be physically and visually compatible, identifiable upon close inspection and properly documented for future research.
- Changes to a property that have acquired historic significance in their own right will be retained and preserved.

- Distinctive materials, features, finishes and construction techniques or examples of craftsmanship that characterize a property will be preserved.
- The existing condition of historic features will be evaluated to determine the appropriate level of intervention needed. Where the severity of deterioration requires repair or limited replacement of a distinctive feature, the new material will match the old in composition, design, color and texture.
- Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.
- Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.

The following additional standards apply to all treatments:

- Use is monitored and regulated to minimize both immediate and long-term damage.
- Use of destructive techniques, such as archeological excavation, is limited to providing sufficient information for research, interpretation, and management needs.
- All work that may affect resources is evaluated by an historical architect and other professionals, as appropriate.
- All modification, repair, or replacement of materials and features is preceded by sufficient study and recording to protect research and interpretive values.
- New work, materials, and replacement features are identified, documented, or permanently marked in an unobtrusive manner to distinguish them from original work, materials, and features. The manner and location of identification is recorded using the Inventory and Condition Assessment Program (ICAP).
- A proposed treatment project is initiated by the appropriate programming document, including a scope of work and cost estimate from an HSR or ICAP. Such projects include preservation maintenance as well as major treatment. No treatment is undertaken without an approved HSR or work procedure documenting the work, and Section 106 compliance.
- A treatment project is directed by a historical architect and performed by qualified technicians.

- Representative features salvaged from a historic structure are accessioned and cataloged, provided that they fall within the park's scope of collection statement.
- All changes made during treatment are graphically documented with drawings and photographs. Records of treatment are managed as archival materials by a curator or archivist within the park's museum collection.

AMERICANS WITH DISABILITIES ACT OF 1990

The Americans with Disabilities Act of 1990 (ADA) establishes comprehensive civil rights protection for disabled Americans, both in employment and in their right to free, unaided access to public buildings. While people with restricted mobility have most frequently benefited from ADA, protection also extends to those with other disabilities, including those with impaired vision or hearing. Requirements for full compliance with ADA regulations are extensive and easiest to apply to new construction. Full compliance for historic buildings is more difficult and sometimes would require significant alterations to the historic character of the property. Where that is the case, ADA authorizes a process for arriving at alternatives to full compliance that can preserve historic character while maximizing a disabled visitor's access to the historic building.

ARCHITECTURAL BARRIERS ACT (ABA)

Standards issued under the Architectural Barriers Accessibility Act (ABA) apply to facilities designed, built, altered, or leased with certain federal funds. Passed in 1968, the ABA is one of the first laws to address access to the built environment. The law applies to federal buildings, including post offices, social security offices, federal courthouses and prisons, and national parks. Coverage is limited to those funding programs that give the federal agency awarding grants or loans the authority to establish facility standards. Deficiencies may exist, but ADA or ABA compliance is not the focus of this HSR.

The scope of this Historic Structure Report assumed the existing structures would be maintained in their current uses and alternate use and treatment options were not developed. As such, the existing site, landscape, and structures were not evaluated for their compliance with the Architectural Barriers Act Accessibility Standard (ABAAS).

However, given the historic character of the site and these structures being listed as contributing to the National Register listing for the C&O Canal,

there may be exceptions granted for these structures. Specific exceptions are listed in section F203 which includes machinery spaces and animal containment areas. These exceptions would likely apply to the Boiler House and portions of the Engineer's Garage respectively. Accessibility compliance is not feasible at the Pivot Bridge Ruins, except for visual observation from the adjacent towpath. Accessibility should be considered carefully for the Comfort Station, portions of the Pump House, and the work areas of the Engineer's Garage. Each case will need to be considered separately and evaluated to determine potential impacts to the historic fabric and character defining features of each structure.

HAZARDOUS MATERIALS

The contracted Scope of Services did not include a hazardous materials consultant to provide survey and testing at the existing structures. However, given the age and function of the historic structures, including the Pivot Bridge Ruins, the Boiler House, the Comfort Station, the Pump House, and the Engineer's Garage, there is a high likelihood that hazardous materials exist at these structures. For management and ongoing use and occupancy of these structures, NPS should make informed decisions knowing these hazardous materials likely exist and have not been properly abated or encapsulated. The A/E Consulting Team strongly recommends that sampling and testing be completed at all structures in the near future as it is possible lead-based paint, asbestos-containing materials (i.e. tile, caulk, pipe insulation), PCB, and mercury would be identified.

In addition to a hazardous materials survey to assess the building materials, it is highly recommended that NPS test the water held in the clear wall of the Pump House for contamination. Though the clear well was not accessible for survey, observation was made from floor openings above where the original pumps had been removed. Water containing a foul smelling green substance was observed which needs to be evaluated as soon as possible to protect the health, safety, and welfare of NPS staff and any visitors to the building. Until this is further evaluated, access to the building should be strictly limited.

NATIONAL PARK SERVICE MANAGEMENT POLICIES

The NPS General Management Policies (2006) guide overall management of historic properties, especially Chapter 5, “Cultural Resource Management.” Based upon the authority of some nineteen Acts of Congress and many more Executive Orders and regulations, these policies require planning to ensure that management processes for making decisions and setting priorities

integrate information about cultural resources, and provide for consultation and collaboration with outside entities.

These policies also support good stewardship to ensure that cultural resources are preserved and protected, receive appropriate treatments (including maintenance), and are made available for public understanding and enjoyment. Chapter 5 of the NPS Policies Manual describes Cultural Resources Management as the following:

> "The Service's cultural resource management program involves research to identify, evaluate, document, register, and establish basic information about cultural resources and traditionally associated peoples; planning to ensure that management processes for making decisions and setting priorities integrate information about cultural resources and provide for consultation and collaboration with outside entities; and stewardship to ensure that cultural resources are preserved and protected, receive appropriate treatments (including maintenance) to achieve desired conditions, and are made available for public understanding and enjoyment." (Official U.S. Government edition 0-16-076874-8 ISBN for U.S. Government Printing Office)

The appearance and condition of resources before treatment, and changes made during treatment, will be documented. Such documentation will be shared with any appropriate state or tribal historic preservation office or certified local government, and added to the park museum cataloging system. Pending treatment decisions reached through the planning process, all resources will be protected and preserved in their existing states. The management policies lay out rules for use of historic properties under the control of the National Park Service. Again, Chapter 5 of the NPS Policies Manual directs that:

> "compatible uses for structures will be found whenever possible [to] help prevent the accelerated deterioration of historic structures due to neglect and vandalism," but goes on to warn against uses of structures that would "threaten the…character of a structure…or that would entail alterations that would significantly compromise its integrity."

FOUNDATION DOCUMENT

PURPOSE STATEMENT

A Foundation Document was prepared for the CHOH in July 2013. It identifies fundamental resources and values associated with the park as well as the park significance and interpretive themes. Preparation of the Foundation Document included an assessment of planning and data needs, other important resources, and identification of key park-wide and major issues. All of these were prioritized and connected with stewardship priorities.

The Purpose Statement for the park reinforces the foundation for future park management and use decisions. It was drafted through careful analysis of the enabling legislation and legislative history that influenced its development. This unit was designated on January 8, 1971 when the initial enabling legislation was signed into law. The following is the Purpose Statement for the CHOH, of which Great Falls Tavern is a part:

> *To preserve and interpret the 19th-century transportation canal from Washington, DC, to Cumberland, Maryland, and its associated scenic, natural, and cultural resources, and to provide opportunities for education and appropriate outdoor recreation.*

The Great Falls Tavern area is amongst the Fundamental Resources and Values identified in the Foundation Document. The structures and landscape of the Great Falls Tavern area are specifically identified under the Historic Districts-Historic Structures-Archaeology section. In addition, Scenic Views Including Great Falls and Potomac Gorge are also identified amongst the Fundamental Resources and Values.

PARK SIGNIFICANCE

Significance expresses why resources are important enough to merit National Park unit designation. Statements of significance describe why an area is significant with a global, national, regional, and system-wide context. These statements are linked to the purpose of the park unit and are supported by data, research and consensus. The Great Falls Tavern area is one section along the 184.5 mile long canal, but it contains an unusual number of historic and natural resources and is one of the most intensively used areas of the canal. Although the structures that are the subjects of this report are not specifically called out in the Park Significance Statements, as historic buildings that also support the activities of the Great Falls Tavern area,

they are integral to nearly all of the Foundation Document's significance statements:

1. The Chesapeake and Ohio Canal National Historical Park preserves and interprets 19th century canal transportation, civil engineering technology, and the evolution of a flat water transportation system in support of the industrial growth of the nation.

2. The Chesapeake and Ohio Canal National Historical Park contains more than 1,300 historic structures, including one of the largest collections of 19th century canal features and buildings in the national park system.

3. The Chesapeake and Ohio Canal National Historical Park preserves archeological evidence of 13,000 years of human habitation along the Potomac River.

4. Through preservation efforts that began in the 1950s, the Chesapeake and Ohio Canal National Historical Park towpath was transformed into one of the most heavily used recreational trails in the nation and serves as the backbone for national and regional trail systems.

5. The Chesapeake and Ohio Canal National Historical Park provides diverse recreational opportunities for millions of visitors annually, including numerous access points to the Potomac River, ranging from urban to rural settings.

6. The 15-mile-long Potomac Gorge, managed in part by the Chesapeake and Ohio Canal National Historical Park, is one of the most biologically diverse natural areas in the national park system.

7. Paralleling the Potomac River for 184.5 miles and travelling through four physiographic provinces, Chesapeake and Ohio Canal National Historical Park provides a natural buffer of forest, woodlands, prairies, and barrens and a wildlife corridor along the second-largest tributary to the Chesapeake Bay.

8. Interpretive and educational opportunities engage a diverse cross section of urban and rural communities along the length of the Chesapeake and Ohio Canal National Historical Park and were envisioned in the park's enabling legislation. Living history events, school programming, canal operations demonstrations, and a nationally renowned Canal Quarters program offer visitors the opportunity to experience different eras of the canal's existence.

BUILDING CODE SUMMARY

Both NPS policies and federal regulations stipulate that when a historic structure is preserved and/or rehabilitated, attempts should be made to meet applicable nationally-accepted model building codes to the maximum extent feasible. Compliance with nationally accepted codes does not automatically trigger a complete code-based upgrade. Alternative criteria exist for alterations to historic structures which typically encourage flexibility in the literal application of the code intent. The Public Buildings Amendment of 1988 instructs Federal agencies to follow "to the maximum extent feasible," as determined by the administrator or head of the agency, the "…nationally recognized model building codes and other applicable nationally recognized codes such as electrical codes, and fire and life safety codes." The NPS consults pertinent national, state, and local codes, and typically adheres to the most strident code requirements. The NPS National Capital Regional Office Structural Fire Officer is the Authority Having Jurisdiction (AHJ) for final determination of code applications for these structures.

The NPS has prepared Design Standards for all construction projects, including those affecting historic structures. The design standard presents all codes that should be reviewed and includes the most recent copies of the following major codes and applicable laws, policies, codes, directives, standards, and NPS guide lines. The design standards present requirements for accessibility, civil, and environmental engineering, landscape architecture, architecture, including roofing and waterproofing, structural, mechanical, safety and fire protection, electrical, lighting,and sustainability disciplines. The recommendations in this document are in accordance with the International Code Council (ICC) Model Codes and Standards, 2018 editions and the NFPA National Fire Codes, including but not limited to the following:

BUILDING

- 2018 ICC International Building Code (IBC);
- 2018 ICC International Existing Building Code (IEBC);
- ANSI/ASSEZ117.1, Safety Requirements for Confined Spaces;
- 2018 NFPA Life Safety Code (NFPA 101) – the most restrictive

MECHANICAL

- 2018 ICC International Mechanical Code (IMC)

PLUMBING:

- 2018 ICC International Plumbing Code (lPC)

FIRE

- 2018 ICC International Fire Code (lFC);

- National Fire Protection Association (NFPA) Codes, Including Annexes (except NFPA 5000)

ENERGY

- 2018 ICC International Energy Conservation Code (IECC) FUEL GAS
- 2018 ICC International Fuel Gas Code (lFUGC)

OTHER LOCAL CODES AND LOCAL UTILITY GUIDELINES, CODES, REGULATIONS:

- National Fire Protection Association (NFPA) 70, 2020 National Electrical Code (NEC)
- Building Construction and Safety Code (NFPA 5000)
- Installation of Lightning Protection Systems (NFPA 780)
- Code for the Protection of Cultural Resource Properties (NFPA 909)
- Code for the Fire Protection of Historic Structures (NFPA 914)
- Safeguarding Construction, Alteration, and Demolition Operations (NFPA 241)

FEDERAL GOVERNMENT LEGISLATION, REGULATIONS, STANDARDS AND GUIDELINES

- 2004 Architectural Barriers Act and ABAAS Guidelines
- Americans with Disabilities Act (ADA) 2010 Design Guidelines
- ANSI A117.1 2003
- Uniform Federal Accessibility Standards (UFAS)
- Occupational Safety and Health Administration (OSHA)
- The authority having jurisdiction (AHJ) for the National Capitol Region is James King, Branch Chief Fire and Emergency Management.
- ASCE 7-16 Minimum Design Loads (and Associated Criteria) for Buildings and Other Structures
- ACI 318-14 Building Code Requirements for Structural Concrete
- ACI 530-16 Building Code Requirements for Masonry Structures
- NDS-2018 National Design Specification (NDS) for Wood Construction
- National Historic Preservation Act of 1966 (NHPA), amended
- The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings (36 CFR 68), 1995
- The Secretary of the Interior's Standards for the Treatment of Historic Properties and the Guidelines for the Treatment of Cultural Landscapes

- The Secretary of the Interior's Standards and Guidelines for Archeological Documentation
- The Secretary of the Interior's Guidelines on Flood Adaptation for Rehabilitating Historic Buildings
- Uniform Code for Building Conservation
- Building Construction and Safety Code (NFPA 5000)
- Director's Order (DO) 50B, Risk Management (Manual 50B)
- Director's Order (DO) 58, Structural Fire Management (Manual 58)
- 5 U.S.C § 7902 (Safety Program)
- 15 U.S.C § 2225 (Fire Prevention and Control)
- 29 U.S.C § 668 (Occupational Safety and Health)
- 40 U.S.C § 619 (Construction, Alteration, and Acquisition of Public Buildings)

INTERNATIONAL BUILDING CODE

Building codes are generally applicable to all buildings whether they are historic or not. As a matter of policy, the NPS and the State of Maryland are guided by the International Building Code (IBC), which includes this statement regarding codes and historic buildings:

> **3406.1** Historic Buildings. The provisions of this code related to the construction, repair, alteration, addition, restoration and movement of structures, and change of occupancy shall not be mandatory for historic buildings where such buildings are judged by the building official to not constitute a distinct life safety hazard [emphasis added].

Threats to public health and safety should always be eliminated. Currently, the conditions present at the Pivot Bridge, Boiler House, Comfort Station, Pump House, and Engineer's Garage do not constitute an immediate threat to life safety.

NFPA CODES

The National Fire Protection Association (NFPA) has promulgated codes that include theater and assembly uses. These include: NFPA 1, Uniform Fire Code, NFPA 101, Life Safety Code, and NFPA 5000, Building Construction and Safety Code. NFPA 914, "Code for Fire Protection of Historic Structures," may also be applicable.

NFPA CODE 914

The National Fire Protection Association (NFPA) has promulgated codes for historic buildings, most notably NFPA 909, "Code for the Protection of Cultural Resources Properties - Museums, Libraries, and Places of Worship," and NFPA 914, "Code for Fire Protection of Historic Structures."

NPS mandates that projects with PreDesign (PD) starting October 1, 2018 or later require compliance with the codes listed below per Department of Interior (DOI) Standards.

- IBC 2018, with Appendices (International Building Code)
- IEBC 2018, with Appendices (International Existing Building Code)
- NFPA 101 Life Safety Code (National Fire Protection Association) - Use when IBC is silent.
- NPS Structural Fire Reference Manual 58.

EXISTING CODE COMPLIANCE

Pivot Bridge Ruins

As the foundation remains of a former bridge, this structure is not subject to the IBC.

Boiler House

The Boiler House does not contain any fire protection systems (fire alarm or fire suppression) as the building is a normally, non-occupied utility (Use Group "U" per IBC) building. An automatic sprinkler system or an addressable fire alarm system are not required by the building code for this building based on occupancy classification and size of building; however, other DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

Comfort Station

The Comfort Station has been converted into a shed to store bicycles. This serves as a Low-hazard Storage Occupancy (S-2 per the IBC). The building is not equipped with any type of fire protection systems (fire alarm or fire suppression) and one is not required; however, other DOI and NPS

requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

Pump House

The Pump House does not contain any fire protection systems (fire alarm or fire suppression). Again, the building is normally non-occupied and is a Use Group "U" per the IBC. No fire protection systems are required for this building based on its use; however, other DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

Engineer's Garage

The Engineer's Garage is a combination of a private garage and livestock shelter and stable. This type of use directly relates to occupancy classification of Utility and Miscellaneous Group "U" per the IBC. The building does not have any type of fire suppression system; however, the building is provided with heat detectors in each bay of the shelter/garage. No fire protection systems are required for this building based on its use, however; other DOI and NPS requirements recommend fire protection systems for historic structures whether rehabilitation occurs or not. The use and size of the building and availability of utilities, particularly water, may make sprinklering difficult. These challenges will need to be evaluated when considering the feasibility of installing a fire suppression system during future design phases.

STRUCTURAL ANALYSIS

A preliminary structural analysis was performed to understand the structural capacity of existing elements and compliance with the building code. Preliminary analysis included roof rafters at the Boiler House, Pump House, Comfort Station, and the Engineer's Garage. This structural analysis is not meant to be a comprehensive assessment, but is meant to inform future design projects involving restoration or alteration.

Elements were analyzed based on the field measurements where available and supplemented with sizes shown on existing drawings when members could not be measured.

MATERIAL PROPERTIES

Material properties were assumed as follows based on the age of construction. Before the design of repairs, reinforcement, or replacement, material properties should be further refined through material testing and/or additional probes.

Wood Framing (assumed properties):

- Spruce-Pine-Fir No. 1
- Fb = 875 psi
- Fv = 135 psi

Concrete Framing assumed properties):

- Normal-weight concrete
- F'c = 2,500 - 3,000 psi

DESIGN LOADS

Preliminary analysis of the roofs included the following design assumptions, aligning with the 2018 International Building Code (IBC), referencing ASCE 7-16.

Boiler House: Assumed Risk Category II

- Dead load: 12 psf
- Sloped roof snow load: 21 psf
- Roof live load: 20 psf

Comfort Station: Assumed Risk Category I

- Dead load: 12 psf
- Sloped roof snow load: 17 psf
- Roof live load: 20 psf

Pump House: Assumed Risk Category II

- Dead load: 15 psf
- Sloped roof snow load: 21 psf
- Roof live load: 20 psf

Engineer's Garage: Assumed Risk Category I

- Dead load: 12 psf
- Sloped roof snow load: 17 psf
- Roof live load: 20 psf

ANALYSIS RESULTS

Preliminary analysis of the roof structures shows that the roofs have adequate capacity for the current IBC snow, live load, and current dead loading. However, the Pump House roof thrust is currently resolved through an unconventional load path that should be further investigated or modified. If heavier roofing assemblies or additional design loads (such as ceilings, attic storage, or mechanical loading) will be introduced, the roof and ceiling assemblies should be assessed for new loading.

The concrete framing at the Pump House was not analyzed due to a lack of information on existing reinforcement layout. To understand the load capacity of the framed floor of the Pump House, additional information is needed from original drawings (to date no reinforcement drawings have been found) or through ground penetrating radar scanning or probe work to measure the size and spacing of existing reinforcement.

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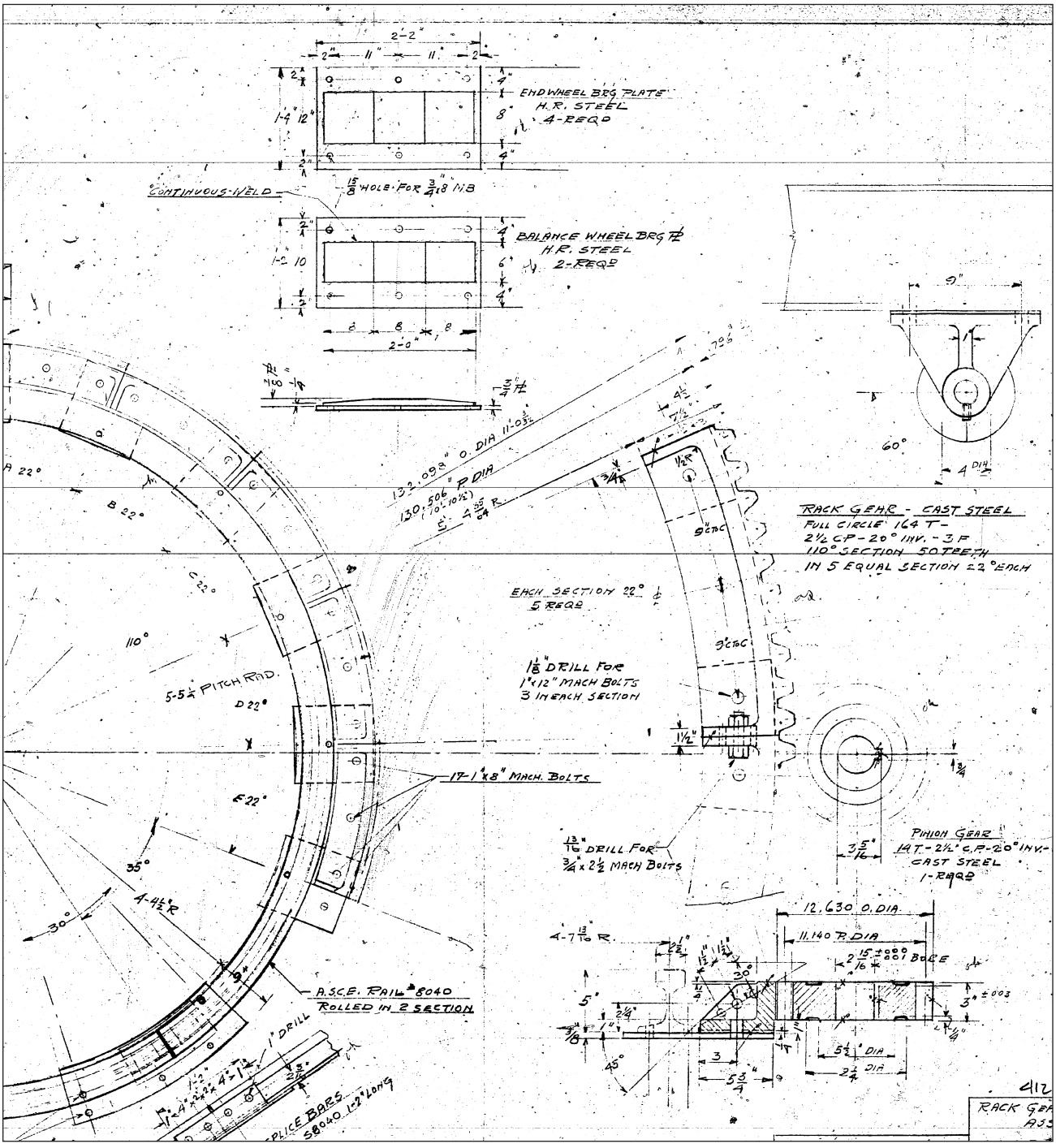

Part III: Documentation

Chapter 9: Photographs
Chapter 10: Existing Conditions Drawings

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Chapter 9: Photographs

PIVOT BRIDGE RUINS (MILE 9.92)

Figure 246. Pivot Bridge Ruins: North abutment, west face.

Figure 247. Pivot Bridge Ruins: North abutment, south face.

Figure 248. Pivot Bridge Ruins: North abutment, east face.

Figure 249. Pivot Bridge Ruins: South abutment, east face.

Figure 250. Pivot Bridge Ruins: South abutment, north face.

Figure 251. Pivot Bridge Ruins: South abutment, west face.

Figure 252. Pivot Bridge Ruins: Central pier, north face.

Figure 253. Pivot Bridge Ruins: Central pier, east face.

Figure 254. Pivot Bridge Ruins: Central pier, south face.

Figure 255. Pivot Bridge Ruins: Central pier, west face.

Figure 256. Pivot Bridge Ruins: Inscription on south face of central pier.

Figure 257. (Left) Pivot Bridge Ruins: Anchor bolt, nut, and plate.
Figure 258. (Right) Pivot Bridge Ruins: steel rod and washers.

Figure 259. Pivot Bridge Ruins: Anchor bolts, nuts, and washers along top of south abutment..

Figure 260. Pivot Bridge Ruins: Bearing plate at central pier.

Figure 261. Pivot Bridge Ruins: pivot bridge rail, gears, and bearing plates at top of central pier.

Figure 262. (Left) Pivot Bridge Ruins: Center pier, pivot bridge rail, gears, and bearing plate.
Figure 263. (Right) Pivot Bridge Ruins: Center pier, pivot bridge bearing plate.

Figure 264. (Left) Pivot Bridge Ruins: Bearing plates at north abutment.
Figure 265. (Right) Pivot Bridge Ruins: Swing stop at south abutment

Figure 266. (Left) Pivot Bridge Ruins: Bearing plate at south abutment adjacent to swing stop.
Figure 267. (Right) Pivot Bridge Ruins: Bearing plate at south abutment.

Figure 268. Pivot Bridge Ruins: View of Pivot Bridge Ruins from southeast.

BOILER HOUSE (MILE 14.27)

Figure 269. Boiler House: View of Boiler House from access road, southwest.

Figure 270. (Left) Boiler House: View of Boiler House from access road, northwest.
Figure 271. (Right) North wall of Boiler House; Historic entry door has been replaced with flush wood door.

Figure 272. Boiler House: Figure Carrier 22-ton Aquasnap air cooled chiller located south of the Pump House.

Figure 273. (Left) Boiler House: Water lines connecting the chiller lines to the interior equipment.
Figure 274. (Right) Boiler House: Water lines connecting the chiller lines to the interior equipment.

Figure 275. (Left) Boiler House: Figure Window 204 located along the west facade.
Figure 276. (Right) Boiler House: Original double hung wood window 203 removed in 2007 to install mechanical louver.

Figure 277. Boiler House: Fuel oil storage tank located east of Boiler House.

Figure 278. Boiler House: Fuel oil storage tank fuel port and leak detector panel.

Figure 279. Boiler House: Exterior concrete slab at north entry door.

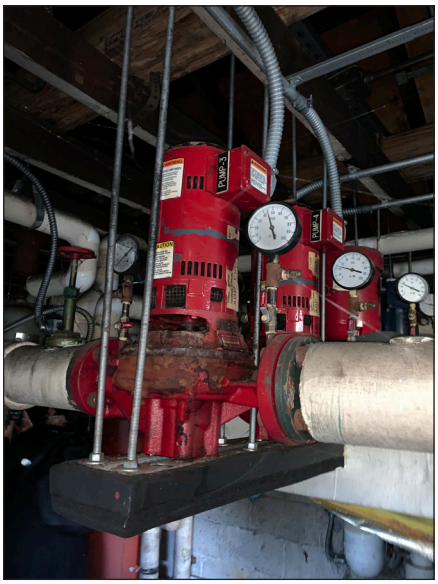

Figure 280. (Left) Boiler House: Smith diesel hot water boiler at the interior of the Boiler House.
Figure 281. (Right) Boiler House: Four inline Bell and Gossett pumps are installed in the Boiler House. Pumps 1 and 2 (P-1 and P-2) serve the chilled water system and pumps 3 and 4 (P-3 and P-4) serve the hot water system.

Figure 282. (Left) Boiler House: Hot water unit heater was installed to heat the boiler house. Heating hot water and chilled water distribution piping enters a pit and is distributed underground.
Figure 283. (Right) Boiler House: Cemline chilled water buffer tank and Bell and Gossett expansion tanks for the hot water and chilled water systems.

Figure 284. (Left) Boiler House: Glycol feed systems are installed to pump glycol to both the hot water and chilled water systems to avoid pipes from freezing.

Figure 285. (Left) Boiler House: The boiler flue gas is ducted and exhausted up through the chimney.
Figure 286. (Right) Boiler House: Chimney flue cleanout.

Figure 287. (Left) Boiler House: Each pump has a wall mounted combination motor started and disconnect switch.
Figure 288. (Right) Boiler House: Panelboard along west wall of Boiler House.

Figure 289. (Left) Boiler House: The boiler house is ventilated by an exhaust fan and an outdoor air intake louver. The outside air intake louver also provides combustion air for the diesel boiler outside.

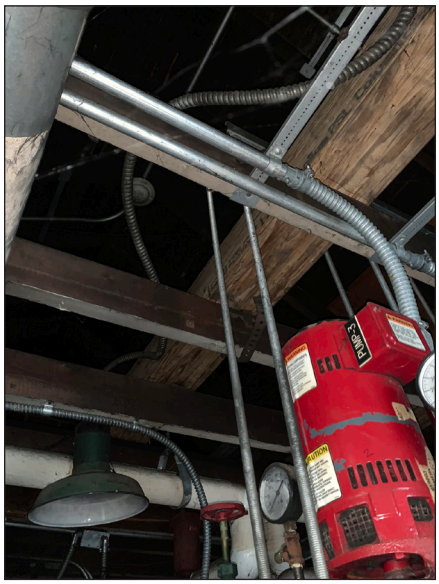

Figure 290. (Left) Boiler House: Interior view of ceiling and roof framing at Boiler House, including LVL beams laid across ceiling ties.
Figure 291. (Right) Boiler House: Interior view of ceiling and roof framing at Boiler House, including LVL beams laid across ceiling ties.

COMFORT STATION (MILE 14.28)

Figure 292. Comfort Station: South facade.

Figure 293. Comfort Station: West facade

Figure 294. Comfort Station: View of Comfort Station from northeast. Great Falls Tavern is seen in the background.

Figure 295. Comfort Station: View of Comfort Station from southeast.

Figure 296. (Left) Comfort Station: South entry into Comfort Station.
Figure 297. (Right) Comfort Station: Portion of privacy screen outside of north entry.

Figure 298. Comfort Station: View of southwest corner of Comfort Station.

Figure 299. (Left) Comfort Station: South entry door into Comfort Station
Figure 300. (Right) Comfort Station: Broken and displaced concrete landing and walkway outside south entry door

Figure 301. (Left) Comfort Station: North entry door.
Figure 302. (Right) Comfort Station: Original vertical board and batten door at utility closet.

Figure 303. (Left) Comfort Station: Exterior aluminum storm window installed at exterior of historic wood hopper window, typical.
Figure 304. (Right) Comfort Station: Interior view of historic wood hopper window, typical.

Figure 305. Comfort Station: Storage of bicycles in former women's restroom.

Figure 306. Comfort Station: Storage of bicycles in former women's restroom.

Figure 307. Comfort Station: Storage of bicycles and workbenches in former men's restroom.

Figure 308. Comfort Station: Radiator piping along west wall of former men's restroom. Original built-in urinals concealed behind wall built below workbench when restroom was re-purposed for storage in 2007.

Figure 309. Comfort Station: Existing interior floor drain, typical.

Figure 310. (Left) Comfort Station: View of utility closet at northwest corner of Comfort Station; Original sink removed and replaced with hose bibb.

Figure 311. (Right) Comfort Station: Electrical panels located within utility closet at Comfort Station.

Figure 312. Comfort Station: Access panel in ceiling of former men's restoom at the Comfort Station.

Figure 313. Comfort Station: View of wood roof rafters above Comfort Station.

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PUMP HOUSE (MILE 14.29)

Figure 314. Pump House: Southwest view of Pump House from the access road. Electrical raceway and wireway present along west facade.

Figure 315. Pump House: Northwest view of Pump House from the access road.

Figure 316. Pump House: East view of Pump House from the decking installed over the coagulation basin.

Figure 317. (Left) Pump House: Wood decking installed over the coagulation basin.
Figure 318. (Right, top) Pump House: Concrete bridge and step connecting Operating gallery to coagulation basin.
Figure 319. (Right, bottom) Pump House: Cast iron raw water line connecting weir to the holding tank of the iron wash trough and sand filtration chamber.

Figure 320. (Left) Pump House: Filtered water line connecting clear well to pressurized tank located east of the coagulating basin.
Figure 321. (Right) Pump House: Concrete platform supporting the motor for the agitation chambers.

Figure 322. Pump House: North view of the Pump House; Fence enclosure around the coagulation basin seen on the left; Roof over the raw water pump pit located in the foreground.

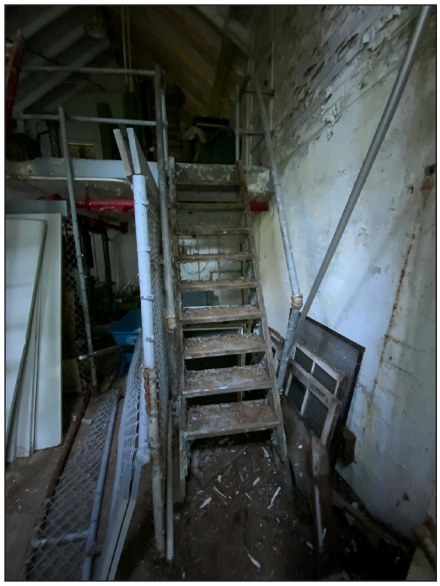
Figure 323. Pump House: Low curved retaining wall located south of the agitation chamber and coagulation basin.

Figure 324. Pump House: Top corbelled brick courses at the chimney along the south wall of the Pump House.

Figure 325. (Left) Pump House: Sistering of roof framing and roof sheathing replacement completed in 2022.
Figure 326. (Right) Pump House: Raw (red) and filtered (green) cast iron water lines used to distribute water through the Pump House.

Figure 327. (Left) Pump House: View of wood roof rafters and brick masonry chimney along
Figure 328. (Right) Pump House: Original sink locating along west wall of operating gallery.

Figure 329. Pump House: Pump House interiors with view of operating gallery.



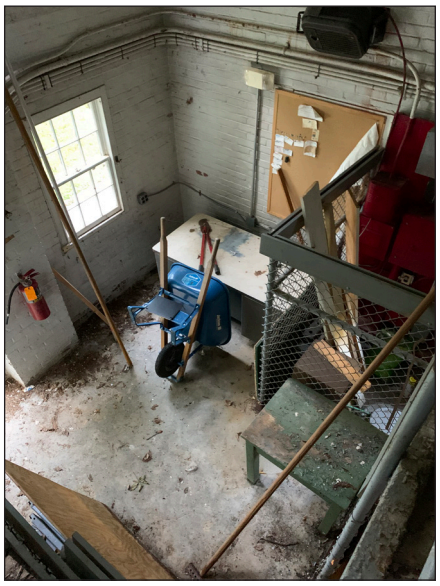


Figure 330. (Left) Pump House: Ships ladder with wood treads providing access to the operating gallery.
Figure 331. (Right) Pump House: View of lower level of Pump House workspace from the operating gallery above.

Figure 332. Pump House: Ships ladder with wood treads providing access to the operating gallery.

Figure 333. (Left) Pump House: Original 5-paneled wood entry door at the south facade of the Pump House.
Figure 334. (Right) Pump House: Original 5-paneled wood at the Operating gallery leading to the agitation chambers and coagulation basin.

Figure 335. (Left) Pump House: Existing wood double hung window along west facade of Pump House.
Figure 336. (Right) Pump House: Existing wood double hung window along east facade of Pump House.

Figure 337. Pump House: View of mat slab and deteriorated topping slab west of the Pump House, over the clear well. The steel cover plate provide access to the clear well below, but was not removable during site survey.

Figure 338. Pump House: Washington Aqueduct manhole (managed by the USACE); Pump House and historic Gatehouse seen in background.

Figure 339. (Left) Pump House: Raw water pump pit; pump and drain seen at bottom of pit; well water line (green) seen on the right.

Figure 340. (Right) Pump House: Water well located north of the Pump House; Pump House seen in the background.

Figure 341. (Left) Pump House: Location of original water meter (no longer extant) along raw water line at the operating gallery level.

Figure 342. (Right) Pump House: Interior view of water well located north of the Pump House.

Figure 343. Pump House: Gears above agitation chambers.

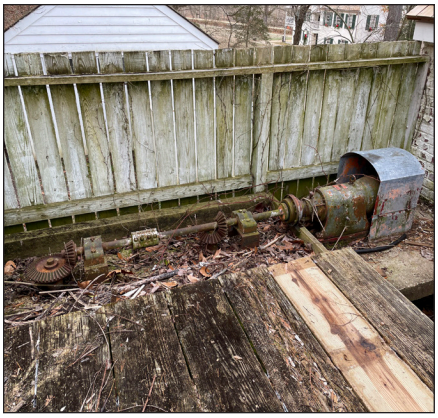


Figure 344. (left) Pump House: Raw water line carrying water to the agitation chambers.
Figure 345. (right) Pump House: motor and gears above agitation chambers.

Figure 346. (Left) Pump House: Manual value stem controlling the soil pit and drainage line at the base of the coagulation basin.
Figure 347. (Right, top) Pump House: View looking down into the coagulation basin; brick stilling wall seen at the top of the image.
Figure 348. (Right, top) Pump House: View of agitation chamber.

Figure 349. (Left) Pump House: Cast iron overflow drain pipe at the coagulation basin.
Figure 350. (Right) Pump House: Weir located at the north end of the coagulation basin; cast iron overflow drain located at the far east end.

Figure 351. (Left) Pump House: Iron grate to strain water running from the weir to the holding tank for the iron wash trough and sand filtration chamber.
Figure 352. (Right) Pump House: Iron raw water line carrying water running from the weir to the holding tank for the iron wash trough and sand filtration chamber.

Figure 353. (Left) Pump House: Raw water waste line from holding tank north of the iron wash trough and sand filtration chamber.
Figure 354. (Right) Pump House: Iron wash trough and sand filtration chamber.

Figure 355. (Left) Pump House: Raw (red) and filtered (green) cast iron water lines used to distribute water through the Pump House; view looking towards iron wash trough and sand filtration chamber.
Figure 356. (Right) Pump House: Raw (red) and filtered (green) cast iron water lines used to distribute water through the Pump House; view looking towards incoming electrical service and distribution panels located along the west wall of the Pump House.

Figure 357. (Left) Pump House: Piping and controls abandoned in place from an air compressor (no longer extant).
Figure 358. (Right) Pump House: Gauge abandoned in place from an air compressor (no longer extant).

Figure 359. (Left) Pump House: Water level gauge at operating gallery.
Figure 360. (Right) Pump House: Loss of head gauge at operating gallery.

Figure 361. (Left) Pump House: Water level gauge at operating gallery.
Figure 362. (Right) Pump House: Manual valve stem at the operating gallery.

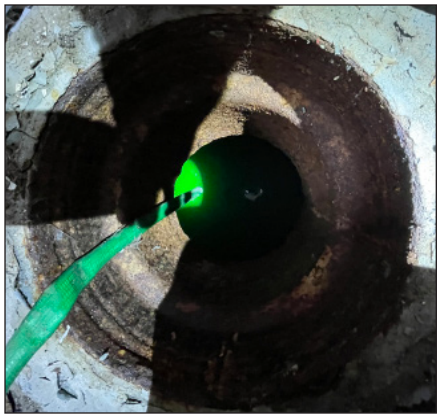


Figure 363. (Left) Pump House: View into clear well.
Figure 364. (Right) Pump House: View into clear well. Well water line seen routed directly into the clear well.

Figure 365. (Left) Pump House: Vault manhole openings above pressurized tank.
Figure 366. (Right) Pump House: Water supply and valves at west end of the pressurized tank located below grade east of the coagulation basin.

Figure 367. (Left) Pump House: Electrical transformer located north of the historic Gatehouse, across the access road from the Pump House.
Figure 368. (Right) Pump House: Exterior wireway proving incoming electrical service to Pump House; located at northwest corner of Pump House.

Figure 369. (Left) Pump House: Exterior wireway distributing electrical service from Pump House to nearby structures; located at west facade of Pump House.
Figure 370. (Right) Pump House: Exterior wireway distributing electrical service from Pump House to nearby structures; located at west facade and southeast of Pump House.

Figure 371. (Left) Pump House: Electrical meter located along west wall of Pump House.
Figure 372. (Right) Pump House: Electrical main distribution panel located along west wall of Pump House.

Figure 373. (Left) Pump House: Original, abandoned electrical panel located along west wall of Pump House.
Figure 374. (Right) Pump House: Original light switches located adjacent to entry door along south wall of Pump House.

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ENGINEER'S GARAGE (MILE 14.35)

Figure 375. Engineer's Garage: West elevation of Garage.

Figure 376. (Left) Engineer's Garage: North elevation of Garage.
Figure 377. (Right) Engineer's Garage: View of entry doors into historic office and shop at south end of Garage; both spaces currently used for storage.

Figure 378. (Left) Engineer's Garage: View of southeast corner of Garage from hill to the east; significant site drainage is directed to this southeast corner of the Garage.
Figure 379. (Right) Engineer's Garage: View of east facade of Garage from hill to the east

Figure 380. Engineer's Garage: View of north facade of Garage.

Figure 381. Engineer's Garage: View of north facade of Garage.

Figure 382. Engineer's Garage: View of double hung windows along north facade of Garage; asphalt shingle roof replaced in 2015; window 512 replaced with access door into storage space.

Figure 383. (Left) Engineer's Garage: View of entry door into historic shop at south end of Garage;
Figure 384. (Right) Engineer's Garage: Enclosed bay of the garage; original garage door has been removed.

Figure 385. Engineer's Garage: New garage door along west facade, installed in 2017.

Figure 386. (Left) Engineer's Garage: Wood stair providing access to upper levels of the landscape adjacent to the southwest corner of the Garage.
Figure 387. (Right) Engineer's Garage: Original wood post at south porch supported by steel threaded rod and plates.

Figure 388. Engineer's Garage: View of exterior hay storage area and surround site walls.

Figure 389. (Left) Engineer's Garage: Example of cracking in CMU and brick exterior wall base.
Figure 390. (Right) Engineer's Garage: Typical wood framed exterior wall assembly above masonry knee walls.

Figure 391. (Left) Engineer's Garage: Exterior electrical load center.
Figure 392. (Right) Engineer's Garage: Security control panel located in the office at the south end of the Engineer's Garage.

Figure 393. (Left) Engineer's Garage: Area of mule stables at the north end of the Garage.
Figure 394. (Right) Engineer's Garage: Equipment storage in the Garage.

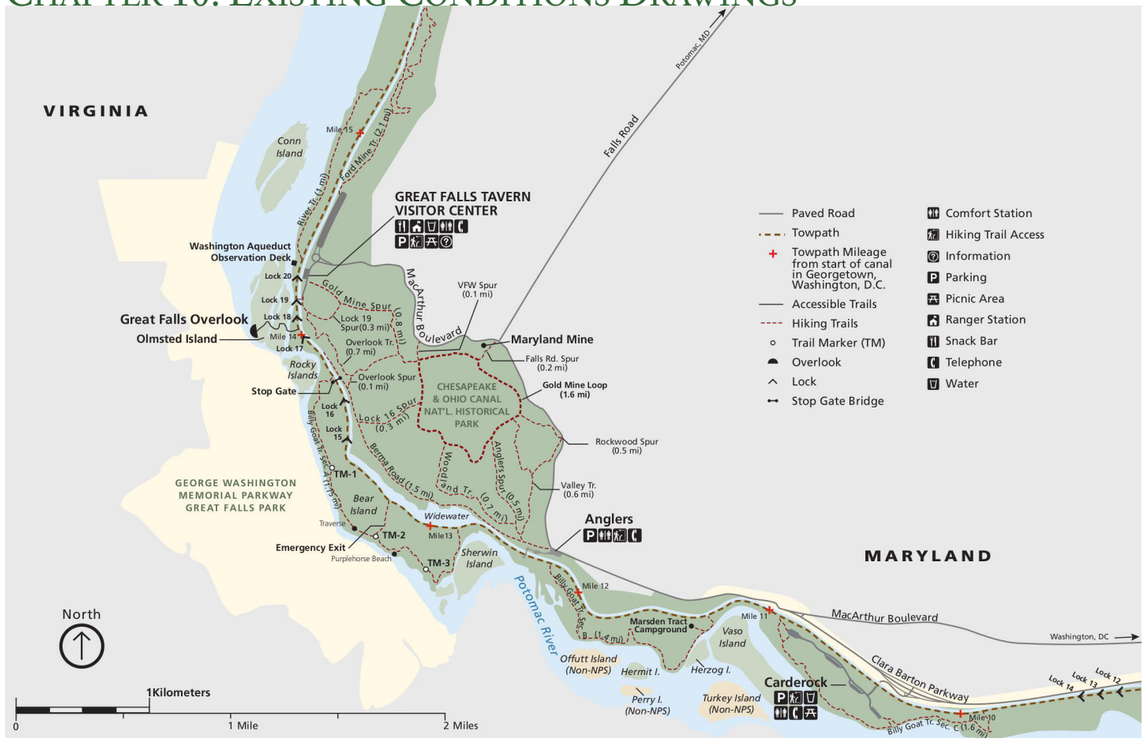
Figure 395. Engineer's Garage: Area of hay storage inside the Garage.

Figure 396. Engineer's Garage: Storage area in location of original shop space in the Garage.

Figure 397. Engineer's Garage: Wood roof rafters above the mule stables in the Garage.

Figure 398. Engineer's Garage: Wood roof rafters above the mule stables in the Garage.

CHAPTER 10: EXISTING CONDITIONS DRAWINGS



VICINITY MAP (NOT TO SCALE)

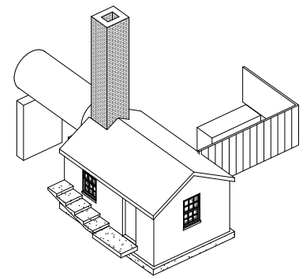
DRAWING LIST

SHEET # OF #	SUBSHEET	SHEET TITLE
1 OF 21	CS	COVER SHEET
GENERAL		
2 OF 21	G0.01	ABBREVIATIONS AND SYMBOLS
EXISTING CONDITIONS		
3 OF 21	A0.01	LOCATION PLANS
4 OF 21	A0.02	SITE PLAN AT GREAT FALLS
5 OF 21	A0.10	PIVOT BRIDGE RUINS - EXISTING PLAN
6 OF 21	A0.11	PIVOT BRIDGE RUINS - EXISTING ELEVATIONS
7 OF 21	A0.12	PIVOT BRIDGE RUINS - EXISTING ELEVATIONS
8 OF 21	A0.13	PIVOT BRIDGE RUINS - EXISTING SECTIONS
9 OF 21	A0.20	BOILER HOUSE - EXISTING FLOOR PLAN AND REF CEILING PLAN
10 OF 21	A0.21	BOILER HOUSE - EXISTING ELEVATIONS
11 OF 21	A0.22	BOILER HOUSE - EXISTING BUILDING SECTIONS
12 OF 21	A0.30	COMFORT STATION - EXISTING FLOOR PLAN AND REF CEILING PLAN
13 OF 21	A0.31	COMFORT STATION - EXISTING ELEVATIONS
14 OF 21	A0.32	COMFORT STATION - EXISTING BUILDING SECTIONS
15 OF 21	A0.40	PUMP HOUSE - EXISTING FLOOR PLAN AND REF CEILING PLAN
16 OF 21	A0.41	PUMP HOUSE - EXISTING ELEVATIONS
17 OF 21	A0.42	PUMP HOUSE - EXISTING BUILDING SECTIONS
18 OF 21	A0.50	ENGINEER'S GARAGE - EXISTING FLOOR PLAN
19 OF 21	A0.51	ENGINEER'S GARAGE - EXISTING REF CEILING PLAN
20 OF 21	A0.52	ENGINEER'S GARAGE - EXISTING NORTH, SOUTH, & EAST ELEVATIONS
21 OF 21	A0.53	ENGINEER'S GARAGE - EXISTING WEST ELEVATION & SECTIONS

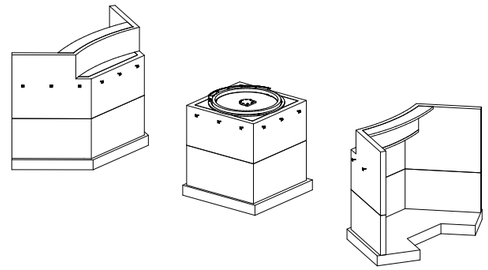
ENGINEER'S GARAGE (MILE 14.35)

PUMP HOUSE (MILE 14.29)

COMFORT STATION (MILE 14.28)



BOILER HOUSE (MILE 14.27)



PIVOT BRIDGE RUINS (MILE 9.92)

HISTORIC STRUCTURE REPORT FOR THE CCC STRUCTURES ON THE C&O CANAL

PMIS 245010
SUBMISSION DATE: MAY 26, 2023

SMITHGROUP			Mark	Sheet	REVISION	Date	Initial
PRIME/ARCH:	STRUCTURAL:	CONSULTANT:					
SMITHGROUP WASHINGTON, DC smithgroup.com	SILMAN BOSTON, MA	BUILDING CONSERVATION ASSOCIATES BOSTON, MA					

RECOMMENDED: _____ Project Manager _____ Date

RECOMMENDED: _____ Superintendent _____ Date

APPROVED: _____ Regional Director _____ Date

EXISTING CONDITIONS

UNITED STATES
DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE
CHESAPEAKE & OHIO CANAL (CHOH)

TITLE OF DRAWING
EXISTING CONDITIONS
LOCATION WITHIN PARK
CCC STRUCTURES
NAME OF PARK
CHEASAPEAKE & OHIO CANAL
REGION: NCR | COUNTY: --- | STATE: MD

DRAWING NO. ---
PMIS/PKG NO. 245010
SHEET 1 OF 21

5/26/2023 3:23:39 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt

ABBREVIATIONS

&	AND
@	AT
AB	ANCHOR BOLT (AB)
A/C	AIR CONDITIONING
AC	ACOUSTICAL
ACT	ACOUSTICAL TILE
ABAAS	ARCHITECTURAL BARRIERS ACT ACCESSIBILITY STANDARD
ADAAG	AMERICANS WITH DISABILITIES ACT AND ARCHITECTURAL BARRIERS ACT ACCESSIBILITY GUIDELINES
ADJ	ADJACENT/ ADJOINING
ADJUST	ADJUSTABLE
AFF	ABOVE FINISH FLOOR
AHU	AIR HANDLING UNIT
ALT	ALTERNATE
ALUM	ALUMINUM
AP	ACCESS PANEL
APPRX	APPROXIMATE
ARCH	ARCHITECTURAL
ANOD	ANODIZED
ASPH	ASPHALT
AUTO	AUTOMATIC
AVE	AVENUE
AVG	AVERAGE
BD	BOARD
BL	BLUESTONE
BLDG	BUILDING
BLKG	BLOCKING
BM	BEAM
BOT	BOTTOM
BTW	BETWEEN
BITUM	BITUMINOUS
BRK	BRICK
BRZ	BRONZE
BUR	BUILT UP ROOFING
CAB	CABINET
CBB	CONCRETE BACKER BOARD
CBD	CHALK BOARD
CCTV	CLOSED CIRCUIT TELEVISION
CEM	CEMENT/ CEMENTITIOUS
CI	CAST IRON
CIP	CAST IN PLACE
CJ	CONTROL JOINT (SEE EXP JT)
CLG	CEILING
CL	CENTERLINE
CLR	CLEAR/ CLEARANCE
CM	CONSTRUCTION MANAGER
CMP	CORRUGATED METAL PIPE
CMU	CONCRETE MASONRY UNIT
CO	CLEAN OUT
COL	COLUMN
COMB	COMBINATION
CONC	CONCRETE
CONN	CONNECTION
CONST	CONSTRUCT/ CONSTRUCTION
CONT	CONTINUOUS
CORR	CORRIDOR
CP	COURTESY PHONE
CPT	CARPET
CT	CERAMIC TILE
CW	COLD WATER
CSK	COUNTERSUNK
CG	CORNER GUARD
CL	CENTERLINE
CLKG	CAULKING
CNTR	COUNTER
CS	CAST STONE
CV	COVE TILE
D	DEPTH
DBH	DIAMETER AT BREAST HEIGHT
DBL	DOUBLE
DEPT	DEPARTMENT
DET	DETAIL
DF	DRINKING FOUNTAIN (SEE EWC)
DH	DOUBLE HUNG
DIA	DIAMETER
DIM	DIMENSION
DIR	DIRECTORY
DIV	DIVISION
DL	DEAD LOAD
DN	DOWN
DR	DOOR
DT	DECORATIVE TILE
DTL	DETAIL
DW	DUMBWAITER
DWG	DRAWING
DWR	DRAWER
E	EAST
EA	EACH
EB	EXPANSION BOLT (SEE AB)
EJ	EXPANSION JOINT (SEE CJ)

EL	ELEVATION
EL	EC ELECTRICAL/ ELECTRIC
EL	EV ELEVATOR
EMER	EMERGENCY
ENCL	ENCLOSURE/ ENCLOSED
ENGR	ENGINEER
ENTR	ENTRANCE
EQ	EQUAL
EQUIP	EQUIPMENT
EWC	ELECTRIC WATER COOLER (SEE DF)
EXG/ EXIST	EXISTING
EXH	EXHAUST
EXP	EXPANDED/ EXPANSION
EXT	EXTERIOR
EXT	EXTRUDED
FA	FIRE ALARM
FAB	FABRICATED
FCU	FAN COIL UNIT
FD	FLOOR DRAIN/ FIRE DAMPER
FE	FIRE EXTINGUISHER
FEC	FIRE EXTINGUISHER CABINET (WITH EXTINGUISHER)
FF	FACE TO FACE (CLEAR DISTANCE)
FHC	FIRE HOSE CABINET
FHS	FLAT HEAD SCREW
FIN	FINISH
FLR	FLOOR/ FLOORING
FLOUR	FLOURESCENT
FND	FOUNTAIN
F.O.	FACE OF
FOS	FACE OF STUD/ SLAB/ STRUCTURE
FOM	FACE OF MASONRY
FP	FIREPROOF
FPM	FEET PER MINUTE
FRT	(PRESSURE) FIRE RETARDANT TREATED
FS	FLOOR SINK
FT	FOOT/ FEET
FTG	FOOTING
FVO	FIELD VERIFY OPENING
FURR	FURRING
FVC	FIRE VALVE CABINET
FX	TR FIXTURE
GA/	GAGE (GAUGE)
GAL	GALLON
GALV	GALVANIZED
GC	GENERAL CONTRACTOR
GEN	GENERAL
GFRC	GLASS FIBER REINFORCED GYPSUM
GL	GLASS
GMT	GLASS MOSAIC TILE
GND	GROUND
GPM	GALLONS PER MINUTE
GRN	GRANITE
GRL	GRILLE
GYP	GYPSUM
GWB	GYPSUM WALL BOARD
H	HIGH
HB	HOSE BIB
HC	HOLLOW CORE/ HANICAP(PED)
HDW	HARDWARE
HGR	HANGER
HIST	HISTORIC
HK	HOUSEKEEPING
HM	HOLLOW METAL (STEEL)
HMF	HOLLOW METAL FRAME
HOR	HORIZONTAL
HP	HIGH POINT
HR	HOUR
HTG	HEATING
HVAC	HEATING, VENTILATION AND AIR CONDITIONING
HW	HOT WATER
HWD	HARDWOOD
ID	INSIDE DIAMETER
IN	INCH(ES)
INCL	INCLUDING/ INCLUDED
INSUL	INSULATE/ INSULATED/ INSULATION
INT	INTERIOR
INV	INVERTED/ INVERT
JB	JUNCTION BOX
JC	JANITORS CLOSET
JT	JOINT
JST	JOIST
KIT	KITCHEN
KO	KNOCKOUT
L	LONG/ LENGTH
LAM	LAMINATED
LAV	LAVATORY

LCC	LEAD COATED COPPER
LCKR	LOCKER
LB(S)	POUND(S)
LF	LINEAR FEET
LH	LEFT HANDED
LIN	LINOLEUM
LL	LIVE LOAD
LP	LOW POINT
LS	LIMESTONE
LT	LIGHT
LTG	LIGHTING
LVR	LOUVER
LWC	LIGHTWEIGHT CONCRETE
MACH	MACHINE
MAS	MASONRY
MANUF	MANUFACTURER
MAT	MATERIAL
MAX	MAXIMUM
MBD	MARKER BOARD
MBL	MARBLE
MECH	MECHANICAL
MED	MEDIUM
MEP	MECHANICAL ELECTRICAL PLUMBING
M.E.	MATCH EXISTING
MIR	MIRROR
MTL	METAL
MEZZ	MEZZANINE
MFR	MANUFACTURE(R)
MFT	MOSAIC FLOOR TILE
MH	MANHOLE
MIN	MINIMUM
MISC	MISCELLANEOUS
MO	MASONRY OPENING
MR	MOISTURE RESISTANT
MTD	MOUNTED
MTG	MOUNTING
MULL	MULLION
MW	MICROWAVE
MLDG	MOLDING
N	NORTH
NIC	NOT IN CONTRACT
NOM	NOMINAL
NRC	NOISE REDUCTION COEFFICIENT
NTS	NOT TO SCALE
NO	NUMBER
OA	OVERALL (OUTSIDE AIR)
OC	ON CENTER(S)
OD	OUTSIDE DIAMETER
O/O	OUT TO OUT
OPER	OPERABLE
OPG	OPENING
OPH	OPPOSITE HAND
OPP	OPPOSITE
ORN	ORNAMENTAL
OS	OTHER SIDE
OZ	OUNCE
PT	PAINT
PA	PUBLIC ADDRESS
PB	PULL BOX
PCF	POUNDS PER CUBIC FOOT
PC	PRECAST
PERF	PERFORATED
PFAB	PREFABRICATED
PL	PLATE/ PROPERTY LINE
PLAM	PLASTIC LAMINATE
PNL	PANEL
PLS	PLASTER
POL	POLISHED
PPT	PRESSURE PRESERVATIVE TREATED
PR	PAIR
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
PT	POINT
PTD	PAINTED
PTN	PARTITION
PVC	POLYVINYL CHLORIDE
PVMT	PAVEMENT
PLYWD	PLYWOOD
PWT	PORCELAIN WALL TILE
PFT	PORCELAIN FLOOR TILE
PVMT	PAVEMENT
PLYWD	PLYWOOD
QT	QUARRY TILE
QTY	QUANTITY
R	RISER
RA	RETURN
RAD/R	RADIUS
RB	RUBBER BASE
RCP	REFLECTED CEILING PLAN
RD	ROOF DRAIN
REBAR	REINFORCING BAR
RECEP	RECEPTION

REC	PT RECEPTACLE
REF	REFERENCE/ REFER TO
REINF	REINFORCE/ REINFORCING
REQD	REQUIRED
REV	REVISION
RM	ROOM
RO	ROUGH OPENING
RUB	RUBBER
S	SOUTH
SA	SUPPLY AIR
SC	SOLID CORE
SCH	SCHEDULE
SCT	STRUCTURAL CLAY TILE
SD	STORM DRAIN/ SOAP DISPENSER
SEC	SECTION
SFT	STANDARD FIXTURE TYPE
SFE	SURFACE MOUNTED FIRE EXTINGUISHER
SFN	STANDARD FIXTURE NUMBER
SHT	SHEET
SHLVG	SHELVING
SIM	SIMILAR
SLT	SLATE TILE
SMD	SEE MECHANICAL DRAWINGS
SPEC	SPECIFICATION
SPKR	SPEAKER
SQ	SQUARE
SF	SQUARE FEET
SS	STAINLESS STEEL
SSD	SEE STRUCTURAL DRAWINGS
ST	STREET/ STONE
STAG	STAGGERED/ STAGGER
STC	SOUND TRANSMISSION CLASS
STD	STANDARD
STL	STEEL
STL	DR STEEL DOOR
STL	FR STEEL FRAME
STOR	STORAGE
STRUCT	STRUCTURAL
STS	SELF-TAPPING SCREW
SUSP	SUSPEND/ SUSPENDED
SYM	SYMMETRICAL
SYS	SYSTEM
TB	TOWEL BAR
TBD	TO BE DETERMINED
TKB	TACKBOARD
TC	TERRA COTTA
T&B	TOP AND BOTTOM
T&G	TONGUE AND GROOVE
TEL	TELEPHONE
TEMP	TEMPERATURE/ TEMPERED
TEMP GL	TEMPERED GLASS
THK	THICK/ THICKNESS
THRES	THRESHOLD
T.O.F.F.	TOP OF FINISHED FLOOR
TOC	TOP OF CONCRETE/ CURB
T.O.S.	TOP OF SLAB
T	TREAD/ TOP
TV	TELEVISION
TYP	TYPICAL
TYP O.S.	TYPICAL OTHER SIDE
TZFT	TERRAZZO FLOOR TILE
UR	URINAL
UC	UNDERCUT
UNFIN	UNFINISHED
UNGD	UNDERGROUND
U.O.N.	UNLESS OTHERWISE NOTED
UL	UNDERWRITERS LABORATORIES
US	UNDER SIDE
UTIL	UTILITIES
VAR	VARIES
VLT	VOLT
V JT	VEE JOINT
VB	VINYL BASE/ VAPOR BARRIER
VBX	VALVE BOX
VCT	VINYL COMPOSITION TILE
VERT	VERTICAL
VEST	VESTIBULE
VIF	VERIFY IN FIELD
VOL	VOLUME
VT	VINYL TILE
VWC	VINYL WALL COVERING
W/	WITH
W/O	WITHOUT
WC	WATER CLOSET
WCV	WALL COVERING
WD	WOOD
WGL	WIRE GLASS
WL	WORK LINE
WP	WORKING POINT/ WATER PROOFING
WT	WEIGHT

ARCHITECTURAL SYMBOLS

DIMENSION SYMBOLS

10' - 0" — DIMENSION SHOWN TO:
- STRUCTURAL GRID
- LAYOUT GRID
- CENTERLINE OF ASSEMBLY
- CENTER OF OPENING
- CENTER OF EQUIP/ FURN

GRID OR CENTER LINE TYPICAL

10' - 0" — DIMENSION SHOWN TO:
- PARTITION ASSEMBLY
- EDGE OF DOOR OPENING
- OTHER BUILDING ELEMENT
- WORKING POINT INDICATED ON DETAIL

CEILINGS

2'X2' LAY IN ACOUSTIC TILE CEILING

GYPSUM BOARD

AP — ACCESS PANEL

+12'-8" — HEIGHT OF CEILING FINISH ABOVE FINISH FLOOR

DOOR AND INTERIOR OPENING

DOOR OPENING MARK

SINGLE OPENING DOOR

PAIR DOORS - EQUAL SIZES

A. THE PURPOSE OF THIS LIST IS TO ILLUSTRATE AND DEFINE TYPICAL GRAPHIC SYMBOLS WHICH MAY TYPICALLY OCCUR ON THE ARCHITECTURAL DRAWINGS.

B. ADDITIONAL SYMBOLS NOT SHOWN OR DEFINED ON THIS SHEET MAY BE USED ON THE ARCHITECTURAL DRAWINGS AND ARE TYPICALLY DEFINED ON OTHER SHEETS.

C. SYMBOLS ARE NOT DRAWN TO SCALE. TO DETERMINE THE ACTUAL SIZES OF ELEMENTS REPRESENTED BY SYMBOLS, REFER TO THE SPECIFICATIONS AND OTHER SHEETS, AS MAY APPLY.

MATERIAL LEGEND

- EARTH
- AGGREGATE BASE COURSE
- CONCRETE
- BRICK MASONRY
- LIMESTONE, SANDSTONE, GRANITE
- PLYWOOD (LARGE SCALE)
- PLASTER CONCRETE, STUCCO
- FINISH WOOD (LARGE SCALE)
- SEMI-RIGID INSULATION (LARGE SCALE)
- BATT INSULATION (LARGE SCALE)
- GLASS
- MORTAR, SAND, FIREPROOFING, GYPSUM BOARD

GRAPHIC SYMBOLS

1 / A1.1 — DETAIL NUMBER / SHEET NUMBER

ELEVATION/ BUILDING SECTION KEY

1 / A1.1

DETAIL CALLOUT

1 / A1.1 FIRST FLOOR PLAN SCALE A

DETAIL TITLE ON DRAWING SHEET

ROOM 000

ROOM/ SPACE NAME & NUMBER

NORTH ARROW

- BREAKLINE
- COLUMN LINE/ CENTERLINE
- LOT LINE/ PROPERTY LINE
- FEATURE ABOVE OR BEHIND
- FEATURE HIDDEN BELOW OR IN FRONT
- MATCHLINE
- LIMIT OF DISTURBANCE
- CONTRACTOR FENCING

SHEET NUMBERING SYSTEM

A0.01
- DRAWING NUMBER
- TRADE:
  - CS = COVER SHEET
  - G = GENERAL
  - C = CIVIL
  - A = ARCHITECTURAL

1" DIMENSION LINE

1 REVISION KEY AND CLOUD

HISTORIC STRUCTURE REPORT DRAWINGS

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE: SmithGroup, WASHINGTON, DC
Structural: Silman, Washington, DC
Material Conservation: Building Conser Assoc, Washington, DC

DESIGNED: SJP
CADD: SJP
TECH REVIEW:
DATE: 05/26/2023

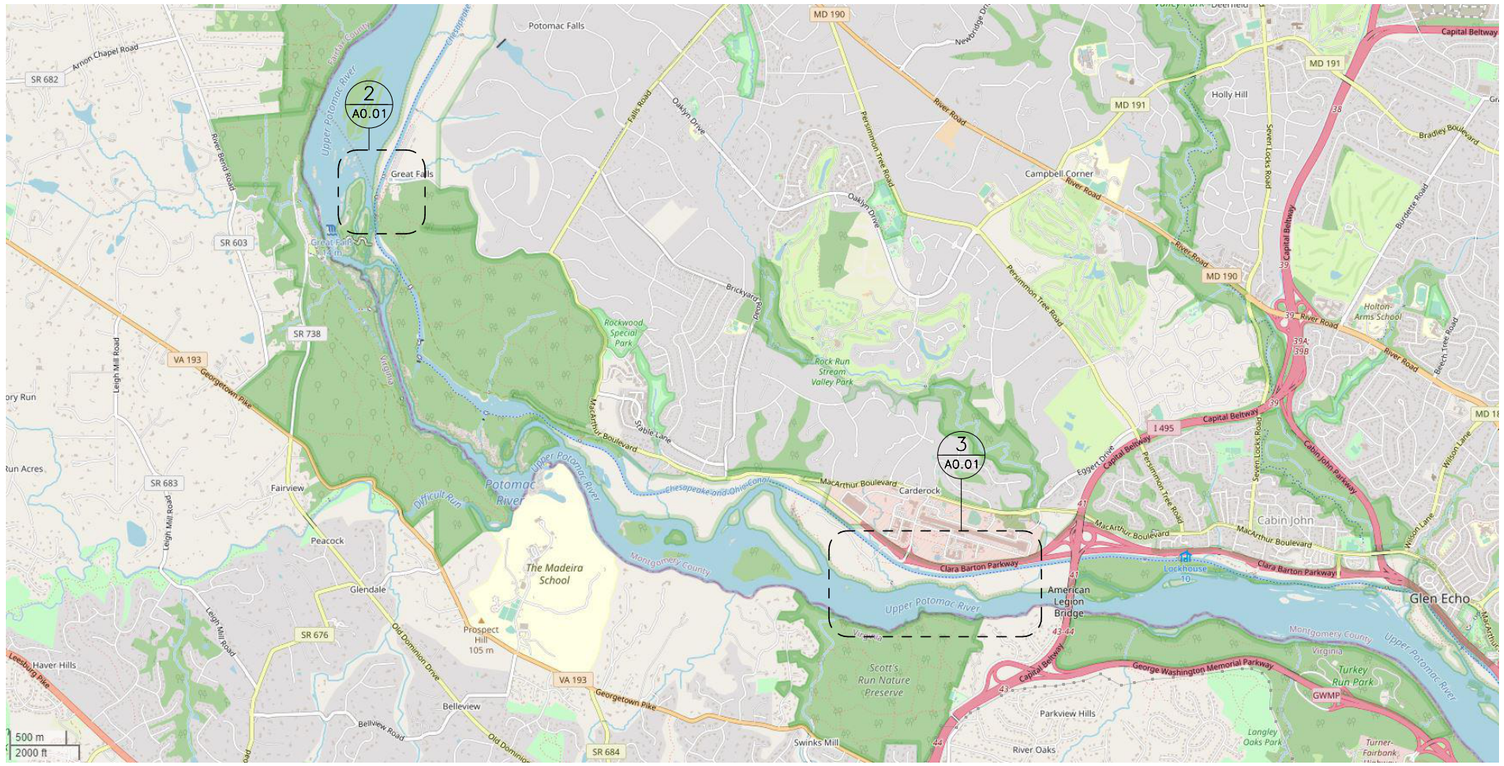
SUB SHEET NO. G0.01

TITLE OF SHEET
EXISTING CONDITIONS
ABBREVIATIONS AND SYMBOLS

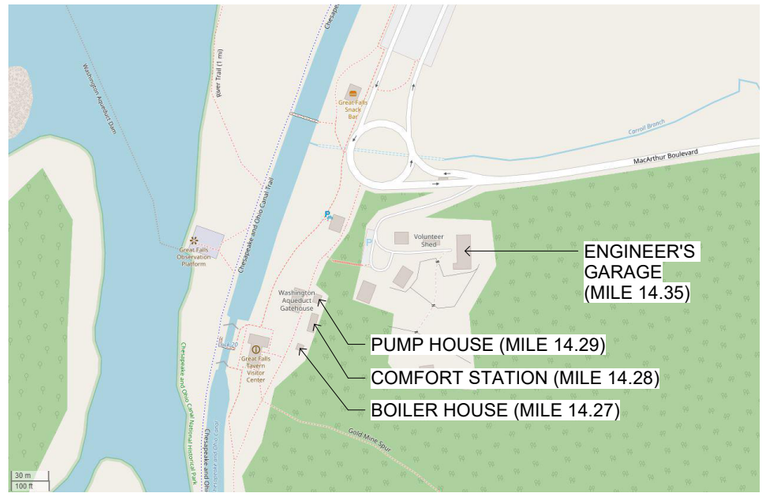
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
PMIS/PKG NO. 245010
SHEET 2 OF 21

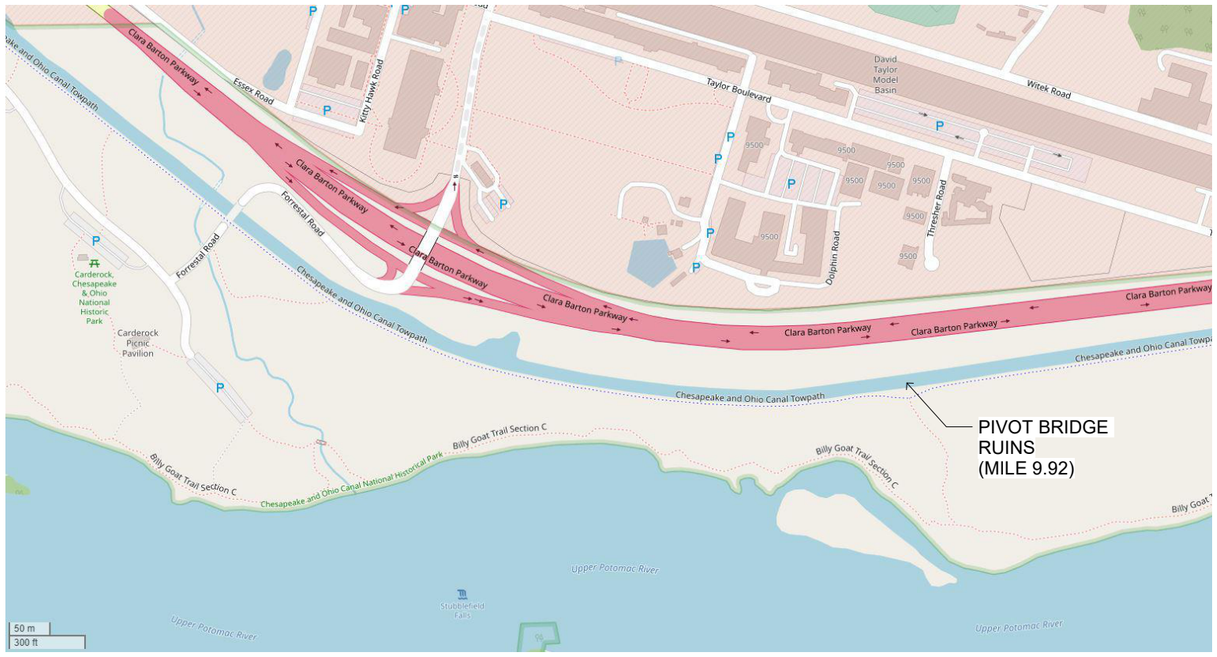
5/26/2023 3:23:39 PM SJP Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.01 LOCATION MAP WITH PIVOT BRIDGE RUINS
SCALE A



2 A0.01 LOCATION MAP AT GREAT FALLS
SCALE A



3 A0.01 LOCATION MAP DETAIL AT PIVOT BRIDGE RUINS
SCALE A

HISTORIC STRUCTURE REPORT DRAWINGS

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

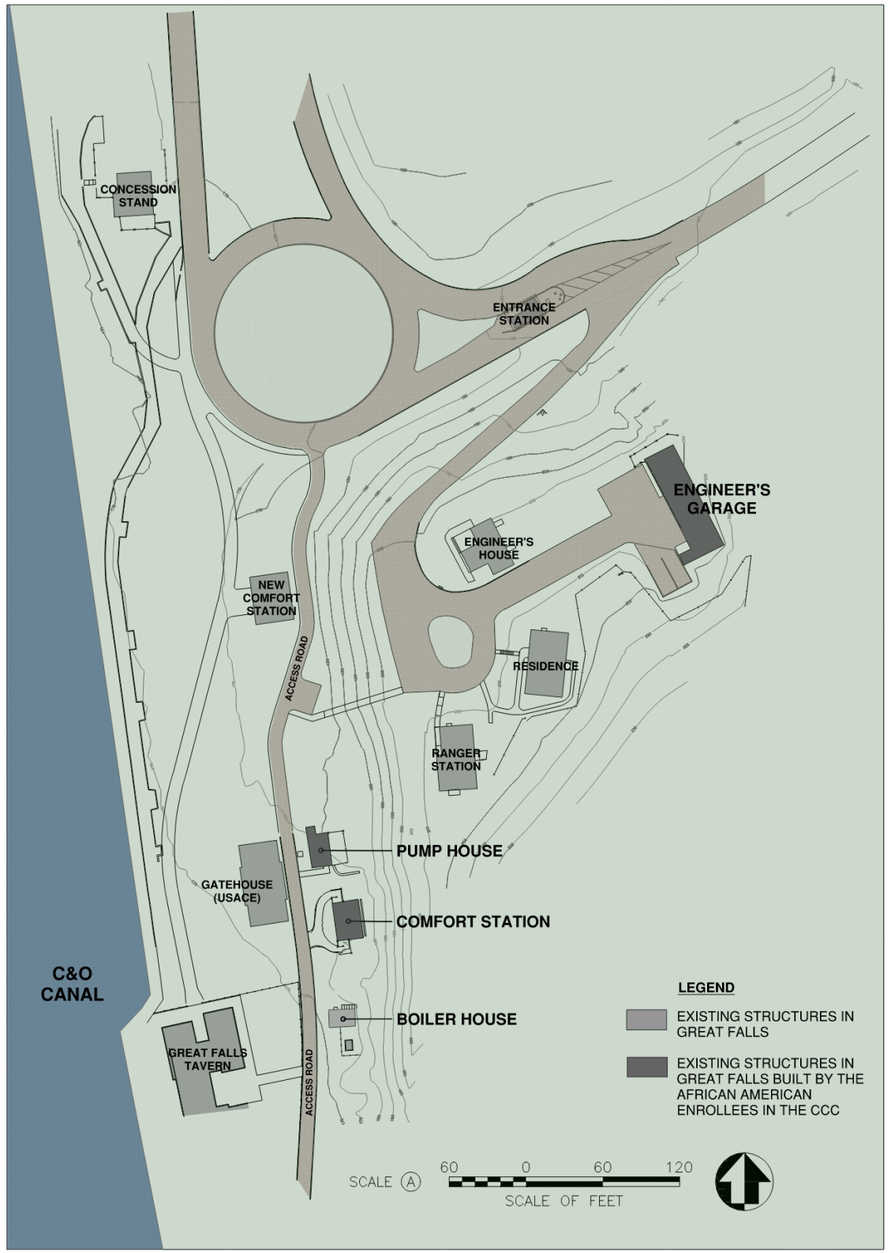
SUB SHEET NO. A0.01

TITLE OF SHEET
EXISTING CONDITIONS
LOCATION PLANS

CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
PMIS/PKG NO. 245010
SHEET 3 OF 21

5/26/2023 3:23:16 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 / A0.02 EXISTING SITE PLAN - BOILER HOUSE, COMFORT STATION, PUMP HOUSE, AND ENGINEER'S GARAGE
SCALE A

SCALE A 60 0 60 120 1" = 60'
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE: SmithGroup WASHINGTON, DC
Structural: Silman Washington, DC
Material Conservation: Building Conser Assoc Washington, DC

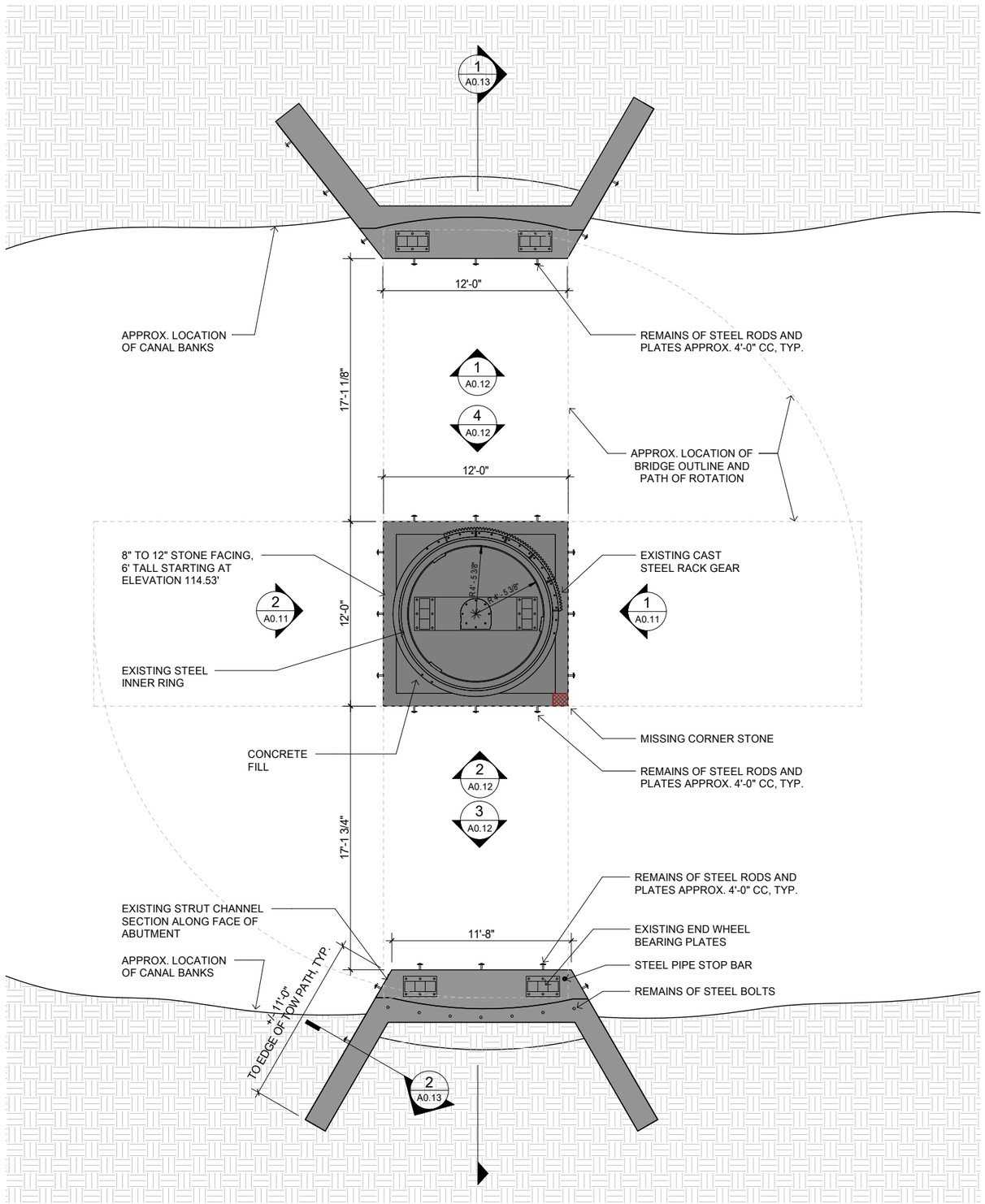
DESIGNED: SJP
CADD: SJP
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.02

TITLE OF SHEET
EXISTING CONDITIONS
SITE PLAN AT GREAT FALLS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- ------
PMIS/PKG NO. 245010
SHEET 4 OF 21

5/26/2023 3:23:16 PM SJP Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.10 PIVOT BRIDGE EXISTING FLOOR PLAN
SCALE A

GENERAL NOTES

VERTICAL DATUMS FOR EACH STRUCTURE WERE TAKEN FROM THE HISTORIC 1941 OR 1951 CONSTRUCTION DRAWINGS FOR EACH STRUCTURE OR FROM THE 2012 UTILITY AS-BUILTS (NPS PROJECT NO. 412-107131).

FINISHED FLOOR ELEVATIONS
PIVOT BRIDGE RUINS - 120.53'
(TOP OF CENTRAL PIER)
BOILER HOUSE - 171.35'
COMFORT STATION - 171' +/-
(NOT NOTED ON PLANS)
PUMP HOUSE - 174.63'
ENGINEER'S GARAGE - 209.95'

EXISTING CONDITIONS LEGEND
- EFFLORESCENCE
- MISSING STONE
- CRACK

SCALE A 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

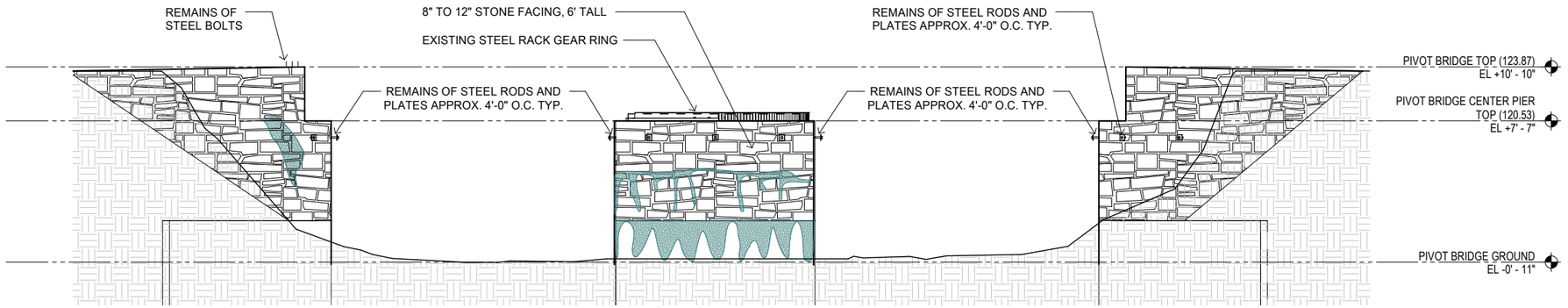
DESIGNED: CZ
CADD: SP
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.10

TITLE OF SHEET
EXISTING CONDITIONS
PIVOT BRIDGE RUINS - EXISTING PLAN
CHEASAPEAKE & OHIO CANAL

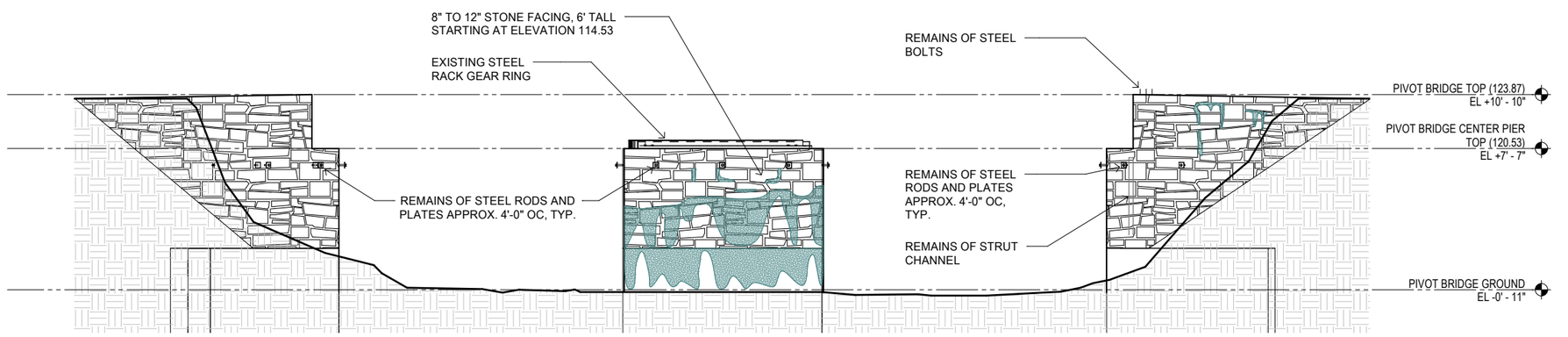
DRAWING NO. --- / ------
PMIS/PKG NO. 245010
SHEET 5 OF 21

5/26/2023 3:23:17 PM SP Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.11 PIVOT BRIDGE RUINS EXISTING EAST ELEVATION

SCALE A



2 A0.11 PIVOT BRIDGE RUINS EXISTING WEST ELEVATION

SCALE A

SCALE Ⓐ 8 0 8 16

SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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ENGINEER'S GARAGE - 209.95'

EXISTING CONDITIONS LEGEND

- EFFLORESCENCE
- MISSING STONE
- CRACK

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE: SmithGroup WASHINGTON, DC
Structural: Silman Washington, DC
Material Conservation: Building Conser Assoc Washington, DC

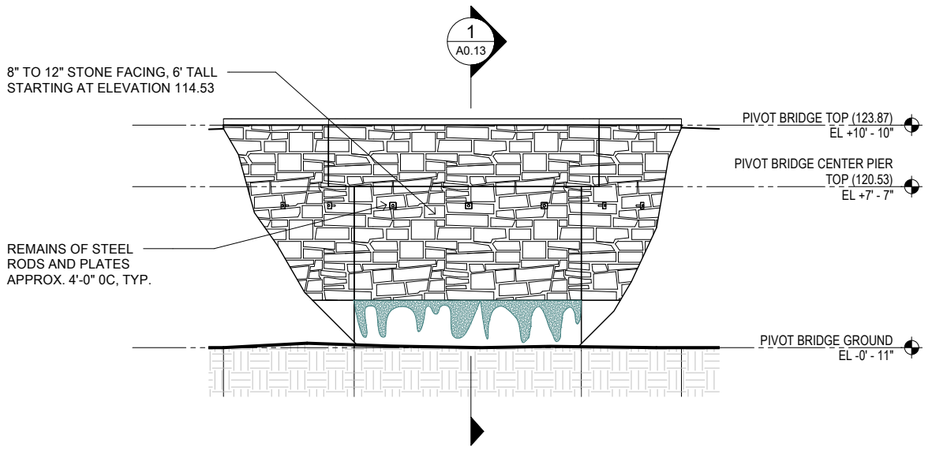
DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.11

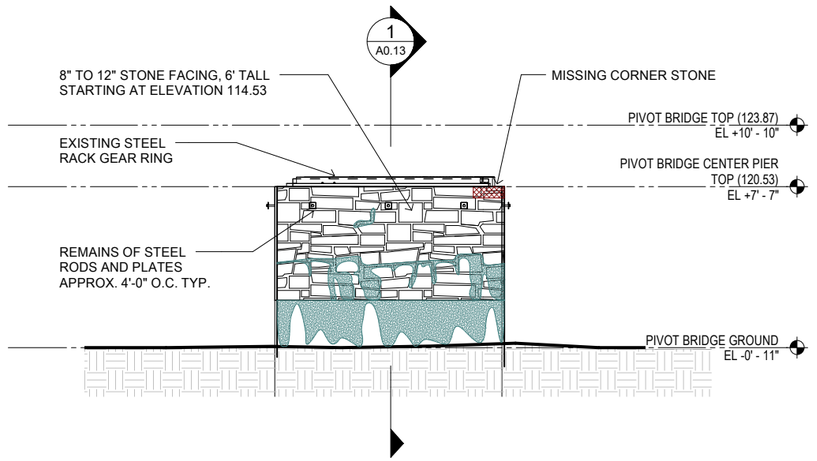
TITLE OF SHEET
EXISTING CONDITIONS
PIVOT BRIDGE RUINS - EXISTING ELEVATIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ---
PMIS/PKG NO. 245010
SHEET 6 OF 21

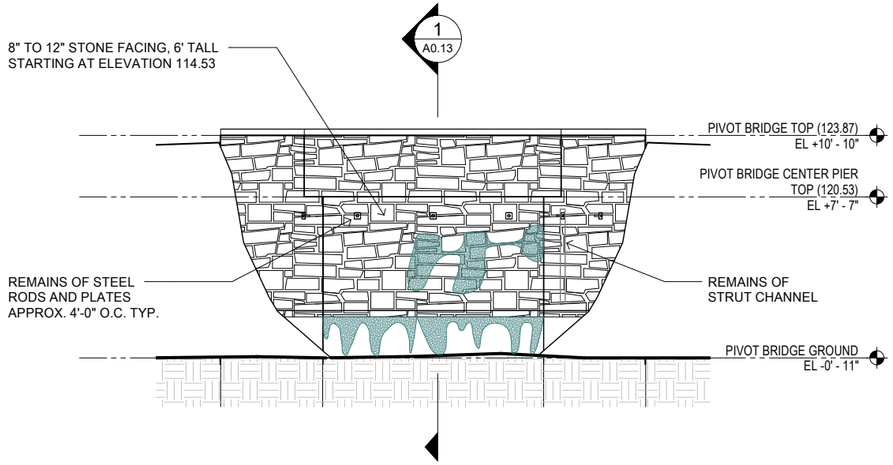
5/26/2023 3:23:19 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



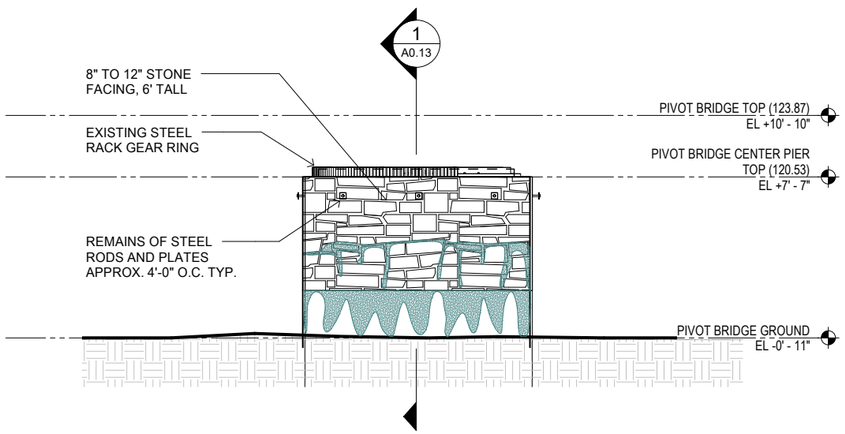
1 A0.12 PIVOT BRIDGE RUINS EXISTING NORTH ELEVATION A
SCALE A



2 A0.12 PIVOT BRIDGE RUINS EXISTING NORTH ELEVATION B
SCALE A



3 A0.12 PIVOT BRIDGE RUINS EXISTING SOUTH ELEVATION A
SCALE A



4 A0.12 PIVOT BRIDGE RUINS EXISTING SOUTH ELEVATION B
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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ENGINEER'S GARAGE - 209.95'

EXISTING CONDITIONS LEGEND
EFFLORESCENCE
MISSING STONE
CRACK

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

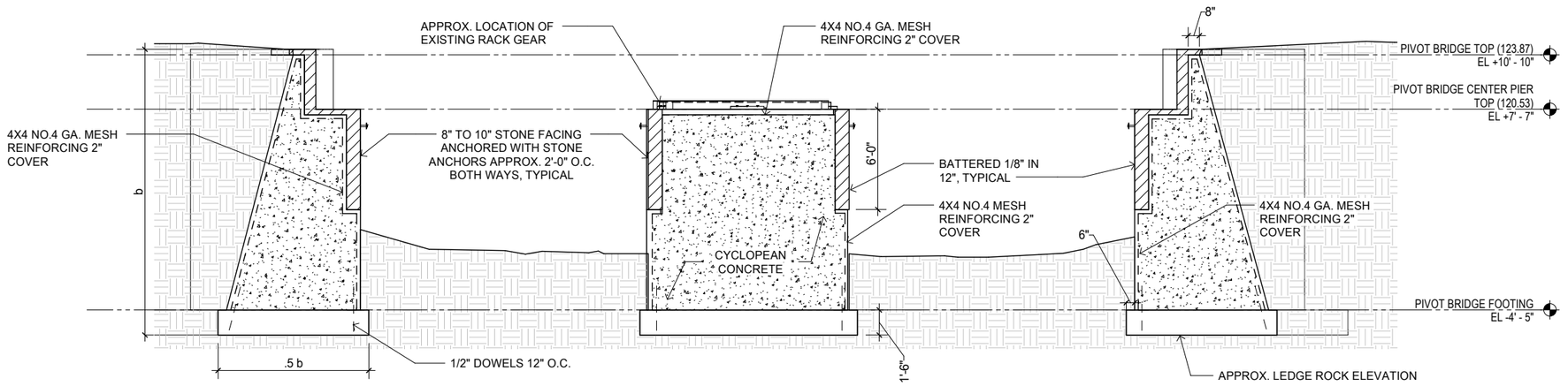
DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.12

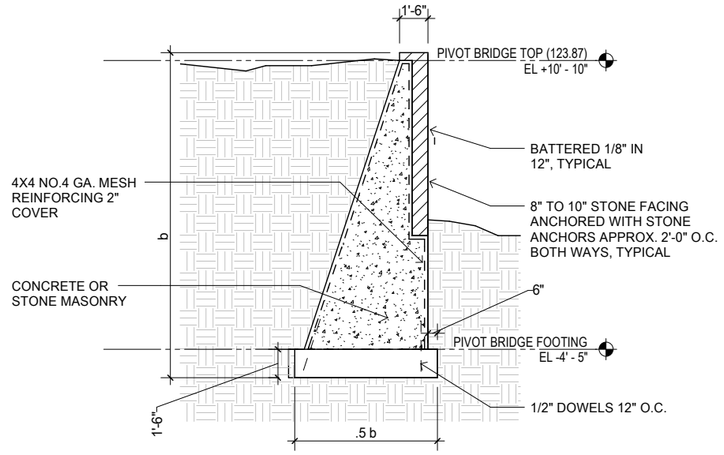
TITLE OF SHEET
EXISTING CONDITIONS
PIVOT BRIDGE RUINS - EXISTING ELEVATIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
PMIS/PKG NO. 245010
SHEET 7 OF 21

5/26/2023 3:23:20 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.13 PIVOT BRIDGE SECTION ACROSS CANAL
SCALE A



2 A0.13 PIVOT BRIDGE SECTION A-A
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE: SmithGroup WASHINGTON, DC
Structural: Silman Washington, DC
Material Conservation: Building Conser Assoc Washington, DC

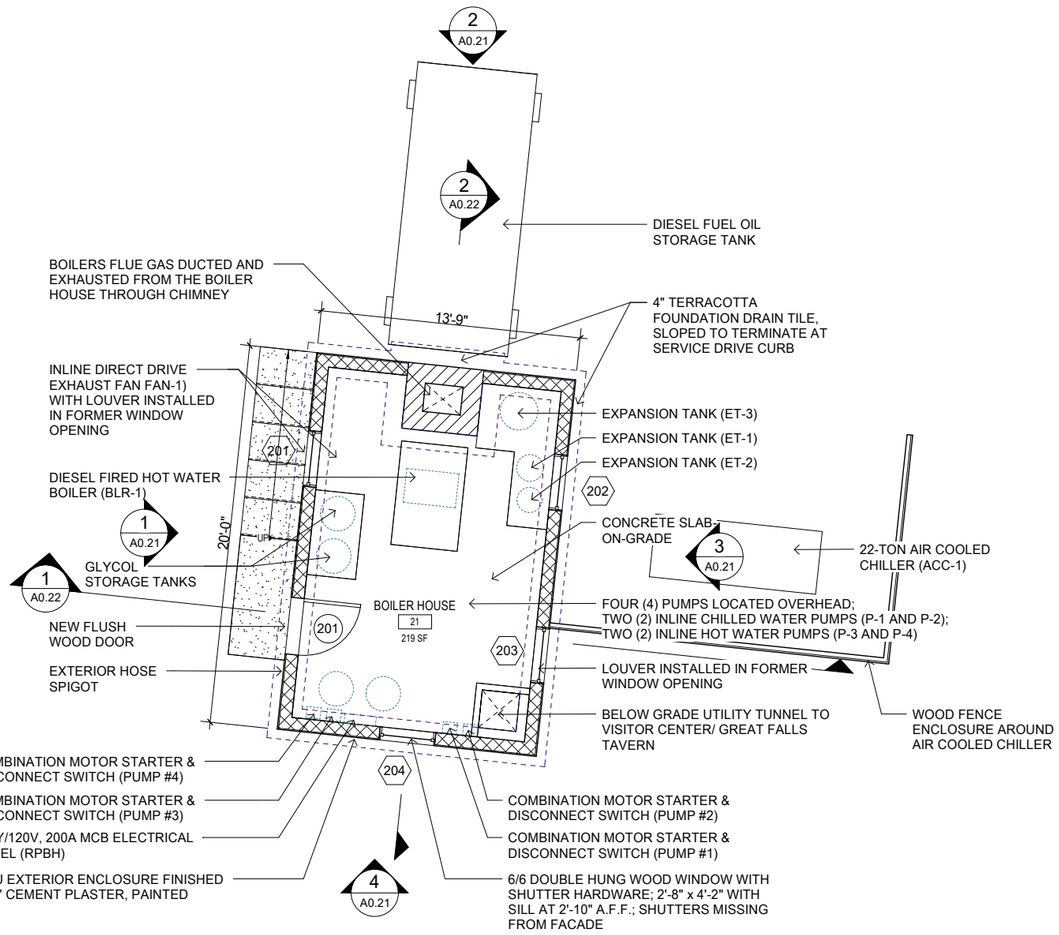
DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.13

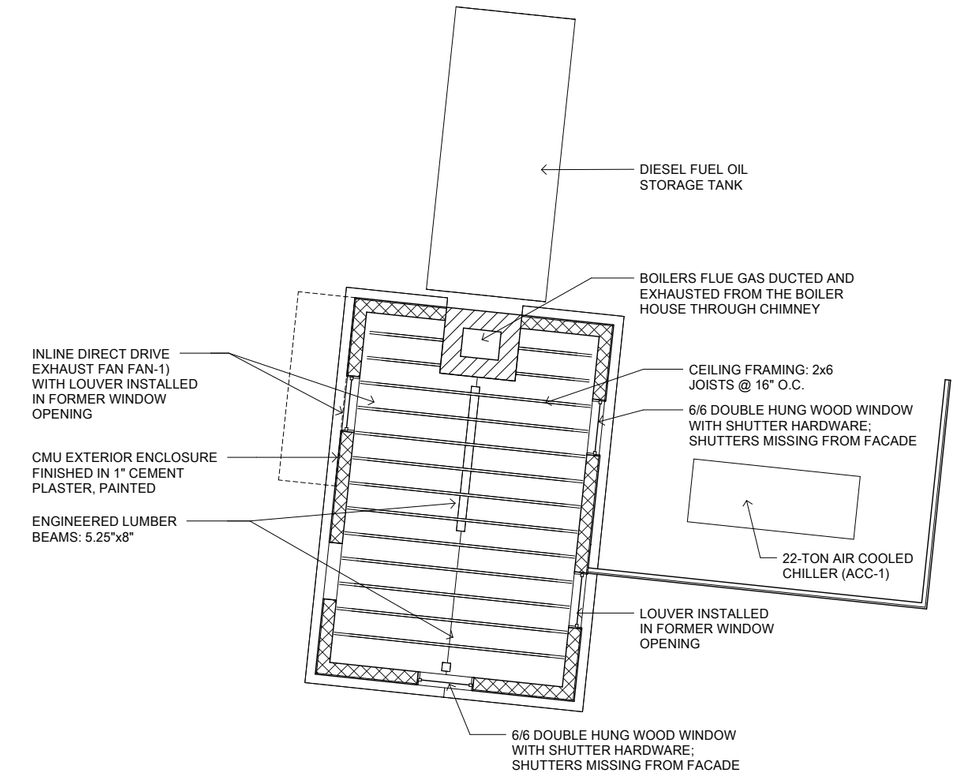
TITLE OF SHEET
EXISTING CONDITIONS
PIVOT BRIDGE RUINS - EXISTING SECTIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- -------
PMIS/PKG NO. 245010
SHEET 8 OF 21

5/26/2023 3:23:21 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.20 BOILER HOUSE EXISTING FLOOR PLAN
SCALE A



2 A0.20 BOILER HOUSE EXISTING REFLECTED CEILING PLAN
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

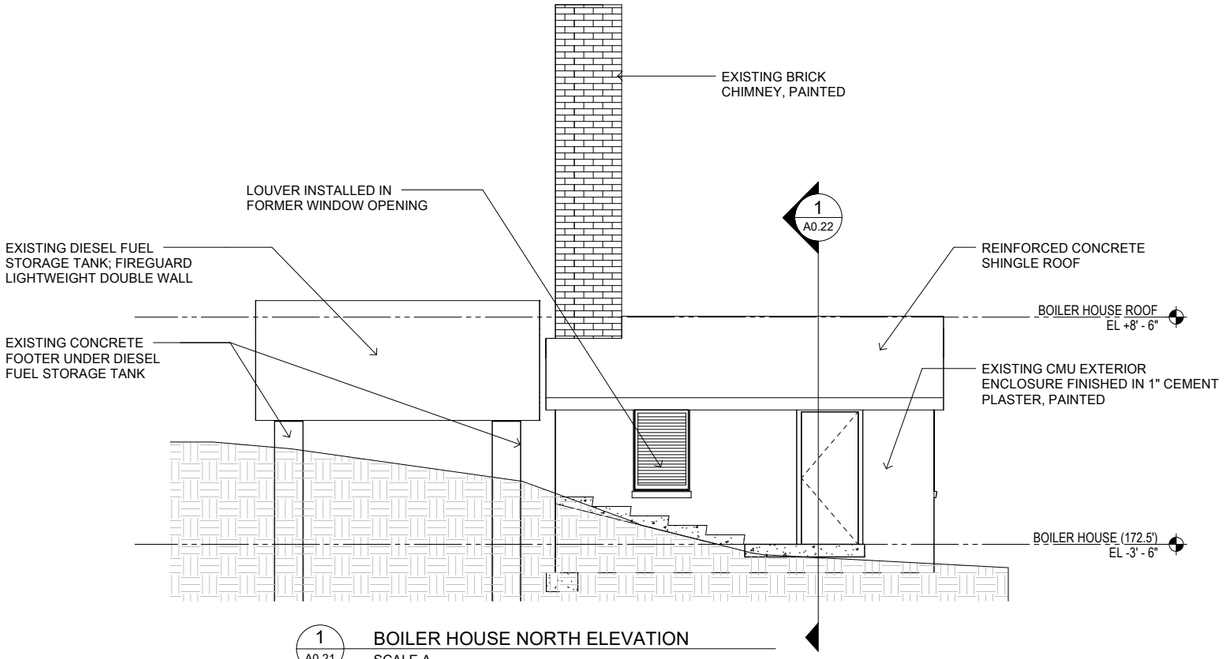
DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.20

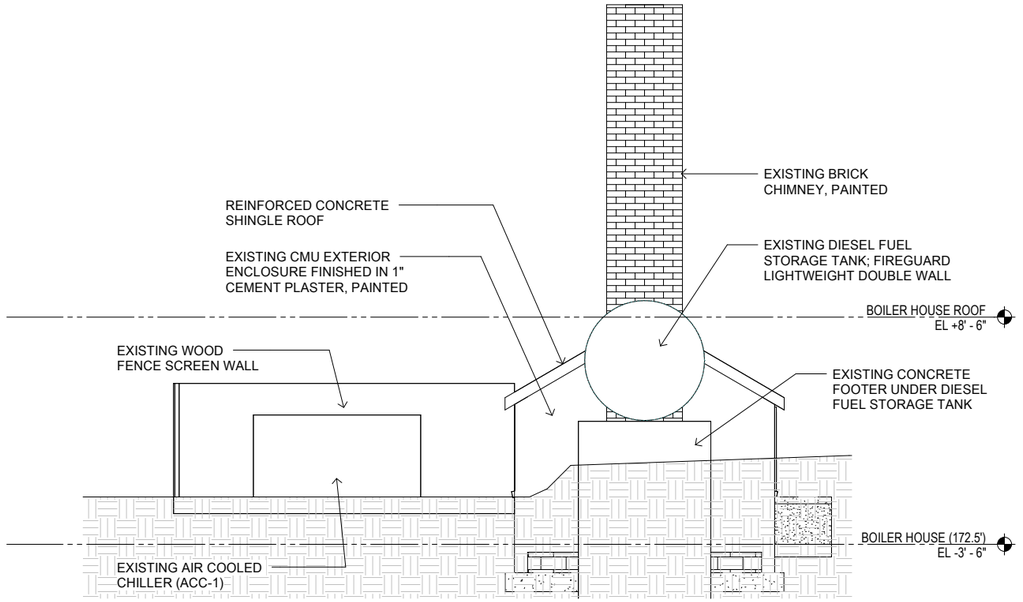
TITLE OF SHEET
EXISTING CONDITIONS
BOILER HOUSE - EXISTING FLOOR PLAN AND REF CELING PLAN
CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
PMIS/PKG NO. 245010
SHEET 9 OF 21

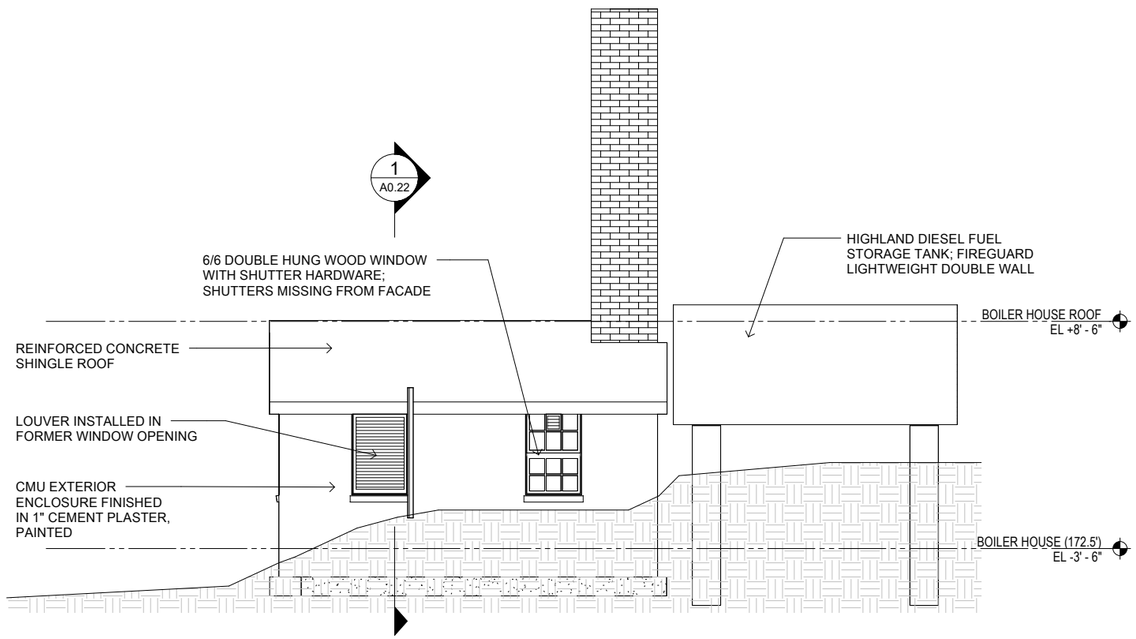
5/26/2023 3:23:22 PM Author Autodesk Docs://Client Projects – National Park Service/C&O Canal CCC Structures HSR–A.rvt



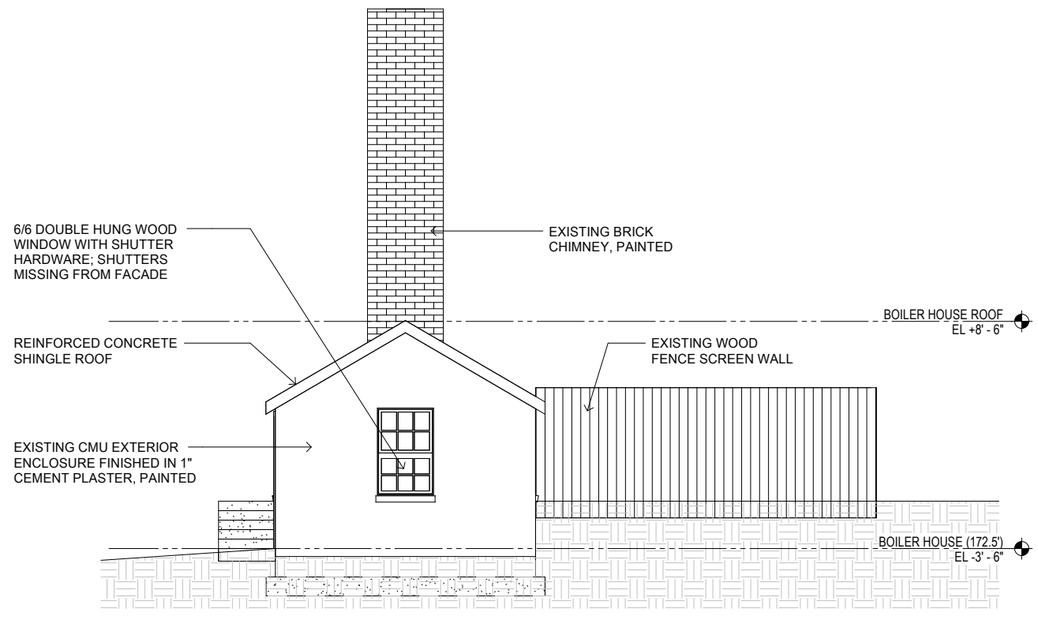
1 A0.21 BOILER HOUSE NORTH ELEVATION
SCALE A



2 A0.21 BOILER HOUSE EAST ELEVATION
SCALE A



3 A0.21 BOILER HOUSE SOUTH ELEVATION
SCALE A



4 A0.21 BOILER HOUSE WEST ELEVATION
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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COMFORT STATION - 171' +/- (NOT NOTED ON PLANS)
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ENGINEER'S GARAGE - 209.95'

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

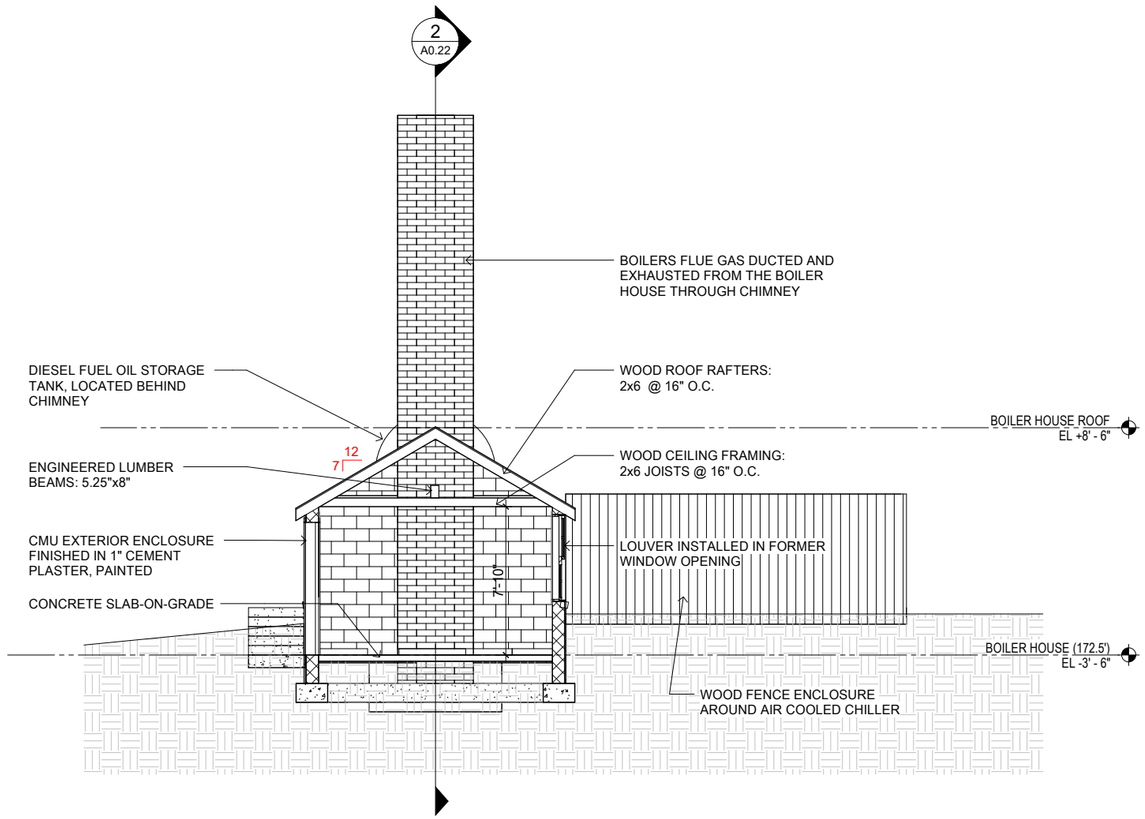
DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.21

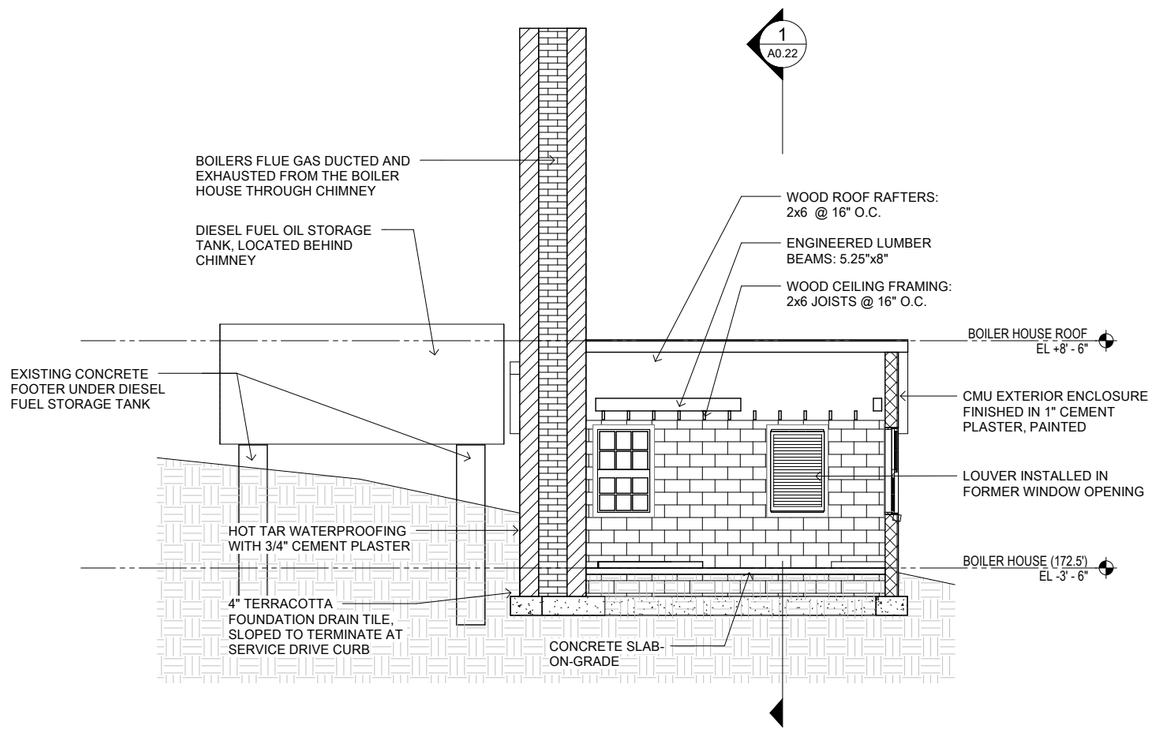
TITLE OF SHEET
EXISTING CONDITIONS
BOILER HOUSE - EXISTING ELEVATIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
PMIS/PKG NO. 245010
SHEET 10 OF 21

5/26/2023 3:23:23 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.22 BOILER HOUSE NORTH/ SOUTH BUILDING SECTION
SCALE A



2 A0.22 BOILER HOUSE EAST/ WEST BUILDING SECTION
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

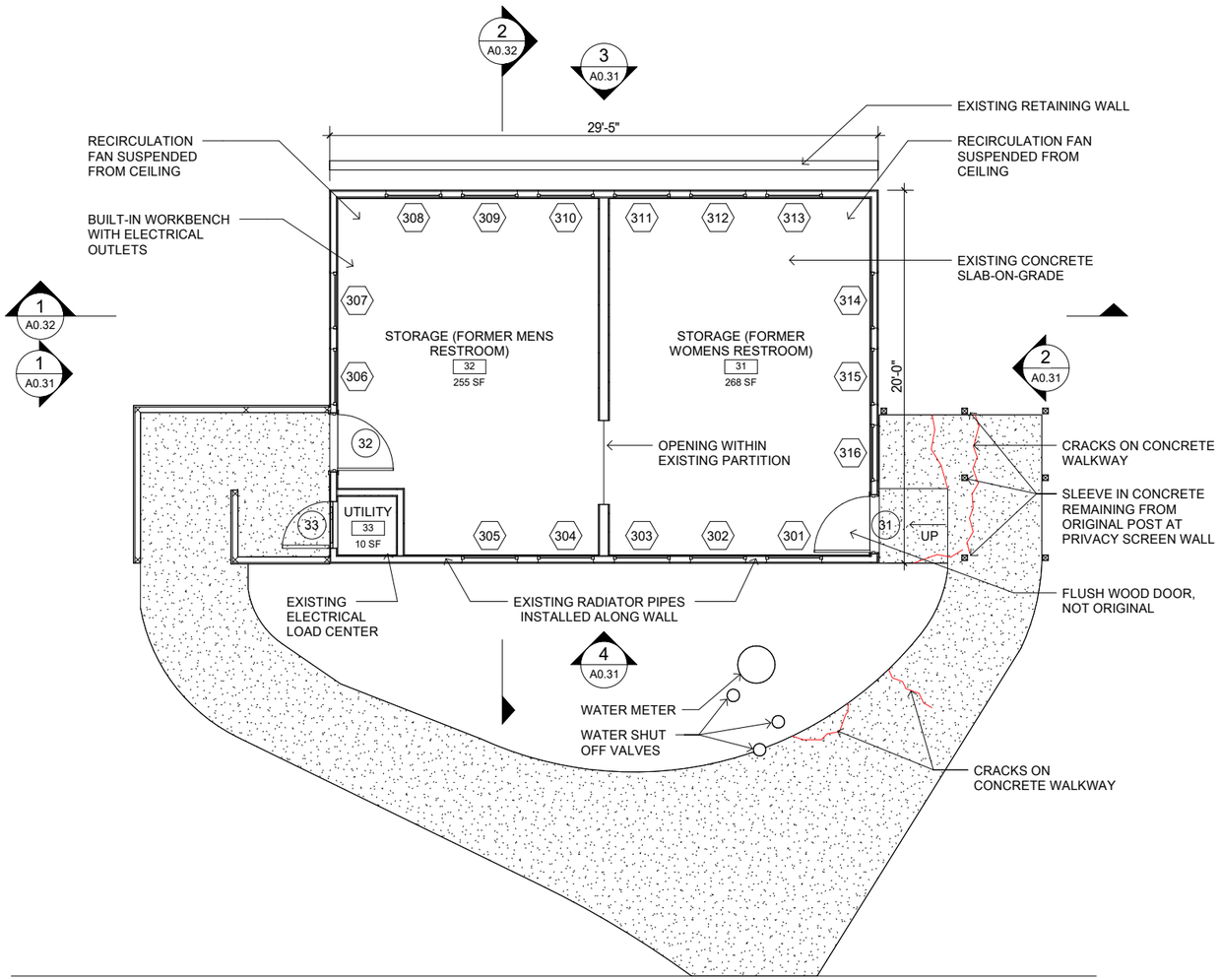
DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.22

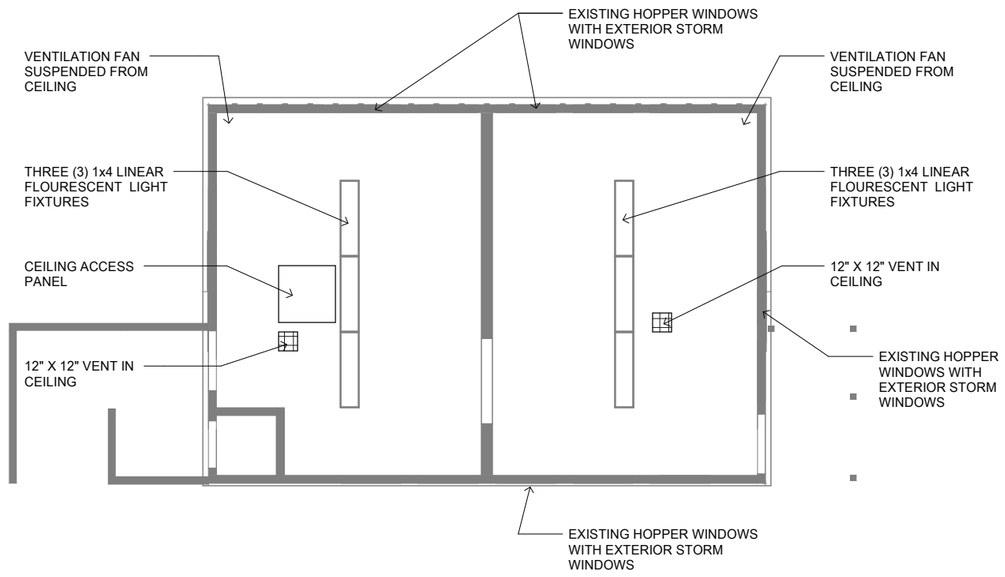
TITLE OF SHEET
EXISTING CONDITIONS
BOILER HOUSE - EXISTING BUILDING SECTIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
PMIS/PKG NO. 245010
SHEET 11 OF 21

5/26/2023 3:23:24 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.30 COMFORT STATION EXISTING FLOOR PLAN
SCALE A



2 A0.30 COMFORT STATION EXISTING REF. CEILING PLAN
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

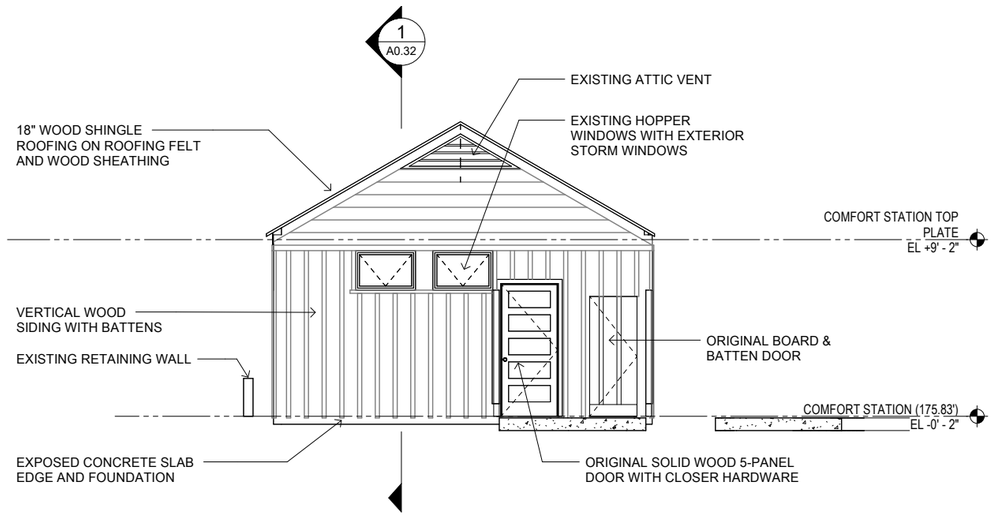
DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.30

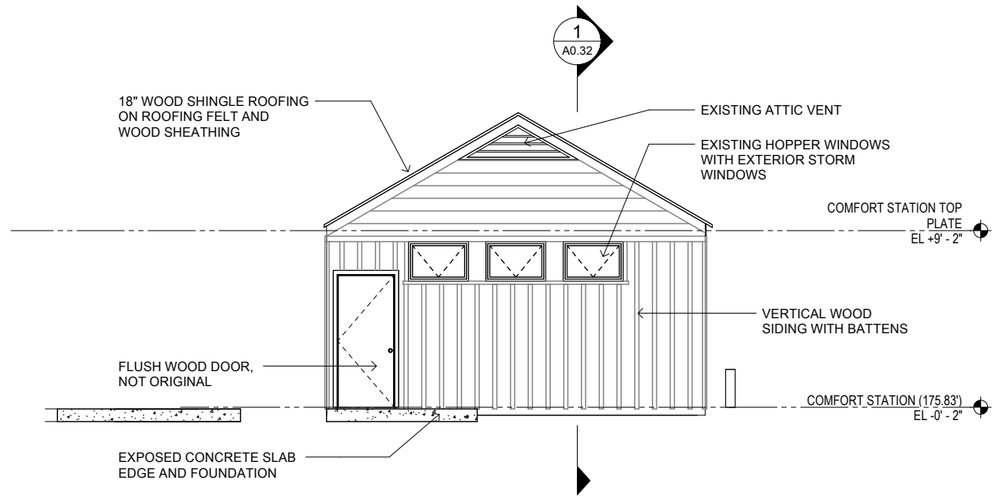
TITLE OF SHEET
EXISTING CONDITIONS
COMFORT STATION - EXISTING FLOOR PLAN AND REF CLG PLAN
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
PMIS/PKG NO. 245010
SHEET 12 OF 21

5/26/2023 3:23:25 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.31 COMFORT STATION - NORTH ELEVATION
SCALE A



2 A0.31 COMFORT STATION - SOUTH ELEVATION
SCALE A

3 A0.31 COMFORT STATION - EAST ELEVATION
SCALE A

4 A0.31 COMFORT STATION - WEST ELEVATION
SCALE A

SCALE A 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE: SmithGroup WASHINGTON, DC
Structural: Silman Washington, DC
Material Conservation: Building Conser Assoc Washington, DC

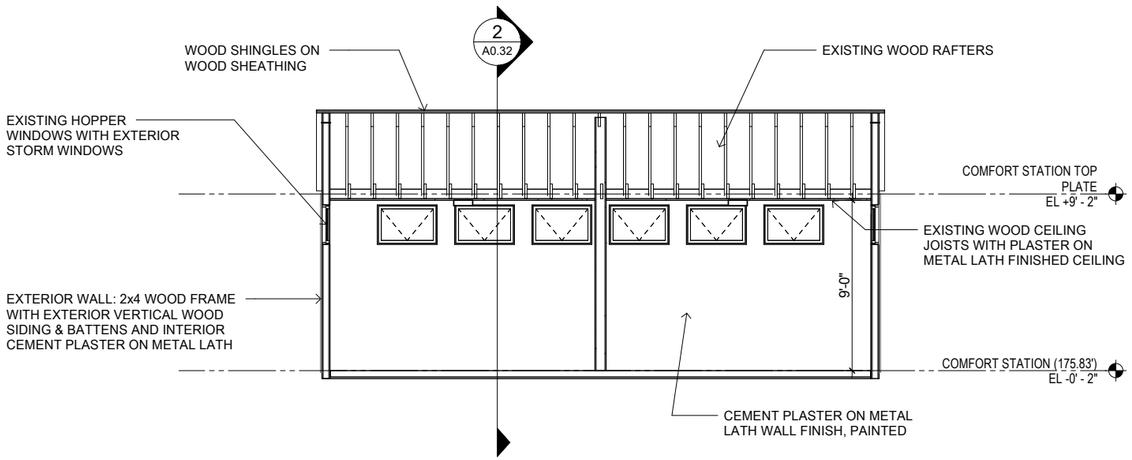
DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.31

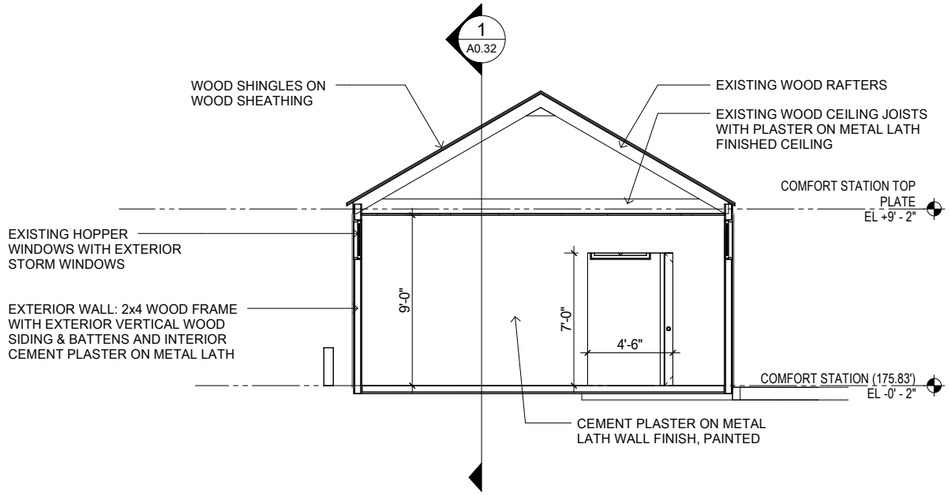
TITLE OF SHEET
EXISTING CONDITIONS
COMFORT STATION - EXISTING ELEVATIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
PMIS/PKG NO. 245010
SHEET 13 OF 21

5/26/2023 3:23:27 PM Author Autodesk Docs://Client Projects - National Park Service/C&O Canal CCC Structures HSR-A.rvt



1 A0.32 COMFORT HOUSE SECTION A
SCALE A



2 A0.32 COMFORT STATION SECTION B
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

VERTICAL DATUMS FOR EACH STRUCTURE WERE TAKEN FROM THE HISTORIC 1941 OR 1951 CONSTRUCTION DRAWINGS FOR EACH STRUCTURE OR FROM THE 2012 UTILITY AS-BUILTS (NPS PROJECT NO. 412-107131).

FINISHED FLOOR ELEVATIONS
PIVOT BRIDGE RUINS - 120.53' (TOP OF CENTRAL PIER)
BOILER HOUSE - 171.35'
COMFORT STATION - 171' +/- (NOT NOTED ON PLANS)
PUMP HOUSE - 174.63'
ENGINEER'S GARAGE - 209.95'

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.32

TITLE OF SHEET
EXISTING CONDITIONS
COMFORT STATION - EXISTING SECTIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
PMIS/PKG NO. 245010
SHEET 14 OF 21

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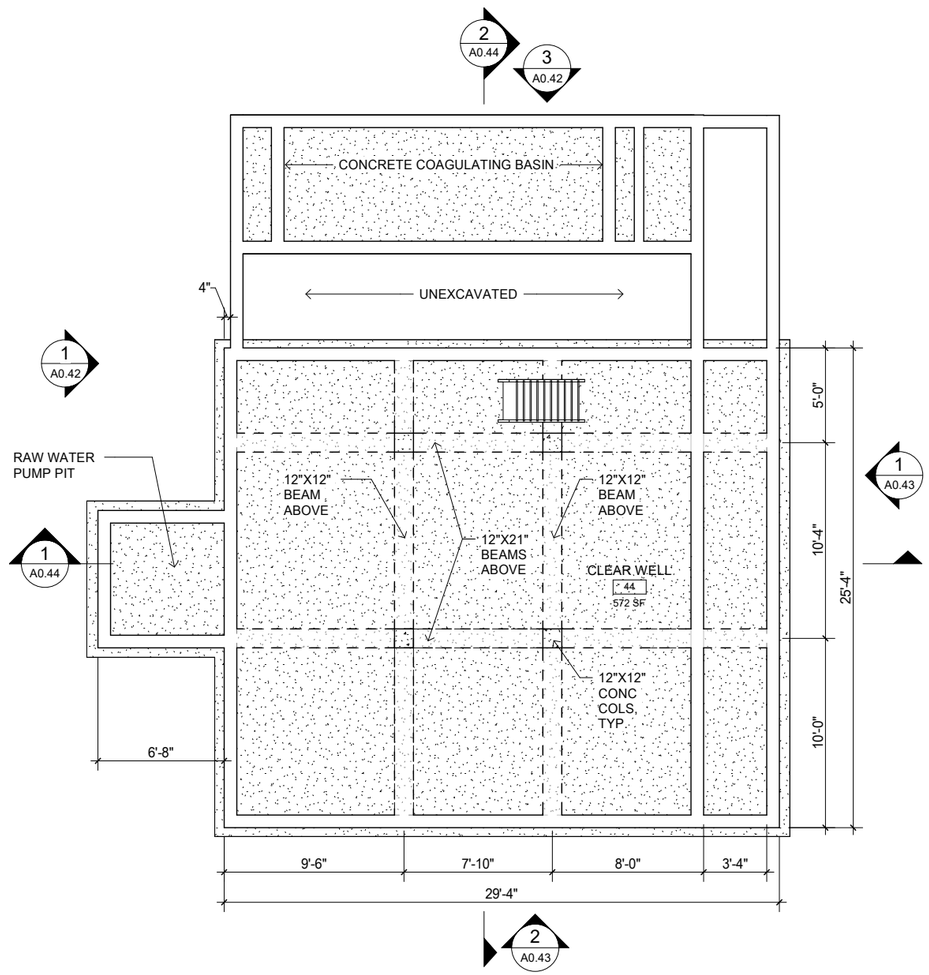
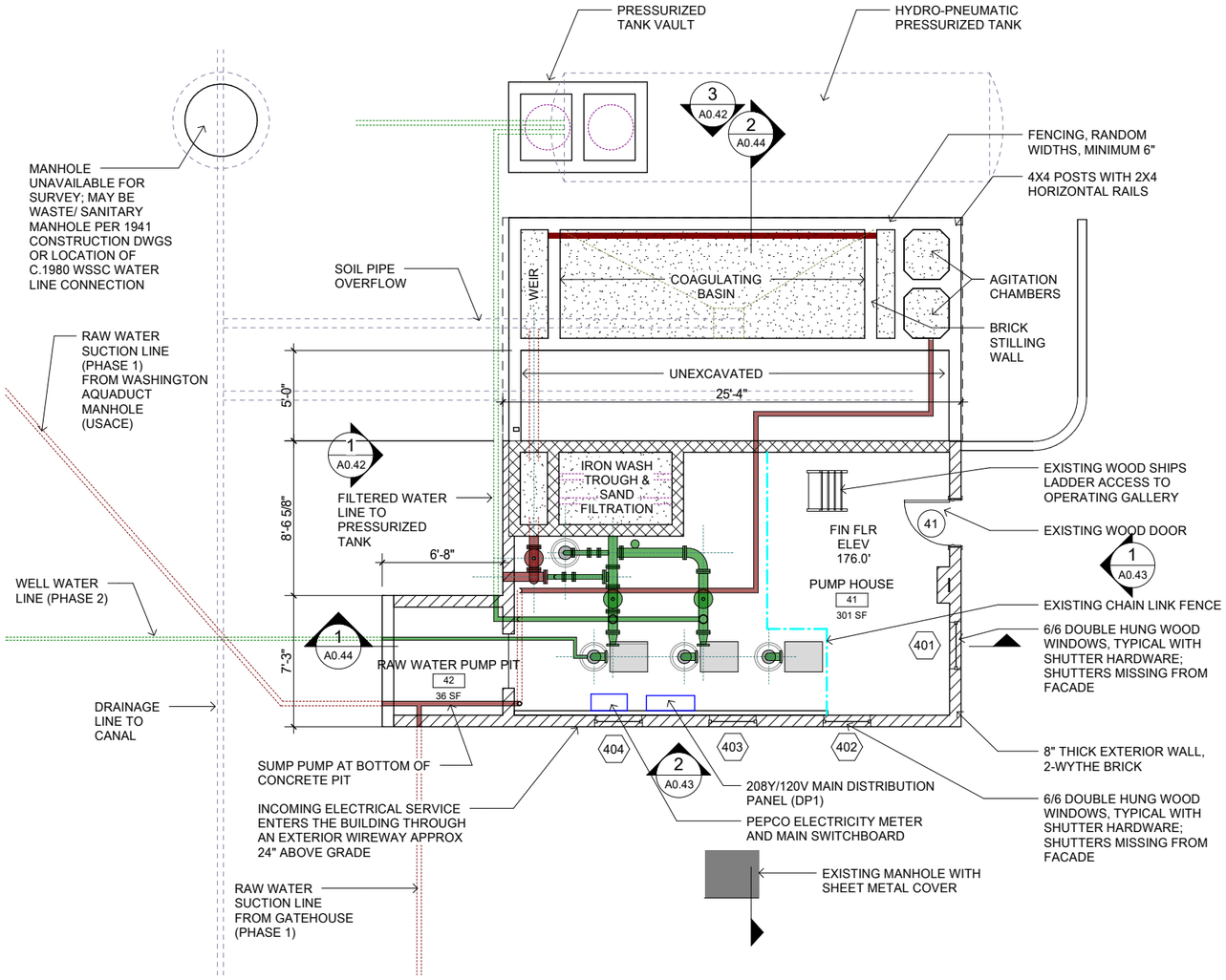


4 A0.40 PUMP HOUSE - EXISTING CLEAR WELL LEVEL FLOOR PLAN
SCALE A



1 A0.40 PUMP HOUSE - EXISTING LEVEL 1 FLOOR PLAN
SCALE A

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SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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ENGINEER'S GARAGE - 209.95'

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.40

TITLE OF SHEET
EXISTING CONDITIONS
PUMP HOUSE - EXISTING FLOOR PLANS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
PMIS/PKG NO. 245010
SHEET 15 OF 21

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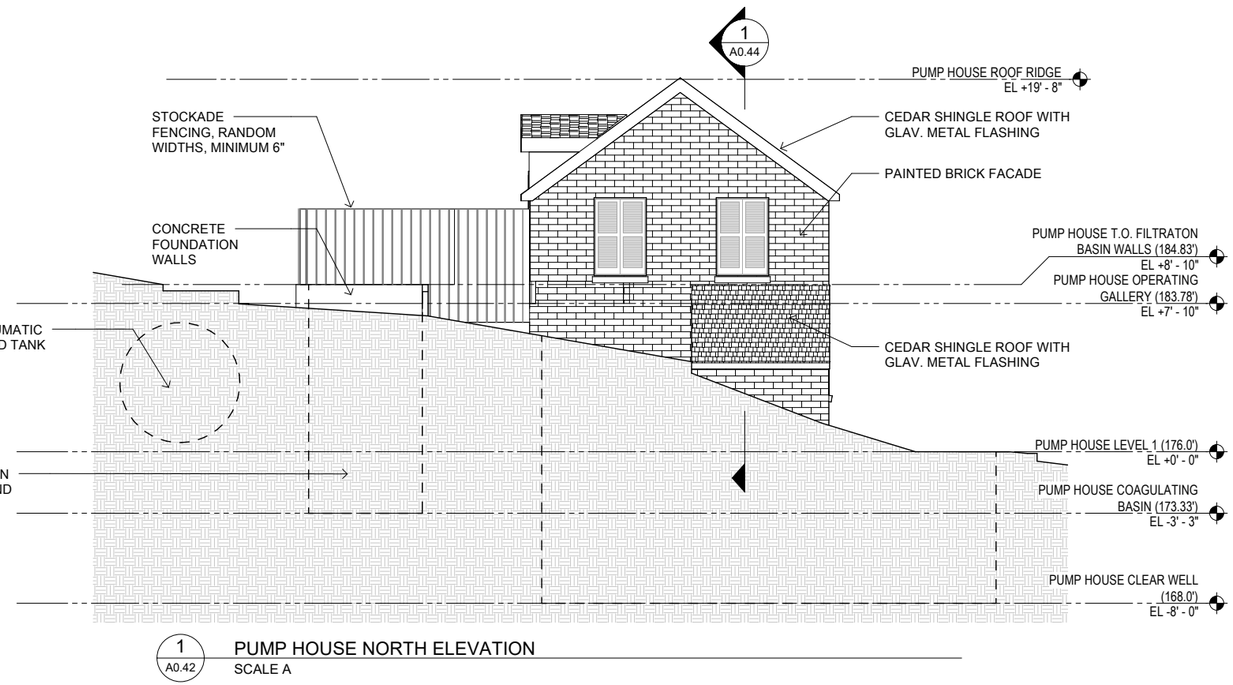

1 A0.42 PUMP HOUSE NORTH ELEVATION
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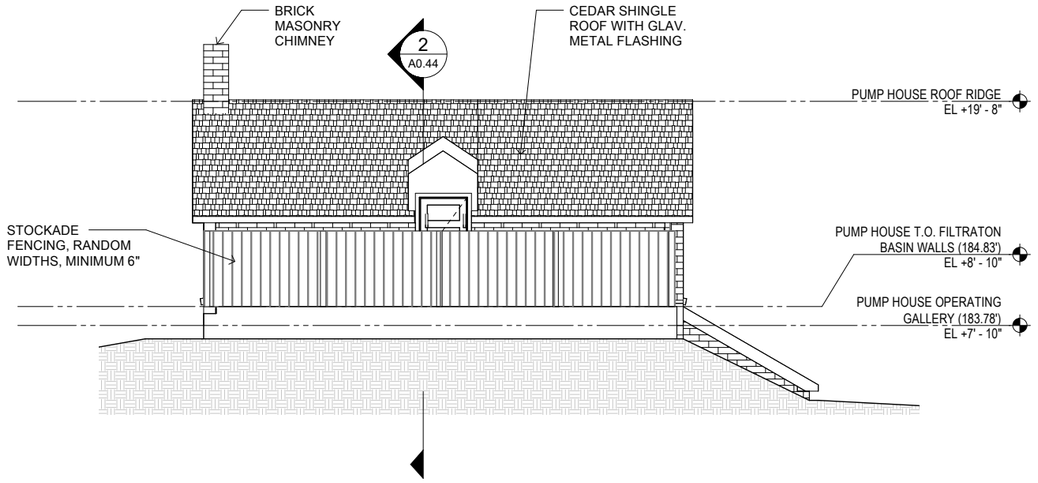

3 A0.42 PUMP HOUSE EAST ELEVATION
SCALE A

SCALE A 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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ENGINEER'S GARAGE - 209.95'

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.42

TITLE OF SHEET
EXISTING CONDITIONS
PUMP HOUSE - EXISTING ELEVATIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
PMIS/PKG NO. 245010
SHEET 16 OF 21

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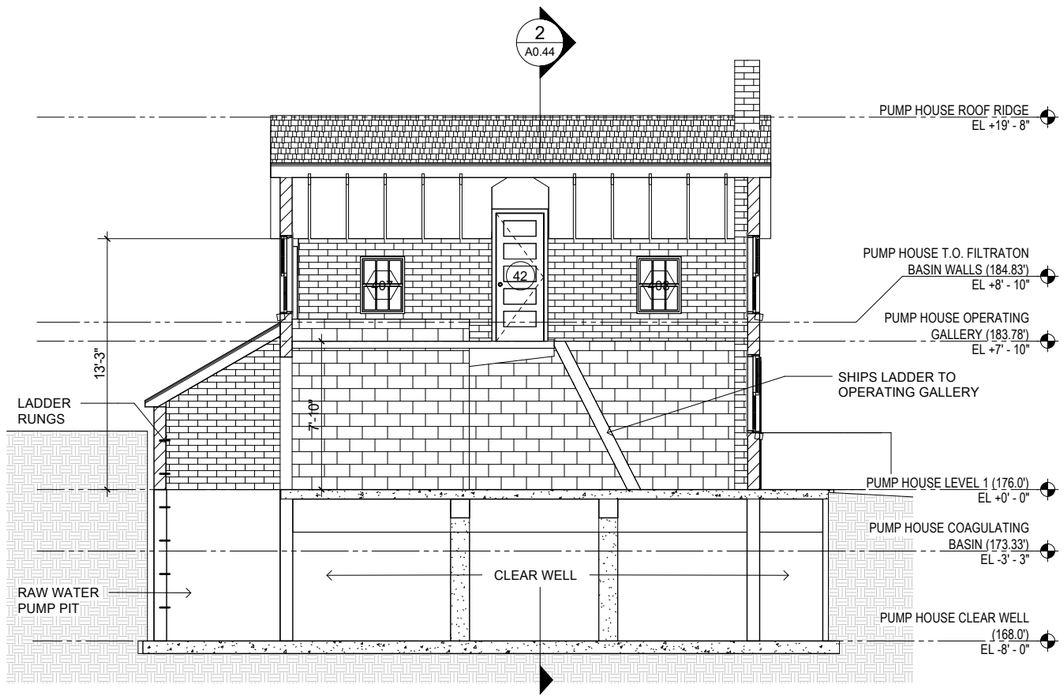

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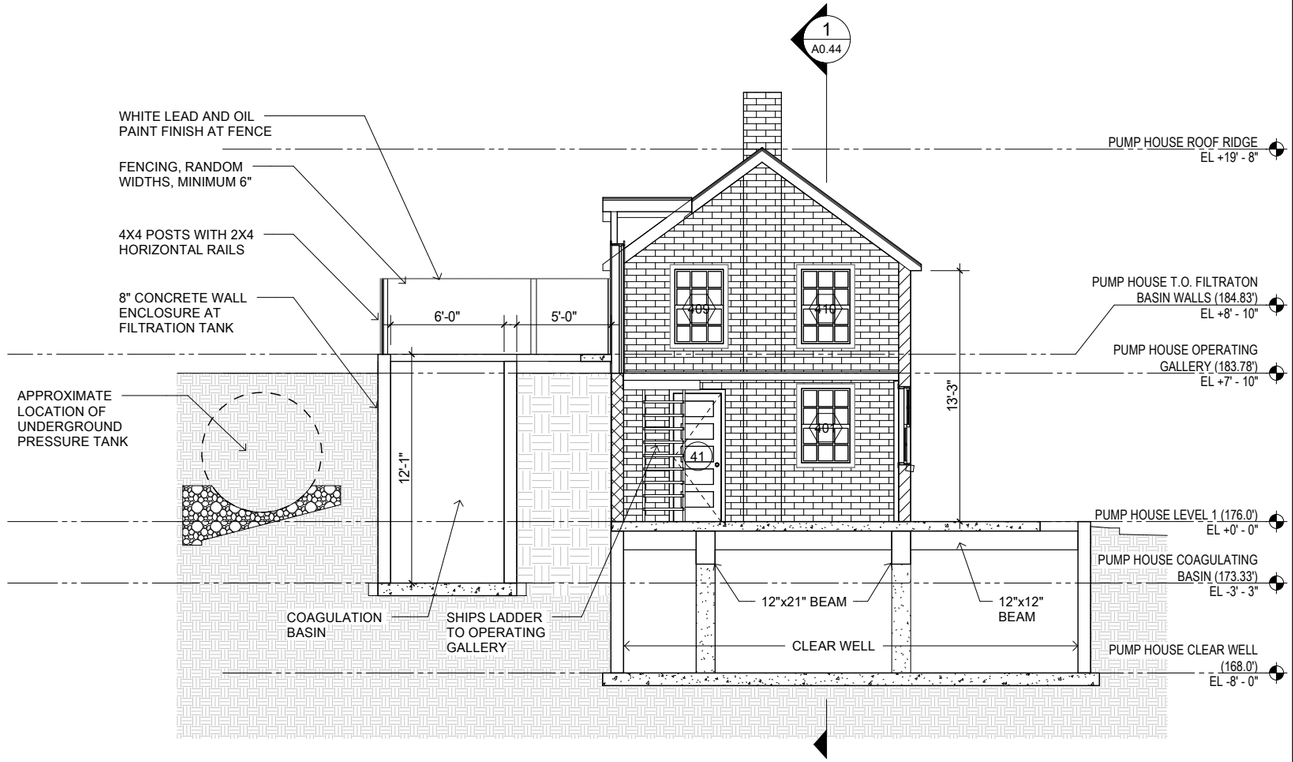

2 A0.44 PUMP HOUSE EAST/ WEST BUILDING SECTION
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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PUMP HOUSE - 174.63'
ENGINEER'S GARAGE - 209.95'

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.44

TITLE OF SHEET
EXISTING CONDITIONS
PUMP HOUSE - EXISTING SECTIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
PMIS/PKG NO. 245010
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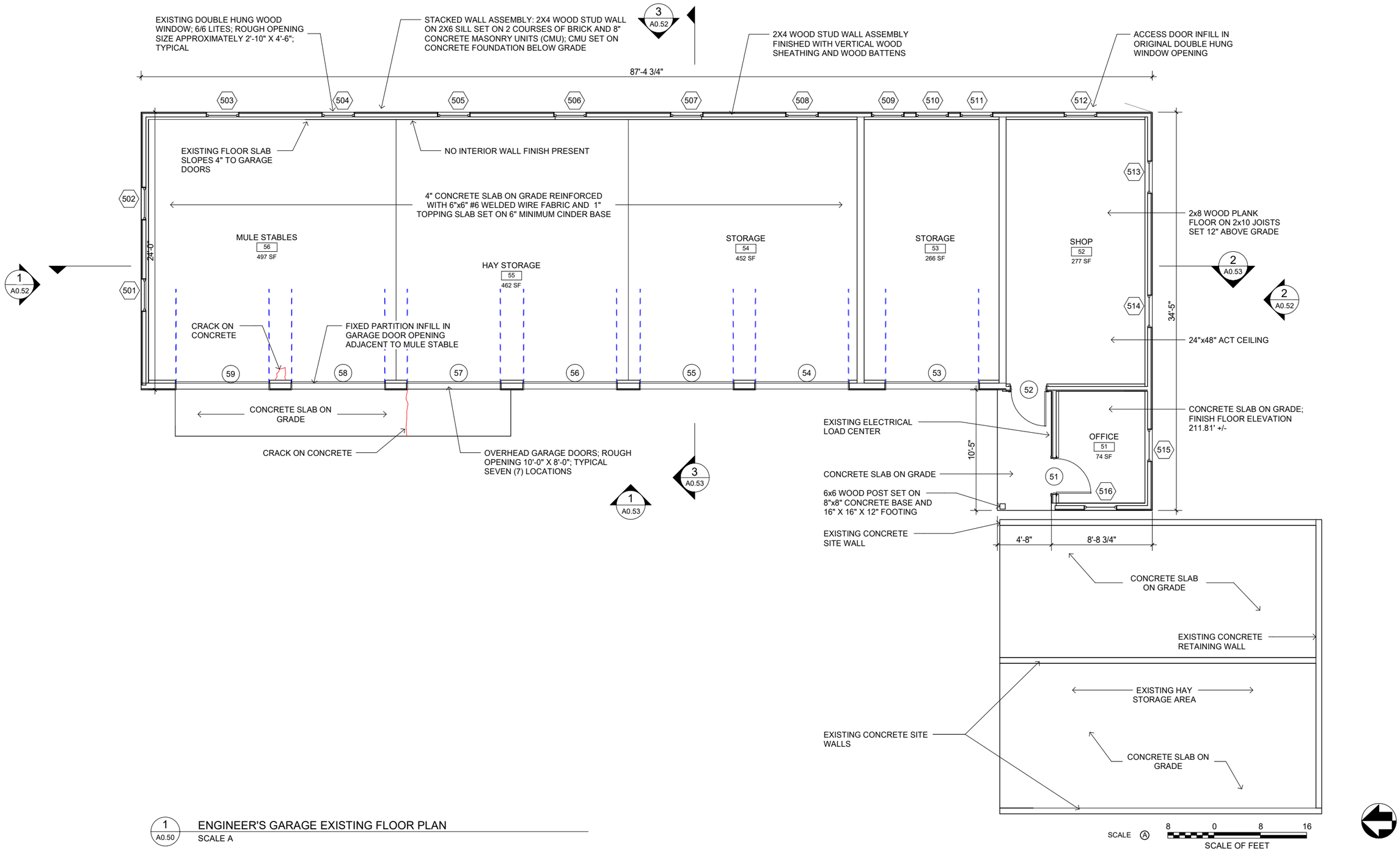

1 A0.50 ENGINEER'S GARAGE EXISTING FLOOR PLAN

SCALE A

GENERAL NOTES

VERTICAL DATUMS FOR EACH STRUCTURE WERE TAKEN FROM THE HISTORIC 1941 OR 1951 CONSTRUCTION DRAWINGS FOR EACH STRUCTURE OR FROM THE 2012 UTILITY AS-BUILTS (NPS PROJECT NO. 412-107131).

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COMFORT STATION - 171' +/- (NOT NOTED ON PLANS)
PUMP HOUSE - 174.63'
ENGINEER'S GARAGE - 209.95'

HISTORIC STRUCTURE REPORT DRAWINGS

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Sliman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.50

TITLE OF SHEET
EXISTING CONDITIONS
ENGINEER'S GARAGE - EXISTING FLOOR PLAN
CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
PMIS/PKG NO. 245010
SHEET 18 OF 21

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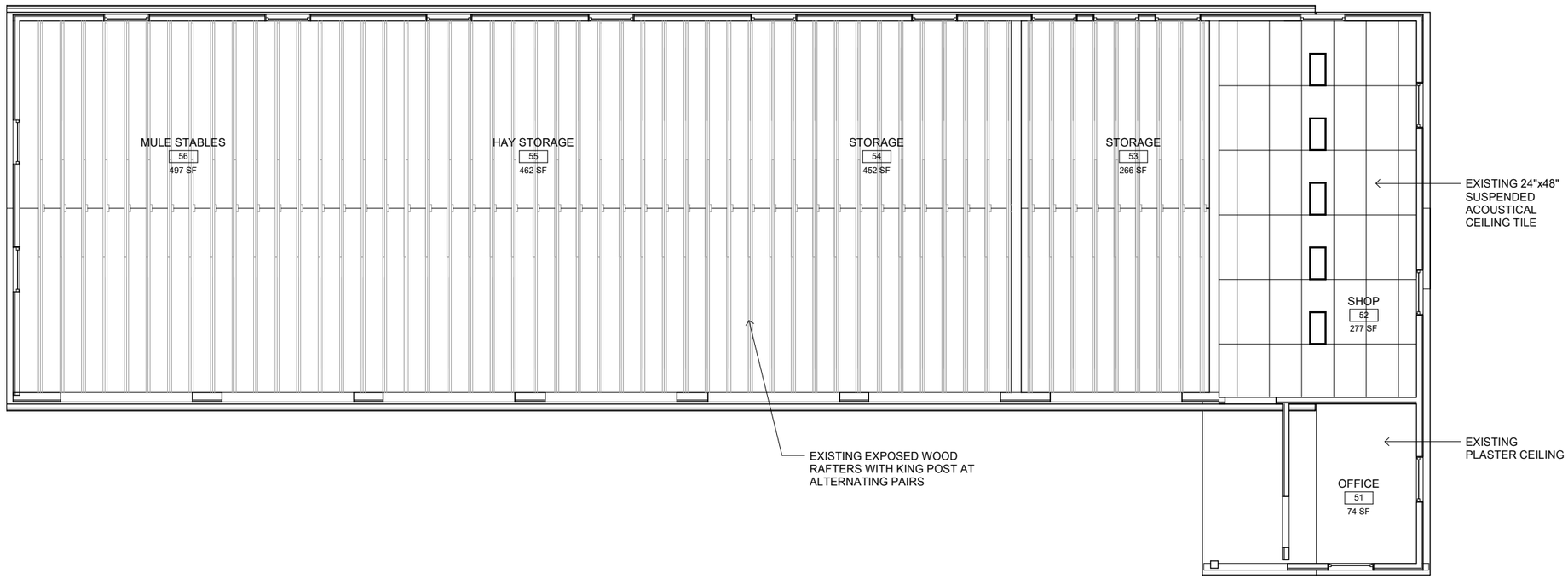

1 / A0.51 ENGINEER'S GARAGE EXISTING REF CEILING PLAN
SCALE A

SCALE Ⓐ 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

GENERAL NOTES

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NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.51

TITLE OF SHEET
EXISTING CONDITIONS
ENGINEER'S GARAGE - EXISTING REFLECTED CEILING PLAN
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
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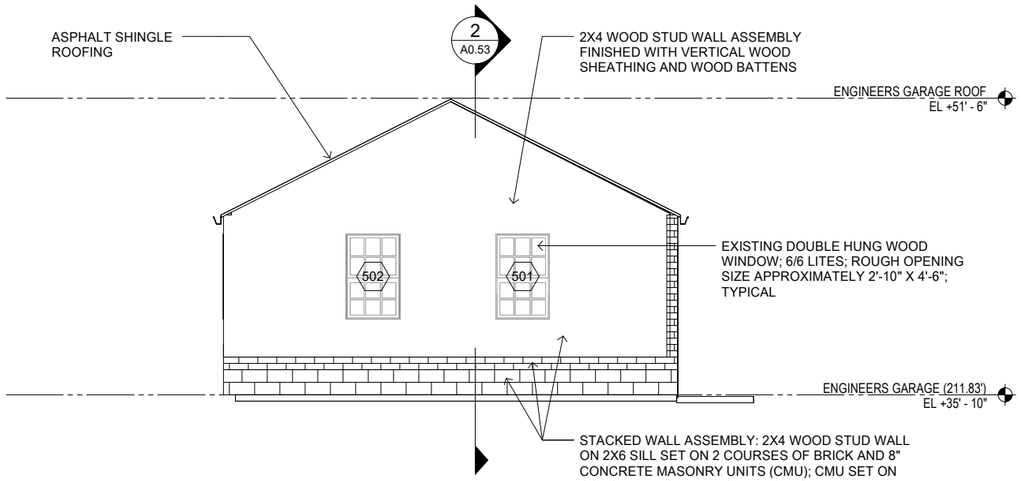

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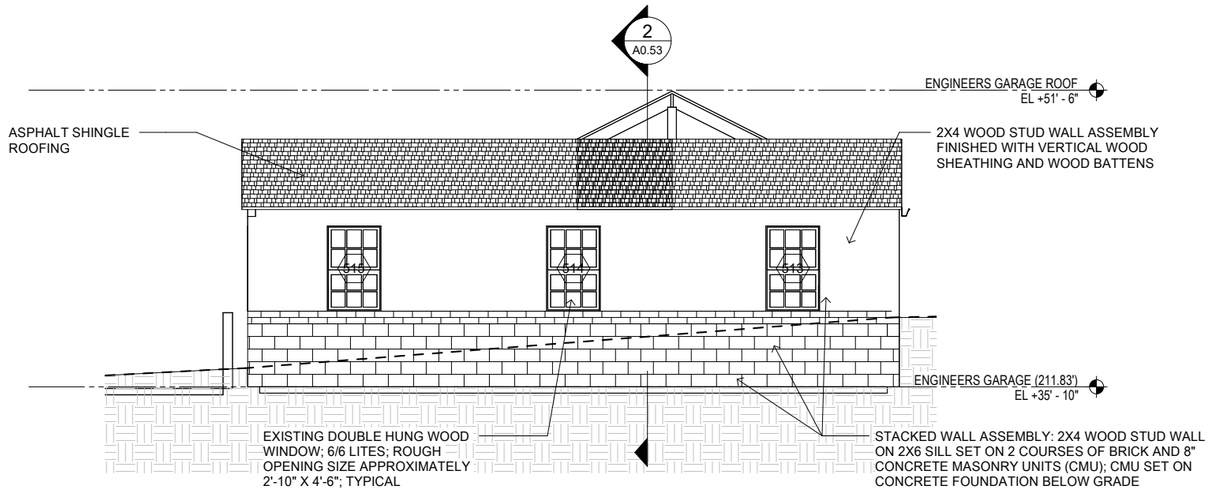

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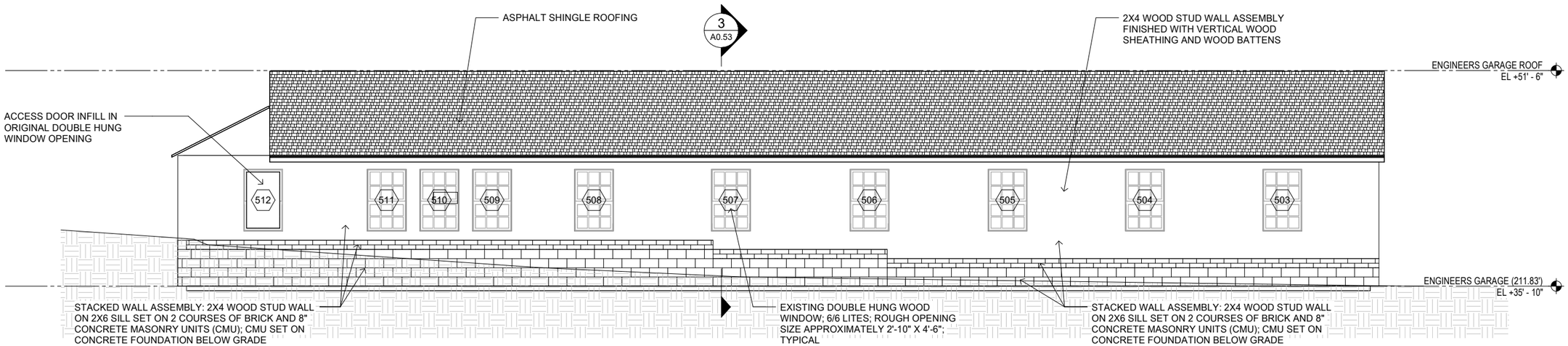

3 A0.52 ENGINEER'S GARAGE - EAST ELEVATION
SCALE A

SCALE A 8 0 8 16
SCALE OF FEET

HISTORIC STRUCTURE REPORT DRAWINGS

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PUMP HOUSE - 174.63'
ENGINEER'S GARAGE - 209.95'

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Material Conservation:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.52

TITLE OF SHEET
EXISTING CONDITIONS
ENGINEER'S GARAGE - EXISTING NORTH, SOUTH, & EAST ELEVATIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- / ------
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SHEET 20 OF 21

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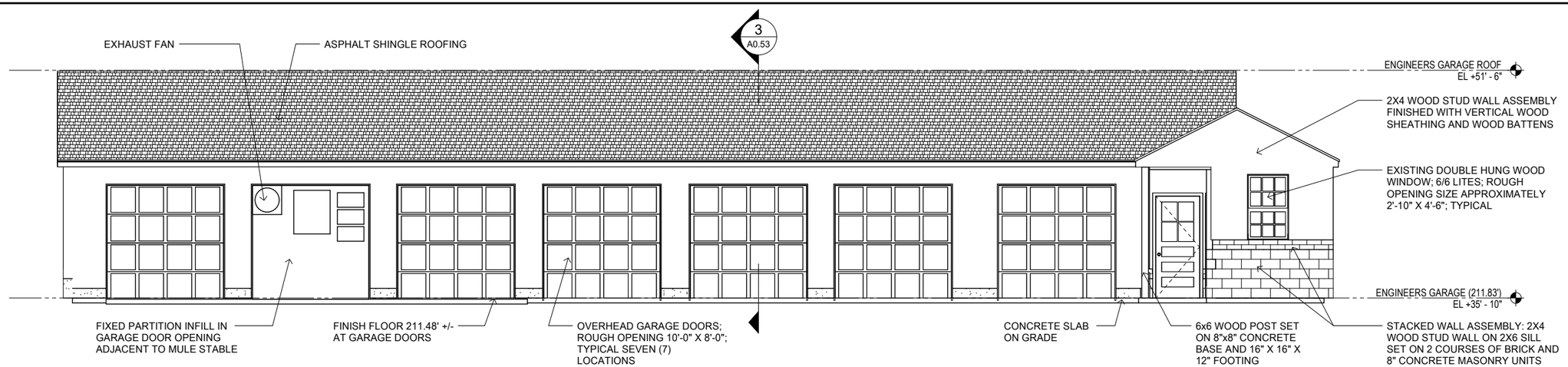

1 A0.53 ENGINEER'S GARAGE - WEST ELEVATION
SCALE A

GENERAL NOTES

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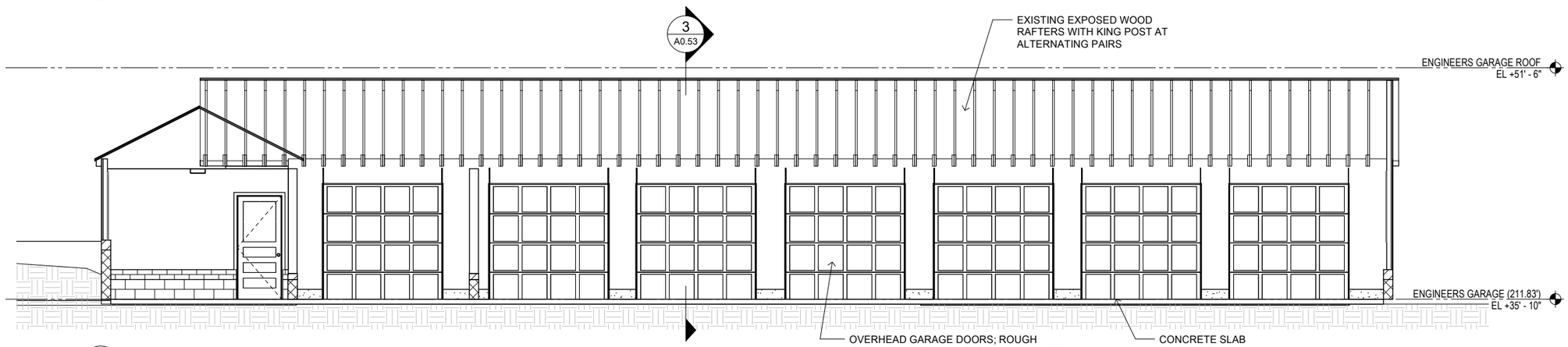

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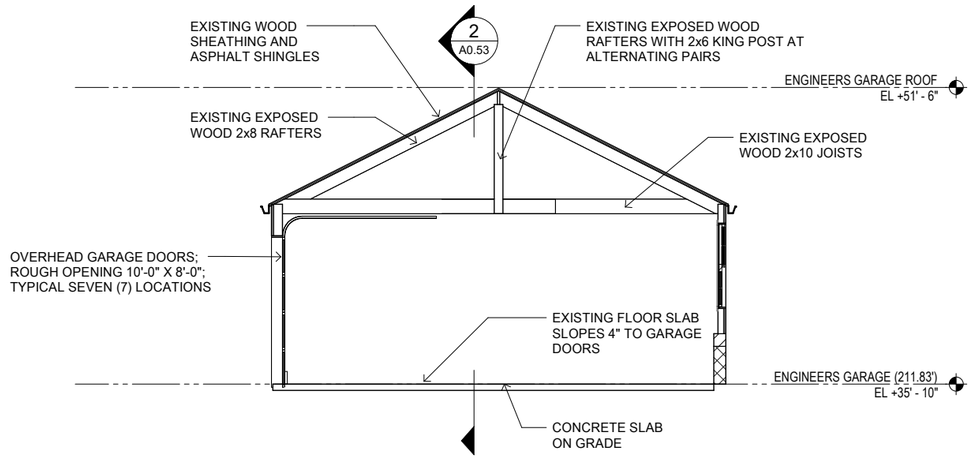

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SCALE A

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HISTORIC STRUCTURE REPORT DRAWINGS

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE: SmithGroup WASHINGTON, DC
Structural: Silman Washington, DC
Material Conservation: Building Conser Assoc Washington, DC

DESIGNED: SJP
CADD: CZ
TECH REVIEW:
DATE: 05/26/2023

SUB SHEET NO. A0.53

TITLE OF SHEET
EXISTING CONDITIONS
ENGINEER'S GARAGE - EXISTING WEST ELEVATIONS & SECTIONS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. --- ------
PMIS/PKG NO. 245010
SHEET 21 OF 21

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Appendices

Appendix A: Bibliography
Appendix B: Materials Analysis

Appendix A: Bibliography

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Record Group 35-GE, Records of the Civilian Conservation Corps. National Archives and Records Administration, College Park, Maryland, Still Photos. Miscellaneous photos in Box 1 of 4.

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Series V: mm 12.62-14.30, Maintenance Files Collection, Chesapeake & Ohio

Canal National Historical Park, Williamsport, Maryland. Miscellaneous files in Box 04 and Box 05.

Series XIX: mm 108.91-110.10, Maintenance Files Collection, Chesapeake & Ohio Canal National Historical Park, Williamsport, Maryland. Miscellaneous files in Box 01.

Appendix B: Materials Analysis

CCC Structures at Chesapeake & Ohio Canal National Historic Site

Washington, D.C.

Materials Analysis

Revised January 2023

BCA

BUILDING CONSERVATION ASSOCIATES INC.

CCC Structures at Chesapeake & Ohio Canal National Historic Site

Washington, D.C.

Materials Analysis

Prepared For
SmithGroup
1700 New York Ave. NW, Suite 100
Washington, D.C. 20006

Prepared By
Building Conservation Associates, Inc.
4821 29th St. S
Arlington, VA 22206

BCA Team
Dorothy Krotzer
Marlene Goeke
Kevin Wohlgemuth
Tessa Honeycutt

Revised January 2023

BCA

BUILDING CONSERVATION ASSOCIATES INC.

1.0 INTRODUCTION

At the request of SmithGroup, Building Conservation Associates, Inc. (BCA) has prepared an analysis of select masonry materials of several structures associated with the Civilian Conservation Corps (CCC) at the Chesapeake & Ohio Canal National Historical Park (CHOH) outside of Washington, D.C. This analysis has been conducted as part of the larger Historic Structure Report (HSR) effort for the site being performed by SmithGroup.

The masonry materials investigated for this study include mortars and plasters from four buildings near the Great Falls Tavern including the Boiler House, Comfort Station, Pump House, and Engineer's Garage, as well as the ruins of a Pivot Bridge about 1.5 miles south of the tavern. The primary goals of the materials analysis are to aid in preparing a construction chronology for the structures and to provide recommendations for potential future masonry repairs to the structures.

The following report summarizes the findings of the masonry materials analysis and puts it into context with the history of the structures, as known through archival sources. For the compositional analysis of the masonry materials, one sample of mortar or plaster was taken from each of the structures by BCA during site visits in October 2020 and sent to Highbridge Materials Consulting, Inc. for petrographic and chemical analysis. The full report from Highbridge Materials Consulting, Inc. (Highbridge) is presented in *Appendix B*.

2.0 BACKGROUND INFORMATION[1]

Under President Franklin D. Roosevelt's New Deal Program, two African American companies of the Civilian Conservation Corps (CCC) were stationed near Cabin John and Carderock, Maryland along the Chesapeake & Ohio Canal in 1938. As part of this program, these CCC workers were tasked with repairing flood damage to the historic canal infrastructure. Their work included lock restoration, erosion control, and landscaping, among other tasks. The CCC employees also participated in the construction of several new structures along the canal near the Great Falls Tavern to aid in the transition of the canal into a recreational site for the National Park Service.[2] These structures included those in this materials analysis study: a pivot bridge, a boiler house, a comfort station, a pump house, and a garage for the U.S. Army Corps of Engineers (USACE).

The CCC camp at Cabin John was established in 1938 and operated until 1942 when it was converted into a defense camp to aid in the war effort. All five of the CCC-built structures in this materials analysis study were constructed during this four-year period. The first of these structures to be built appears to be the pivot bridge that crossed the canal prism, which was used for access to the CCC camp at Carderock (Figure 1).[3] Unlike the other four structures in this study, the pivot bridge is the only one no longer fully extant; only the stone foundations and remnants of steel gears remain. It is possible that damage to the main part of the bridge occurred during Hurricane Agnes in 1972, which reportedly caused significant flooding of the canal and washed away several bridges.[4]

The other four structures near the Great Falls Tavern were all built between 1941 and 1942 to accommodate the needs of the public upon the opening of the canal for recreation as well as for USACE working on the canal infrastructure. The comfort station is a wood-framed building, cladded in vertical board and batten siding, with a wood-shingle roof and clerestory hopper windows (Figure 2). The interior was coated with a cement plaster on wire lath.[5] This building was designed to provide public bathroom facilities for visitors to the Great Falls area of the canal. The National Park Service modified the building for use as storage and maintenance for their bike share program, including opening up the partition between the two interior spaces.

The CCC built a water filtration plant/pump house to provide a water source to the nearby structures, like the comfort station (Figure 3). This 1.5-story structural brick building with a wood-shingle roof housed the necessary equipment including a coagulating basin, steel pressure tank, and a concrete clear well to pump water throughout the area.[6]

USACE worked alongside the CCC in the restoration of the canal infrastructure and required a facility to store their work vehicles and equipment. The CCC built a six-stall garage for their use (Figure 4). The garage also included space for a repair shop, storage, and office.[7] The L-shaped wood frame building included concrete flooring and a concrete block and brick foundation.[8] The

[1] Archival sources reviewed by BCA are referenced in footnotes throughout the report. These sources were provided to BCA by SmithGroup.
[2] Howard, Josh, *"Our Only Alma Mater": The Civilian Conservation Corps and the C&O Canal (*Special History Study, 2017), 47-57.
[3] Historic American Buildings Survey, "Conservation Corps Activities in the National Capital Region of the National Park Service, HABS No. C-858" (Washington, D.C.: National Park Service, 2004), 91.
[4] National Park Service, "Great Falls Tavern Cultural Landscape Report" (Washington, D.C.: National Park Service, 2009), 26.
[5] Howard, *"Our Only Alma Mater,"* 115.
[6] National Park Service, "Great Falls Tavern Cultural Landscape Report," 21.
[7] Howard, *"Our Only Alma Mater,"* 115.
[8] Historic American Buildings Survey, "Conservation Corps Activities," 67.

interior was converted to a mule barn in 1967.[9] As a result, the interior was altered and divided into mule stalls. The garage is still used for the CHOH mule-pulled canal boat program.[10]

The boiler house was used to heat the comfort station and other nearby structures and also housed chlorinating equipment (Figure 5).[11] Similar to others found at Fort Hunt and Fort Washington, this boiler house was constructed of concrete block masonry with a brick chimney and a wood shingle roof.[12] The boiler was insulted in asbestos block which was covered in a mixture of Portland cement and asbestos. The NPS switched from a coal to oil boiler in 1951 and additional modern equipment was installed in the 1970s.[13]

[9] Ibid. page 93.
[10] National Park Service, "Great Falls Tavern Cultural Landscape Report," 27; https://www.nps.gov/choh/planyourvisit/great-falls-canal-boat-rides.htm..
[11] National Park Service, "Great Falls Tavern Cultural Landscape Report," 41.
[12] Howard, *"Our Only Alma Mater,"* 115.
[13] Historic American Buildings Survey, "Conservation Corps Activities," 93.

Figure 1. Pivot Bridge pier ruin, view looking west (BCA 2020).

Figure 2. Comfort Station, view looking east (BCA 2020).

Figure 3. Pump House, view looking southeast (BCA 2020).

Figure 4. Engineer's Garage, view looking east (BCA 2020).

Figure 5. Boiler House, view looking southeast (BCA 2020).

3.0 METHODOLOGY

Extraction of the masonry samples occurred during two site visits by BCA in October 2020. During the site visits, each of the structures was physically examined for intact areas from which representative samples of mortars or plasters could be removed. The locations of these samples were selected based on the potential for original materials. The samples were removed using masonry chisels and a hammer.

A total of five representative samples of the various masonry materials was removed, one from each structure (Table 1). These included: interior mortar from the wall of the boiler house (Figure 6-Figure 7); exterior mortar from the wall of the pump house (Figure 8-Figure 9); interior plaster from the comfort station (Figure 10-Figure 11); interior mortar from the foundation of the engineer's garage (Figure 12-Figure 13); and mortar from the piers of the pivot bridge (Figure 14-Figure 15). Sample locations are included in the table below and also illustrated in *Appendix A*.

These samples were initially examined visually by BCA to preliminarily characterize the materials prior to submitting them to Highbridge for more in-depth analysis. Highbridge performed petrographic examination, chemical analysis (atomic absorption spectroscopy), and acid dissolution/sand extraction to separate these components.[14] The goal of this analysis was to identify the binder and aggregate components of each of the masonry materials, as well as the original component ratio. The acid dissolution allowed for the extraction of the aggregate portion of select, representative materials. Although Highbridge's findings are summarized in *Section 4.0* of this report, their full report (including their methods of examination and data) has also been included in *Appendix B*.

Sample #	Location	Material	Masonry/Substrate
CHOH-01	Boiler House, interior west wall	Mortar	Cement block masonry
CHOH-02	Pump House, north and south exterior elevations	Mortar	Brick masonry
CHOH-03	Comfort Station, interior north wall	Plaster	Expanded metal lath
CHOH-04	Engineer's Garage, interior east foundation wall	Mortar	Brick/Cement block masonry
CHOH-05	Pivot Bridge, exterior piers	Mortar	Stone (quartzitic schist) masonry[15]

Table 1. Table of masonry sample locations and materials.

[14] The extracted sand samples will be stored at BCA and can be returned at NPS's request.
[15] William E. Davies, "The Geology and Engineering Structures of the Chesapeake and Ohio Canal," Glen Echo, MD: C&O Canal Association (1999), 70.

4.0 SUMMARY OF FINDINGS

The results of the laboratory analysis of the masonry materials at the five CCC Structures at CHOH indicate that all of the materials analyzed are portland cement-based mixes. With the exception of the mortar from the boiler house, all contain gray portland cement and a small amount of dry lime hydrate. The boiler house mortar is instead a mortar made with masonry cement. All five samples contain a quartzose natural sand aggregate which is mineralogically consistent between samples, suggesting that they all came from the same source and likely a source local to the site. The table below summarizes the results of the analysis.

Sample	Location	Material	Masonry/ Substrate	Binder type	Cement : lime ratio	Binder : sand ratio
CHOH-01	Boiler House, interior south wall	Mortar	Cement block masonry	Masonry cement	n/a	1 : 3.6
CHOH-02	Pump House, north and south exterior elevations	Mortar	Brick masonry	Cement - lime	~1 : 0.25	1 : 2.5
CHOH-03a	Comfort Station, interior north wall	Plaster – scratch coat	Expanded metal lath	Cement - lime	1 : 0.38	1 : 2.5
CHOH-03b	Comfort Station, interior north wall	Plaster – brown coat	Expanded metal lath	Cement - lime	1 : 0.28	1 : 2.5
CHOH-04	Engineer's Garage, interior east foundation wall	Mortar	Brick/Cement block masonry	Cement - lime	1 : 0.1 – 1 : 0.25	1 : 2.0
CHOH-05	Pivot Bridge, exterior piers	Mortar	Stone masonry	Cement - lime	1 : 0.17	1 : 2.1

Table 2. Table of materials analysis results (Highbridge Materials Consulting, Inc.).

Boiler House (CHOH-01)

The mortar sample from the interior of the boiler house is the only sample that is composed of a masonry cement rather than a cement-lime binder. Masonry cements are pre-packaged mixes of portland cement with plasticizers, typically crushed limestone, and sometimes air entrainers. The plasticizers in masonry cements are inert and do not contribute chemically to the mortar; rather, they help create a workable mix. Masonry cements are mixed with sand on-site.

The masonry cement in this sample contains gray portland cement, a dolomitic plasticizer, and an air-entraining mixture. Masonry cements are not proportioned like other binder mixes; instead, they are mixed to meet physical specifications. The percentage of portland cement in this masonry cement (68%) is similar to modern Type S masonry cements which are made with about 66% portland cement. However, the sample overall is softer and exhibits greater permeability than modern Type S masonry cements. Its properties are more similar to a modern Type O masonry cement.

The binder to sand ratio for this sample is estimated to be 1 part binder to 3.6 parts sand. This is considered slightly oversanded by today's standards. The aggregate is broadly graded which

may contribute to the permeability of the sample. The mortar was well consolidated and compacted, and is in sound condition, without cracking or chemical degradations of mix.

Pump House (CHOH-02)

The mortar sample from the Pump House is essentially a portland cement mortar gauged with a small amount of lime. The cement : lime ratio is 1 : 0.25 and the binder to sand ratio is 1 : 2.5. The high cement content results in a hard, glassy, and non-absorptive mortar. The Portland cement is well-hydrated and undispersed lime particles are sparsely observed in the sample. It is likely that the lime was added as a packaged dry hydrate.

Based on petrographic examination, the mortar components appear to be well-blended and it was adequately consolidated and compacted during installation. It also appears to be in sound condition without micro-cracking, significant weathering, or other physical distress.

Comfort Station (CHOH-03)

The interior plaster from the comfort station is a two-coat cement plaster which is composed of highly cement-rich mixes. The plaster construction includes a scratch coat and a brown coat but no finish coat - the brown coat was directly painted. Both plaster coats are hard and not particularly water permeable. The cement to lime ratio is 1 : 0.38 for the scratch coat and 1: 0.28 for the brown coat, and there is an overall binder to sand ratio of 1 : 2.5 for both layers.

The proportions are consistent with a Type C base coat portland cement plaster, which is appropriate for use on expanded metal lath.[16] The gradation of the sand, however, is considered overly fine for a plaster aggregate. The plaster is in sound condition, with no cracking, chemical degradation or secondary mineralizations observed.

Engineer's Garage (CHOH-04)

Similar to the Pump House, the mortar sample from the Engineer's Garage is a cement-rich mortar with a small amount of lime. The cement : lime ratio is estimated to be between 1 : 0.1 and 1 : 0.25 by volume and the binder to sand ratio is 1 : 2. The high cement and low lime content results in a mortar with high strength, low elasticity, and low permeability. The mortar constituents were well mixed and the mortar was well consolidated and cured.

Based on the fracture pattern of the sand particles during sampling, a high bond strength between the aggregate and paste can be identified. The mortar itself is in sound condition with no noticeable cracking or other deterioration. There are also no potentially deleterious mineralizations and no chemical degradation of the binder.

Pivot Bridge (CHOH-05)

The pivot bridge sample is also a cement-rich mortar with lime. The cement : lime ratio is approximated 1 : 0.17, similar to that of the engineer's garage. The binder : sand ratio is

[16] *ASTM C926 – Standard Specification for Application of Portland Cement-Based Plaster.*

approximately 1 : 2.1. This hard, glassy, non-absorptive mortar is typical of early 20th century hard masonry (schist/granite) construction. The mortar constituents appear well-blended.

The pivot bridge mortar exhibits significant carbonation and decalcification of the binder due to its significant exposure to water. This has resulted in a more porous and weaker mortar matrix with a friable surface crust and sand grains that remain proud of the surface where the binder has been lost by weathering.

Figure 6. Sample mortar from Boiler House (BCA 2020).

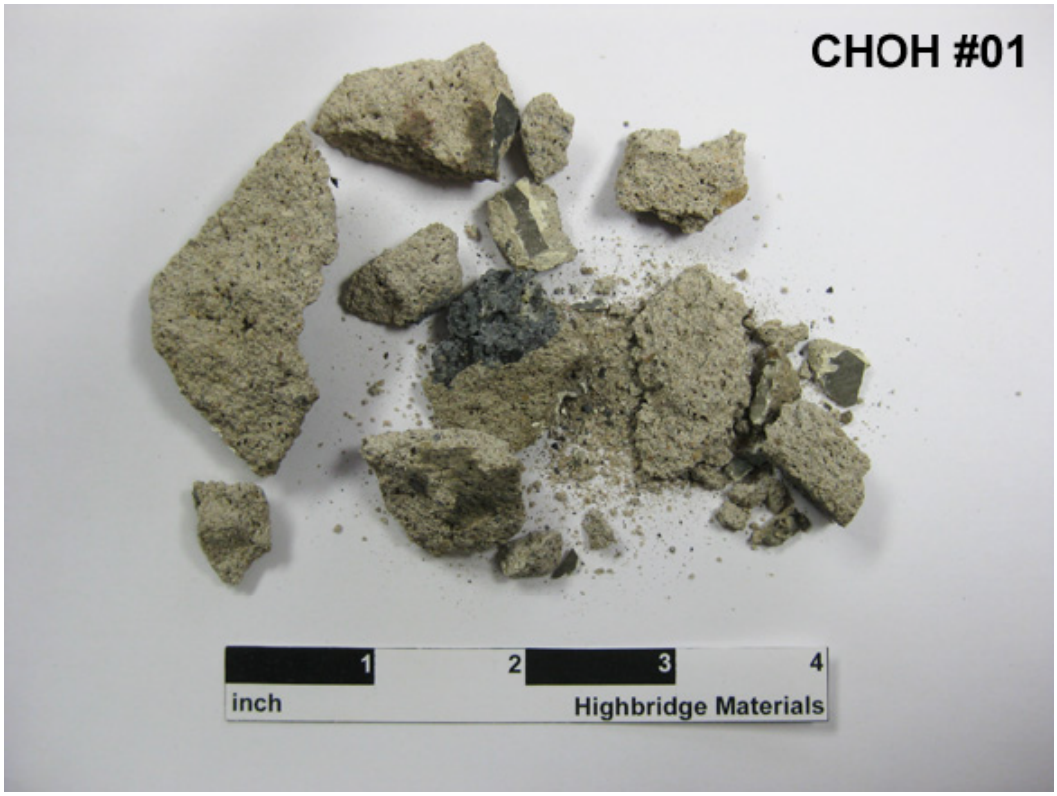


Figure 7. Sample mortar from Boiler House (Highbridge 2020).

Figure 8. Sample mortar from Pump House (BCA 2020).

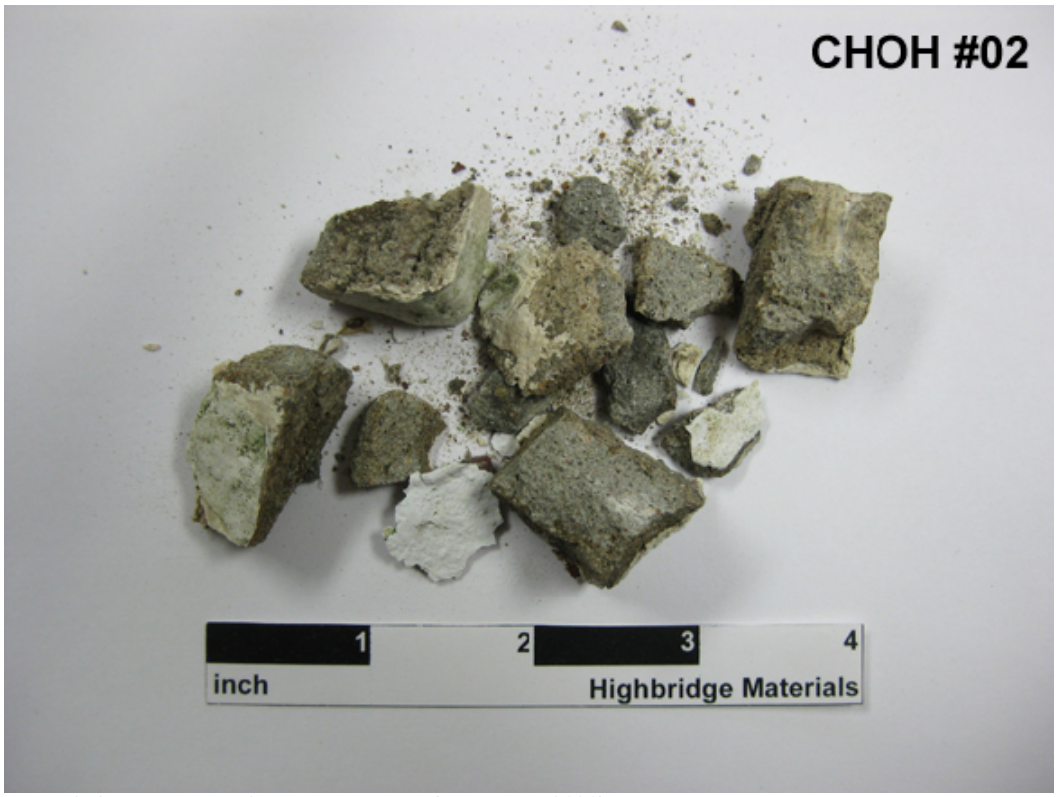


Figure 9. Sample mortar from Pump House (Highbridge 2020).

Figure 10. Sample plaster from Comfort Station (BCA 2020).

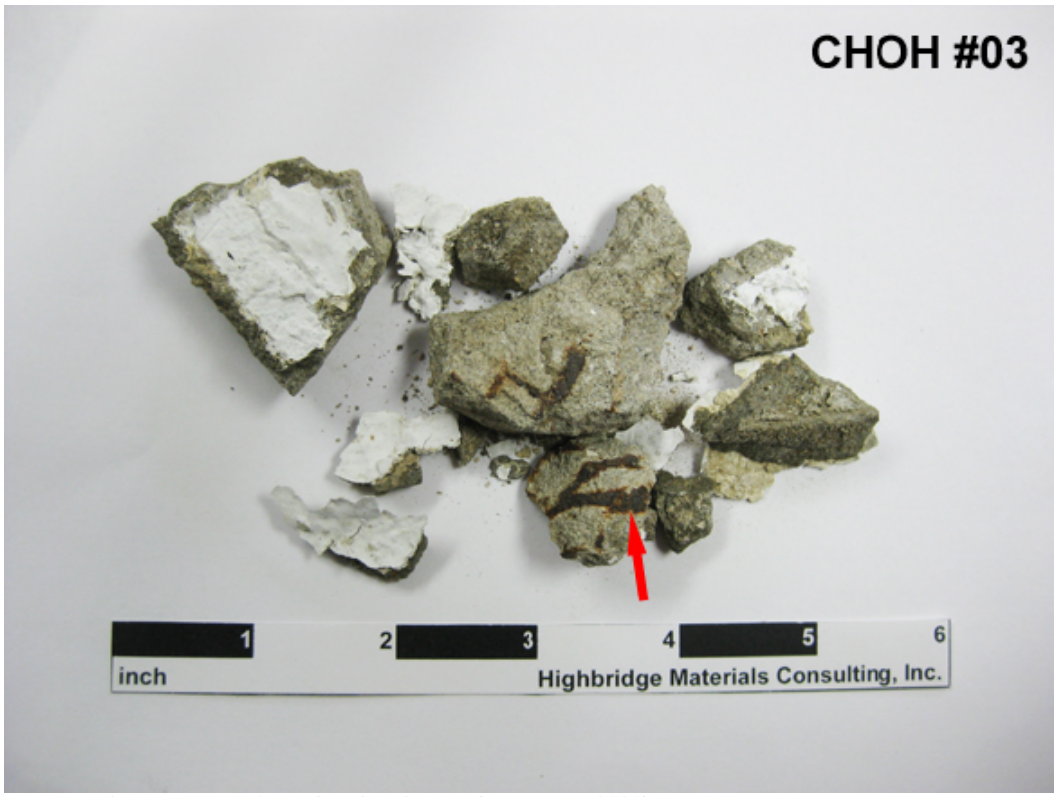


Figure 11. Sample plaster from Comfort Station (Highbridge 2020).

Figure 12. Sample mortar from Engineer's Garage (BCA 2020).

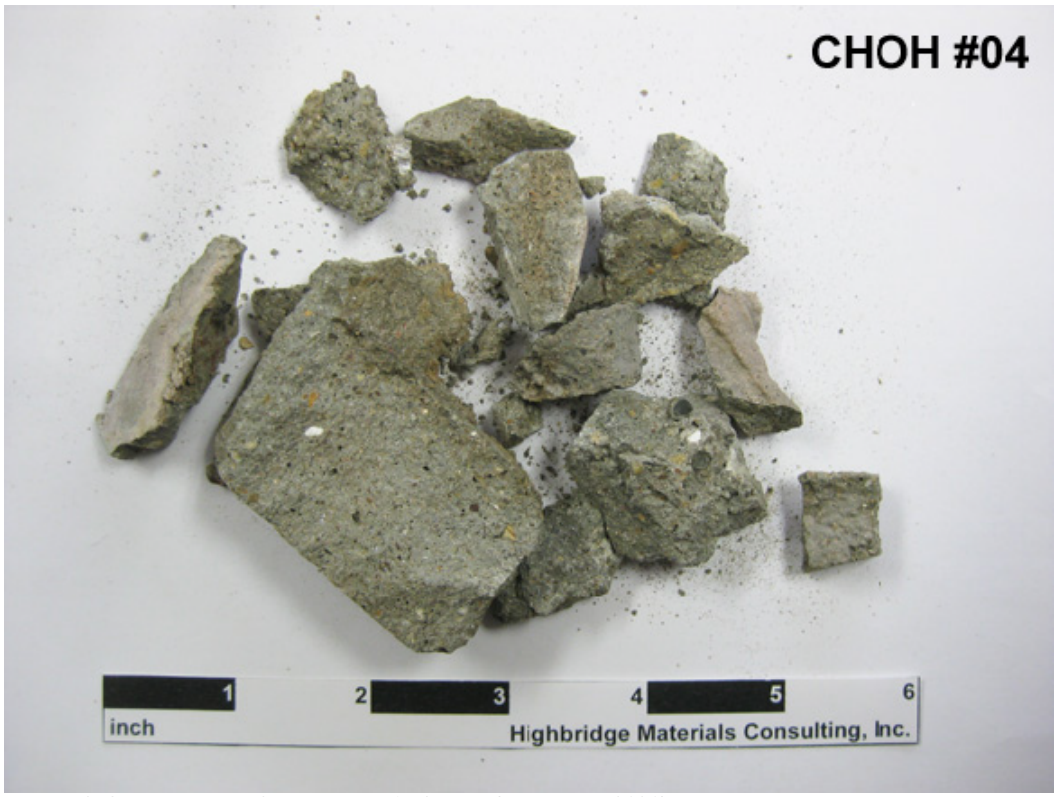


Figure 13. Sample mortar from Engineer's Garage (Highbridge 2020).

Figure 14. Sample mortar from Pivot Bridge (BCA 2020).

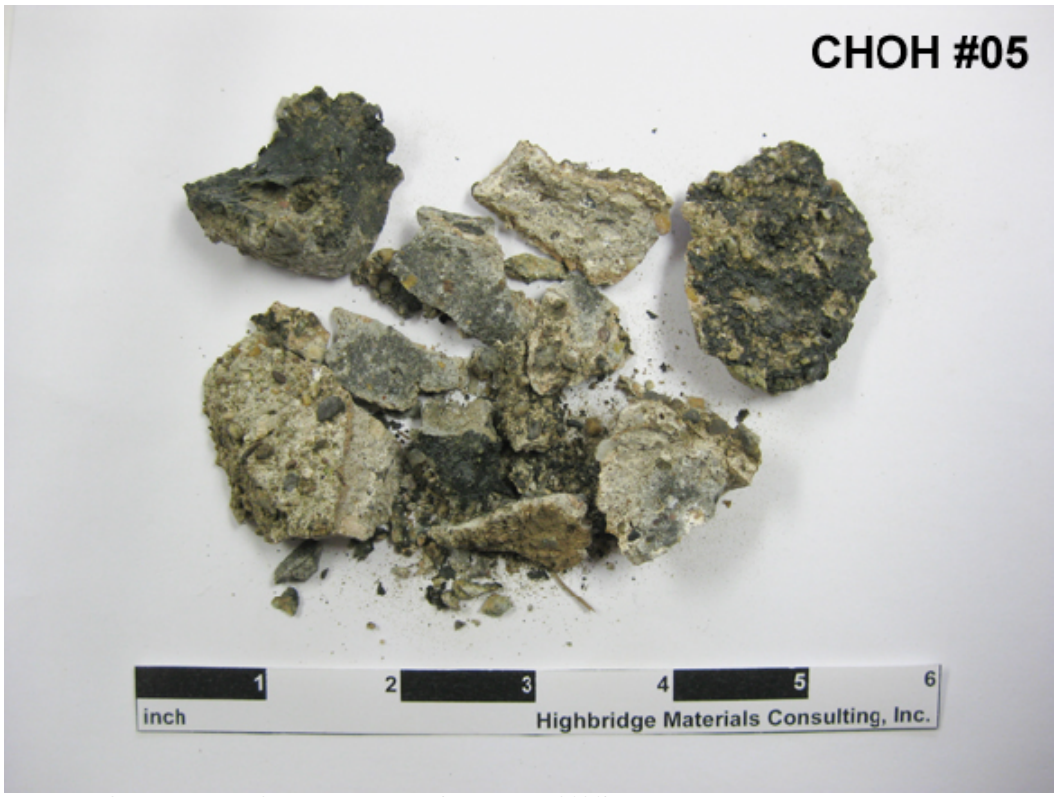


Figure 15. Sample mortar from Pivot Bridge (Highbridge 2020).

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The analysis performed on the masonry materials of the five CCC structures at CHOH provides documentation of the original materials used in their construction. The early 1940s construction of the pump house, comfort station, engineer's garage, and pivot bridge, as well as the materials and proportions used for the mortars, suggest that they were mixed on-site using materials typical of the period (namely packaged dry lime hydrate, masonry cement and portland cement). In addition, the sand appears to have been obtained locally. They are all composed of a heavy proportion of portland cement, making them very hard, durable, and with generally low water permeability.

The masonry cement mortar used for the boiler house was likely a pre-packaged masonry cement. Such pre-packaged mortars have been widely commercially available since the 1920s. Slightly different in composition than the cement-lime mortars at the other structures, this mortar was hard enough to support the utilitarian cement block construction of the boiler house, while still allowing for moderate permeability where high heat and humidity are present.

All of the sample material, with the exception of the mortar from the pivot bridge, are in sound condition. This is likely due to either their interior location (CHOH-01, 03, and 04) or painted coatings (CHOH-02) which may have provided some protection from weathering.

5.2 Recommendations

Due to the exceeding hardness and low-permeability of all five of these existing mortars and plasters, it is not recommended that the composition or properties of these mortars be replicated. Instead, new mortars and plasters should follow current standards and be softer, more breathable and permeable materials so as to be sacrificial to the substrate. In addition, masonry cements are not recommended. They are known to not bond as well with substrates as mixes with lime. In addition, because they are proprietary products mixed to meet certain physical specifications, the composition of the mixes is not known.

For the mortars at the Boiler House, Pump House, and Engineer's Garage, a Type N cement-lime mortar in the following proportions is recommended:

- 1 part gray portland cement
- 1 parts hydrated lime (Type S)
- 6 parts sand, selected to match the color and gradation of the existing sand but conforming to requirements of *ASTM C144 – Standard Specification for Aggregate for Masonry Mortar.*

For the plaster on expanded metal lath on the interior walls of the Comfort Station, a Type C cement-lime plaster in the following proportions is recommended:

- 1 part gray portland cement
- 0.75 part hydrated lime (Type S)
- 5.25 parts sand, selected to match the color and gradation of the existing sand but conforming to requirements of *ASTM C897 – Standard Specification for Aggregate for Job-Mixed Portland Cement-Based Plasters.*

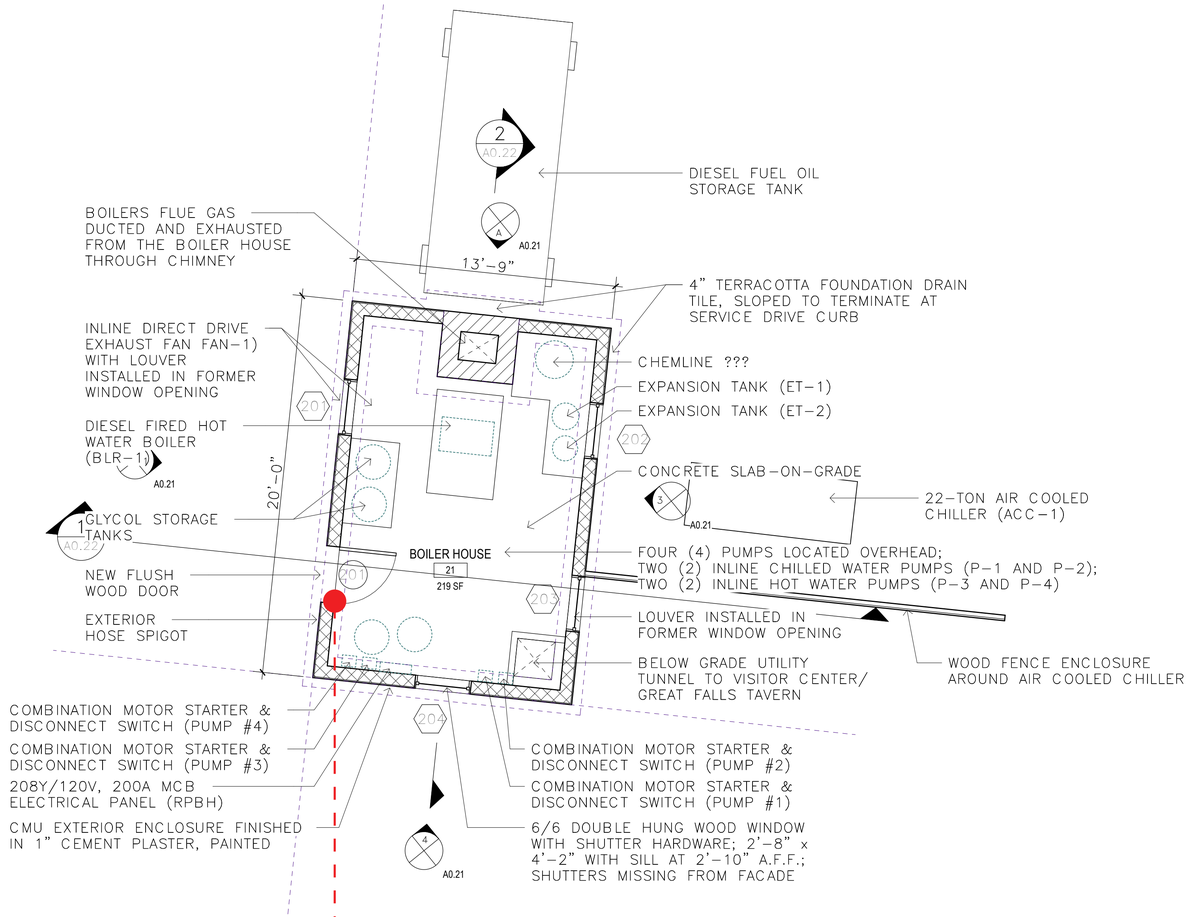
Per *ASTM C926 – Standard Specification for Application of Portland Cement-Based Plaster.* the same mix can be used for both coats as long as the brown coat contains the same or more sand than the scratch coat.

For the mortar at the quartzitic schist masonry piers of the Pivot Bridge Ruins, a Type N cement-lime mortar in the following proportions is recommended:

- 1 part gray portland cement
- 1 part hydrated lime (Type S)
- 5 parts sand, selected to match the color and gradation of the existing sand but conforming to requirements of *ASTM C144 – Standard Specification for Aggregate for Masonry Mortar.*

APPENDIX A: SAMPLE LOCATIONS

Location of Masonry Material Samples Removed by BCA - October 2020



1 A0.20 BOILER HOUSE EXISTING FLOOR PLAN

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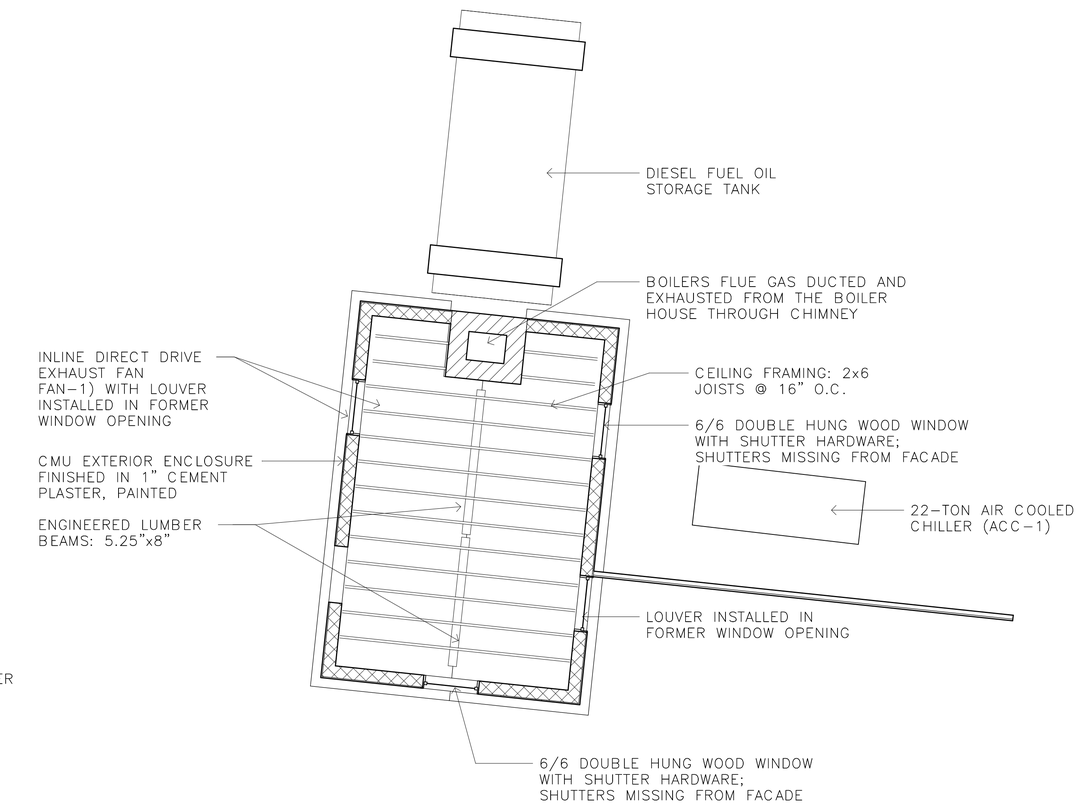

2 A0.20 BOILER HOUSE EXISTING REFLECTED CEILING PLAN

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SCALE OF FEET

NOT FOR CONSTRUCTION

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Structural: Silman Washington, DC
Consultant 2: Building Conser Assoc Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 12/31/2020

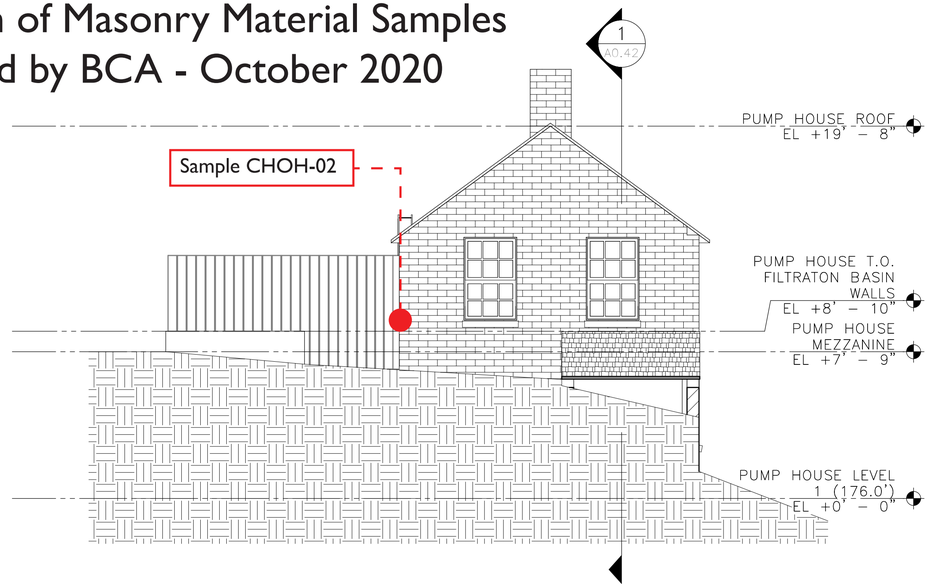
SUB SHEET NO. A0.20

TITLE OF SHEET
BOILER HOUSE – EXISTING FLOOR PLAN AND REF CELING PLAN
CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
PMIS/PKG NO. xxxxxx
SHEET 4 OF XX

12/30/2020 10:36:04 PM Author BIM 360://12693.000 - C&O Canal HSR/C&O Canal HSR-A.rvt

Location of Masonry Material Samples Removed by BCA - October 2020



1 A0.41 PUMP HOUSE NORTH ELEVATION
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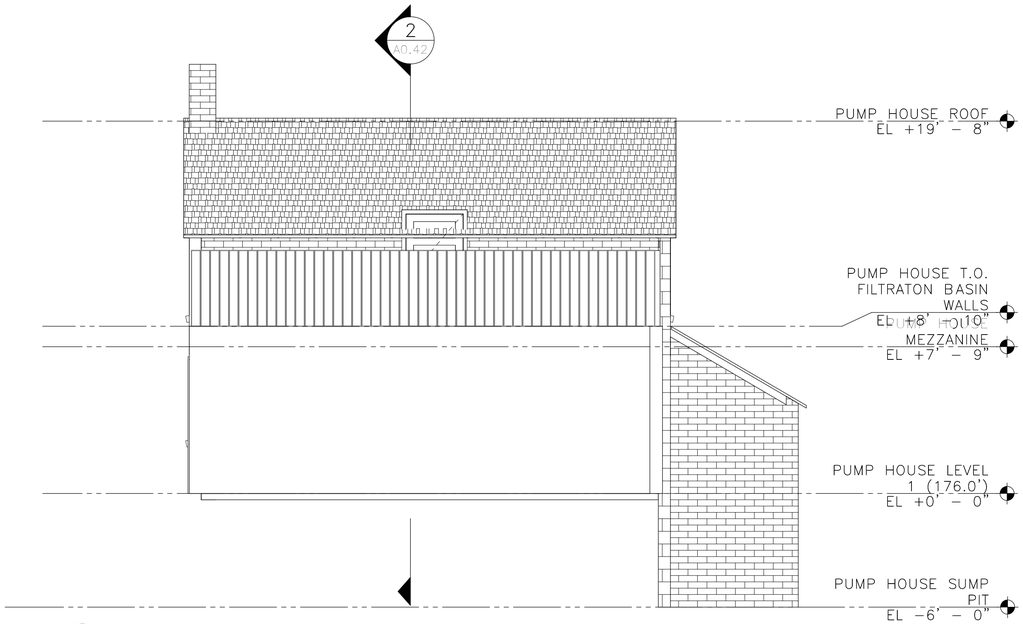

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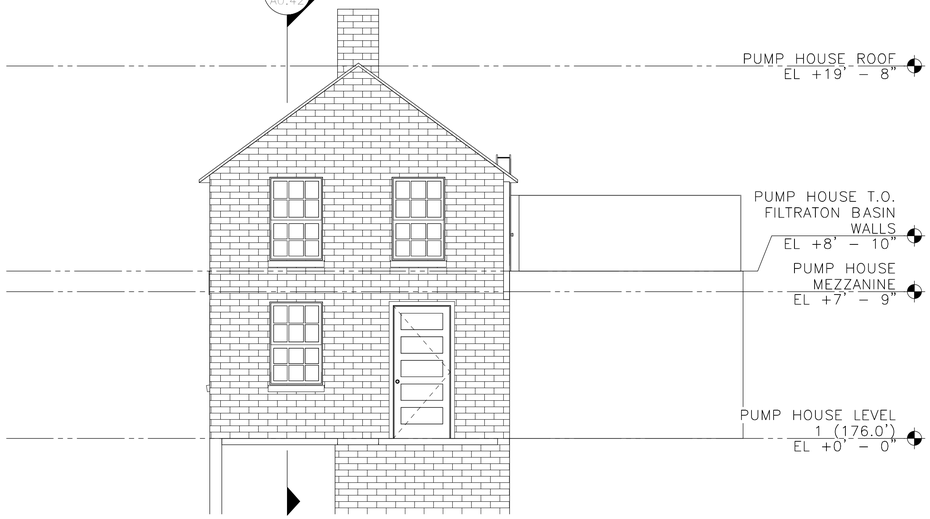

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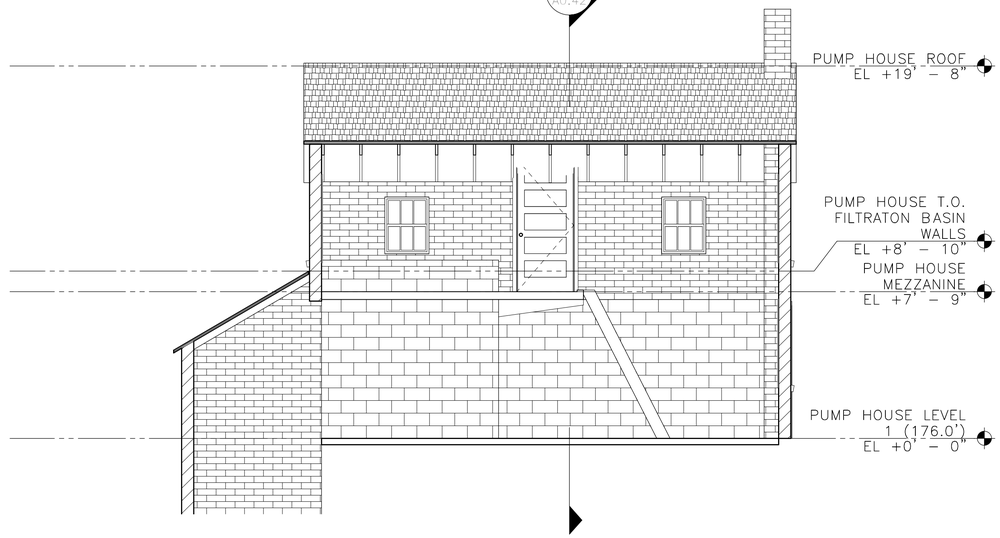

4 A0.41 PUMP HOUSE WEST ELEVATION
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SCALE OF FEET

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Structural: Silman Washington, DC
Consultant 2: Building Conser Assoc Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 12/31/2020

SUB SHEET NO. A0.41

TITLE OF SHEET
PUMP HOUSE – EXISTING ELEVATIONS
CHEASAPEAKE & OHIO CANAL

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SHEET 6 OF XX

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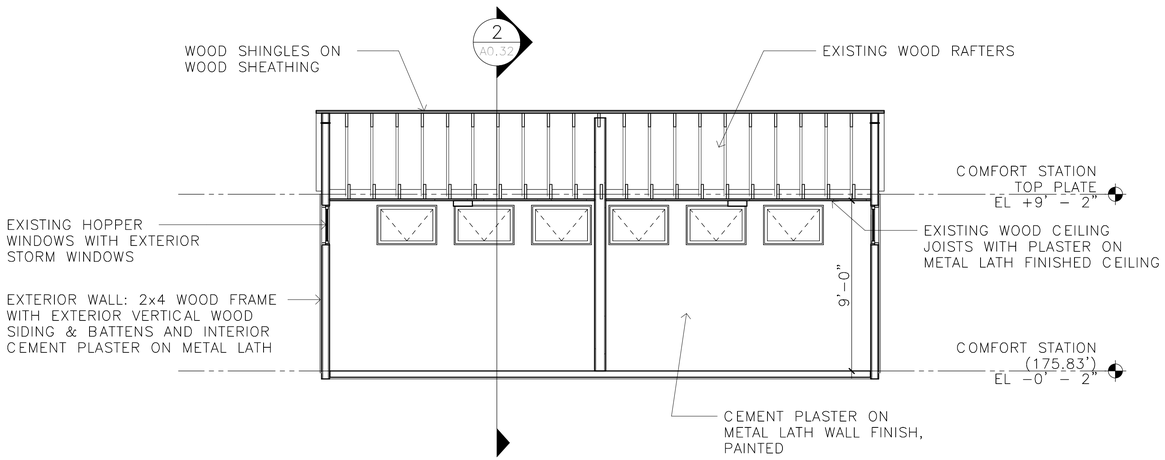
Location of Masonry Material Samples
Removed by BCA - October 2020



1 A0.32 COMFORT HOUSE SECTION A
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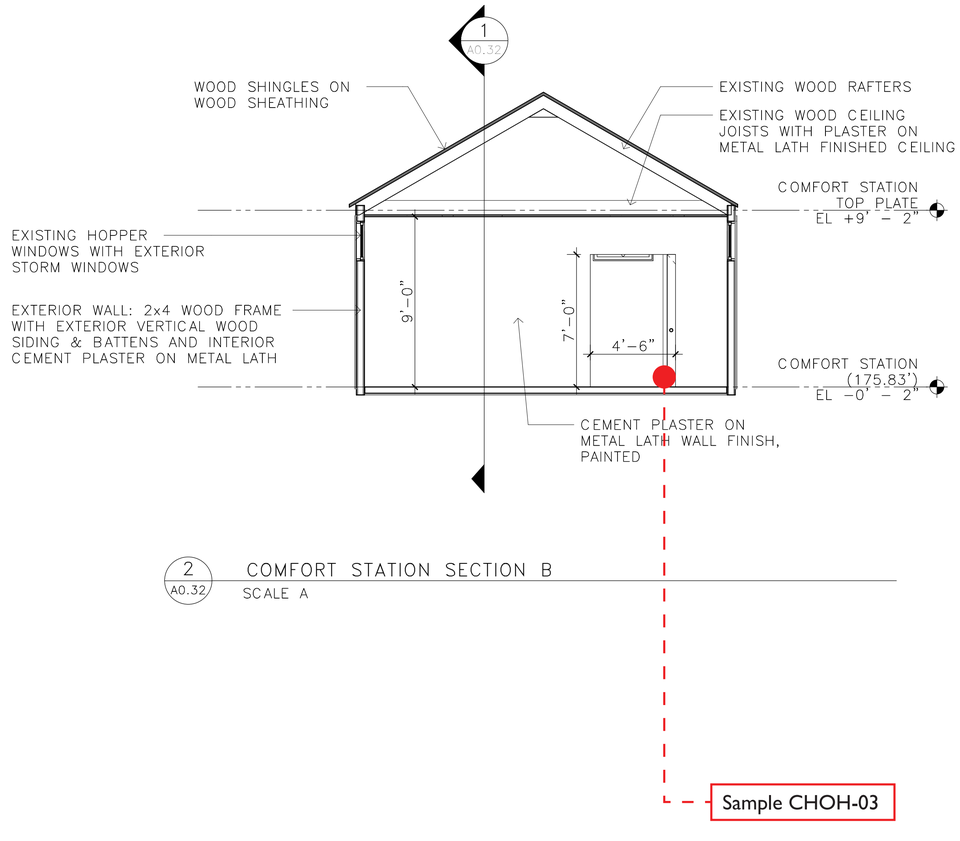

2 A0.32 COMFORT STATION SECTION B
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PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Consultant 2:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 12/31/2020

SUB SHEET NO. A0.32

TITLE OF SHEET
COMFORT STATION – EXISTING SECTIONS AND DETAILS
CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
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SHEET 5 OF XX

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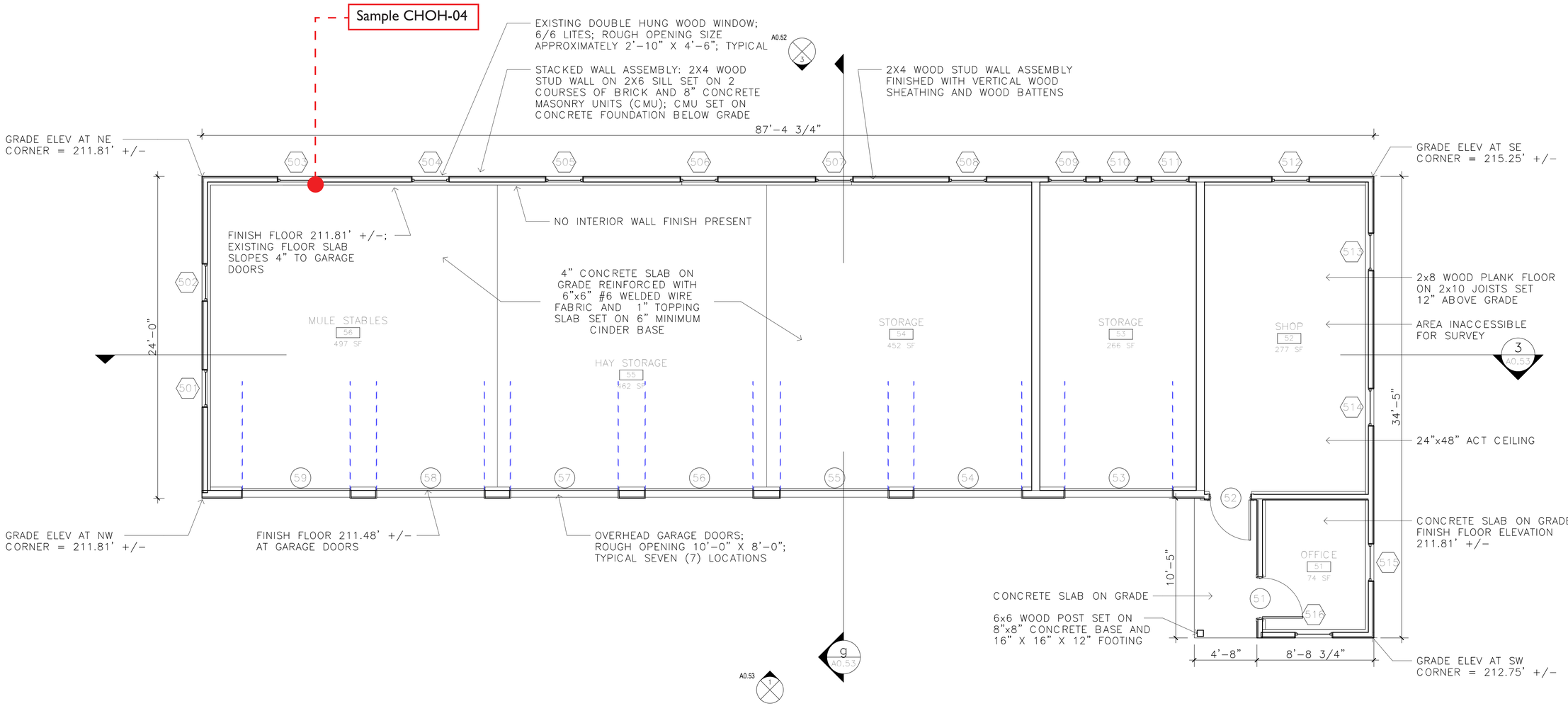
Location of Masonry Material Samples Removed by BCA - October 2020



1 A0.50 ENGINEER'S GARAGE EXISTING FLOOR PLAN

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SCALE OF FEET

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE: SmithGroup WASHINGTON, DC
Structural: Silman Washington, DC
Consultant 2: Building Conser Assoc Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 12/31/2020

SUB SHEET NO. A0.50

TITLE OF SHEET: ENGINEER'S GARAGE – EXISTING FLOOR PLAN

CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
PMIS/PKG NO. xxxxxx
SHEET 7 OF XX

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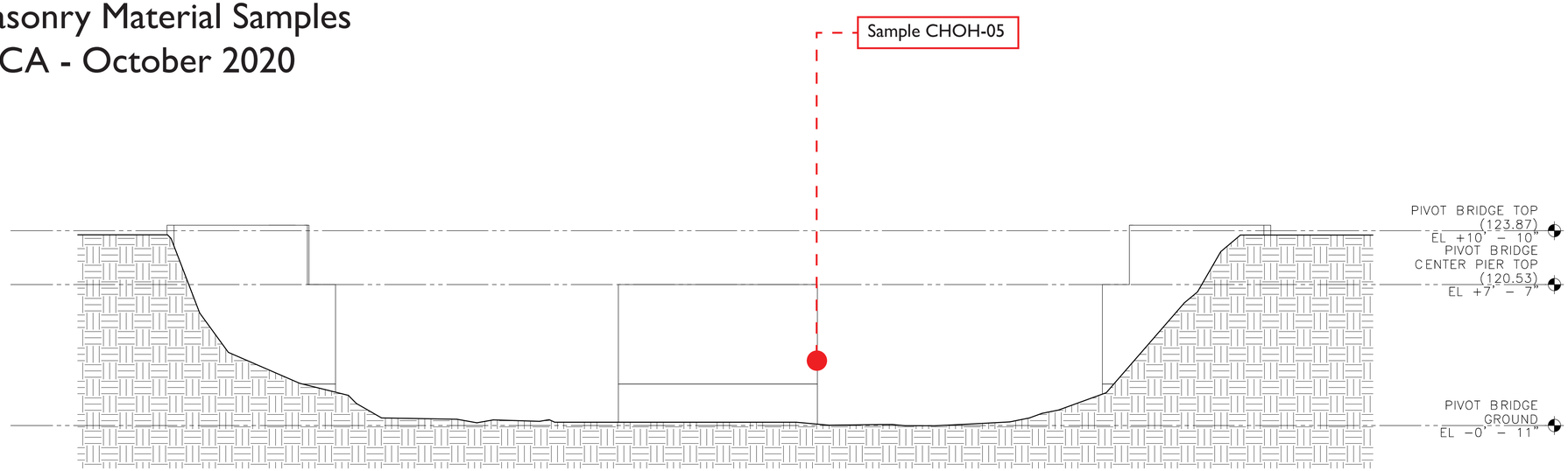
Location of Masonry Material Samples Removed by BCA - October 2020



1 / A0.11 PIVOT BRIDGE RUINS EXISTING EAST ELEVATION

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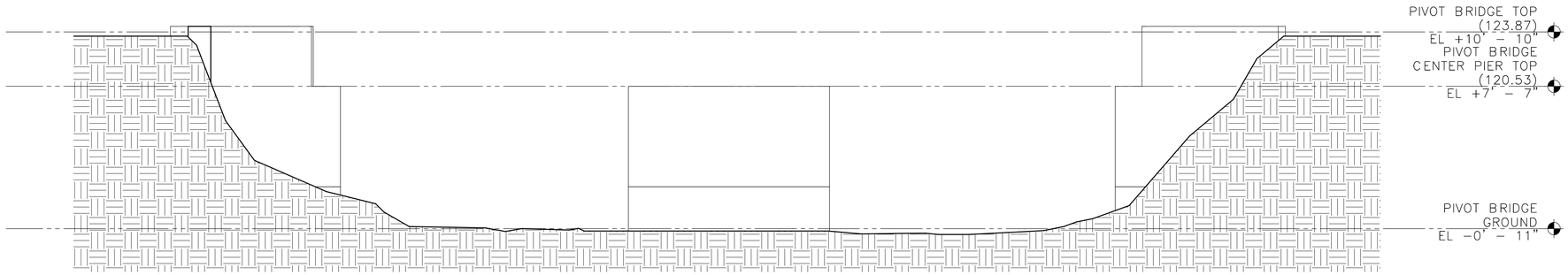

2 / A0.11 PIVOT BRIDGE RUINS EXISTING WEST ELEVATION

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SCALE Ⓐ 4 0 4 8

SCALE OF FEET

NOT FOR CONSTRUCTION

PRIME/ARCHITECTURE:
SmithGroup
WASHINGTON, DC
Structural:
Silman
Washington, DC
Consultant 2:
Building Conser Assoc
Washington, DC

DESIGNED: Designer
CADD: Author
TECH REVIEW:
DATE: 12/31/2020

SUB SHEET NO. A0.11

TITLE OF SHEET
PIVOT BRIDGE RUINS - EXISTING ELEVATIONS

CHEASAPEAKE & OHIO CANAL

DRAWING NO. ---
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SHEET 4 OF XX

12/30/2020 10:36:03 PM Author BIM 360://12693.000 - C&O Canal HSR/C&O Canal HSR-A.rvt

APPENDIX B: MATERIALS ANALYSIS REPORT FROM HIGHBRIDGE MATERIALS CONSULTING, INC.

Mortar Analysis Report - Pivot Bridge

Chesapeake & Ohio Canal National Historical Park
Washington, D.C. and Maryland

Prepared for
Building Conservation Associates, Inc.

Client ID
BUIL005

Report No.
SL1581-05

Report Date
11/22/20

HIGHBRIDGE MATERIALS CONSULTING, INC.

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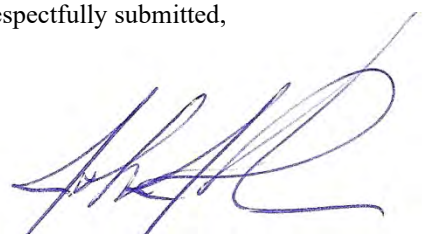
Cover Image

Photograph of the pivot bridge ruin at the C&O Canal National Historical Park. Photo courtesy of Mr. Kevin Wohlgemuth of Building Conservation Associates.

Respectfully submitted,



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1. Executive Summary

This report presents the results of a compositional and condition analysis of a mortar sample recovered from the stone foundation of a pivot bridge ruin constructed ca. 1941 and located at the C&O Canal National Historical Park outside Washington, D.C.

The material is identified as a cement-based mortar gauged with hydrated lime. The cement is a gray portland and the plasticizer is a dolomitic dry lime hydrate. The cement to lime ratio is estimated at 1 : 0.17 by volume. The aggregate is a coarse-grained and broadly graded natural sand. The binder to sand ratio is estimated at 1 : 2.1. The design is typical of early twentieth century granite masonry construction. Where the mortar is fresh and unaffected by secondary chemical reactions, the binder is hard, glassy, and non-absorptive as expected of the rich composition. The color in these areas is a dark gray.

The mortar has experienced an aggressive bicarbonation reaction that has resulted in decalcification of the binder. Toward the surface, the binder has become weakened and the microporosity is substantially increased. Sand grains remain proud along the surface due to attrition of the surrounding binder. The color of the paste in the affected regions is buff to pale orange.

2. Introduction

On October 21, 2020, Highbridge received five mortar and plaster samples from Mr. Kevin Wohlgemuth of Building Conservation Associates reported to have been sampled from various structures at the C&O Canal National Historical Park outside of Washington, D.C. All materials are believed by Mr. Wohlgemuth to be original to the ca. 1941 construction. The sample information provided by the client is presented in Table 2.1 below.

Table 2.1: Sample Identifications

Sample ID	Description
CHOH #01	Boiler house, interior, mortar from concrete block wall
CHOH #02	Pump house, exterior, mortar from brick masonry
CHOH #03	Comfort station, interior, cement plaster from metal lath wall
CHOH #04	Engineer's garage, interior, mortar from concrete block and brick foundation
CHOH #05	Pivot bridge, exterior, mortar from stone rubble foundation

At the client's request, a compositional analysis is performed on each of the mortar and plaster samples. The testing includes a petrographic examination and chemical analysis to identify constituents, estimate proportions, and assess overall condition. Acid digestions to extract sand samples for description and gradation are also included in the testing scope. This report presents the results for the pivot bridge mortar (Sample CHOH #05). Results for the other samples are presented under separate cover.

3. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within ASTM C1324-20. Data collection is performed or supervised by a degreed geologist who by nature of their education is qualified to operate the analytical equipment employed. Analysis and interpretation is performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 4 of ASTM C856/C856M-20.

Chemical analysis is performed in general accordance with the procedures outlined in ASTM C1324-20. Water, carbon dioxide, and aggregate weight percentages are determined gravimetrically. Oxide weight percentages are determined by inductively coupled plasma - optical emission spectroscopy (ICP-OES). While ASTM classifies C1324 as a test method, it is intended to serve as a guideline for qualified practitioners with ample experience in the various materials under consideration. Section 10.2 indicates the need for discretion on the part of the laboratory to ensure that methods are tailored to specific mortar compositions. As such, Highbridge chooses specific digestion methods, supplementary tests, instrumentation protocols, and mathematical models to best characterize each individual mortar under consideration. Many of these are proprietary methods that have been researched internally.

The following personnel contributed to the examination:

Technician:	J. Bertoldi
Analyst:	M. Ricotta
Chemist:	H. Hartshorn
Petrographer:	J. Walsh

4. Petrographic Findings and Discussion

4.1 - Materials

The aggregate is a coarse-grained natural sand more similar to that of a concrete fine aggregate or a torpedo sand. Quartz and metaquartzite are primary constituents. Ironstone particles are moderately abundant and these contain sandy and micaceous varieties. Minor constituents include mudstone, siltstone, and chert. Traces include glauconite, mica schist, epidote, feldspar, and granite. No clay coatings or friable materials are identified and the sand is considered hard, non-porous, and durable for use in cementitious mortars. The minor amount of chert identified is too low to result in alkali-silica reactivity.

The aggregate extracted from the mortar through acid digestion is semi-translucent to semi-opaque. The sand is mildly variegated in appearance due to coarser particles in shades of orange, pink, gray, and white. The finer particles contribute a brownish-gray color overall (Munsell code approximately 10YR 7/1). The sand is moderately sharp-textured with equidimensional particles that are subangular in shape on average. In fact, grain shapes vary considerably with a tendency for increasing angularity with decreasing grain size.

The particle size distribution was evaluated by passing the extracted aggregate through a standard sieve stack. It would have been desirable to dissolve about twice as much material given the coarseness of the sand. However, the results presented in Section 5 are considered to be reasonably accurate. Though all material passes the No. 4 sieve, the nominal top size is defined at this mesh. The peak abundance lies between the No. 30 and No. 50 sieves. The fines content is minor. As described for other mortars evaluated for this study, the applicable standard for masonry sands in 1941 was ASTM C144-39T. This standard only provided requirements for the coarse and fine ends of the gradation curve depending on the type of masonry joint. Compared to these provisions, the aggregate extracted from Sample CHOH #05 would be appropriate for use in mortar joints of at least 1/2" thickness. However, with over 15% retained above the No. 8 sieve, the gradation profile would not comply with the modern version of this standard (ASTM C144-18). Of course, the modern standard was not written to consider historical stone wall masonry construction.

The binder consists of portland cement gauged with hydrated lime. Significant alteration has occurred in service that has degraded the binder and overprinted much of the original microtexture. However, there are small sections of mortar that are close to being representative of the original hydration condition. In these areas, the mortar is dark gray, very hard, glassy, and non-absorptive. Petrographically, the cementitious paste has a low capillary porosity in these regions. In one area viewed petrographically, calcium hydroxide from the original cement hydration is preserved as very fine-grained crystal masses within the cement paste and as discontinuous deposits along paste-aggregate contacts.

Residual portland cement grains are detected in high abundance throughout the sample though they are mostly decalcified expect in the unaltered areas of the paste. Here, the cement consists mostly of fine-grained calcium silicate agglomerates with interstitial iron-bearing ferrite. Single alite grains with thin hydration rims are a minor constituent. The ferrite identifies the cement as a gray variety and this is confirmed by a chemically-measured SiO_2/Fe_2O_3 ratio of 7.5. Many of the residual cement particles in this region contain unhydrated calcium silicate minerals. The rest are simply skeletons of ferrite surrounding the empty impressions of former calcium silicates.

Undispersed lime particles are present in moderately low concentration. The chemical analysis indicates that the lime is a dolomitic variety. The particles are fine-grained and generally less than 0.15 millimeters in diameter. The grains are texturally nondescript. The size and texture are both consistent with lime originally in the form of a packaged dry hydrate. Most of the lime is fully carbonated though there is a significant proportion containing slaked but uncarbonated lime. This is even observed where the paste has been decalcified due to secondary reactions in service. Dolomitic limes carbonate much more slowly than high-calcium varieties, and the presence of uncarbonated lime after 80 years is not unusual.

4.2 - Component Proportions

Chemical analysis was used to estimate the component proportions of the mortar and these results are presented in Section 6. The cement to lime ratio is estimated at 1 : 0.17 by volume and the binder to sand ratio at 1 : 2.1. The calculation does not take into account the calcium lost through decalcification of the binder. An error analysis indicates very little change to the estimated ratios and the reported mix design should be considered reasonably robust.

The mortar design does not comply with any proportional cement-lime mixtures specified today for unit masonry in ASTM C270-19ae1. Specifically, the mortar is overly rich with too little lime and too little sand. However, rich mixtures such as this were commonly used for granite and other hard stone masonry in the early twentieth century. Assuming no softer mortars were used in the substrate, the only potential deficiency in these types of design would be a low water retention and a difficulty in establishing a tight bond with the masonry. Of course, this does not preclude the use of a softer mix for repair or repointing. Using modern portland cement to recreate the design of the existing mortar would produce a mix prone to significant shrinkage cracking shortly after final set. As described in previous reports for this study, it is not within the scope of the laboratory to recommend or specify repair designs or strategies.

4.3 - Condition and Service Performance

Based on the sample pieces examined petrographically, the mortar constituents appear to have been well-blended. There are no sand streaks or binder lumps with the exception of two or three millimeter-scale clots of undispersed lime. The quality of the mix water blending cannot be addressed due to significant alteration of the paste matrix. Only one very small area of relatively fresh paste is observed petrographically and this indicates a uniform cementitious hydrate without significant granularity or bleeding. The fresh mixture was well consolidated and compacted. The total air content is estimated at only 3-5% by volume.

The laboratory is not aware of the relationship of the sample pieces to the masonry. There are surfaces that appear to represent the weathered face of the masonry and these typically exhibit the most corroded areas of the mortar. Sometimes, a degradation profile can be traced several millimeters inward to less affected paste. However, there are cases where corrosion increases again toward the interior. This could suggest that there was incipient detachment of the mortar sample pieces from the existing construction and that weathering had occurred from both the front and the rear. Alternatively, the examined pieces could represent pointing mixes and water could have been entrapped behind the pointing. With all this said, only the surface condition of the mortar can be described here. It is not known if mortar deeper in the bed is in sound condition.

Tracing the chemical reaction profile from the least affected paste, the unaltered binder has a dense cementitious hydrate with a low capillary porosity, abundant unhydrated portland grains, and residual calcium hydroxide from the original cement hydration. Outward from the fresh paste is a zone of depleted binder where the calcium hydroxide has been consumed. There is some autogenous healing of microscopic shrinkage cracks with secondary calcium hydroxide in this region. The next region outward is somewhat variable in character and usually several millimeters in thickness. Decalcification of the binder has resulted in the dissolution of all calcium silicate in the original cement. The cementitious hydrate has also been leached causing a variable increase in capillary porosity depending on the degree of decalcification. Popcorn calcite deposition has occurred in the most porous parts of this region. Finally, a surface veneer up to 1 millimeter in thickness is characterized by an extreme microporosity and a complete loss of all calcium species. The veneer is basically a desiccated and friable crust of hydrous silica, alumina, and iron oxide. Sand grains remain proud along the surface of this veneer where the weakened binder has been lost by attrition.

The chemical decay observed in this sample is characteristic of a bicarbonation reaction, otherwise known as aggressive carbonation. While the literature describing the reaction is limited to the study of portland cement concrete, the author has often observed the reaction in portland cement based-mortar subject to significant water infiltration. In general, bicarbonation is most common in older cement-based mixtures subject to a high level of water percolation for long periods of time. Bicarbonate ion may be elevated in pore solution containing dissolved carbon dioxide once the pH has been reduced by calcium hydroxide leaching. The bicarbonate attacks the cementitious paste and decalcifies the calcium silicate hydrate. Calcium carbonate is precipitated in the reaction as discrete "popcorn-like" crystals throughout the cement paste and sometimes as sparry crystal growths within open pores.

The net effect of the bicarbonate reaction is to weaken the binder and increase its permeability. Only the directly affected paste is weakened. Any adjacent mortar that appears healthy would not be at risk for decomposition if the environmental factors causing the reaction were removed. Proximity to altered paste alone does not threaten the continued serviceability of the healthy material. Specifically, there are no salts that might migrate from the decomposed area unless these were introduced independently of the bicarbonation reaction. With this said, the deeper bedding mortar may be perfectly sound despite the intense degradation of the surface mortar.

5. Aggregate Sieve Analysis

Aggregate analysis was performed by digesting the sample in an acid sufficient to dissolve the binder. The fines are examined petrographically to ensure that all recovered material represents sand rather than undigested binder components. In this particular sample, much of the material passing a No. 325 sieve is found to consist of hydrous silica produced by the incomplete digestion of the portland cement component. As such, the fines are not included in the calculated gradation profiles below. The exclusion of any silt or clay from the aggregate is considered a negligible error.

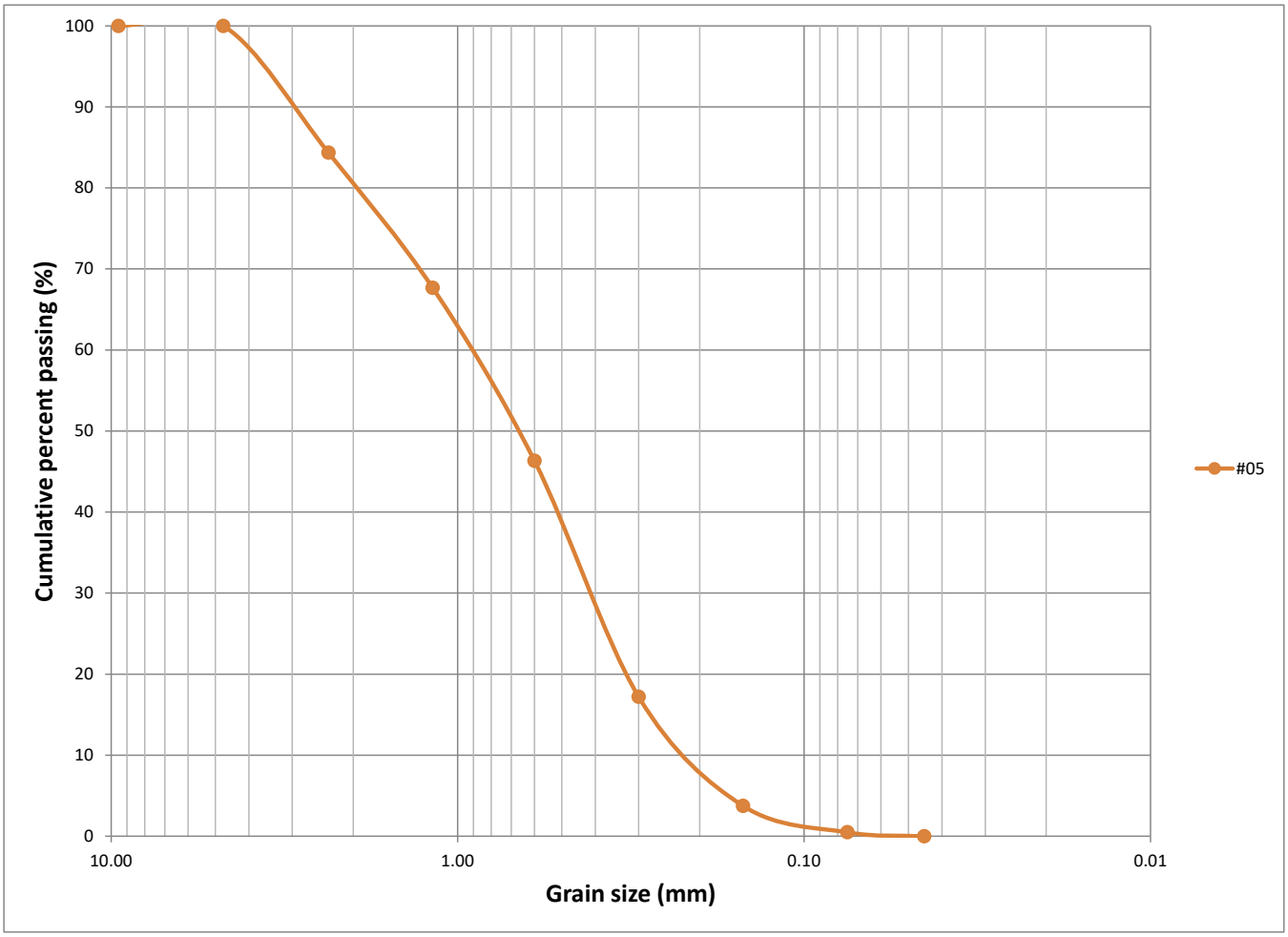
A qualitative description of the sand is given in the discussion above, and the recovered sample is returned to the client. The sample size is significantly smaller than would be required to perform a sieve analysis on fresh aggregate materials as per ASTM C136, and some small errors should be expected.

Table 5.1: Acid Digestion Data

Sieve size	Retention (g)	Cumulative passing (%)	Cumulative retained (%)
No. 4	0.00	100.0	0.0
No. 8	2.15	84.3	15.7
No. 16	2.29	67.7	32.3
No. 30	2.93	46.3	53.7
No. 50	4.00	17.2	82.8
No. 100	1.84	3.8	96.2
No. 200	0.45	0.5	99.5
Pan	0.07	0.0	100.0
Fineness modulus			**2.81**

Chart 5.1: Aggregate Sieve Analysis

The following chart presents the particle size distribution curve for the extracted sand sample. The chart plots the data from the cumulative passing values in Table 5.1.



6. Chemical Analysis

Table 6.1: Chemical Analysis Results

Sample ID	CHOH #05
Component (wgt. %)	
SiO_2	7.01
CaO	19.25
MgO	1.60
Al_2O_3	1.44
Fe_2O_3	0.94
Insoluble residue	56.21
LOI to 110°C	3.28
LOI 110°C-550°C	4.85
LOI 550°C-950°C	5.23
Measured totals	**99.81**

Notes:
1. The digestion procedure included a cold acid and hot base digestion as described in ASTM C1324. The insoluble residue was determined gravimetrically from the same procedure used to measure the soluble oxides.

Table 6.2: Calculated Components

Sample ID	CHOH #05
Component	
Portland cement (wgt. %)	32
Lime expressed as dry hydrate (wgt. %)	2.3
Sand (wgt. %)	66
Cement : lime ratio (by volume)	1 : 0.17
Binder : sand ratio (by volume)	1 : 2.1

Notes:
1. The proportions are calculated with corrections made to account for a secondary silica enrichment and an assumption that the lime is purely dolomitic. A portion of the measured MgO is attributed to the gray portland cement assuming that all SiO_2 belongs to the cement and that the SiO_2/MgO ratio in this component is 7. The remaining MgO is attributed to a dolomitic lime. Sufficient CaO is deducted from the measured value to satisfy a purely dolomitic lime with a CaO/MgO ratio of 1.4. The CaO and MgO are reported as their respective dry hydroxides through molecular weight conversion to present the weight percentage of lime in dry hydrate form. The remaining CaO is attributed to the portland cement. This value is used to calculate the SiO_2 in the cement by forcing a 3.0 CaO/SiO_2 ratio. The remaining SiO_2 is considered to have been leached from the sand. The acid-insoluble residue is assumed to represent the aggregate and the additional SiO_2 is added to this value to calculate a corrected sand. The calculated cement, lime, and sand weights are then normalized to 100% to return the materials to a dry weight basis. Volumetric ratios are calculated assuming bulk weights for portland cement, hydrated lime, and damp, loose sand of 94 lbs./ft.^{3}, 40 lbs./ft.^{3}, and 80 lbs./ft.^{3} respectively.

Appendix I: Visual Description of Sample as Received

Sample ID	**CHOH #05**
Description	The sample consists of multiple small to medium mortar fragments weighing a total of 85 grams.
Surfaces	Exposed surfaces of the mortar exhibit a high relief, coarse sand exposure. The surfaces are partially coated with a black material that appears to be bituminous. No bed surfaces are included with the sample.
Hardness / Friability	The paste is very hard and glassy. The mortar is nonfriable and highly indurate.
Appearance	Freshly exposed surfaces have a highly variable appearance. The freshest areas have a subvitreous translucent luster and are dark gray in color (Munsell code approximately 2.5Y 4.5/1). Areas that are likely altered are duller in appearance and are light buff to pale orange in color (Munsell code approximately 10YR 7/2 to 7/3.5).
Absorptivity	The fresher part of the matrix is not noticeably water absorptive. However, the altered areas are moderately absorptive.
Other details	No cracks are visible in hand sample. There is moderately high occurrence of air-voids lined with white mineralizations. Trace white binder inclusions less than 1 millimeter are also detected.

Appendix II: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The stereoscopic microscope is used for simple magnification. Sample types examined under this microscope include fractured surfaces, fine constituents extracted through chemical or physical means, or honed or polished cross sections. The polarized light microscope (PLM) magnifies but also employs principals of optical crystallography. The most common sample preparation for the PLM is the petrographic thin section. For this preparation, cross-sectioned samples are mounted to glass slides and are milled to a thickness sufficient to allow light to be transmitted through the material. These are usually prepared without water and with minimal heat to avoid altering minerals that are water or temperature-sensitive. In many cases, the samples are impregnated with a low-viscosity, blue-dyed epoxy. When so treated, blue areas represent some type of void space (e.g., air-voids, capillary pores, cracks, etc.). The polarized light photomicrographs are taken using a variety of optical settings chosen to best demonstrate the feature(s) of interest. These are distinguished as follows:

Plane polarized light (abbreviated as PPL)

This method uses the refractive power of different constituents to produce an artificial sense of surface relief. Otherwise, the method is the closest to a simple magnification of the material. The setting is often used to demonstrate granular relationships or microstructure. Pore spaces and cracks are observable with this setting if the blue-dyed epoxy is used.

Conoscopic polarized light (abbreviated as CPL)

In this setting, the transmitted light is condensed just before passing through the thin section. The method tends to bring colors or finer particulates into higher contrast at the expense of image sharpness. The setting is often used to image grain boundary failures in dimension stone, pigment particulates in binders, or gel phases in the micropores of cement pastes.

Cross polarized light (abbreviated as XPL)

The setting places the thin section between two pieces of polarizing film oriented at 90° to one another. In isotropic materials (e.g., glasses, simple salts), all light is absorbed and the materials appear black. In anisotropic crystals, two light rays traveling at different speeds are produced within the thin section and these offset waves interfere at the upper polarizing film. The interference produces a color that can be used to calculate properties of the crystal structure and aid in identification of mineral species. In essence, the colors are artificial. It should be noted that color is a function of orientation and color differences do not necessarily indicate material differences.

Compensator plates

When in XPL mode, full-wave or quarter-wave compensator plates may be inserted into the light path to add or subtract interference. Technically, these methods are used to calculate properties of the crystal structure. However, they can also be used to alter the image appearance to help improve contrast between different constituents. They can also reveal preferred orientations in some materials (e.g., oriented residual crystallinity in fired ceramics).

Scale bars are included with all photomicrographs. In higher magnification images, the µm symbol represents microns. One micron is equal to 0.001 millimeter.

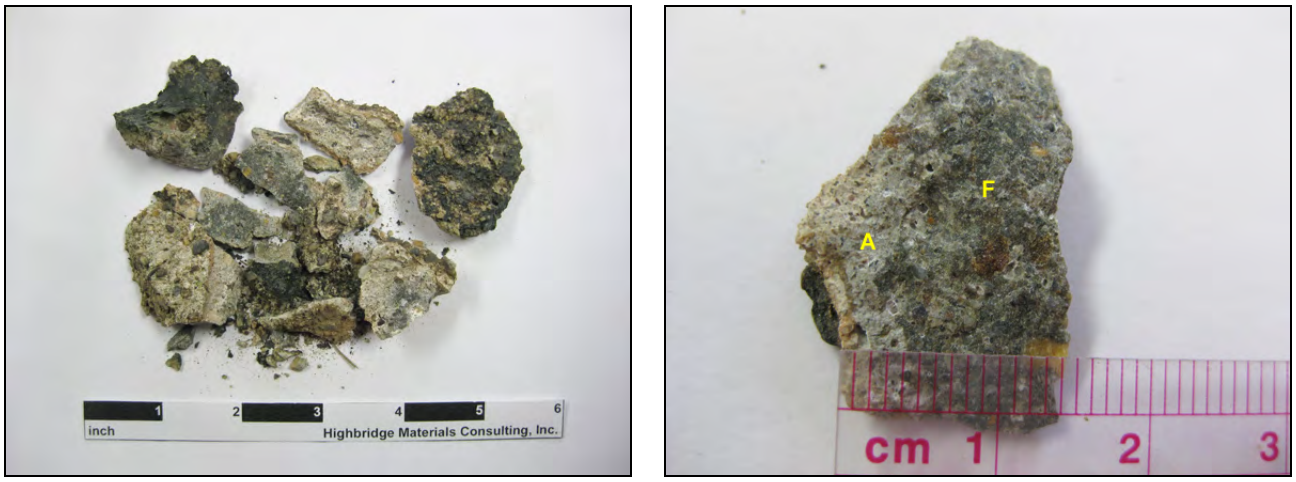


Figure 1: (Left) Photograph of the pivot bridge mortar sample received by Highbridge for examination. (Right) An interior portion of a mortar piece is shown to illustrate the color changes that have occurred as a result of chemical decay. The fresh paste (F) is dark gray as expected from the highly cement-rich composition. The altered paste (A) goes from light gray to buff to pale orange.

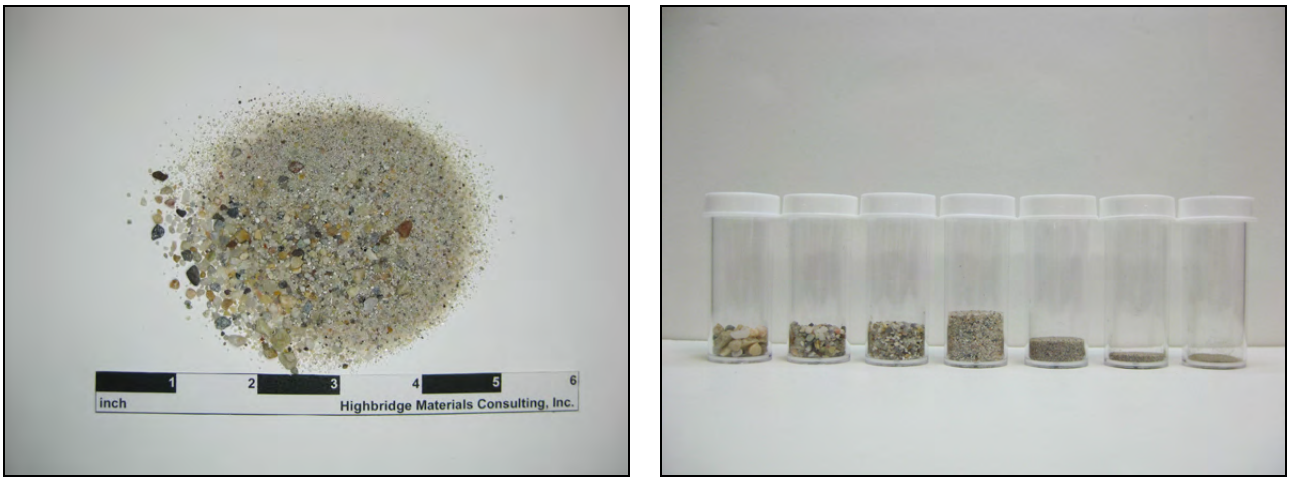


Figure 2: Photographs of the aggregate extracted through acid digestion. The total extraction is shown at left. The sand is moderately variegated in appearance with a light gray color overall. The sand is shown at right after gradation through a standard sieve stack. The coarse-grained sand is quite broadly graded.

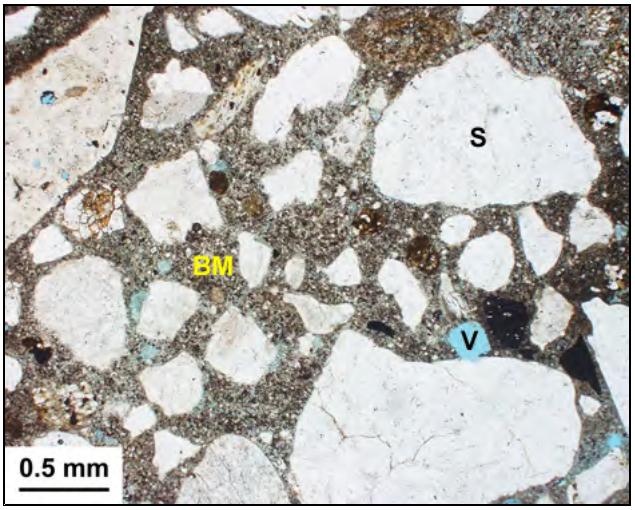


Figure 3: PPL photomicrograph illustrating the overall microtexture of the mortar. The sample is impregnated with a blue-dyed epoxy to highlight cracks, pores, and voids. The absorption of the dyed epoxy into the binder matrix (BM) indicates a low microporosity. This is consistent with the high portland cement content. The mortar is impermeable as a result. Sand grains are evenly distributed throughout the mixture but are not closely-spaced. This is consistent with the 1 : 2 binder to sand ratio calculated chemically. Air-voids are minimal (V) and the mortar is well-consolidated.

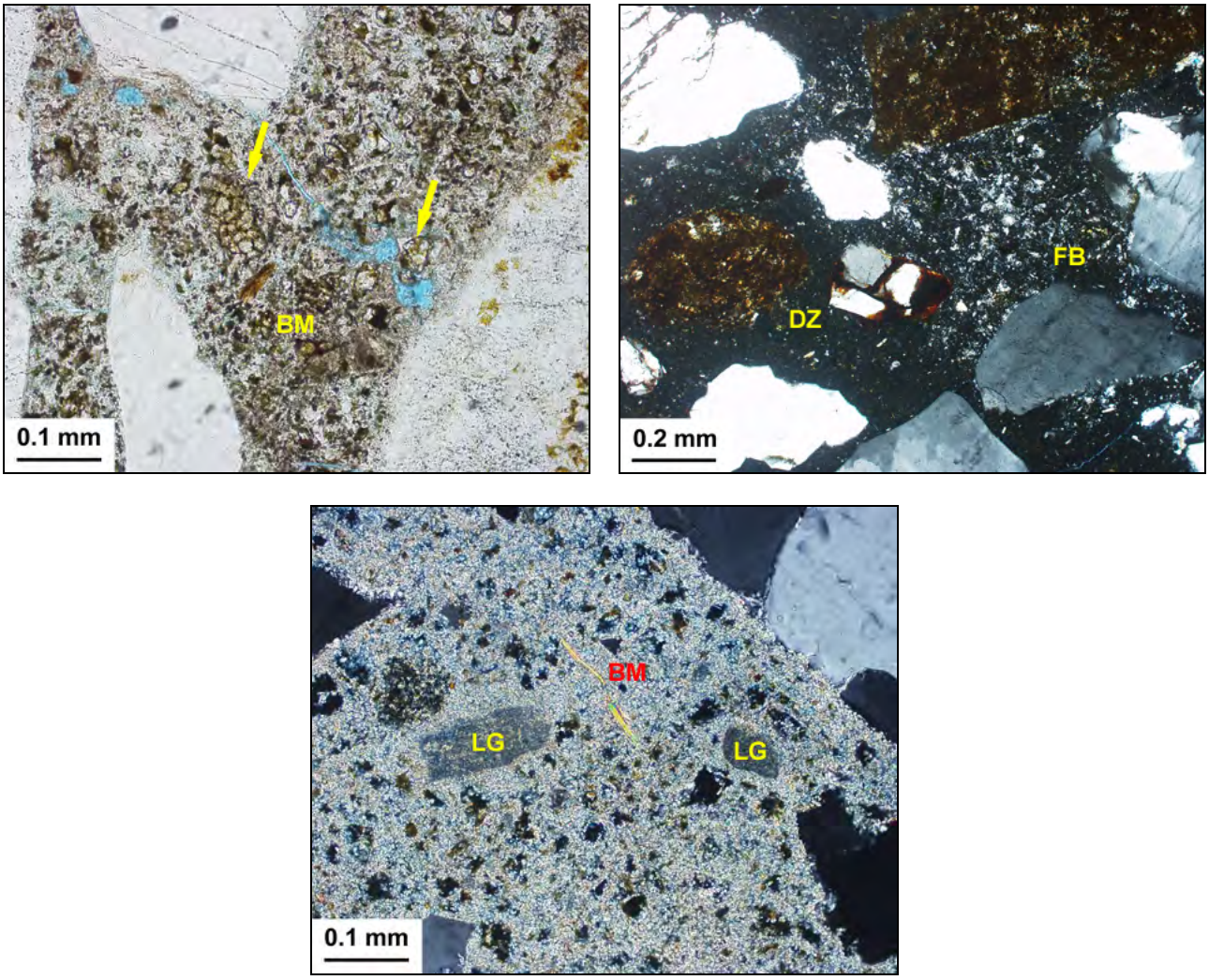


Figure 4: Photomicrographs illustrating the binder constituents and their condition. (Upper left PPL image) The arrows indicate residual portland cement grains where the paste remains chemically unaltered. The cement grains shown here are mostly unhydrated. Despite the high concentration of unhydrated cement particles, the surrounding binder matrix (BM) is dense and well-formed. (Upper right XPL image) The fresh binder (FB) exhibits bright crystal masses that represent residual calcium hydroxide from the original cement hydration. A depleted zone (DZ) is shown just adjacent to the fresh paste where calcium hydroxide has been consumed due to decalcification of the binder. (Lower XPL image) Undispersed lime grains are present in moderate concentration (LG). The ones shown here still contain some slaked but uncarbonated lime. This is not unusual to observe in older mortar containing dolomitic lime. The bright color of the adjacent binder matrix indicates that it is carbonated (BM).

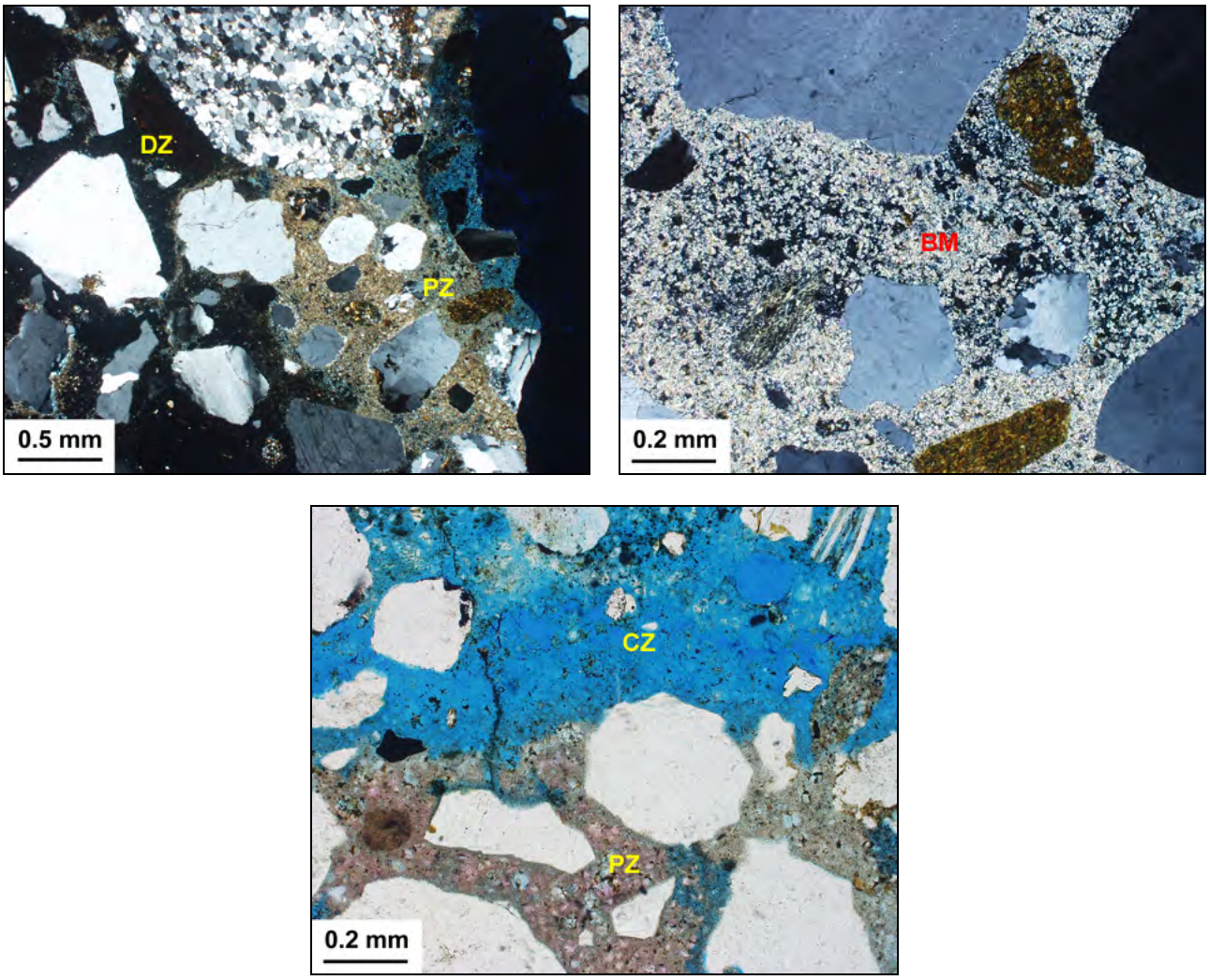


Figure 5: Photomicrographs illustrating characteristics associated with the bicarbonation reaction that mostly affects the outward facing portions of the mortar. (Upper left XPL image) A depleted zone (DZ) is shown that is similar to the one shown in the last figure. Outward from this is a porous zone (PZ) where the microporosity of the decalcified paste has increased. The zone contains secondary calcium carbonate and this produces the golden color under crossed polars. (Upper right XPL image) The binder matrix in this image (BM) contains small bright spots of so-called "popcorn calcite deposition". This is found within the porous zone and is characteristic of bicarbonation reactions. (Lower PPL image) The outer surface of the mortar is shown. A corroded zone (CZ) overlies the porous zone (PZ). All calcium-based species have been leached in this outer veneer leaving a residual crust of silica, alumina, and iron oxide. The intense blue color caused by the absorption of dyed epoxy used in the sample preparation indicates the extreme microporosity of this weakened layer.

Mortar Analysis Report - Boiler House

Chesapeake & Ohio Canal National Historical Park
Washington, D.C. and Maryland

Prepared for
Building Conservation Associates, Inc.

Client ID
BUIL005

Report No.
SL1581-01

Report Date
11/22/20

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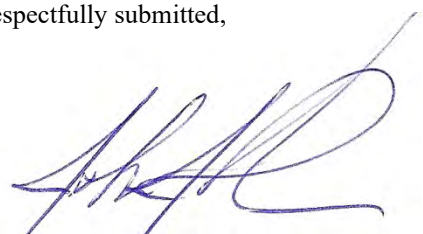
Cover Image

Photograph of the boiler house at the C&O Canal National Historical Park. Photo courtesy of Mr. Kevin Wohlgemuth of Building Conservation Associates.

Respectfully submitted,



John J. Walsh
President/ Senior Petrographer
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Heather Hartshorn
Chemist/ Staff Scientist
Highbridge Materials Consulting, Inc.

1. Executive Summary

This report presents the results of a compositional and condition analysis of a mortar sample recovered from the interior block wall of a boiler house constructed ca. 1941 and located at the C&O Canal National Historical Park outside Washington, D.C.

The material is identified as a masonry cement mortar with a medium-grained and well-graded natural sand. The masonry cement consists of gray portland cement, a mixed dolomitic plasticizer, and an air-entraining admixture. The cement content in the masonry cement is estimated at 68% by weight. If compared to modern designs, the binder proportioning would be similar to that of a Type S blend. However, the comparison is not really appropriate and the qualitative properties of the hardened mix are more consistent with those of a Type O blend. The binder to sand ratio is estimated at 1 : 3.6 by volume and this is considered moderately oversanded by today's standards.

The cured product is moderately hard and somewhat water permeable. The material is well mixed and consolidated. The mortar is uniform in appearance with a buff color (Munsell code approximately 10YR 7/2). The mortar is fully carbonated as expected for the long exposure. No deleterious service effects are observed.

2. Introduction

On October 21, 2020, Highbridge received five mortar and plaster samples from Mr. Kevin Wohlgemuth of Building Conservation Associates reported to have been sampled from various structures at the C&O Canal National Historical Park outside of Washington, D.C. All materials are believed by Mr. Wohlgemuth to be original to the ca. 1941 construction. The sample information provided by the client is presented in Table 2.1 below.

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CHOH #01	Boiler house, interior, mortar from concrete block wall
CHOH #02	Pump house, exterior, mortar from brick masonry
CHOH #03	Comfort station, interior, cement plaster from metal lath wall
CHOH #04	Engineer's garage, interior, mortar from concrete block and brick foundation
CHOH #05	Pivot bridge, exterior, mortar from stone rubble foundation

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The petrographic examination is conducted in accordance with the standard practices contained within ASTM C1324-20. Data collection is performed or supervised by a degreed geologist who by nature of their education is qualified to operate the analytical equipment employed. Analysis and interpretation is performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 4 of ASTM C856/C856M-20.

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The following personnel contributed to the examination:

Technician:	J. Bertoldi
Analyst:	M. Ricotta
Chemist:	H. Hartshorn
Petrographer:	J. Walsh

4. Petrographic Findings and Discussion

4.1 - Materials

The aggregate is a medium-grained natural sand consisting primarily of quartz with lesser silty and sometimes micaceous ironstone. Other sedimentary grains include graywacke sandstone and siltstone. Graywacke sandstone and siltstone, feldspar, and chert grains are minor components. Trace constituents include glauconite and epidote. No clay coatings or friable materials are identified and the sand is considered hard, non-porous, and durable for use in mortar mixtures. The loose mica flakes from the ironstone particles are not excessive, and would not have increased the water demand or freeze-thaw susceptibility of the mix. Chert grains are far too few to cause the mortar to be susceptible to alkali-aggregate reactions.

A sample of the aggregate was extracted from the mortar through acid digestion. The recovered sand is semi-translucent to semi-opaque and mostly uniform in appearance. The color is light brownish-gray (Munsell code approximately 10YR 7/1.75). Minor variegation is produced by gray, white, and rust-colored particles. The sand is sharp-textured consisting of equidimensional grains that are subangular in shape on average. The extracted sand was passed through a standard sieve stack to evaluate the gradation profile and the results are presented in Section 5. The nominal top size is found at the No. 8 sieve, the peak abundance lies between the No. 30 and No. 50 sieves, and the fines content is minor. ASTM C144-39T was the applicable standard for masonry sands in 1941. Based on these requirements, the maximum aggregate size and the amount of material passing the No. 50 sieve would be considered appropriate for joints of average thickness. While this version of the standard was generally more permissible, the particle size distribution would also comply with ASTM C144-18, the modern standard for masonry sands.

The binder is interpreted to have been supplied as a prepackaged masonry cement consisting of gray portland cement, a dolomitic plasticizer, and an air-entraining admixture. No pigments are detected as part of the blend. Masonry cements are specially prepared dry packaged mixtures marketed for masonry use. Proportioning of the binders and other additives is done in a plant setting. Only sand and water are required to be added on site. Prepackaged masonry cements became commercially available in the 1920s. The first use of air-entrainment in masonry cements is not well-documented. However, the ca. 1941 construction date reported for this sample would represent an early example of the technology.

The cured binder is uniform and homogeneously developed with a moderately high capillary porosity. Calcium hydroxide from the original cement hydration has all reacted in carbonation reactions and is not present within the paste. The cement hydration is highly advanced and virtually all hydraulic calcium silicate has been consumed. Residual cement particles are found in moderately low concentration mostly as fine-grained agglomerates of former belite defined by a skeleton of residual iron-bearing ferrite. The ferrite identifies the cement as a gray variety and this is confirmed by a chemically measured SiO_2/Fe_2O_3 ratio of 5.6. Unhydrated belite is rare.

The plasticizer used in the masonry cement appears to be a mixture of crushed dolomitic limestone and a highly disaggregated dolomitic lime. The dolomitic composition is indicated by the MgO content measured chemically. The material is detected petrographically in relatively high concentration throughout the hardened paste. It includes crushed angular fragments of crystalline dolomite, and very fine-grained rhombs of what appears to be carbonated lime. The latter are consistent with the textures often observed in dolomitic lime when calcined dolomite disaggregates in the kiln to produce a fine lime dust. Though speculative, it is possible the plasticizer represents some type of byproduct of dolomitic lime manufacture. Specifically, the crushed dolomite might represent unfired dust from the lime rock crushing, and the fine carbonated lime some type of burned kiln waste.

The total air content is estimated at approximately 8-10%. The fine spherical morphology of a large proportion of the voids indicates that the mortar was intentionally air-entrained. The majority of voids range in size from about 0.05 to 0.25 millimeters. The entrained air structure is relatively well developed though the volume is not as great as typically observed in modern masonry cement mortars. Nevertheless, the air is uniformly distributed throughout the binder matrix with no clustering.

4.2 - Component Proportions

Masonry cements have never been specified by the proportion of individual binder components. Instead, compliance has always been based on meeting physical property requirements regardless of how that is achieved through material blending. What this means is that only one type of masonry cement would have been available to the builders when the boiler house was constructed. The typing of masonry cements using the same letter designations as cement-lime mixtures is a relatively recent practice. Even here, the manufacturer is only held to a physical specification and is allowed to use any type of blending to achieve those requirements. Still, it is useful to estimate the specific binder proportions wherever possible through mortar analysis. The chemical analysis was used to determine these proportions and the results are presented in Section 6.

The long service of the mortar has caused some chemical changes that affect how the mortar design is calculated from the chemistry. One of these is the minor decomposition of sand grains that resulted in the release of some solubilized silica into the cementitious paste. The other is the carbonation of the lime portion of the plasticizer causing that portion to gain weight over time. Two compositional estimates are presented in Table 6.2. The first simply follows the algorithm suggested by ASTM C1324. The second takes another approach that is more sensitive to the mixed quality of the plasticizer. The latter is considered to be a better estimate.

The percentage of portland cement incorporated into the total masonry cement is estimated at 68% by weight. To put this in perspective, ASTM C1324 suggests that many modern masonry cements that comply with a Type S property requirement are prepared with about 66% portland cement. However, it should be understood that the mortar represented by Sample CHOH #01 is quite a bit softer and much more permeable than any Type S masonry cement mortar offered on the market today. In fact, the qualitative properties of the sample fragments are probably closer to many Type O blends.

The total binder to sand ratio is calculated at 1 : 3.6 by volume. Technically this would be considered an oversanded mortar though the broad aggregate gradation may be expected to mitigate small deficiencies in proportioning. Still, the water demand of the fresh mixture may have been somewhat higher as a result. To some degree this might explain the relatively high capillary porosity of the binder as the micropore structure in the hardened paste is essentially a function of the evaporable water present in the fresh mixture. Though it is outside the laboratory's scope to recommend repair strategies, it is important to state that it is never advisable to use high sand contents in an attempt to reduce strength or increase permeability when designing repair mortars.

4.3 - Condition and Service Performance

The constituents were all adequately blended based on the sample pieces examined petrographically. There are no sand streaks or coarse binder lumps. The mix water was thoroughly incorporated into the mixture and there is no evidence for inappropriate late retempering. The entrained air structure is well developed and the fine voids are uniformly distributed throughout the matrix. The mortar was well consolidated and compacted. Consolidation voids are relatively minor throughout the hardened mix. The cured binder is moderately hard and somewhat water permeable. The mortar itself is cohesive and non-friable. As described earlier, the qualitative properties of the mortar are "softer" than those that might be expected of a Type S masonry cement mortar. The term "soft" is used loosely here to encompass the more technical properties of strength, elasticity, and capillarity.

No significant deleterious service effects are identified petrographically. The mortar appears to have remained physically sound and no cracking is detected microscopically. The binder paste is fully carbonated but this is a normal and desirable consequence of long-term exposure. Other than this, no secondary mineralizations are detected and there is no sign of chemical degradation of the binder or any expansive chemical reactions.

5. Aggregate Sieve Analysis

Aggregate analysis was performed by digesting the sample in an acid sufficient to dissolve the binder. The fines are examined petrographically to ensure that all recovered material represents sand rather than undigested binder components. In this particular sample, much of the material passing a No. 325 sieve is found to consist of hydrous silica produced by the incomplete digestion of the portland cement component. As such, the fines are not included in the calculated gradation profiles below. The exclusion of any silt or clay from the aggregate is considered a negligible error.

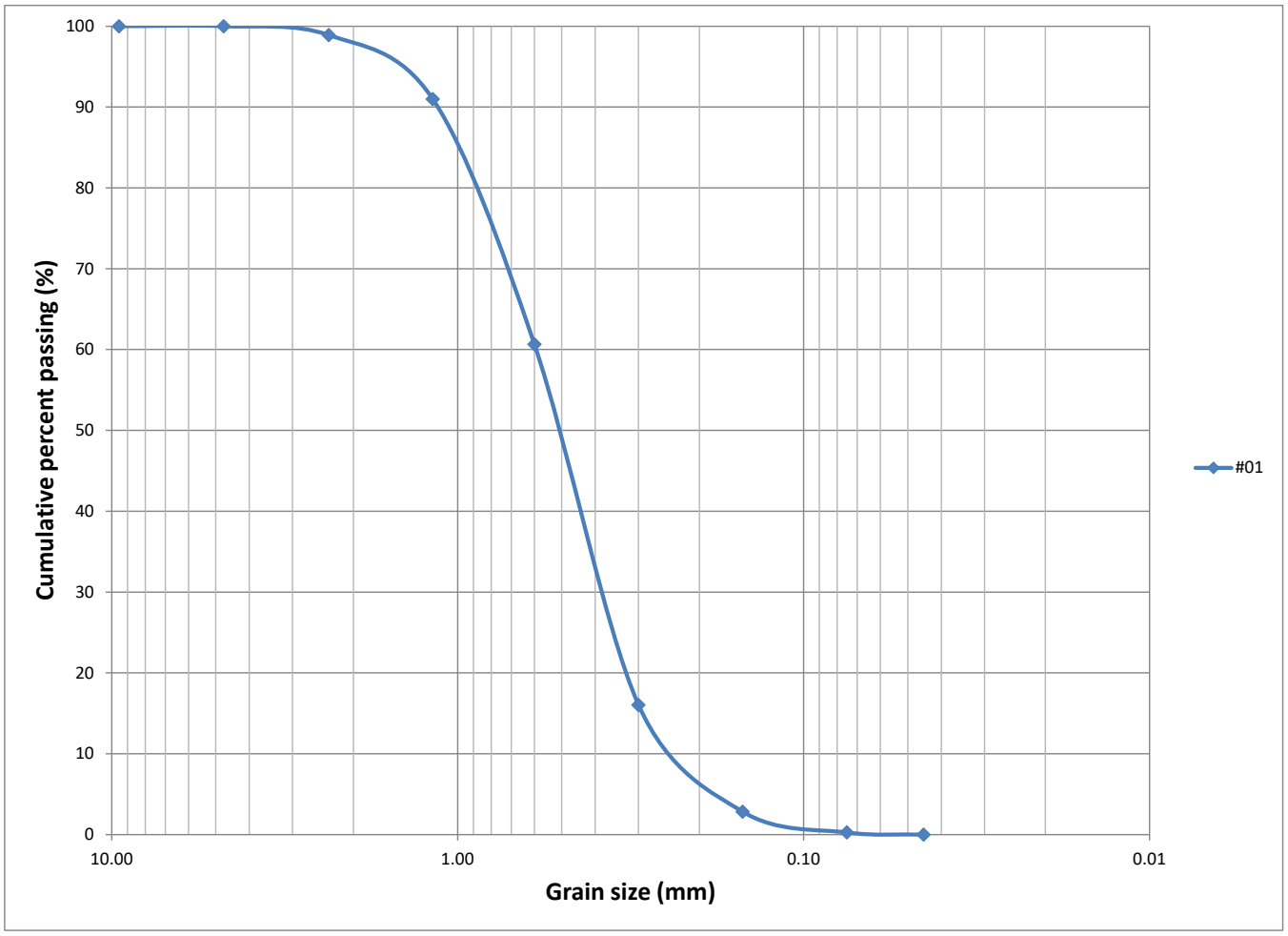
A qualitative description of the sand is given in the discussion above, and the recovered sample is returned to the client. The sample size is significantly smaller than would be required to perform a sieve analysis on fresh aggregate materials as per ASTM C136, and some small errors should be expected.

Table 5.1: Acid Digestion Data

Sieve size	Retention (g)	Cumulative passing (%)	Cumulative retained (%)
No. 4	0.00	100.0	0.0
No. 8	0.18	98.9	1.1
No. 16	1.27	91.0	9.0
No. 30	4.85	60.7	39.3
No. 50	7.13	16.0	84.0
No. 100	2.11	2.8	97.2
No. 200	0.41	0.3	99.7
Pan	0.04	0.0	100.0
Fineness modulus			**2.31**

Chart 5.1: Aggregate Sieve Analysis

The following chart presents the particle size distribution curve for the extracted sand sample. The chart plots the data from the cumulative passing values in Table 5.1.



6. Chemical Analysis

Table 6.1: Chemical Analysis Results

Sample ID	**CHOH #01**
Component (wgt. %)	
SiO_2	3.17
CaO	10.45
MgO	1.57
Al_2O_3	0.89
Fe_2O_3	0.56
Insoluble residue	72.97
LOI to 110°C	0.45
LOI 110°C-550°C	2.89
LOI 550°C-950°C	7.62
Measured totals	**100.57**

Notes:
1. The digestion procedure included a cold acid and hot base digestion as described in ASTM C1324. The insoluble residue was determined gravimetrically from the same procedure used to measure the soluble oxides.

Table 6.2: Calculated Components

Assuming a normal gray portland cement chemistry with a CaO/SiO_2 ratio of 3.0, the CaO remaining after accounting for the cement results in a binder with a CaO/MgO ratio of 0.94. This is too low even for a purely dolomitic plasticizer with a theoretical CaO/MgO of 1.4. The laboratory interprets this to indicate an enrichment of SiO_2 caused by the slow decomposition of sand particles due to long-term exposure to alkaline cement paste. This is a fairly common phenomenon. The compositions reported below account for this enrichment. The first column approaches this using a simple calculation scheme suggested by ASTM C1324. The second column presents a better assessment that accounts for the materials observed petrographically and any secondary carbonation that may have occurred.

The calculation typically used for masonry cement binders assumes that all of the plasticizer is in the form of a crushed carbonate rock. In this sample, it appears that a significant proportion of the binder consists of a now carbonated lime. This means that some of the CO_2 usually attributed to the original binder may be secondary. If it is assumed that about half of the plasticizer is a carbonated lime rather than a crushed carbonate, and an appropriate amount of CO_2 is deducted from the chemical analysis to account for this lime, the portland cement content in the masonry cement increases to 68% and the sand content increases to yield a binder to sand ratio of 1 : 3.6.

Sample ID	**CHOH #01**	
Component	Calculated using ASTM C1324	Corrected calculation method
Portland cement (wgt. %)	14	14
Masonry cement (wgt. %)	24	20
Sand (wgt. %)	76	80
Cement content in masonry cement (wgt. %)	56	68
Binder : sand ratio (by volume)	1 : 2.8	1 : 3.6

Notes:

1. In the first column, the proportional estimates are based on the standard masonry cement calculation given in ASTM C1324 with corrections made to account for a secondary silica enrichment and an assumption that the plasticizer is purely dolomitic. All of the measured MgO is attributed to the plasticizer. Enough CaO is deducted from the chemical analysis to give the plasticizer a CaO/MgO ratio of 1.4, representing a purely dolomitic source. The remaining CaO is attributed to the portland cement. This value is used to calculate the SiO_2 in the cement by forcing a 3.0 CaO/SiO_2 ratio. The remaining SiO_2 is considered to have been leached from the sand. The acid-insoluble residue is assumed to represent the aggregate and the additional SiO_2 is added to this value to calculate a corrected sand. Masonry cement is calculated by difference from 100% by subtracting the corrected insoluble residue (i.e. sand) as well as the low temperature losses on ignition (assumed to represent water). The masonry cement and sand weights are then normalized to 100%. The portland cement determined from the earlier calculations is reported as a percentage of the total masonry cement. Volumetric ratios are calculated assuming the bulk densities for Type N masonry cement and damp, loose sand are 70 lbs./ft.^{3} and 80 lbs./ft.^{3} respectively.
2. In the second column, the individual constituents are calculated directly from the oxide and insoluble residue measurements after the same SiO_2 correction is made as described above. The CaO and MgO available for the plasticizer are each divided in half and then converted to either a dolomitic dry hydrated lime or a crushed dolomite based on molecular weight conversion factors. The cement and sand are calculated as before. All weights are normalized to 100%. Volumetric ratios are calculated for Type S masonry cement and damp, loose sand assuming bulk densities of 75 lbs./ft.^{3} and 80 lbs./ft.^{3} respectively.

Appendix I: Visual Description of Sample as Received

Sample ID	**CHOH #01**
Description	The sample consists of several small to medium mortar fragments with a low abundance of loose granules and powder. Some pieces contain paint or other coatings. One piece is adhered to a concrete masonry block fragment. The total sample weighs 57 grams.
Surfaces	Tooled surfaces are covered with paint but appear to have planar profiles underneath the coating. Bed surfaces are all sandy-textured. Others are more irregularly planar. Some have gray soiling.
Hardness / Friability	The paste is moderately hard and the mortar is non-friable and cohesive.
Appearance	Freshly exposed surfaces have a moderately dull luster and are buff in color (Munsell code approximately 10YR 7/2).
Absorptivity	The matrix is slowly to moderately water absorptive.
Other details	No cracks, efflorescence, mineral deposits, or binder inclusions are visible in hand sample.

Appendix II: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The stereoscopic microscope is used for simple magnification. Sample types examined under this microscope include fractured surfaces, fine constituents extracted through chemical or physical means, or honed or polished cross sections. The polarized light microscope (PLM) magnifies but also employs principals of optical crystallography. The most common sample preparation for the PLM is the petrographic thin section. For this preparation, cross-sectioned samples are mounted to glass slides and are milled to a thickness sufficient to allow light to be transmitted through the material. These are usually prepared without water and with minimal heat to avoid altering minerals that are water or temperature-sensitive. In many cases, the samples are impregnated with a low-viscosity, blue-dyed epoxy. When so treated, blue areas represent some type of void space (e.g., air-voids, capillary pores, cracks, etc.). The polarized light photomicrographs are taken using a variety of optical settings chosen to best demonstrate the feature(s) of interest. These are distinguished as follows:

Plane polarized light (abbreviated as PPL)

This method uses the refractive power of different constituents to produce an artificial sense of surface relief. Otherwise, the method is the closest to a simple magnification of the material. The setting is often used to demonstrate granular relationships or microstructure. Pore spaces and cracks are observable with this setting if the blue-dyed epoxy is used.

Conoscopic polarized light (abbreviated as CPL)

In this setting, the transmitted light is condensed just before passing through the thin section. The method tends to bring colors or finer particulates into higher contrast at the expense of image sharpness. The setting is often used to image grain boundary failures in dimension stone, pigment particulates in binders, or gel phases in the micropores of cement pastes.

Cross polarized light (abbreviated as XPL)

The setting places the thin section between two pieces of polarizing film oriented at 90° to one another. In isotropic materials (e.g., glasses, simple salts), all light is absorbed and the materials appear black. In anisotropic crystals, two light rays traveling at different speeds are produced within the thin section and these offset waves interfere at the upper polarizing film. The interference produces a color that can be used to calculate properties of the crystal structure and aid in identification of mineral species. In essence, the colors are artificial. It should be noted that color is a function of orientation and color differences do not necessarily indicate material differences.

Compensator plates

When in XPL mode, full-wave or quarter-wave compensator plates may be inserted into the light path to add or subtract interference. Technically, these methods are used to calculate properties of the crystal structure. However, they can also be used to alter the image appearance to help improve contrast between different constituents. They can also reveal preferred orientations in some materials (e.g., oriented residual crystallinity in fired ceramics).

Scale bars are included with all photomicrographs. In higher magnification images, the µm symbol represents microns. One micron is equal to 0.001 millimeter.

Figure 1: Photograph of the boiler house masonry mortar sample received by Highbridge for examination. The mortar is a mostly uniform buff color.

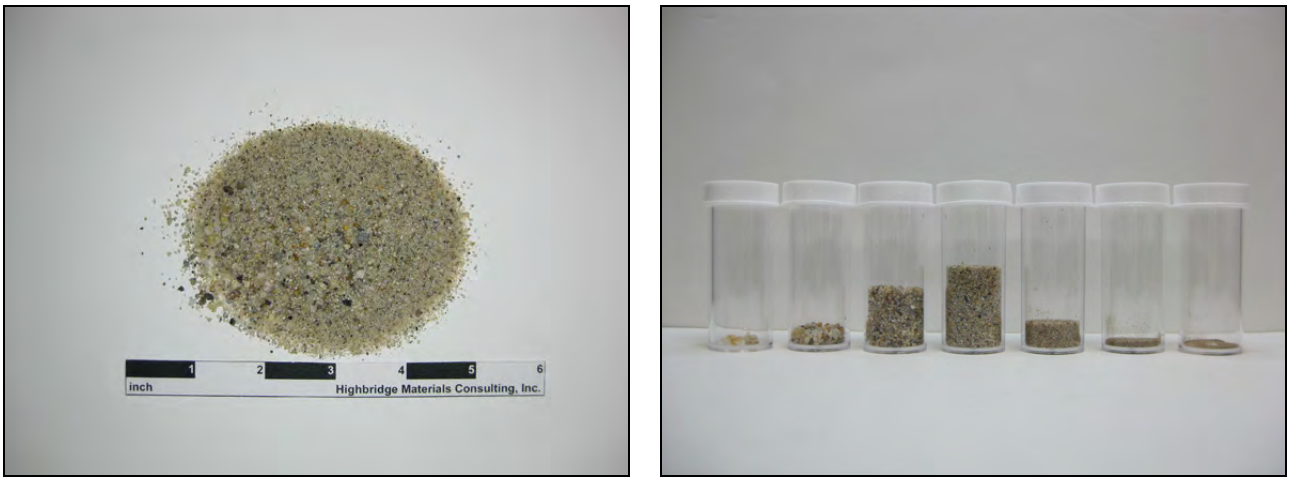


Figure 2: Photographs of the aggregate extracted through acid digestion. The total extraction is shown at left. The sand is uniform in appearance with a light brownish gray color overall. The sand is shown at right after gradation through a standard sieve stack. The medium-grained sand is broadly graded.

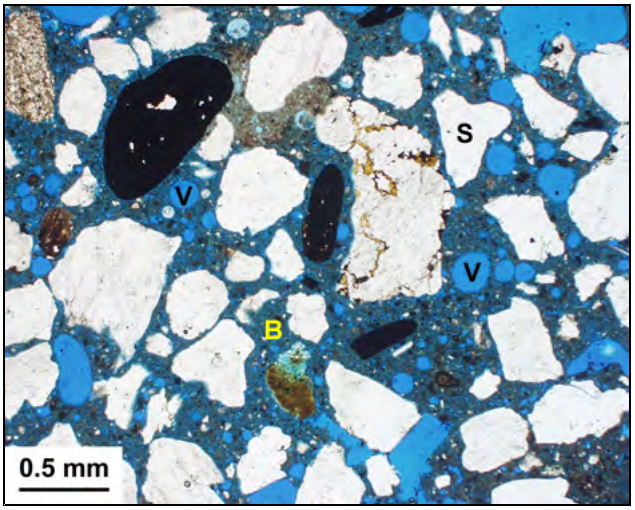


Figure 3: PPL photomicrograph illustrating the overall microtexture of the mortar. The sample is impregnated with a blue-dyed epoxy to highlight cracks, pores, and voids. The absorption of the dyed epoxy into the binder (B) indicates a high microporosity. The sand (S) is sharp-textured and uniformly distributed throughout the mortar. There is a moderate abundance of fine spherical air-voids (V) consistent with intentional air-entrainment.

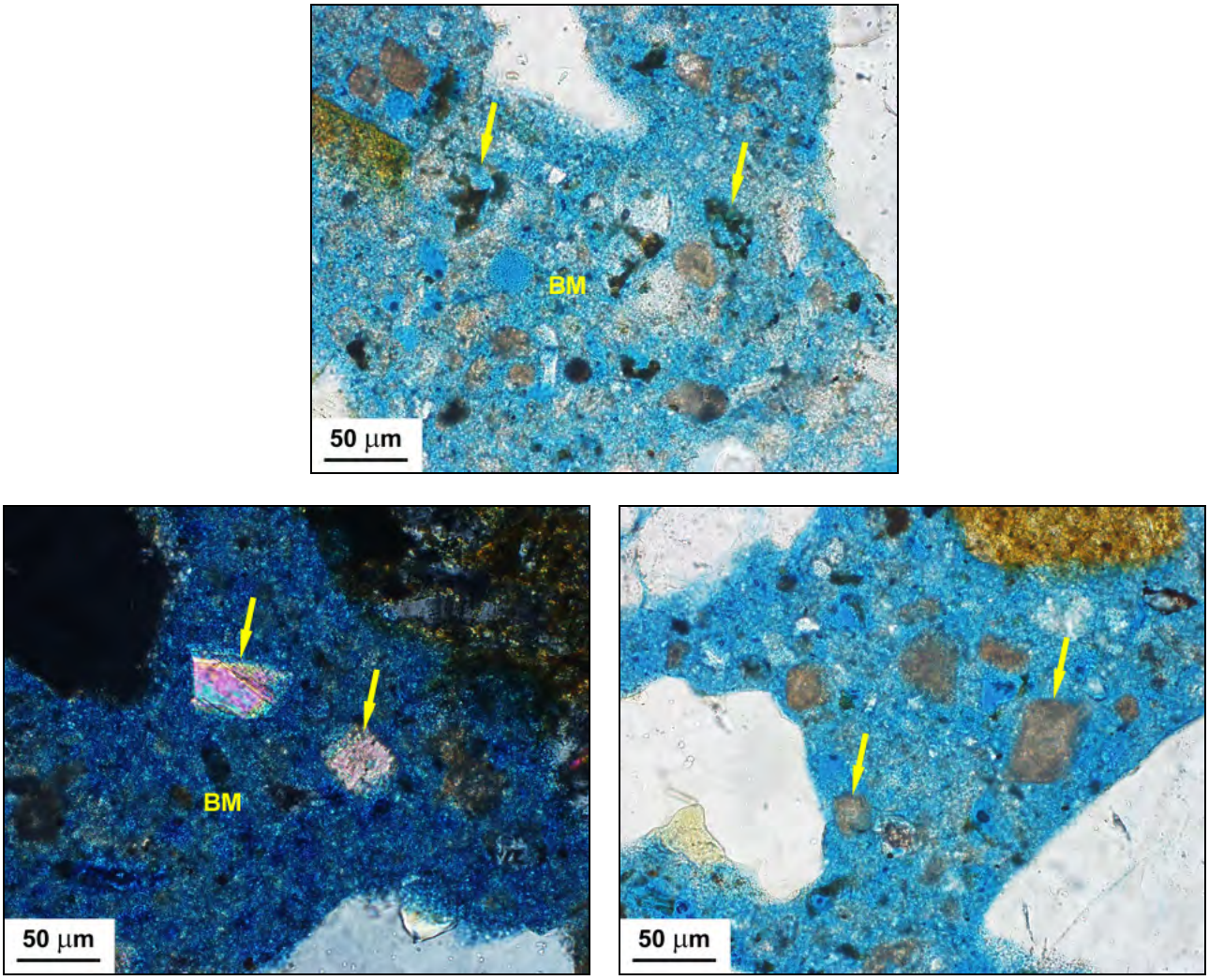


Figure 4: Photomicrographs illustrating the binder constituents. (Upper PPL image) The arrows indicate fully hydrated portland cement relicts. The brown-colored ferrite within the agglomerates indicates the cement is a gray variety. The adjacent binder matrix (BM) is well-formed though highly porous as indicated by the absorption of the blue-dyed epoxy used in the sample preparation. (Lower left XPL image) Part of the plasticizer includes fine, angular fragments of crystalline dolomite (arrows). Note that the binder matrix is bright-colored under crossed polars. This indicates that it is fully carbonated. (Lower right PPL image) The arrows indicate rhombs of very fine-grained carbonated lime. These represent another portion of the plasticizer. The two plasticizing materials taken together suggest some type of byproduct or waste material from lime manufacture.

Plaster Analysis Report - Comfort Station

Chesapeake & Ohio Canal National Historical Park
Washington, D.C. and Maryland

Prepared for
Building Conservation Associates, Inc.

Client ID
BUIL005

Report No.
SL1581-03

Report Date
11/22/20

HIGHBRIDGE MATERIALS CONSULTING, INC.

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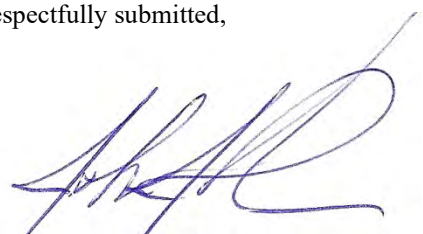
Cover Image

Photograph of the comfort station at the C&O Canal National Historical Park. Photo courtesy of Mr. Kevin Wohlgemuth of Building Conservation Associates.

Respectfully submitted,



John J. Walsh
President/ Senior Petrographer
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Heather Hartshorn
Chemist/ Staff Scientist
Highbridge Materials Consulting, Inc.

1. Executive Summary

This report presents the results of a compositional and condition analysis of an interior plaster sample recovered from the comfort station constructed ca. 1941 and located at the C&O Canal National Historical Park outside Washington, D.C.

The sample represent a two-coat cement plaster assembly presumably over expanded metal lath. The layers include only a scratch coat and base coat. No decorative finish layer is included in the design. The material constituents include gray portland cement, dolomitic hydrated lime, and a fine-grained natural sand. Based on modern proportional standards, both mixtures would be consistent with Type C mixtures though the low sand contents would only be appropriate for first coat work. Cement to lime ratios are calculated at 1 : 0.38 and 1 : 0.28 for the scratch and brown coats respectively. Binder to sand ratios are estimated at 1 : 2.5 for both layers.

The cured plaster is hard, indurate, and not particularly water permeable. The materials were well mixed and installed. Some minor loss of mix water in the brown coat may have occurred shortly after placement but with no consequent loss in material quality. The plaster layers are uniform in appearance. The scratch coat is light buff and the brown coat is gray. Carbonation has progressed through the full thickness of the plaster assembly. It is possible that the pH reduction accompanying the reaction has depassivated this metal lath and contributed to its corrosion.

2. Introduction

On October 21, 2020, Highbridge received five mortar and plaster samples from Mr. Kevin Wohlgemuth of Building Conservation Associates reported to have been sampled from various structures at the C&O Canal National Historical Park outside of Washington, D.C. All materials are believed by Mr. Wohlgemuth to be original to the ca. 1941 construction. The sample information provided by the client is presented in Table 2.1 below.

Table 2.1: Sample Identifications

Sample ID	Description
CHOH #01	Boiler house, interior, mortar from concrete block wall
CHOH #02	Pump house, exterior, mortar from brick masonry
CHOH #03	Comfort station, interior, cement plaster from metal lath wall
CHOH #04	Engineer's garage, interior, mortar from concrete block and brick foundation
CHOH #05	Pivot bridge, exterior, mortar from stone rubble foundation

At the client's request, a compositional analysis is performed on each of the mortar and plaster samples. The testing includes a petrographic examination and chemical analysis to identify constituents, estimate proportions, and assess overall condition. Acid digestions to extract sand samples for description and gradation are also included in the testing scope. This report presents the results for the comfort station plaster (Sample CHOH #03). Results for the other samples are presented under separate cover.

3. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within ASTM C1324-20. Data collection is performed or supervised by a degreed geologist who by nature of their education is qualified to operate the analytical equipment employed. Analysis and interpretation is performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 4 of ASTM C856/C856M-20.

Chemical analysis is performed in general accordance with the procedures outlined in ASTM C1324-20. Water, carbon dioxide, and aggregate weight percentages are determined gravimetrically. Oxide weight percentages are determined by inductively coupled plasma - optical emission spectroscopy (ICP-OES). While ASTM classifies C1324 as a test method, it is intended to serve as a guideline for qualified practitioners with ample experience in the various materials under consideration. Section 10.2 indicates the need for discretion on the part of the laboratory to ensure that methods are tailored to specific mortar compositions. As such, Highbridge chooses specific digestion methods, supplementary tests, instrumentation protocols, and mathematical models to best characterize each individual mortar under consideration. Many of these are proprietary methods that have been researched internally.

The following personnel contributed to the examination:

Technician:	J. Bertoldi
Analyst:	M. Ricotta
Chemist:	H. Hartshorn
Petrographer:	J. Walsh

4. Petrographic Findings and Discussion

4.1 - Materials

The provided sample is identified as a cement plaster comprising two base coats and no finish coat. The same type of sand is identified in the both coats. The aggregate is a fine-grained natural sand consisting primarily of quartz with a moderate concentration of ironstone particles. There are a variety of minor constituents include opaque grains, graywacke sandstone and siltstone, mica schist and phyllite, and feldspar. Traces include chert, glauconite, amphibole, and epidote. No clay coatings or friable materials are identified and the sand is considered hard, non-porous, and durable for use in cement plasters. The mineralogy of the opaque grains is not distinguished. However, reflected light observations reveal that no potentially deleterious sulfides are included.

An acid digestion was used to extract sand samples from both plaster coats. Both are semi-translucent to semi-opaque with a uniform appearance. Colors are a similar light buff though the sand in the brown coat is slightly richer in tone. Munsell codes are approximately 10YR 7/1.5 to 10YR 7/1.75. The sands are sharp-textured consisting of equidimensional grains that are subangular to angular in shape. Gradations were evaluated by passing the extracted sands through a standard sieve stack. These results are presented in Section 5. In both cases, the nominal top size is found at the No. 16 sieve, the peak abundance lies between the No. 30 and No. 50 sieves, and the fines content is moderate. These gradation profiles would not comply with the permissible limits of the modern standard for cement plaster sands (ASTM C897-15(2020)). The sand would be considered overly fine with insufficient material retained cumulatively on many of the sieve sizes. Additionally, too much sand is retained between the No. 50 and No. 100 sieves to comply with ASTM C897. With this said, it should be understood that the only standard available for plaster in 1941 was ASTM C35 for gypsum-based interior plasters. Even here, the sand would be just out of compliance due to its fineness.

The binder in both coats consists of portland cement gauged with hydrated lime. No type of natural or artificial fiber reinforcement is present in either coat. The cementitious paste is well-formed in both layers. The capillary porosity is moderate to moderately high in the scratch coat and moderate in the brown coat. In both cases, the micropore structure is indicative of a workable mixture when freshly prepared.

The hydraulic binder is identified as a gray portland cement. The high abundance of iron-bearing ferrite in both layers is indicative of a gray cement. The identification is supported by an SiO_2/Fe_2O_3 ratio measured chemically at approximately 5. Whether or not fully hydrated, residual cement agglomerates indicate a more coarsely ground product than typically observed in mortars and plasters of the 1940s. Many of the agglomerates have diameters that would cause them to approach or be retained on a No. 100 sieve. Most cements of the 1940s would have a high percentage of the cement weight passing this mesh. In both layers, there is a high abundance of residual cement in the form of calcium silicate agglomerates (alite and belite) with interstitial ferrite phase. Virtually all of the hydraulic calcium silicate is consumed in hydration reactions in the scratch coat leaving behind empty cement shells defined only by the relict ferrite. Many of the cement agglomerates remain unhydrated in the brown coat. However, this does not indicate an inhibited hydration. The surrounding cementitious paste is dense and well-formed.

Undispersed lime grains are observed in moderate concentration in both layers. The chemical analysis indicates that the lime is a dolomitic variety. Petrographically, the undispersed lime is very fine-grained and texturally non-descript. The texture is consistent with lime added as a prepackaged dry hydrate though the observation cannot be considered diagnostic. Nevertheless, the use of prepackaged lime would be expected for the early 1940s. Most of the lime particles are fully carbonated. There are uncommon occurrences of uncarbonated lime in the centers of some undispersed particles in the scratch coat. This is not an unexpected observation in dolomitic limes as these tend to carbonate much more slowly than high-calcium varieties. In fact, the degree of carbonation observed in this sample is greater than usually encountered.

4.2 - Component Proportions

Material proportions of the base coat plaster layers are calculated from the chemical analysis and these results are presented in Section 6. The modern standard for cement plaster is ASTM C926-20b. Compared to proportions specified in this standard, both mixtures would classify as Type C base coat mixes. The sand content in the brown coat would be a little lower than permitted for a second coat. In modern practice, Type C mixtures are considered appropriate to use with non-absorptive substrates or expanded metal lath.

The cement to lime ratios are calculated at 1 : 0.38 and 1 : 0.28 for the scratch and brown coats respectively. The binder to sand ratios are calculated at 1 : 2.5 for both layers. It should be noted that where volume proportions are given, these are based on estimated original bulk densities of the materials. However, limes are subject to great variation in volume due to factors such as settling or "fluffing". Table 6.2 also presents the weight percentages of the dry ingredients (cement, dry hydrated lime, and sand). These are more accurate as they represent direct measurements of material mass and are not based on assumptions of bulk density. Of course, this discussion is academic since it is usually desirable to modify the original design if modern materials will be used to replace their historic counterparts. The findings of a plaster analysis are best used to constrain possible repair designs rather than as a prescription for a specific formulation.

4.3 - Original Placement

The samples provided for examination represent a two-coat cement plaster assembly. However, the samples were provided as small fragments and it is mot possible to fully evaluate the installation quality. It appears that the scratch coat was applied over expanded metal lath given the shape of corrosion product impressions at the base of this layer. There is some keying of the scratch coat into the lath but not much in the pieces examined. The total thickness of the assembly is approximately 1/2". In most places, the two coats are of about equal thickness. The outer face of the scratch coat is not visible. However, it appears roughly planar in cross section and was likely floated. There are no deep trowel furrows evident in the scratch layer. If thinner scratches were applied, these are not obvious in cross section. The brown coat was well consolidated against the scratch coat. Consolidation voids are minimal and the quality of the contact suggests a wet-on-wet placement. As with the scratch coat, the surface of the brown coat is concealed, in this instance by paint coatings. In cross section, the finished surface appears relatively planar. No texturing is suggested. There are no defects identified petrographically.

Based on the petrographic observations, all plaster constituents were relatively well blended. There are no sand streaks in either layer. A few very fine clots of cement and lime are detected petrographically in the two layers, but these are quite minor. The quality of the cementitious paste suggests fresh plaster mixes that were sufficiently plastic to ensure workability and placeability, but stiff enough to avoid sagging. The mix water was well incorporated in both mixes and there is no evidence for inappropriate late retempering. Both layers were well compacted when placed, and total air contents are estimated at only 4-6% by volume. Voids are generally less than 0.5 millimeters in diameter and are evenly spaced throughout each layer.

The binder was adequately cured in both layers. Curing conditions may always vary across an installation and care should be taken in extrapolating observations from small samples. In any case, the thorough hydration of the scratch coat cement indicates that there was not any excess loss of mix water to the substrate. There is a higher abundance of unhydrated cement grains in the brown coat layer. This suggests either some absorption of mix water into the scratch coat, or loss of moisture to the environment through evaporation. In either case, the cement in the brown coat layer is more than adequately hydrated. If there was any loss of moisture, this had no impact on the quality of the plaster other than causing the brown coat to appear darker and grayer than the scratch coat.

4.4 - Condition and Service Performance

The two cured plaster layers are hard and indurate with a relatively low permeability. The scratch coat appears to be slightly softer and more permeable than the brown coat. The qualitative properties are consistent with the cement-rich compositions determined chemically.

Both plaster layers are fully carbonated. While the degree of carbonation is expected for the long service history, the reduction in pH that accompanies the carbonation reaction is capable of depassivating any embedded steel. As such, the carbonation may have contributed to any lath corrosion that may be evident on site. Some corrosion product is observable along the bases of the sample pieces. However, the sample size is too small to offer any evaluation of the lath condition.

The plaster itself appears to be in sound condition. No microcracking of any kind is detected petrographically. This includes the surface perpendicular microcracks typically observed in cement plasters. Chemical degradation of the binder is also absent. No secondary mineralizations are detected at the scale of the light microscope other than the carbonation.

5. Aggregate Sieve Analysis

Aggregate analysis was performed by digesting the sample in an acid sufficient to dissolve the binder. The fines are examined petrographically to ensure that all recovered material represents sand rather than undigested binder components. In this particular sample, much of the material passing a No. 325 sieve is found to consist of hydrous silica produced by the incomplete digestion of the portland cement component. As such, the fines are not included in the calculated gradation profiles below. The exclusion of any silt or clay from the aggregate is considered a negligible error.

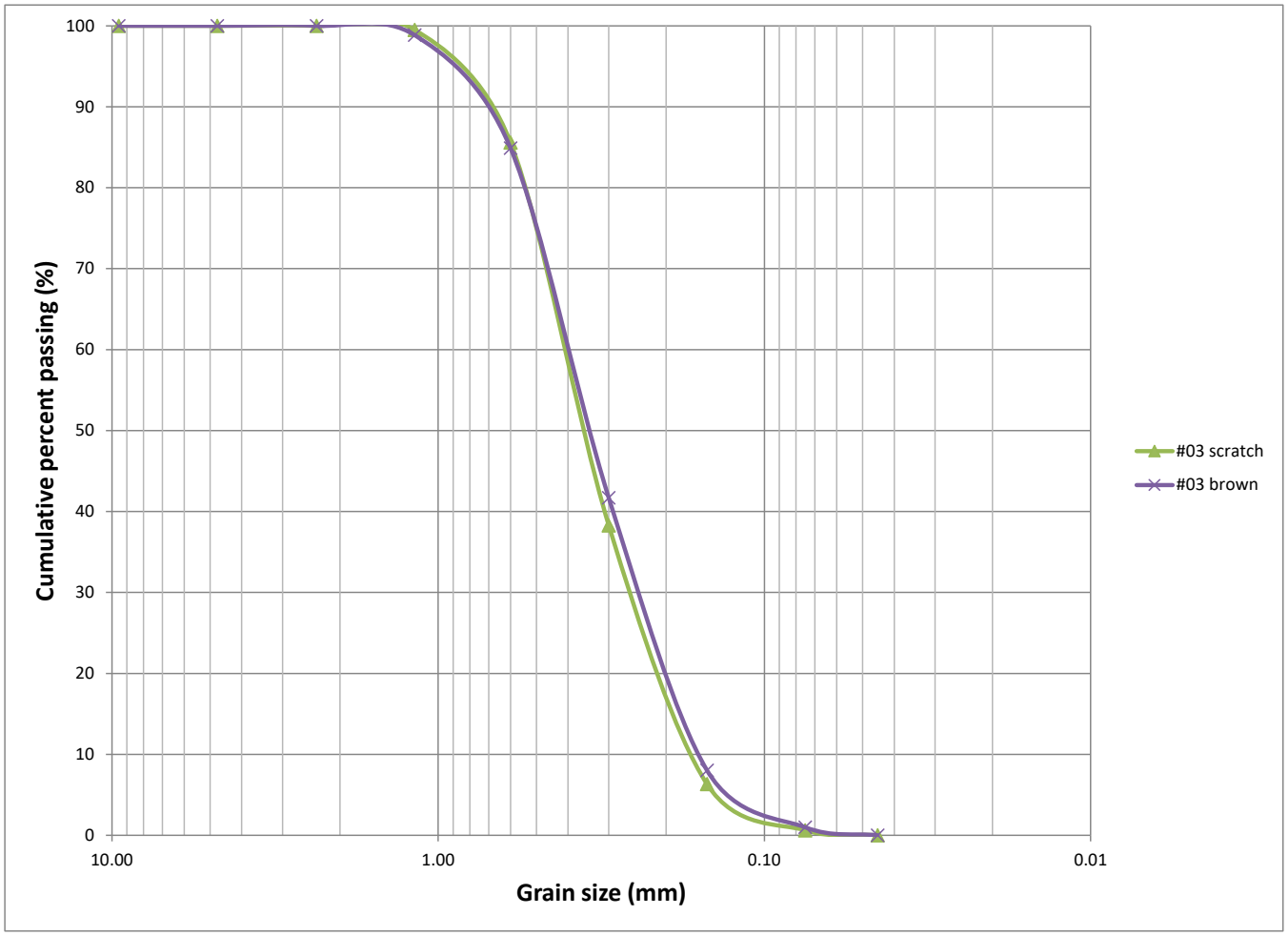
A qualitative description of the sand is given in the discussion above, and the recovered sample is returned to the client. The sample size is significantly smaller than would be required to perform a sieve analysis on fresh aggregate materials as per ASTM C136, and some small errors should be expected.

Table 5.1: Acid Digestion Data

	Raw data - weight retained (g)		Cumulative passing (wgt. %)		Cumulative retained (wgt. %)	
Sieve size	**Scratch coat**	**Brown coat**	**Scratch coat**	**Brown coat**	**Scratch coat**	**Brown coat**
No. 4	0.00	0.00	100.0	100.0	0.0	0.0
No. 8	0.00	0.00	100.0	100.0	0.0	0.0
No. 16	0.04	0.04	99.5	98.8	0.5	1.2
No. 30	1.10	0.50	85.6	84.9	14.4	15.1
No. 50	3.75	1.56	38.3	41.7	61.7	58.3
No. 100	2.54	1.22	6.3	8.0	93.7	92.0
No. 200	0.45	0.25	0.6	1.0	99.4	99.0
Pan	0.05	0.04	0.0	0.0	100.0	100.0
Fineness modulus					**1.70**	**1.67**

Chart 5.1: Aggregate Sieve Analysis

The following chart presents the particle size distribution curves for the extracted sand samples. The chart plots the data from the cumulative passing values in Table 5.1.



6. Chemical Analysis

Table 6.1: Chemical Analysis Results

Sample ID	CHOH #03	
Layer	**Scratch coat**	**Brown coat**
Component (wgt. %)		
SiO_2	4.48	4.82
CaO	14.91	15.87
MgO	1.84	1.38
Al_2O_3	1.19	1.41
Fe_2O_3	0.87	1.00
Insoluble residue	61.47	62.67
LOI to 110°C	1.63	1.70
LOI 110°C-550°C	2.72	3.39
LOI 550°C-950°C	11.90	9.62
Measured totals	**101.01**	**101.87**

Notes:
1. The digestion procedure included a cold acid and hot base digestion as described in ASTM C1324. The insoluble residue was determined gravimetrically from the same procedure used to measure the soluble oxides.

Table 6.2: Calculated Components

Sample ID	CHOH #03	
Layer	**Scratch coat**	**Brown coat**
Component		
Portland cement (wgt. %)	25	26
Lime expressed as dry hydrate (wgt. %)	4.0	3.1
Sand (wgt. %)	71	71
Cement : lime ratio (by volume)	1 : 0.38	1 : 0.28
Binder : sand ratio (by volume)	1 : 2.5	1 : 2.5

Notes:
1. The portland cement weight is calculated from the measured SiO_2, assuming a typical content of 21% SiO_2 by weight for gray portland cement. Sufficient CaO and MgO are subtracted from the measured values to satisfy this cement content. The remaining CaO and MgO have a ratio of 1.2 that is close to the theoretical limit of 1.4 for a dolomitic lime. The assumed MgO content of the cement is adjusted slightly to allow the lime to have a 1.4 CaO/MgO ratio. The remaining CaO and MgO are reported as their respective dry hydroxides through molecular weight conversion to represent the lime as a dry hydrate. The sand weight is taken directly from the insoluble residue. The reported weight percentages of the dry ingredients are then normalized to 100%. Volumetric ratios are calculated assuming bulk weights for portland cement, hydrated lime, and damp, loose sand of 94 lbs./ft.^{3}, 40 lbs./ft.^{3}, and 80 lbs./ft.^{3}, respectively.

Appendix I: Visual Description of Sample as Received

Sample ID	CHOH #03
Description	The sample consists of several small interior plaster fragments weighing a total of 81 grams. The total depth of the plaster is approximately 1/2". The assembly appears to consist of two approximately 1/4" coats applied over an expanded metal lath. The lath is not included with the sample. One piece contains an approximately 3/8" thick scratch coat and a 1/8" thick brown coat. No finish coat is present in any sample. White paint coats most of the sample pieces.
Surfaces	The inner surface of the plaster is compact. In some places, corrosion product is found in the shape of expanded metal lath. Based on the shape of the impressions, the plaster is keyed through the lathwork but not too any significant depth. The outer face of the scratch coat is not exposed in any part of the sample. In cross section, the scratch coat appears to have been floated to a planar surface. No evidence for any deep troweling is evident in cross section. Any thinner scratching that might have been performed would not be apparent in cross section. The brown coat was well compacted against the scratch layer. The finished surface is usually coated with white paint. In cross section, the finished surface appears relatively planar and untextured.
Scratch coat qualities	The paste is moderately hard and the matrix is indurate and nonfriable. Freshly exposed surfaces have a moderately dull luster and are light buff in color (Munsell code approximately 1Y 7/1.5). The matrix is somewhat slowly water absorptive. A low abundance of white binder inclusions are identified and these are generally less than 1 millimeter in diameter.
Brown coat qualities	The paste is hard and the matrix is indurate and nonfriable. Freshly exposed surfaces have a moderately subvitreous translucent luster and are gray in color (Munsell code approximately 2.5Y 5.25/1). The matrix is slowly water absorptive.
Other details	No cracks, efflorescence, or mineral deposits are visible in hand sample.

Appendix II: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The stereoscopic microscope is used for simple magnification. Sample types examined under this microscope include fractured surfaces, fine constituents extracted through chemical or physical means, or honed or polished cross sections. The polarized light microscope (PLM) magnifies but also employs principals of optical crystallography. The most common sample preparation for the PLM is the petrographic thin section. For this preparation, cross-sectioned samples are mounted to glass slides and are milled to a thickness sufficient to allow light to be transmitted through the material. These are usually prepared without water and with minimal heat to avoid altering minerals that are water or temperature-sensitive. In many cases, the samples are impregnated with a low-viscosity, blue-dyed epoxy. When so treated, blue areas represent some type of void space (e.g., air-voids, capillary pores, cracks, etc.). The polarized light photomicrographs are taken using a variety of optical settings chosen to best demonstrate the feature(s) of interest. These are distinguished as follows:

Plane polarized light (abbreviated as PPL)

This method uses the refractive power of different constituents to produce an artificial sense of surface relief. Otherwise, the method is the closest to a simple magnification of the material. The setting is often used to demonstrate granular relationships or microstructure. Pore spaces and cracks are observable with this setting if the blue-dyed epoxy is used.

Conoscopic polarized light (abbreviated as CPL)

In this setting, the transmitted light is condensed just before passing through the thin section. The method tends to bring colors or finer particulates into higher contrast at the expense of image sharpness. The setting is often used to image grain boundary failures in dimension stone, pigment particulates in binders, or gel phases in the micropores of cement pastes.

Cross polarized light (abbreviated as XPL)

The setting places the thin section between two pieces of polarizing film oriented at 90° to one another. In isotropic materials (e.g., glasses, simple salts), all light is absorbed and the materials appear black. In anisotropic crystals, two light rays traveling at different speeds are produced within the thin section and these offset waves interfere at the upper polarizing film. The interference produces a color that can be used to calculate properties of the crystal structure and aid in identification of mineral species. In essence, the colors are artificial. It should be noted that color is a function of orientation and color differences do not necessarily indicate material differences.

Compensator plates

When in XPL mode, full-wave or quarter-wave compensator plates may be inserted into the light path to add or subtract interference. Technically, these methods are used to calculate properties of the crystal structure. However, they can also be used to alter the image appearance to help improve contrast between different constituents. They can also reveal preferred orientations in some materials (e.g., oriented residual crystallinity in fired ceramics).

Scale bars are included with all photomicrographs. In higher magnification images, the µm symbol represents microns. One micron is equal to 0.001 millimeter.

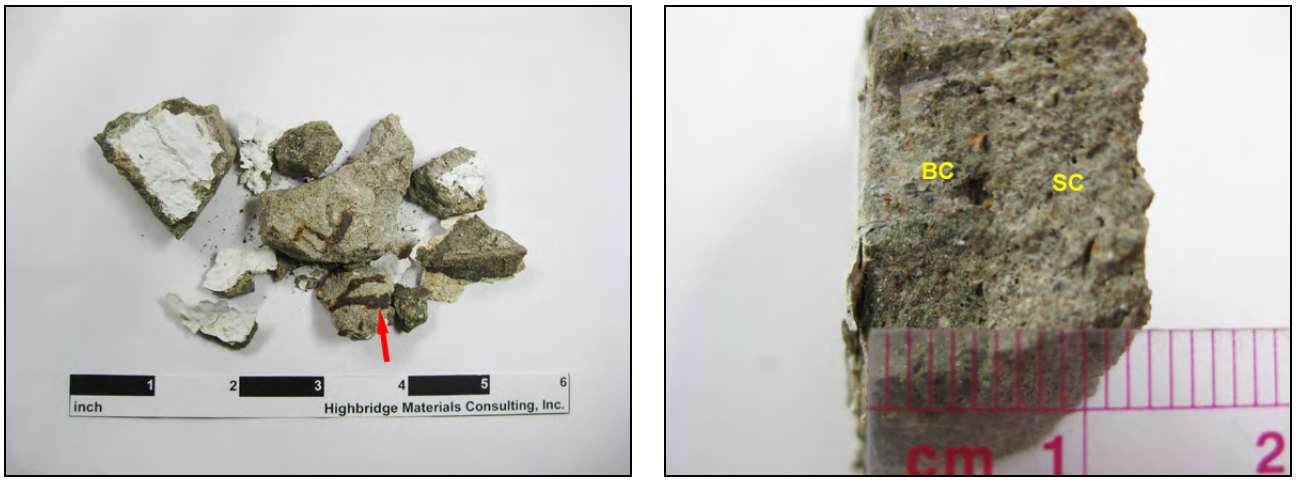


Figure 1: Photographs of the comfort station plaster sample received by Highbridge for examination. (Left) The total sample is shown. The arrow indicates impressions of corrosion product in the shape of expanded metal lath. (Right) A piece of the plaster is shown in cross section. The assembly is a two-coat preparation with approximately equal thicknesses of scratch coat (SC) and brown coat (BC).

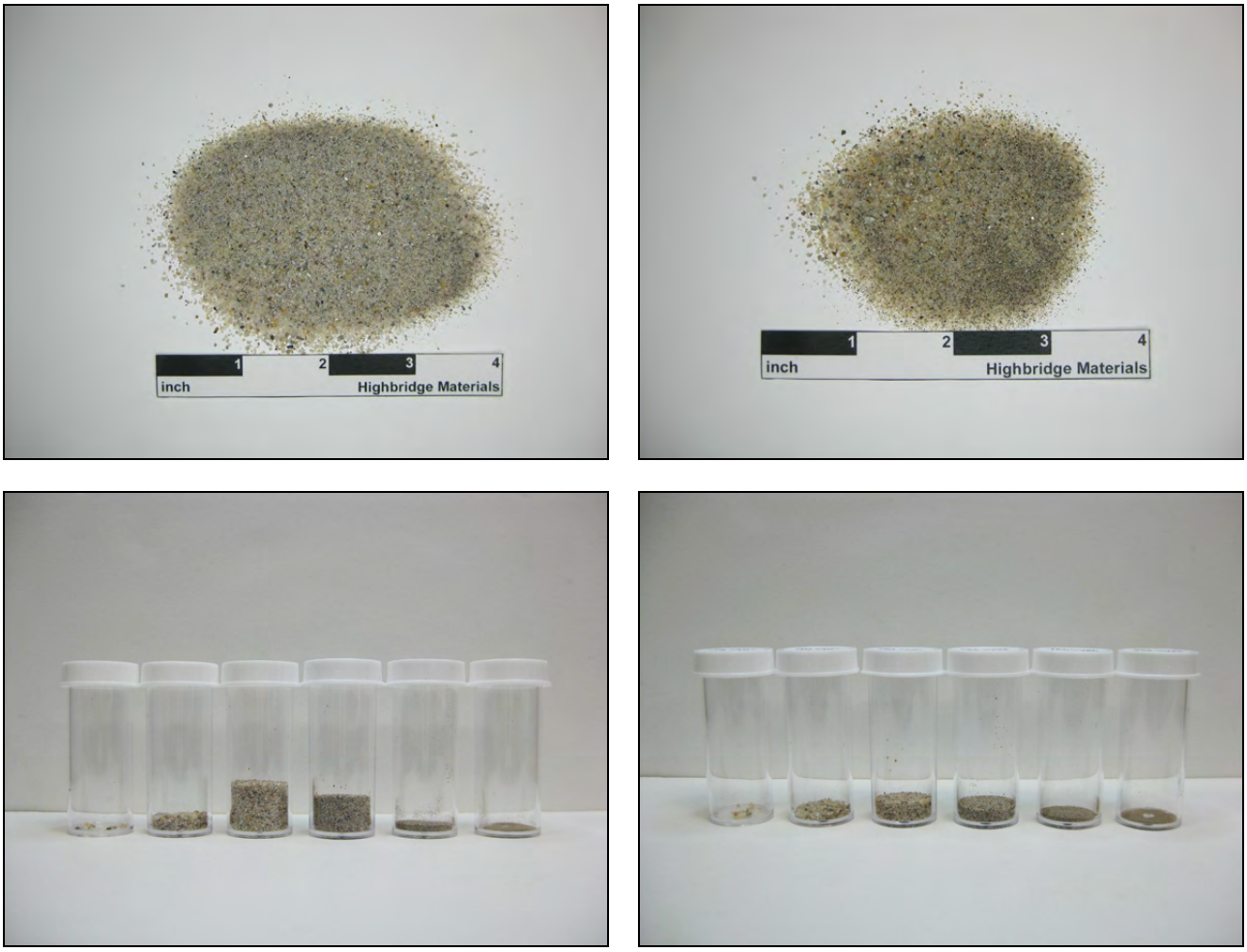


Figure 2: Photographs of the aggregate extracted through acid digestion. The scratch coat sands ate shown at left and the brown coat sands at right. The total extraction is shown in the upper images. The aggregates are light buff in color though the sand in the brown coat is slightly richer in appearance. The lower images display the aggregates after gradation through a standard sieve stack. Both are fine-grained and have nearly identical particle size distributions.

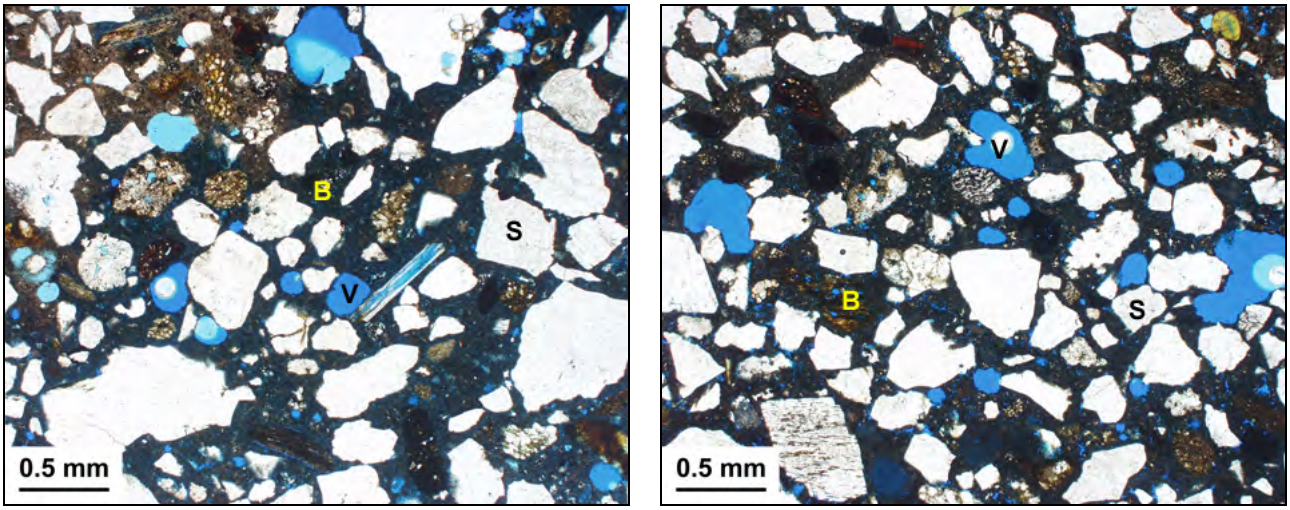


Figure 3: PPL photomicrographs illustrating the overall microtexture of the plaster. The scratch coat is shown at left and the brown coat at right. The sample is impregnated with a blue-dyed epoxy to highlight cracks, pores, and voids. The absorption of the dyed epoxy into the binder matrix (B) indicates a moderate microporosity. The paste quality in both layers is consistent with stiff but sufficient workable fresh mixtures. The sand (S) is sharp-textured and uniformly distributed throughout each coat. Air-voids are minimal (V) and the layers are well-consolidated.

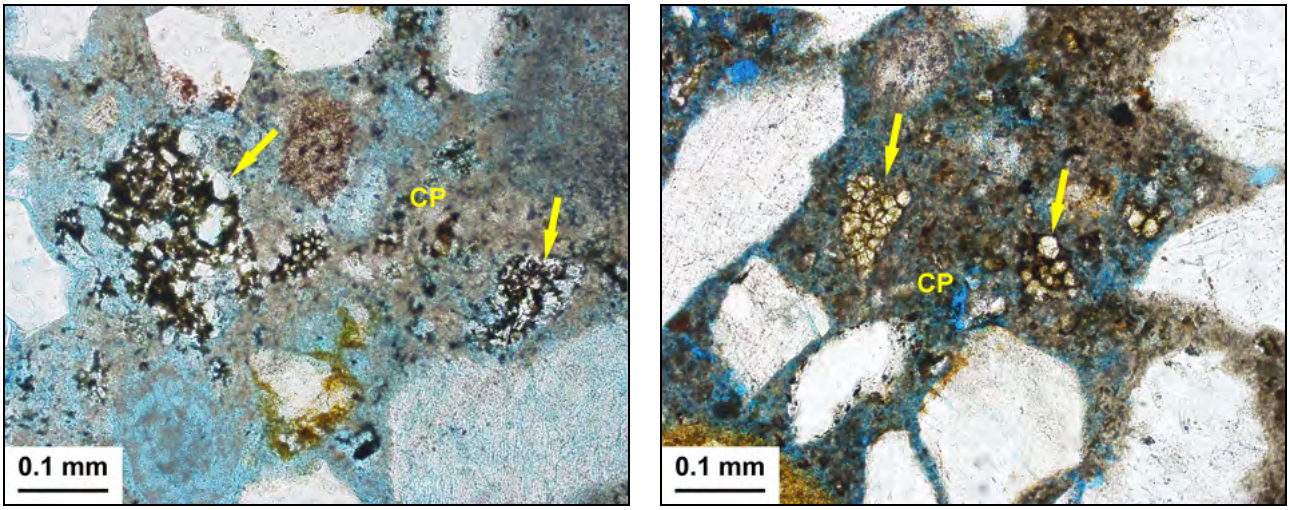


Figure 4: PPL photomicrographs illustrating the portland cement component and its hydration. The scratch coat is shown at left and the brown coat at right. The arrows indicate residual agglomerates of gray portland cement. The coarseness is unusual for the ca. 1941 construction date. The calcium silicates have been consumed in the scratch coat but remain partially unhydrated in the brown coat. Nevertheless, the adjacent cementitious paste is well formed in both layers (CP).

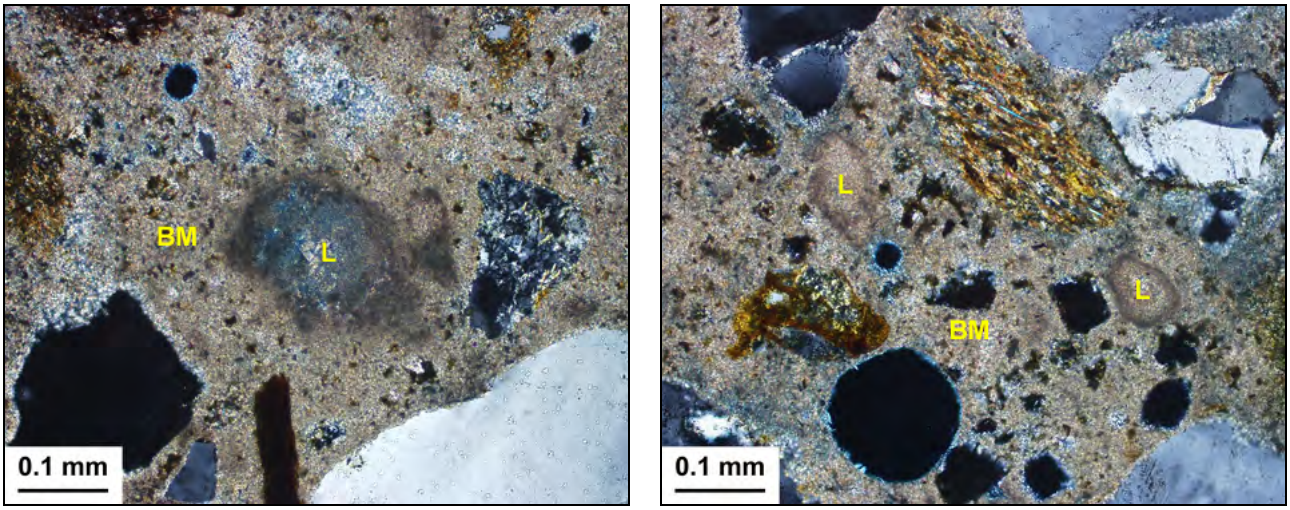


Figure 5: XPL photomicrographs illustrating the lime component in both plaster layers. The scratch coat is shown at left and the brown coat at right. Undispersed lime grains are fine and internally nondescript. The golden color under crossed polars indicates that most of the lime is uncarbonated. Note that the surrounding binder matrix is similarly carbonated (BM). The grayish colors within the lime grain shown for the scratch coat indicates an uncarbonated interior characteristic of the more slowly reactive dolomitic limes.

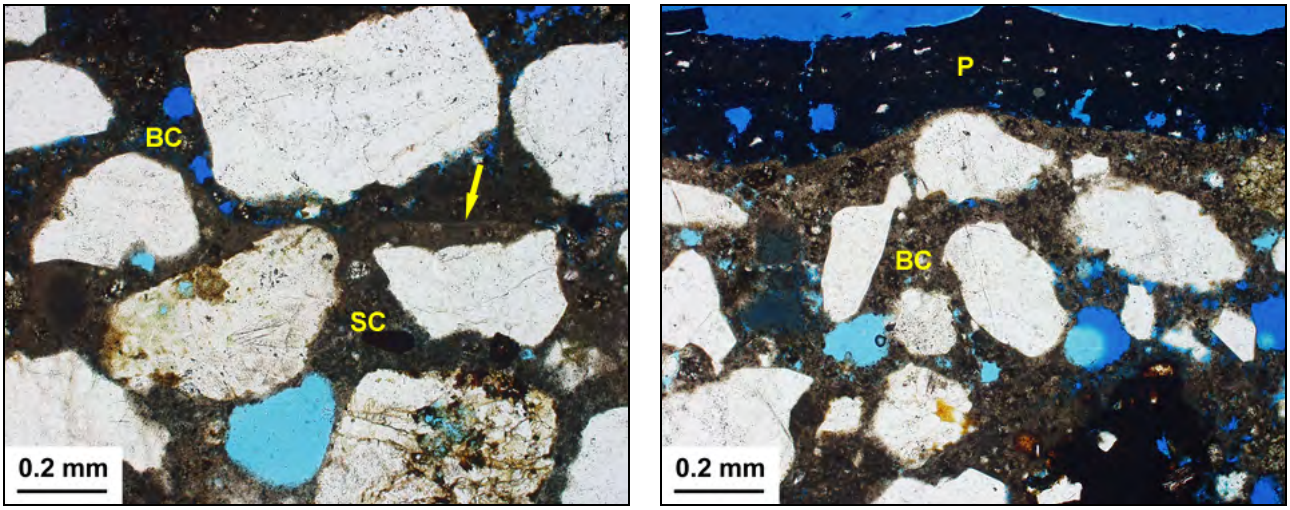


Figure 6: PPL photomicrographs. (Left) The contact (arrow) is shown between the scratch coat (SC) and brown coat (BC). The contact surface is tight and there is no significant voidage at the surface. (Right) The outer surface of the plaster is shown with the paint (P) over the brown coat (BC). Note that there is no obvious weathering along the original surface.

Mortar Analysis Report - Pump House

Chesapeake & Ohio Canal National Historical Park
Washington, D.C. and Maryland

Prepared for
Building Conservation Associates, Inc.

Client ID
BUIL005

Report No.
SL1581-02

Report Date
11/22/20

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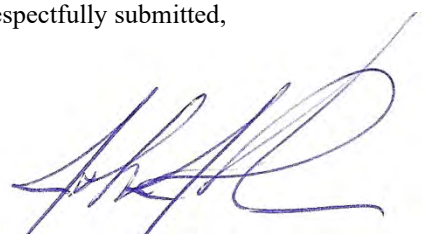
Cover Image

Photograph of the pump house at the C&O Canal National Historical Park. Photo courtesy of Mr. Kevin Wohlgemuth of Building Conservation Associates.

Respectfully submitted,



John J. Walsh
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1. Executive Summary

This report presents the results of a compositional and condition analysis of a mortar sample recovered from the exterior brick masonry of a pump house constructed ca. 1941 and located at the C&O Canal National Historical Park outside Washington, D.C.

The material is identified as a cement-lime mixture with a medium-grained and well-graded natural sand. The cement is a gray variety and the lime was almost certainly added as a prepackaged dry hydrate. The lime may have been a high-calcium variety. Though not accurately quantified, the mortar is clearly no more lime-rich than one with a 1 : 0.25 cement to lime ratio by volume. The binder to sand ratio is estimated at approximately 1 : 2.5.

The cured product is hard, glassy, and not noticeably water permeable. The material was well mixed and consolidated. The mortar is uniform in appearance with a light gray color (Munsell code approximately 2.5Y 6.25/1). Carbonation has extended only several millimeters inward from the joint face due to the dense character of the matrix. No deleterious service effects are observed in the provided sample pieces.

2. Introduction

On October 21, 2020, Highbridge received five mortar and plaster samples from Mr. Kevin Wohlgemuth of Building Conservation Associates reported to have been sampled from various structures at the C&O Canal National Historical Park outside of Washington, D.C. All materials are believed by Mr. Wohlgemuth to be original to the ca. 1941 construction. The sample information provided by the client is presented in Table 2.1 below.

Table 2.1: Sample Identifications

Sample ID	Description
CHOH #01	Boiler house, interior, mortar from concrete block wall
CHOH #02	Pump house, exterior, mortar from brick masonry
CHOH #03	Comfort station, interior, cement plaster from metal lath wall
CHOH #04	Engineer's garage, interior, mortar from concrete block and brick foundation
CHOH #05	Pivot bridge, exterior, mortar from stone rubble foundation

At the client's request, a compositional analysis is performed on each of the mortar and plaster samples. The testing includes a petrographic examination and chemical analysis to identify constituents, estimate proportions, and assess overall condition. Acid digestions to extract sand samples for description and gradation are also included in the testing scope. This report presents the results for the pump house mortar (Sample CHOH #02). Results for the other samples are presented under separate cover.

3. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within ASTM C1324-20. Data collection is performed or supervised by a degreed geologist who by nature of their education is qualified to operate the analytical equipment employed. Analysis and interpretation is performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 4 of ASTM C856/C856M-20.

Chemical analysis is performed in general accordance with the procedures outlined in ASTM C1324-20. Water, carbon dioxide, and aggregate weight percentages are determined gravimetrically. Oxide weight percentages are determined by inductively coupled plasma - optical emission spectroscopy (ICP-OES). While ASTM classifies C1324 as a test method, it is intended to serve as a guideline for qualified practitioners with ample experience in the various materials under consideration. Section 10.2 indicates the need for discretion on the part of the laboratory to ensure that methods are tailored to specific mortar compositions. As such, Highbridge chooses specific digestion methods, supplementary tests, instrumentation protocols, and mathematical models to best characterize each individual mortar under consideration. Many of these are proprietary methods that have been researched internally.

The following personnel contributed to the examination:

Technician:	J. Bertoldi
Analyst:	M. Ricotta
Chemist:	H. Hartshorn
Petrographer:	J. Walsh

4. Petrographic Findings and Discussion

4.1 - Materials

The aggregate is a medium-grained natural sand consisting primarily of quartz. Ironstone grains are found in moderate concentration. Minor components include sedimentary rock grains (mostly siltstone and mudstone), mica schist grains, and feldspar. Traces include chert, glauconite, and a few heavy accessory minerals. No clay coatings or friable materials are identified and the sand is considered hard, non-porous, and durable for use in masonry mortars.

The aggregate sample extracted from the mortar through acid digestion is semi-translucent to semi-opaque. The sand is mostly uniform in appearance with a light buff color (Munsell code approximately 10YR 7/1.75). The sand is sharp-textured consisting of equidimensional grains that are subangular to angular in shape. The extracted sand was passed through a standard sieve stack to evaluate the gradation profile and the results are presented in Section 5. The nominal top size is found at the No. 8 sieve, the peak abundance lies between the No. 30 and No. 50 sieves, and the fines content is minor. ASTM C144-39T was the applicable standard for masonry sands in 1941. Based on these requirements, the maximum aggregate size and the amount of material passing the No. 50 sieve would be considered appropriate for the indicated brick joint. When compared to the modern standard (ASTM C144-18), the particle size distribution falls just within the permissible gradation limits. Specifically, the 49.9% of material retained within the peak interval is just less than the 50% maximum allowable.

The binder is a mixture of portland cement and hydrated lime. The cementitious binder is well-formed with a moderate capillary porosity. Calcium hydroxide from the original cement hydration is still present and unaltered where the mortar remains uncarbonated. The hydroxide occurs as fine-grained crystal masses within the paste and as discontinuous deposits along aggregate interfaces. The morphology of the hydroxide is consistent with a fresh mortar having sufficient mix water to produce workable plastic mixture.

The portland cement hydration is thorough and advanced, and relatively little hydraulic calcium silicate remains unhydrated. The only abundant cement mineral is the iron-bearing ferrite phase. The ferrite identifies the cement as a gray variety and this is also indicated by a chemically-measured SiO_2/Fe_2O_3 ratio of 5.6. Unreacted alite and belite are only observed in any quantity where their continued hydration has been inhibited by the denser carbonated paste near the surface of the mortar joint. Still, there is a high abundance of residual cement grains throughout the sample cross section. Most of these are medium-grained agglomerates of former calcium silicate with a residual skeleton of iron-bearing ferrite. Many of the finer agglomerates are so-called Williamson grains. These are cement particles where dense cementitious hydrate has filled the space once occupied by the hydraulic cement minerals. The larger agglomerates and not usually filled in this manner.

Undispersed lime particles are observed sparsely throughout the mortar sample. The chemical analysis suggests that the lime might have been a high-calcium variety but the results are not unequivocal on this point. Petrographically, the undispersed lime is very-fined grained and texturally non-descript. Given the reported construction date, it is almost certain that the lime was added as a packaged dry hydrate. The microtexture is at least consistent with lime in this form, though not diagnostic. The lime particles are carbonated wherever the binder is carbonated on the whole. However, the lime remains uncarbonated at depth in the joint.

4.2 - Component Proportions

The qualitative properties of the mortar in hand sample are consistent with a cement-rich mortar design. The paste is hard and glassy, and the binder is not noticeably absorptive. Within the outer carbonated region, sand grains are cleanly broken through where the mortar has been freshly fractured during sampling. This is commonly observed in high strength mortars.

The petrographic observations also indicate a low-lime content. Undispersed lime particles are quite sparse. The uncarbonated binder lacks the speckled quality under crossed polars that indicates any significant dispersed lime. Petrography cannot be used to accurately assess mortar proportions. However, reasonable constraints can be made in some cases and the petrographic character of this particular mix would suggest a mortar no more lime-rich than a Type M mixture with a cement to lime ratio of 1 : 0.25. If this binder ratio is back-calculated into the measured chemistry, the binder to sand ratio is calculated at approximately 1 : 2.5 by volume. This is generally consistent with the sand spacing observed petrographically.

The qualitative estimates are necessary as the chemical analysis does not allow for a more refined estimate in this particular case. The measured CaO/SiO_2 ratio is lower than that found in a typical gray portland cement and leaves no calcium for the lime component. This silica enrichment is common in older cement-rich mortars that have not had opportunity to carbonate rapidly. The alkaline cement paste reacts with the sand grains and this releases SiO_2 into the matrix that did not originally belong to the binder. When the lime is clearly dolomitic and the lime content not too low, the laboratory has additional methods that can correct for the silica enrichment. Those methods are not available for this particular composition.

It is not within the scope of the laboratory to recommend repair mortar designs. However, some commentary is warranted based on the identified material. Generally speaking, the findings of a mortar analysis are best used to constrain possible repair designs rather than as a prescription for a specific formulation. The presence of a highly dense cement-rich mortar from the mid-twentieth century indicates that the substrate mortar is not likely to be the limiting factor in selecting an appropriate repair mixture. If one were to rely on ASTM C270 to choose a mortar appropriate for the construction type, it is unlikely that the selected mix would be appreciably harder or less permeable than the existing substrate mortar.

4.3 - Condition and Service Performance

The mortar components are estimated to have been well-blended based on the samples examined petrographically. The binders are thoroughly dispersed and there are no coarser clots. No streaking or lensing of the aggregate is detected. The mix water was well-incorporated into the fresh mixture and there is no evidence for inappropriate late retempering. The mortar was adequately consolidated and compacted. The total void content is estimated at only 3-4% by volume. The cured binder is hard, glassy, and not noticeably water permeable. The mortar itself is highly indurate and cohesive. The qualitative properties of the mortar are consistent with those of a cement-rich design prepared to a reasonably stiff but placeable consistency.

The mortar appears to be in sound condition based on the petrographic observations. No microcracking or other physical distress is detected. No erosion or other weathering effects are observed microscopically below the surface coatings. The mortar cross section exhibits typical chemical features of an older portland cement-based mixture. Carbonation of the mortar is limited to the outermost several millimeters of the joint face due to the low permeability of the cured paste. The carbonation reaction is an innocuous one. In fact, the carbonation serves to strengthen and densify the near-surface paste. The only other mineralization noted is a trace occurrence of ettringite as a thin lining along air-void surfaces at depth in the examined profile. The ettringite deposition is likely the result of minor pore water fluxes over the long service history. In this configuration, ettringite does not impact the quality or serviceability of the mortar. It should not be taken as a sign of degradation.

5. Aggregate Sieve Analysis

Aggregate analysis was performed by digesting the sample in an acid sufficient to dissolve the binder. The fines are examined petrographically to ensure that all recovered material represents sand rather than undigested binder components. In this particular sample, much of the material passing a No. 325 sieve is found to consist of hydrous silica produced by the incomplete digestion of the portland cement component. As such, the fines are not included in the calculated gradation profiles below. The exclusion of any silt or clay from the aggregate is considered a negligible error.

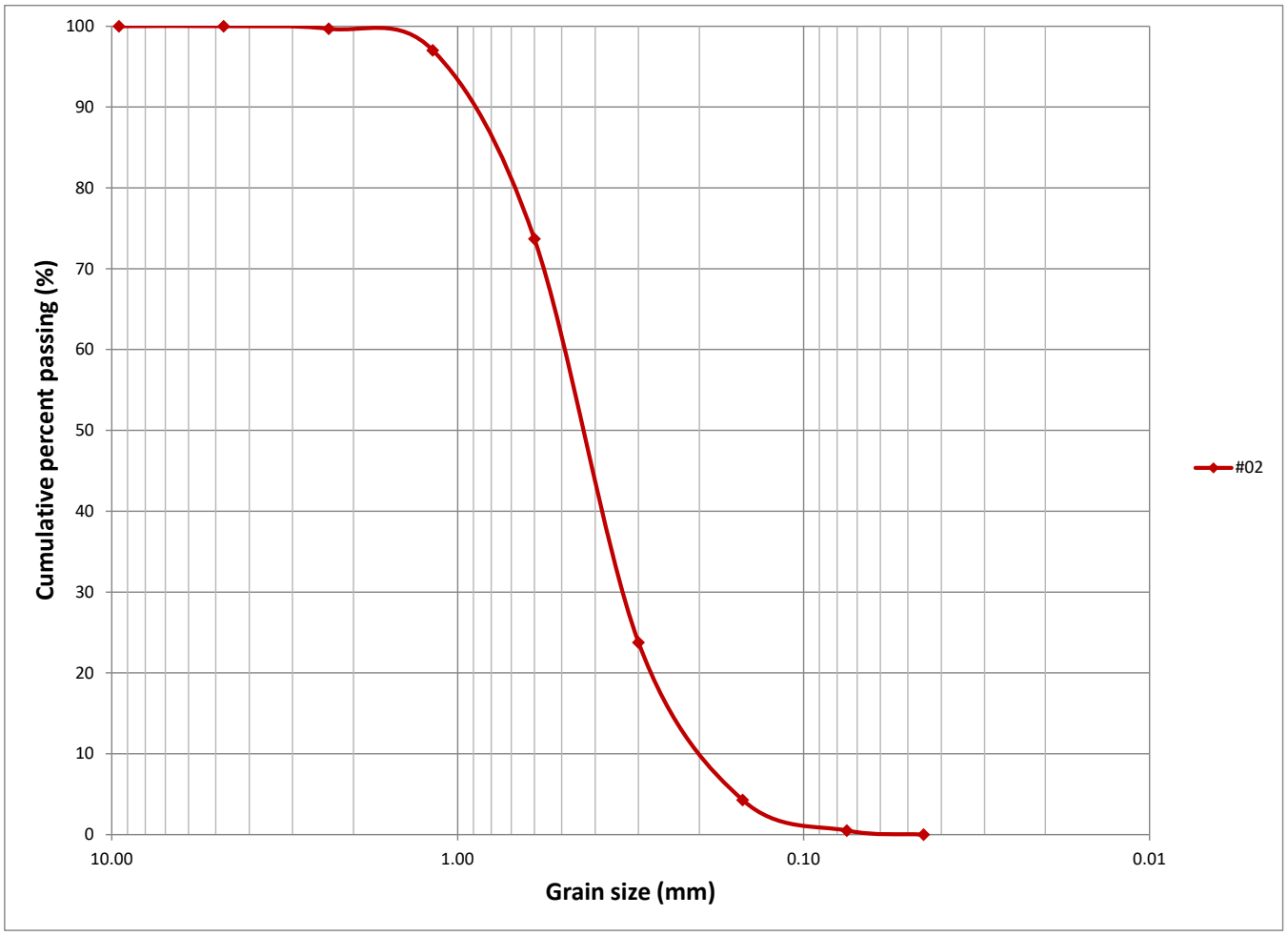
A qualitative description of the sand is given in the discussion above, and the recovered sample is returned to the client. The sample size is significantly smaller than would be required to perform a sieve analysis on fresh aggregate materials as per ASTM C136, and some small errors should be expected.

Table 5.1: Acid Digestion Data

Sieve size	Retention (g)	Cumulative passing (%)	Cumulative retained (%)
No. 4	0.00	100.0	0.0
No. 8	0.03	99.7	0.3
No. 16	0.22	97.0	3.0
No. 30	1.90	73.7	26.3
No. 50	4.06	23.8	76.2
No. 100	1.59	4.3	95.7
No. 200	0.31	0.5	99.5
Pan	0.04	0.0	100.0
Fineness modulus			**2.02**

Chart 5.1: Aggregate Sieve Analysis

The following chart presents the particle size distribution curve for the extracted sand sample. The chart plots the data from the cumulative passing values in Table 5.1.



6. Chemical Analysis

Table 6.1: Chemical Analysis Results

Sample ID	**CHOH #02**
Component (wgt. %)	
SiO_2	5.95
CaO	16.17
MgO	0.85
Al_2O_3	1.67
Fe_2O_3	1.06
Insoluble residue	59.90
LOI to 110°C	3.20
LOI 110°C-550°C	3.96
LOI 550°C-950°C	7.66
Measured totals	**100.42**

Notes:
1. The digestion procedure included a cold acid and hot base digestion as described in ASTM C1324. The insoluble residue was determined gravimetrically from the same procedure used to measure the soluble oxides.

Appendix I: Visual Description of Sample as Received

Sample ID	**CHOH #02**
Description	The sample consists of multiple small mortar pieces taken from the outside corner of a brick masonry joint. The pieces are covered with a white paint or other coating. The sample weighs a total of 50 grams.
Surfaces	The joint profile is masked by the overlying coatings. In cross section these appear relatively planar. Bed surfaces are compact, planar, and sandy-textured. The bed surfaces have some gray soiling and brick residues.
Hardness / Friability	The paste is hard and the mortar is non-friable and cohesive. The carbonated rind is quite hard and sand particles are transected along induced fracture surfaces.
Appearance	Freshly exposed surfaces have a moderately subvitreous translucent luster and are light gray in color (Munsell code approximately 2.5Y 6.25/1). The carbonated paste is a buff color (Munsell code approximately 10YR 7/2.5)
Absorptivity	The matrix is not noticeably water absorptive.
Other details	No cracks, efflorescence, mineral deposits, or binder inclusions are visible in hand sample.

Appendix II: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The stereoscopic microscope is used for simple magnification. Sample types examined under this microscope include fractured surfaces, fine constituents extracted through chemical or physical means, or honed or polished cross sections. The polarized light microscope (PLM) magnifies but also employs principals of optical crystallography. The most common sample preparation for the PLM is the petrographic thin section. For this preparation, cross-sectioned samples are mounted to glass slides and are milled to a thickness sufficient to allow light to be transmitted through the material. These are usually prepared without water and with minimal heat to avoid altering minerals that are water or temperature-sensitive. In many cases, the samples are impregnated with a low-viscosity, blue-dyed epoxy. When so treated, blue areas represent some type of void space (e.g., air-voids, capillary pores, cracks, etc.). The polarized light photomicrographs are taken using a variety of optical settings chosen to best demonstrate the feature(s) of interest. These are distinguished as follows:

Plane polarized light (abbreviated as PPL)

This method uses the refractive power of different constituents to produce an artificial sense of surface relief. Otherwise, the method is the closest to a simple magnification of the material. The setting is often used to demonstrate granular relationships or microstructure. Pore spaces and cracks are observable with this setting if the blue-dyed epoxy is used.

Conoscopic polarized light (abbreviated as CPL)

In this setting, the transmitted light is condensed just before passing through the thin section. The method tends to bring colors or finer particulates into higher contrast at the expense of image sharpness. The setting is often used to image grain boundary failures in dimension stone, pigment particulates in binders, or gel phases in the micropores of cement pastes.

Cross polarized light (abbreviated as XPL)

The setting places the thin section between two pieces of polarizing film oriented at 90° to one another. In isotropic materials (e.g., glasses, simple salts), all light is absorbed and the materials appear black. In anisotropic crystals, two light rays traveling at different speeds are produced within the thin section and these offset waves interfere at the upper polarizing film. The interference produces a color that can be used to calculate properties of the crystal structure and aid in identification of mineral species. In essence, the colors are artificial. It should be noted that color is a function of orientation and color differences do not necessarily indicate material differences.

Compensator plates

When in XPL mode, full-wave or quarter-wave compensator plates may be inserted into the light path to add or subtract interference. Technically, these methods are used to calculate properties of the crystal structure. However, they can also be used to alter the image appearance to help improve contrast between different constituents. They can also reveal preferred orientations in some materials (e.g., oriented residual crystallinity in fired ceramics).

Scale bars are included with all photomicrographs. In higher magnification images, the µm symbol represents microns. One micron is equal to 0.001 millimeter.

Figure 1: Photographs of the pump house masonry mortar sample received by Highbridge for examination. (Left) The total sample is shown. The mortar is mostly light gray in color. Joint surfaces are covered with a white coating. (Right) A close-up is shown of a freshly fractured cross section. The joint surface is oriented toward the left of the image. The depth of the section is approximately 1/2". The arrow indicates the sharp boundary between carbonated and uncarbonated paste. Sand grains are transected in the carbonated zone indicating a high strength.

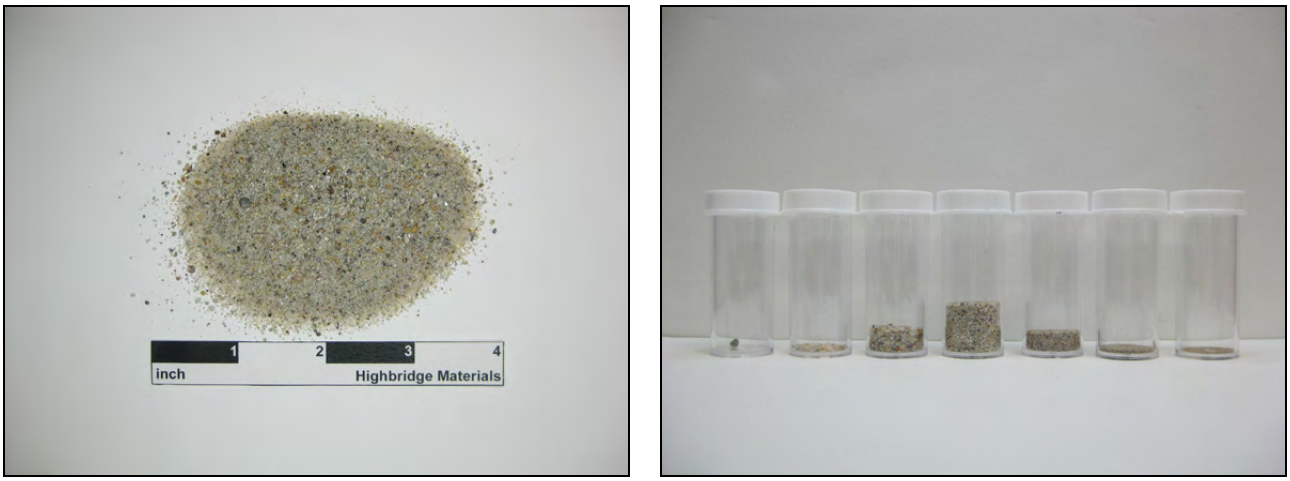


Figure 2: Photographs of the aggregate extracted through acid digestion. The total extraction is shown at left. The sand is uniform in appearance with a buff color. The sand is shown at right after gradation through a standard sieve stack. The medium-grained sand is broadly graded though about 50% of the material is found at the peak sieve interval.

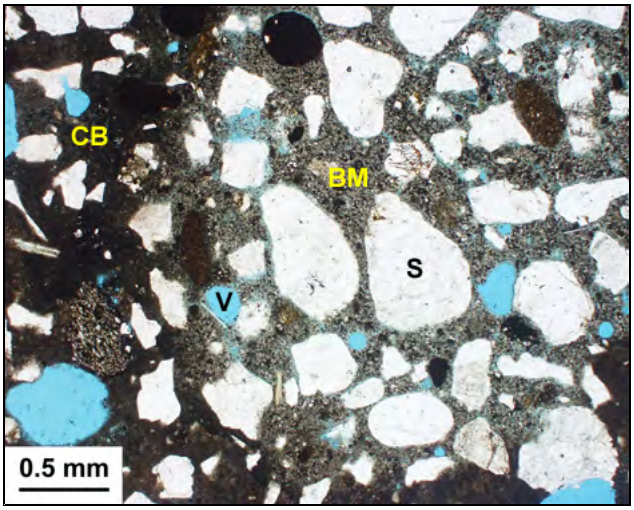


Figure 3: PPL photomicrograph illustrating the overall microtexture of the mortar. The sample is impregnated with a blue-dyed epoxy to highlight cracks, pores, and voids. The absorption of the dyed epoxy into the binder matrix (BM) indicates a moderate microporosity. Note that the carbonated binder to the left is much denser (CB). The sand (S) is sharp-textured and uniformly distributed throughout the mortar. Air-voids are minimal (V) and the mortar is well-consolidated.

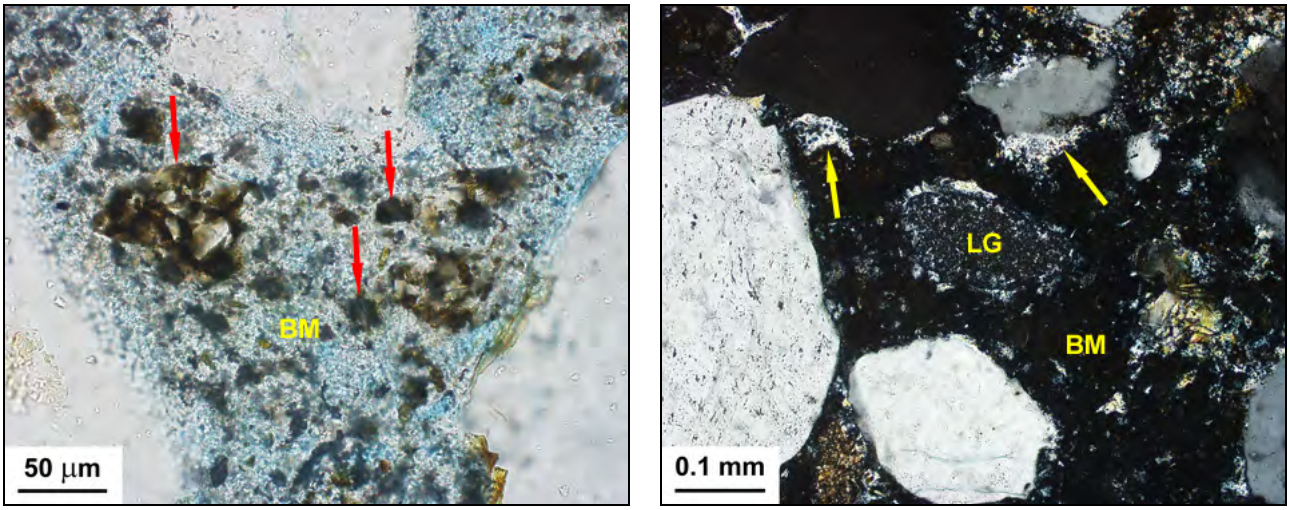


Figure 4: Photomicrographs illustrating the binder constituents. (Left PPL image) The arrows indicate fully hydrated portland cement relicts. The brown-colored ferrite within the agglomerates indicates the cement is a gray variety. The smaller grains indicated by the right arrows are Williamson grains. The space originally filled by cement minerals are now filled with a dense brown cementitious product. The grain at left is more clearly a medium-grained agglomerate of former calcium silicates. The adjacent binder matrix (BM) is well-formed. (Right XPL image) Undispersed lime grains (LG) are sparse. The speckled character of the grain shown here indicates that it has not yet carbonated. The same can be said of the adjacent binder matrix (BM). The arrows indicate calcium hydroxide crystals from the original cement hydration. There is a lack of speckling in the surrounding binder that indicates a cement-rich composition with a limited amount of lime.

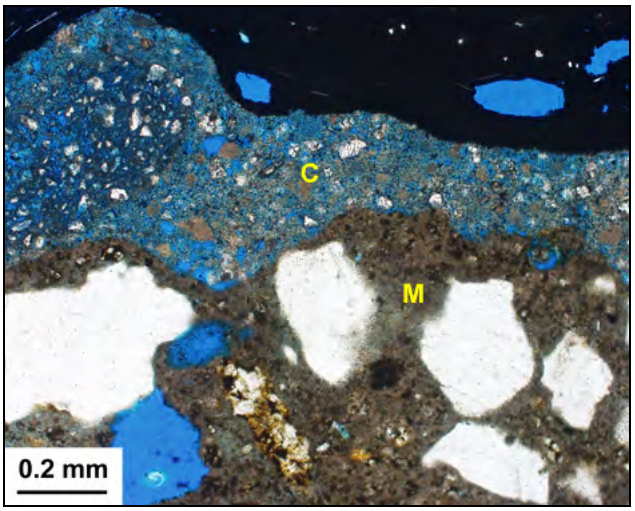


Figure 5: PPL photomicrograph. The contact is shown between the mortar (M) and surface coating (C). Note that there is no obvious weathering or erosion along the original joint face.

Mortar Analysis Report - Engineer's Garage

Chesapeake & Ohio Canal National Historical Park
Washington, D.C. and Maryland

Prepared for
Building Conservation Associates, Inc.

Client ID
BUIL005

Report No.
SL1581-04

Report Date
11/22/20

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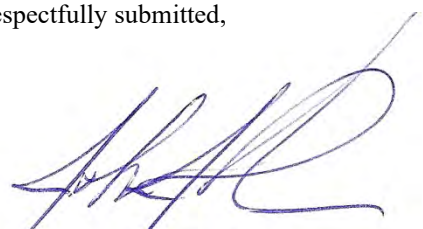
Cover Image

Photograph of the engineer's garage at the C&O Canal National Historical Park. Photo courtesy of Mr. Kevin Wohlgemuth of Building Conservation Associates.

Respectfully submitted,



John J. Walsh
President/ Senior Petrographer
Highbridge Materials Consulting, Inc.

Heather Hartshorn
Chemist/ Staff Scientist
Highbridge Materials Consulting, Inc.

1. Executive Summary

This report presents the results of a compositional and condition analysis of a mortar sample recovered from the interior brick and block masonry of an engineer's garage constructed ca. 1941 and located at the C&O Canal National Historical Park outside Washington, D.C.

The mortar provided for analysis is a uniform, product with a medium gray color (Munsell code approximately 2.5Y 5-6/1). The material is identified as a portland cement-based mortar gauged with hydrated lime. The cement is a gray portland and the lime is likely a dolomitic dry hydrate. The cement to lime ratio is estimated between 1 : 0.1 and 1 : 0.25 based on the qualities of the binder and this is supported by the chemical analysis. The aggregate is a coarse-grained and broadly graded natural sand. The binder to sand ratio is estimated at 1 : 2 by volume. The constituents were well mixed and the mortar was well consolidated and cured. Based on qualitative properties evident in hand sample, the hardened mortar has high strength, low elasticity, and low permeability. This is all consistent with the determined composition.

Carbonation of the paste is observed but this is expected of the long service history. The provided sample is sound and there is no physical or chemical degradation identified petrographically. In fact, there is an expectation of high material durability potentially at the expense of the surrounding masonry depending on the properties of these units.

2. Introduction

On October 21, 2020, Highbridge received five mortar and plaster samples from Mr. Kevin Wohlgemuth of Building Conservation Associates reported to have been sampled from various structures at the C&O Canal National Historical Park outside of Washington, D.C. All materials are believed by Mr. Wohlgemuth to be original to the ca. 1941 construction. The sample information provided by the client is presented in Table 2.1 below.

Table 2.1: Sample Identifications

Sample ID	Description
CHOH #01	Boiler house, interior, mortar from concrete block wall
CHOH #02	Pump house, exterior, mortar from brick masonry
CHOH #03	Comfort station, interior, cement plaster from metal lath wall
CHOH #04	Engineer's garage, interior, mortar from concrete block and brick foundation
CHOH #05	Pivot bridge, exterior, mortar from stone rubble foundation

At the client's request, a compositional analysis is performed on each of the mortar and plaster samples. The testing includes a petrographic examination and chemical analysis to identify constituents, estimate proportions, and assess overall condition. Acid digestions to extract sand samples for description and gradation are also included in the testing scope. This report presents the results for the engineer's garage mortar (Sample CHOH #04). Results for the other samples are presented under separate cover.

3. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within ASTM C1324-20. Data collection is performed or supervised by a degreed geologist who by nature of their education is qualified to operate the analytical equipment employed. Analysis and interpretation is performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 4 of ASTM C856/C856M-20.

Chemical analysis is performed in general accordance with the procedures outlined in ASTM C1324-20. Water, carbon dioxide, and aggregate weight percentages are determined gravimetrically. Oxide weight percentages are determined by inductively coupled plasma - optical emission spectroscopy (ICP-OES). While ASTM classifies C1324 as a test method, it is intended to serve as a guideline for qualified practitioners with ample experience in the various materials under consideration. Section 10.2 indicates the need for discretion on the part of the laboratory to ensure that methods are tailored to specific mortar compositions. As such, Highbridge chooses specific digestion methods, supplementary tests, instrumentation protocols, and mathematical models to best characterize each individual mortar under consideration. Many of these are proprietary methods that have been researched internally.

The following personnel contributed to the examination:

Technician:	J. Bertoldi
Analyst:	M. Ricotta
Chemist:	H. Hartshorn
Petrographer:	J. Walsh

4. Petrographic Findings and Discussion

4.1 - Materials

The aggregate is a coarse-grained natural sand consisting primarily of quartz. Ironstone grains are found in moderate concentration. These are sometimes sandy or silty. Minor components include sedimentary rock grains (mostly graywacke siltstone and mudstone), mica schist grains, chert, and feldspar. Traces include glauconite, epidote, and rutile. No clay coatings or friable materials are identified and the sand is considered hard, non-porous, and durable for use in cementitious mortars.

An aggregate sample was extracted from the mortar through acid digestion. The sand is semi-translucent to semi-opaque and moderately variegated in appearance. The overall color is buff (Munsell code approximately 10YR 7/1.75) though a variety of orange, gray, and white tones are present in many of the coarser particles. These would likely impart some textural and tonal variegation on a weathered joint surface if any are present in the masonry. The sand is moderately sharp-textured. Though grain shapes vary, the aggregate is subangular in shape on average. Particles are mostly equidimensional in aspect.

The extracted sand was passed through a standard sieve stack to evaluate the gradation profile and the results are presented in Section 5. The aggregate is coarse-grained and quite broadly graded. The nominal top size is found at the No. 4 sieve though most grains pass this mesh. The peak abundance lies between the No. 30 and No. 50 sieves. The fines content is minor. ASTM C144-39T was the applicable standard for masonry sands in 1941. This earlier standard emphasized the ends of the gradation curve for given joint types. Based on these requirements, the particle size distribution for this particular sand would be considered appropriate for mortar joints of 1/2" or thicker. However, with over 10% retained above the No. 8 sieve, the gradation profile would not comply with the modern version of this standard (ASTM C144-18).

The binder consists of portland cement gauged with hydrated lime. The design is cement-rich and this has resulted in a dense cementitious hydrate that has a moderately low capillary porosity on average. Still, the water content was sufficient to produce a workable mixture. As a result, the cured binder is uniform and not grainy.

Residual portland cement grains are observed in moderately high concentration throughout the examined sample. Some areas contain cement residuals for which almost all calcium silicate has been consumed in hydration reactions. Other areas contain an abundance of unhydrated particles within an otherwise dense and well-formed paste. In either case, most residual cement grains are medium-grained agglomerates of calcium silicate with a skeleton of interstitial iron-bearing ferrite. Where hydration is less advanced, single alite grains with thin hydration rims are also identified. The agglomerates are found in sizes that would be approaching and retained on the No. 200 sieve. The cement is identified as a gray variety based on the abundance of iron-bearing ferrite and a chemically-measured SiO_2/Fe_2O_3 ratio of 5.3.

Undispersed lime particles are observed in moderate concentration. Given the relatively low lime content indicated for the mortar, the quantity of visible lime particles suggests that there is unlikely to be much submicroscopic lime distributed more thoroughly throughout the cementitious paste. The lime grains have a particulate texture and are mostly less than 0.1 millimeters in diameter. The microtexture is consistent with lime added as a prepackaged dry hydrate. The lime is nondescript and no impurities are evident petrographically. Much of the lime is carbonated though a moderate proportion of particles contain some amount of uncarbonated lime with the center of the grain. The amount of uncarbonated material suggests that the lime was dolomitic. The more magnesian limes are slower to carbonate than high-calcium varieties. It is usually possible to confirm this through the chemical analysis. However, the low lime content in conjunction with chemical changes that have occurred to the mortar in service make it difficult to distinguish the source of any measured magnesium. It is possible for all measured magnesium to have derived from the cement alone.

4.2 - Component Proportions

The mortar is cement-rich and has a cement to lime proportion estimated between 1 : 0.1 and 1 : 0.25 by volume. The total binder to sand ratio is approximately 1 : 2. The cement to lime estimate is largely based on the petrographic character of the binder and the qualitative properties of the mortar in hand sample. The chemical composition is consistent with this range. However, there are interferences caused by minor reactions in the sand that preclude a more accurate estimate of the binder ratios. The calculation of binder to sand ratio is based on the chemical analysis (Section 6) and this result is found to be robust throughout the estimated range of binder compositions. The spacing of sand particles observed petrographically is consistent with this estimate.

In Highbridge Report SL1581-02, another cement-rich mortar was described from the pump house brick masonry. In that report, some commentary was offered regarding possible repair considerations. Of course, it is not within the scope of the laboratory to provide specific guidance. Nonetheless, the identification of an exceptionally hard and dense mortar likely offers the specifier a great deal of latitude in selecting a repair material. It would be difficult to design a mortar that would be considered appropriate for the construction and environmental exposure that would be substantially harder, less elastic, and less permeable than the existing substrate mortar. Implicit in this discussion is the assumption that replicating a mortar with this composition would not be appropriate for any type of brick or block masonry.

4.3 - Condition and Service Performance

Based on the sample pieces examined petrographically, the mortar constituents are estimated to have been well-blended. No sand streaks or coarse binder lumps are detected. As discussed earlier, it is suspected that the lime is mostly in the form of fine particulates usually less than 0.1 millimeters in diameter. There is likely not much more dispersal of the plasticizer. Nevertheless, the particulates are evenly distributed throughout the mortar. The mix water was also well incorporated into the mixture. There is no evidence for inappropriate late retempering. The mortar was prepared to a sufficient plasticity and was adequately consolidated in the joint. There are some irregular microvoids that indicate very local instances of incomplete consolidation but these are exceptionally minor. Most other voids are fine and subspherical in shape, and the total air content is estimated at approximately 3-4% by volume.

In hand sample, the binder paste is quite hard and glassy. The permeability of the paste is also quite low. When the mortar is intentionally fractured, the fracture surfaces cut cleanly through sand particles rather than deflect around the grains. This indicates a high bond strength between aggregate and paste, and this in turn indicates a high mortar strength typical of highly cement-rich compositions.

The examined mortar is in sound condition. No physical cracking or other mechanical distress is identified petrographically. No potentially deleterious mineralizations are detected and there is no chemical degradation of the binder. The only observed chemical effect of service is the carbonation of the binder. Calcium hydroxide from the original cement hydration is consumed in carbonation reactions in all parts of the mortar examined petrographically. In some areas, the precipitation of submicroscopic carbonate is thorough. In other areas, the deposition is present but less complete. The occurrence of variable carbonation likely has some relationship to the environmental exposure of the mortar. However, the orientation and context of the provided mortar pieces are not known by the author.

There is an expectation of high material durability due to the high cement content of the mortar. Deleterious service effects expected of this type of composition include those related to excessive stiffness and impermeability. It is more likely to observe damage to the surrounding masonry when substrate mortars are as strong, stiff, and dense as the one identified here. An assessment of the masonry condition is not part of this study.

5. Aggregate Sieve Analysis

Aggregate analysis was performed by digesting the sample in an acid sufficient to dissolve the binder. The fines are examined petrographically to ensure that all recovered material represents sand rather than undigested binder components. In this particular sample, much of the material passing a No. 325 sieve is found to consist of hydrous silica produced by the incomplete digestion of the portland cement component. As such, the fines are not included in the calculated gradation profiles below. The exclusion of any silt or clay from the aggregate is considered a negligible error.

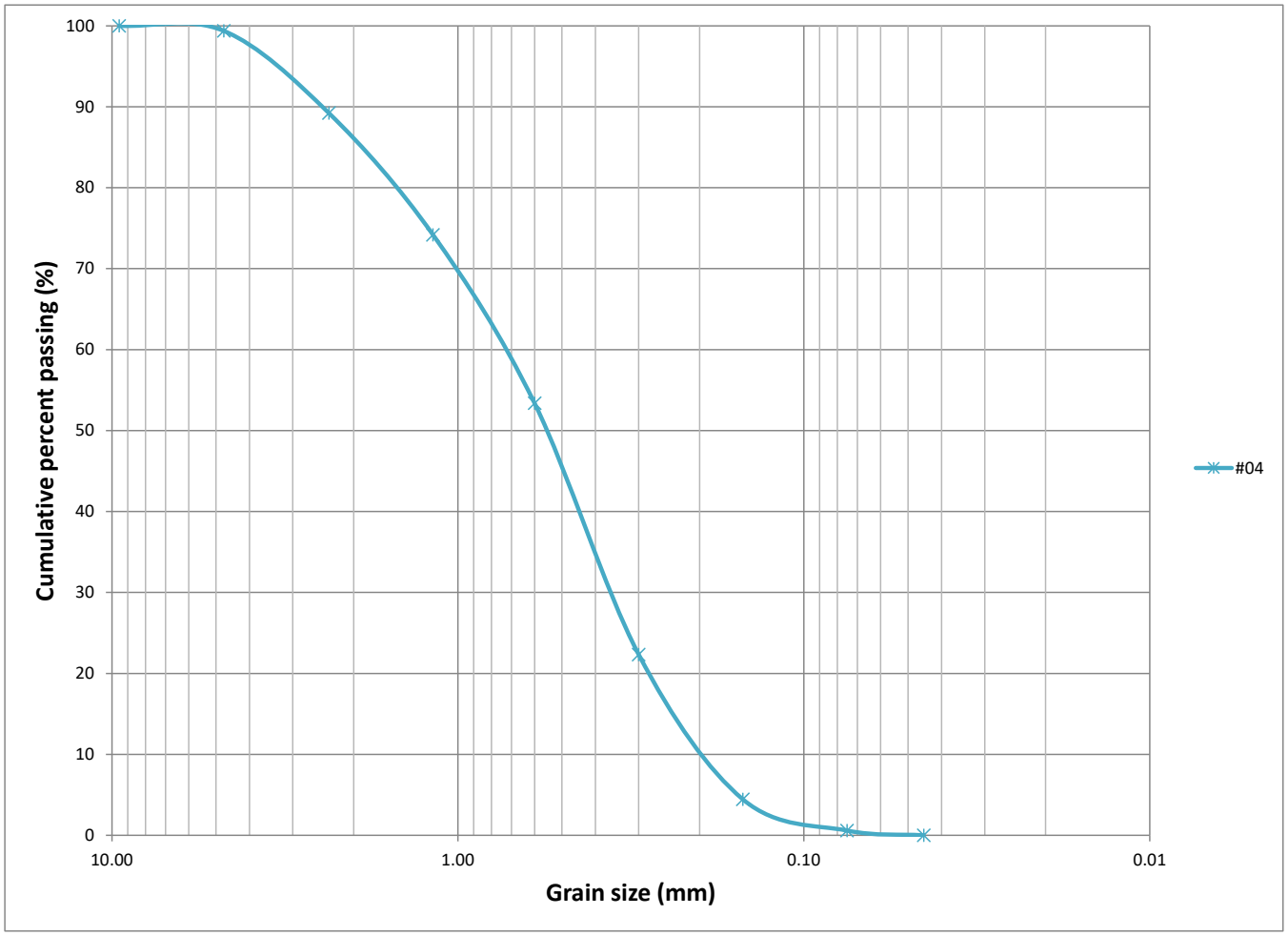
A qualitative description of the sand is given in the discussion above, and the recovered sample is returned to the client. The sample size is significantly smaller than would be required to perform a sieve analysis on fresh aggregate materials as per ASTM C136, and some small errors should be expected.

Table 5.1: Acid Digestion Data

Sieve size	Retention (g)	Cumulative passing (%)	Cumulative retained (%)
3/8”	0.00	100.0	0.0
No. 4	0.10	99.4	0.6
No. 8	1.53	89.2	10.8
No. 16	2.26	74.2	25.8
No. 30	3.13	53.4	46.6
No. 50	4.66	22.3	77.7
No. 100	2.69	4.4	95.6
No. 200	0.58	0.6	99.4
Pan	0.09	0.0	100.0
Fineness modulus			**2.57**

Chart 5.1: Aggregate Sieve Analysis

The following chart presents the particle size distribution curve for the extracted sand sample. The chart plots the data from the cumulative passing values in Table 5.1.



6. Chemical Analysis

Table 6.1: Chemical Analysis Results

Sample ID	**CHOH #04**
Component (wgt. %)	
SiO_2	6.62
CaO	19.12
MgO	1.00
Al_2O_3	1.80
Fe_2O_3	1.24
Insoluble residue	54.96
LOI to 110°C	2.26
LOI 110°C-550°C	3.83
LOI 550°C-950°C	8.81
Measured totals	**99.64**

Notes:
1. The digestion procedure included a cold acid and hot base digestion as described in ASTM C1324. The insoluble residue was determined gravimetrically from the same procedure used to measure the soluble oxides.

Appendix I: Visual Description of Sample as Received

Sample ID	**CHOH #04**
Description	The sample consists of multiple small to medium bedding mortar fragments weighing a total of 139 grams.
Surfaces	No tooled surfaces are obvious in hand sample. Bed surfaces are irregular in shape but compact. The texture is paste-rich but not creamy-textured.
Hardness / Friability	The paste is very hard and glassy. The mortar is nonfriable and highly indurate.
Appearance	Freshly exposed surfaces have a subvitreous translucent luster and are gray in color (Munsell code approximately 2.5Y 5-6/1).
Absorptivity	The matrix is not noticeably water absorptive.
Other details	No cracks, efflorescence, or mineral deposits are identified in hand sample. A low abundance of white binder inclusions are observed between 1 and 2 millimeters diameter. There are trace brownish-gray binder inclusions approximately 2 millimeters in diameter.

Appendix II: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The stereoscopic microscope is used for simple magnification. Sample types examined under this microscope include fractured surfaces, fine constituents extracted through chemical or physical means, or honed or polished cross sections. The polarized light microscope (PLM) magnifies but also employs principals of optical crystallography. The most common sample preparation for the PLM is the petrographic thin section. For this preparation, cross-sectioned samples are mounted to glass slides and are milled to a thickness sufficient to allow light to be transmitted through the material. These are usually prepared without water and with minimal heat to avoid altering minerals that are water or temperature-sensitive. In many cases, the samples are impregnated with a low-viscosity, blue-dyed epoxy. When so treated, blue areas represent some type of void space (e.g., air-voids, capillary pores, cracks, etc.). The polarized light photomicrographs are taken using a variety of optical settings chosen to best demonstrate the feature(s) of interest. These are distinguished as follows:

Plane polarized light (abbreviated as PPL)

This method uses the refractive power of different constituents to produce an artificial sense of surface relief. Otherwise, the method is the closest to a simple magnification of the material. The setting is often used to demonstrate granular relationships or microstructure. Pore spaces and cracks are observable with this setting if the blue-dyed epoxy is used.

Conoscopic polarized light (abbreviated as CPL)

In this setting, the transmitted light is condensed just before passing through the thin section. The method tends to bring colors or finer particulates into higher contrast at the expense of image sharpness. The setting is often used to image grain boundary failures in dimension stone, pigment particulates in binders, or gel phases in the micropores of cement pastes.

Cross polarized light (abbreviated as XPL)

The setting places the thin section between two pieces of polarizing film oriented at 90° to one another. In isotropic materials (e.g., glasses, simple salts), all light is absorbed and the materials appear black. In anisotropic crystals, two light rays traveling at different speeds are produced within the thin section and these offset waves interfere at the upper polarizing film. The interference produces a color that can be used to calculate properties of the crystal structure and aid in identification of mineral species. In essence, the colors are artificial. It should be noted that color is a function of orientation and color differences do not necessarily indicate material differences.

Compensator plates

When in XPL mode, full-wave or quarter-wave compensator plates may be inserted into the light path to add or subtract interference. Technically, these methods are used to calculate properties of the crystal structure. However, they can also be used to alter the image appearance to help improve contrast between different constituents. They can also reveal preferred orientations in some materials (e.g., oriented residual crystallinity in fired ceramics).

Scale bars are included with all photomicrographs. In higher magnification images, the µm symbol represents microns. One micron is equal to 0.001 millimeter.

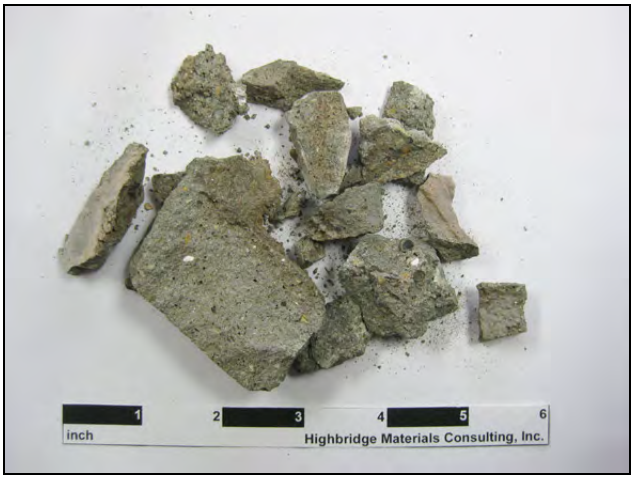


Figure 1: Photograph of the engineer's garage masonry mortar sample received by Highbridge for examination. The mortar is medium gray in color.

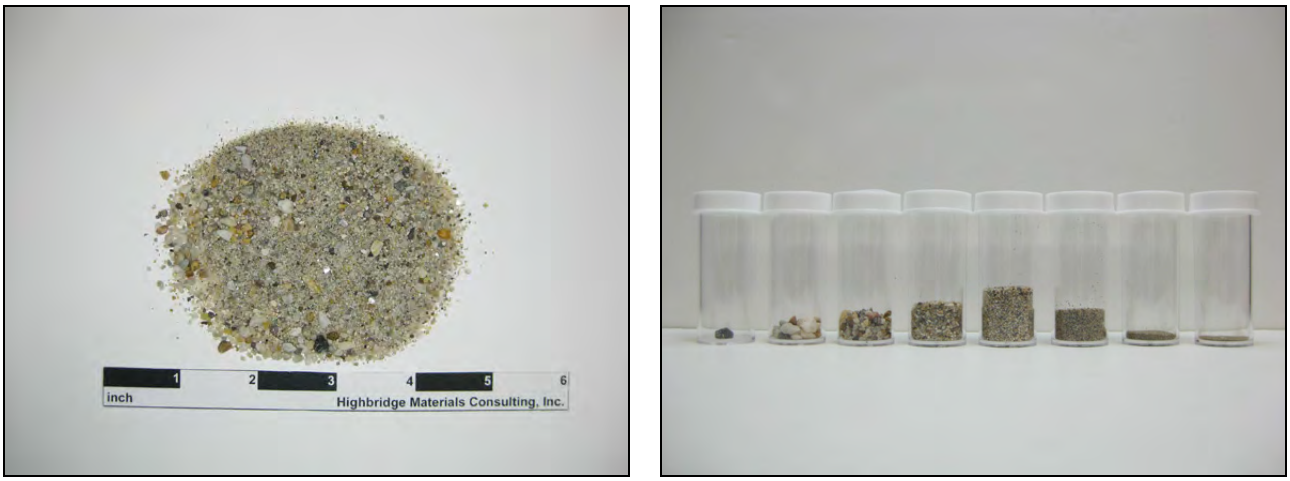


Figure 2: Photographs of the aggregate extracted through acid digestion. The total extraction is shown at left. The sand is moderately variegated in appearance with a buff color overall. The sand is shown at right after gradation through a standard sieve stack. The coarse-grained sand is quite broadly graded.

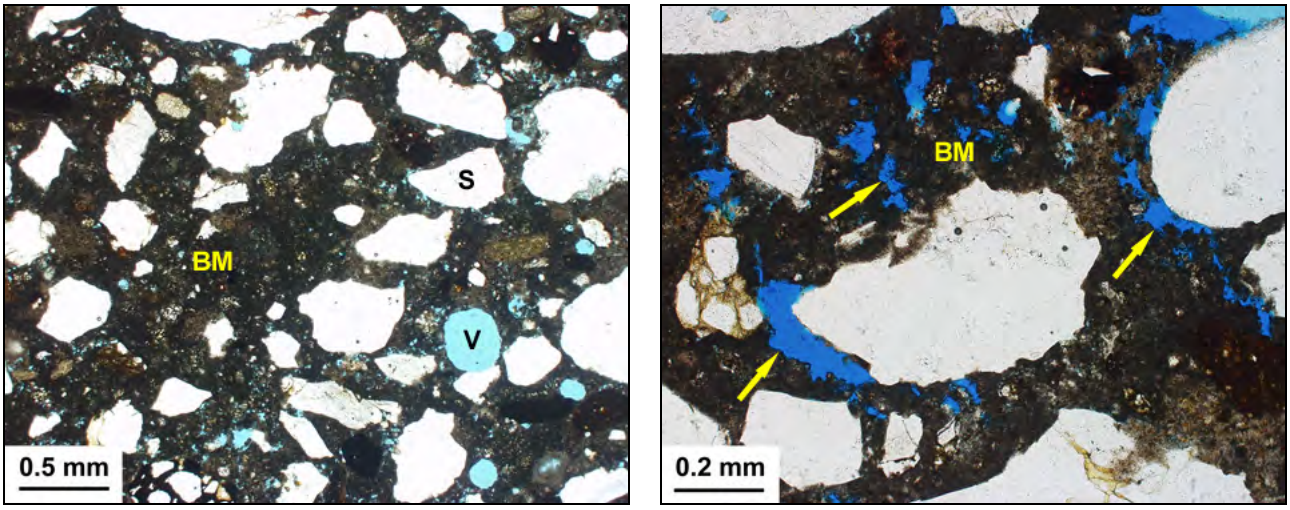


Figure 3: PPL photomicrographs illustrating the overall microtexture of the mortar. The sample is impregnated with a blue-dyed epoxy to highlight cracks, pores, and voids. The absorption of the dyed epoxy into the binder matrix (BM) indicates a low microporosity. This is consistent with the high portland cement content. The mortar is impermeable as a result. In the lower magnification image at left, sand grains are evenly distributed throughout the mixture but are not closely-spaced. This is consistent with the 1 : 2 binder to sand ratio calculated chemically. Air-voids are minimal (V) and the mortar is well-consolidated. Microscopic consolidation voids are very minor and examples are indicated by the arrows in the higher magnification image at right.

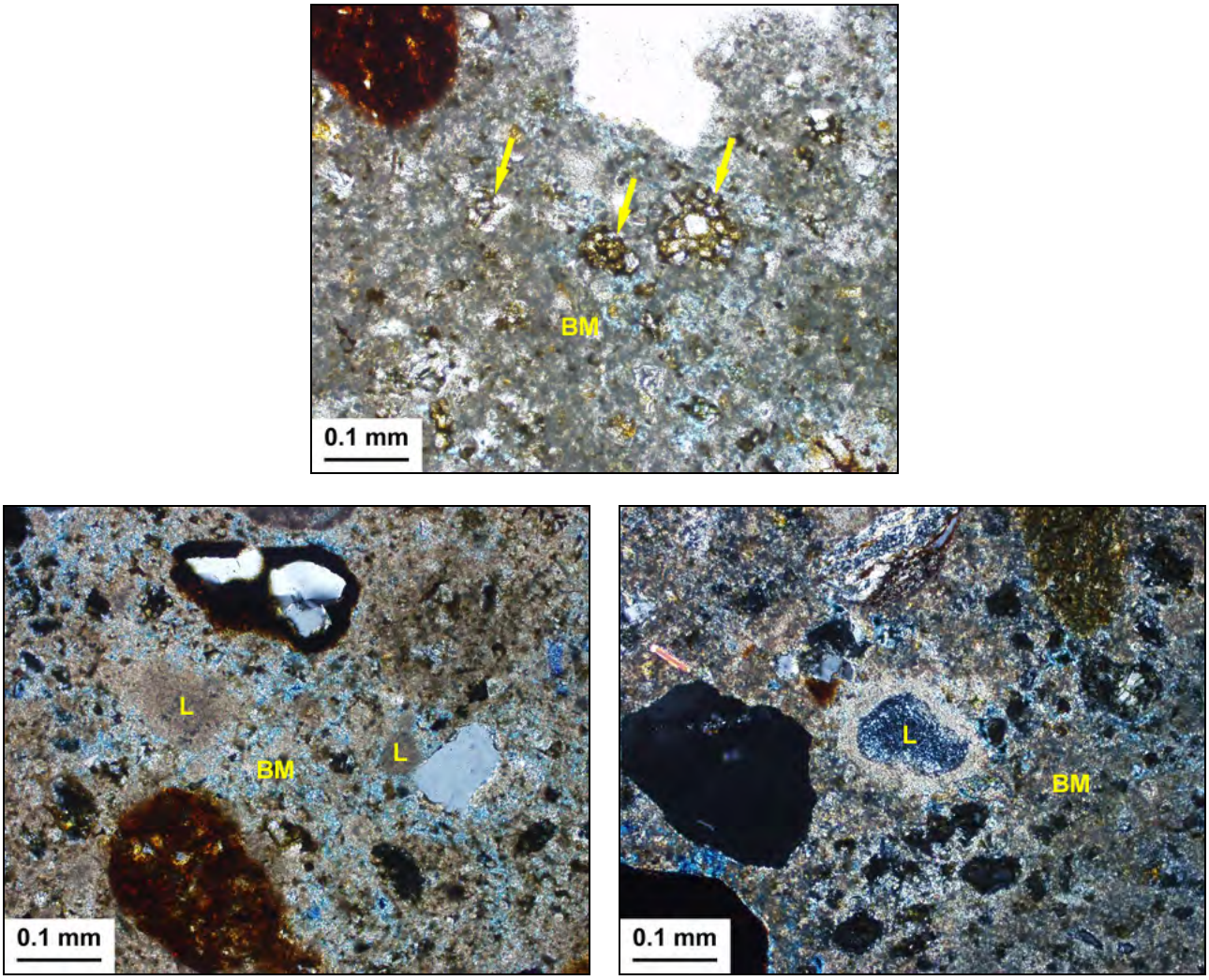


Figure 4: Photomicrographs illustrating the binder constituents. (Upper PPL image) The arrows indicate residual portland cement grains. The ones shown here remain unhydrated. This is not unusual to observe in mortars of high cement content. The surrounding binder matrix (BM) is well-formed despite an abundance of unhydrated cement. (Lower XPL images) Lime grains (L) are moderately abundant as fine particulates. In the lower left image, the golden color of the lime particles indicates that they are fully carbonated. The adjacent binder matrix is similarly colored and is also densely carbonated (BM). In the lower right image, the lime grain has a gray interior indicating that it remains uncarbonated. The adjacent matrix contains some carbonate deposition but not as much as the paste shown in the lower left image.

Materials Analysis - Summary Report

Chesapeake & Ohio Canal National Historical Park
Washington, D.C. and Maryland

Prepared for
Building Conservation Associates, Inc.

Client ID
BUIL005

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11/22/20

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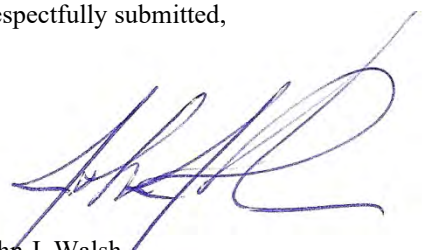
Cover Image

Photograph of the pump house at the C&O Canal National Historical Park. Photo courtesy of Mr. Kevin Wohlgemuth of Building Conservation Associates.

Respectfully submitted,



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1. Introduction

On October 21, 2020, Highbridge received five mortar and plaster samples from Mr. Kevin Wohlgemuth of Building Conservation Associates reported to have been sampled from various structures at the C&O Canal National Historical Park outside of Washington, D.C. All materials are believed by Mr. Wohlgemuth to be original to the ca. 1941 construction. The sample information provided by the client is presented in Table 2.1 below.

Table 1.1: Sample Identifications

Sample ID	Description
CHOH #01	Boiler house, interior, mortar from concrete block wall
CHOH #02	Pump house, exterior, mortar from brick masonry
CHOH #03	Comfort station, interior, cement plaster from metal lath wall
CHOH #04	Engineer's garage, interior, mortar from concrete block and brick foundation
CHOH #05	Pivot bridge, exterior, mortar from stone rubble foundation

At the client's request, a compositional analysis is performed on each of the mortar and plaster samples. The testing includes a petrographic examination and chemical analysis to identify constituents, estimate proportions, and assess overall condition. Acid digestions to extract sand samples for description and gradation are also included in the testing scope. This report summarizes all findings. The detailed analyses may be found individually in Highbridge Reports SL1581-01 through SL1581-05.

The following personnel contributed to the examination:

Technician:	J. Bertoldi
Analyst:	M. Ricotta
Chemist:	H. Hartshorn
Petrographer:	J. Walsh

2. Summary of Findings

All mortars examined for this report are portland cement-based mixtures. With the exception of Sample CHOH #01, the mortars are cement-lime mixes with gray portland cement and what is interpreted to be a dry lime hydrate. In some cases, the latter is shown to be dolomitic in composition. Sample CHOH #01 is a masonry cement mortar containing gray portland cement, a dolomitic plasticizer, and an air-entraining admixture. The plasticizer is suspected of being a byproduct or waste product of lime manufacture.

All five mixes contain a quartzose natural sand. Mineralogical compositions are essentially the same between all samples indicating a local source. Sand colors are typically light gray to buff. There is a mild variegation in shades orange, gray, and white wherever there are particles coarser than a No. 8 sieve. The gradation profiles differ between the five samples. Table 2.2 presents the quantified gradation profiles for all samples. These are shown graphically in Chart 2.1.

Component proportions of the original mortars are estimated from the chemical analysis with some contribution from visual and petrographic observations (Table 2.1). The estimates of cement to lime ratio are more approximate for Samples CHOH #02 and CHOH #04. However, the properties of the mortars are fairly clear from the laboratory observations.

Table 2.1: Estimated Component Proportions

Sample ID	Binder type	Cement to lime ratio	Binder to sand ratio
CHOH #01	Masonry cement	Type S	1 : 3.6
CHOH #02	Cement - lime	~ 1 : 0.25	1 : 2.5
CHOH #03 - scratch coat	Cement - lime	1 : 0.38	1 : 2.5
CHOH #03 - brown coats	Cement - lime	1 : 0.28	1 : 2.5
CHOH #04	Cement - lime	1 : 0.1 to 1 : 0.25	1 : 2.0
CHOH #05	Cement - lime	1 : 0.17	1 : 2.1

Specific comments regarding individual samples are as follows:

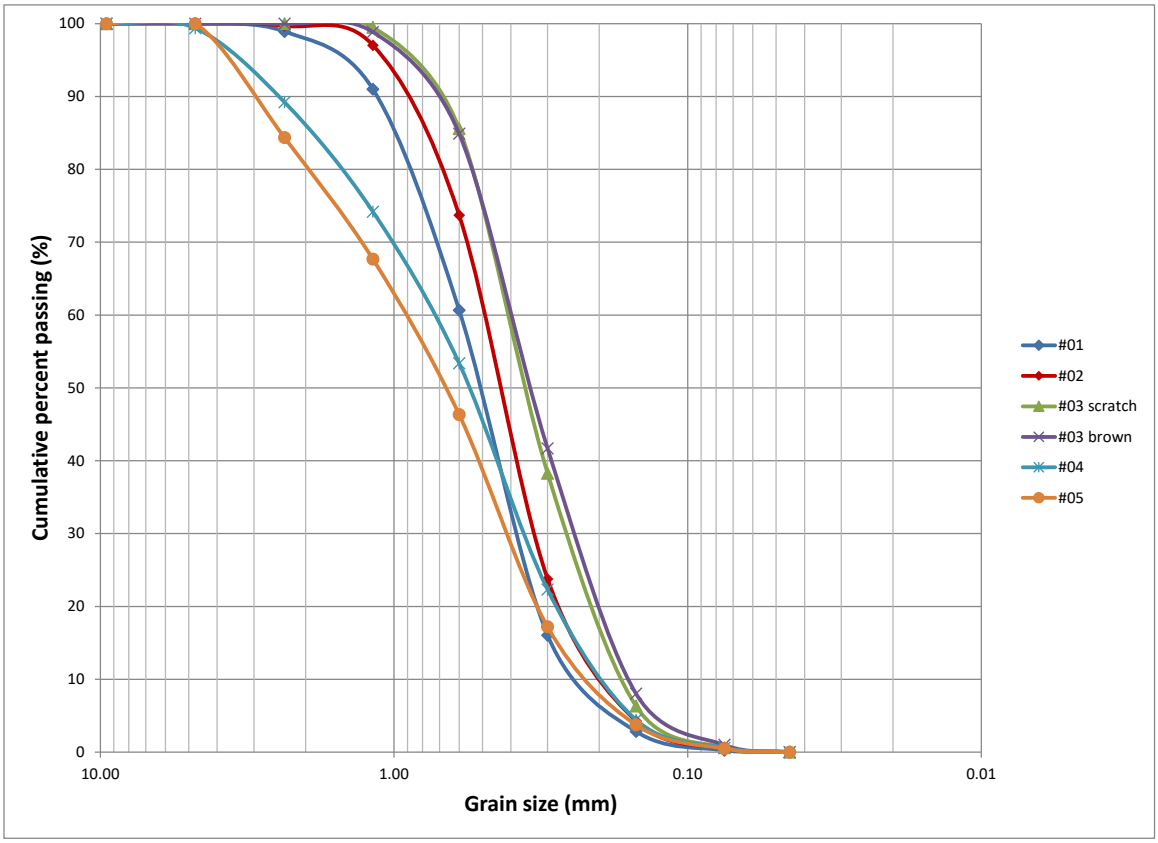
- Sample CHOH #01 is the only mortar that exhibits a modest permeability. While the composition is consistent with a modern Type S blend, the qualitative properties in hand sample are closer to that of a Type O.
- Sample CHOH #03 is a two-coat cement plaster with no finish coat applied over expanded metal lath. Proportions are consistent with a Type C plaster. This is considered appropriate for non-absorptive substrates or over expanded metal lath.
- Samples CHOH #02, #04, and #05 are all highly cement-rich mixtures that are hard, glassy, and non-absorptive. Lime contents are estimated at no more than 0.25 per unit volume of portland cement.
- Most of the material provided for analysis is in sound condition with secondary service effects limited to normal carbonation of the binder. The exception is Sample CHOH #05 where there has been a significant bicarbonation reaction. Decalcification of the binder has resulted from the reaction, and portions of the matrix have been made porous and weak.

Table 2.2: Sand Gradation Profiles- Cumulative Percent Passing

Sieve size	Sample ID					
	CHOH #01	CHOH #02	CHOH #03 scratch coat	CHOH #03 brown coat	CHOH #04	CHOH #05
3/8"	100.00	100.00	100.00	100.00	100.0	100.00
No. 4	100.0	100.0	100.0	100.0	99.4	100.0
No. 8	98.9	99.7	100.0	100.0	89.2	84.3
No. 16	91.0	97.0	99.5	98.8	74.2	67.7
No. 30	60.7	73.7	85.6	84.9	53.4	46.3
No. 50	16.0	23.8	38.3	41.7	22.3	17.2
No. 100	2.8	4.3	6.3	8.0	4.4	3.8
No. 200	0.3	0.5	0.6	1.0	0.6	0.5
Pan	0.0	0.0	0.0	0.0	0.0	0.0
Fineness modulus	**2.31**	**2.02**	**1.70**	**1.67**	**2.57**	**2.81**

Chart 2.1: Aggregate Sieve Analysis

The following chart presents the particle size distribution curves for the extracted sand samples. The chart plots the data from the cumulative passing values in Table 2.2.



Appendix I: Photographs

Figure 1: Photographs of the five samples delivered to Highbridge for analysis. The samples were recovered from various structures at the C&O Canal Historical National Park. All were built ca. 1941.