Dry Tortugas National Park

Dry Tortugas Light Station

Keeper's Residence

# Historic Structure Report

Prepared for

Dry Tortugas National Park

Southeast Region, National Park Service

by

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**2009**

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Historic Structure Report
Dry Tortugas Light Station Keeper's Residence
Dry Tortugas National Park

LCS#: 091388 (Dry Tortugas Keeper's Residence)

Cover Image: Early twentieth century image of Dry Tortugas Keeper's Residence.

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# Dry Tortugas Light Station
# Keeper's Residence Historic Structure Report
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# Management Summary

The Dry Tortugas Keeper's Residence was constructed in 1922-23 to provide much-needed residential living space for the principal lighthouse keeper and his family during a period of modernizing the Light Station.

The Keeper's Residence was one of several structures built to accommodate the light keepers, their families and the equipment and supplies necessary to maintain the Lighthouse and support habitation in this remote location.

The Keeper's Residence housed keepers and USCG personnel from its initial construction through the mid-1980s when the Lighthouse optic was automated, eliminating the need for continual occupation of the site. The decision to automate the lamp was made after the rotating mechanism of the existing second-order lens was damaged during repairs to the Lantern.

In 1992, legislation was passed to abolish Fort Jefferson National Monument (designated by Franklin Delano Roosevelt in 1935) and establish Dry Tortugas National Park (DRTO).

As part of the Park's enabling legislation, Loggerhead Key, along with the resources of the Light Station (with the exception of the Lighthouse) were transferred from the United States Coast Guard to the National Park Service (NPS). As part of the 2007 Cooperative Agreement, the NPS was required to reserve a room within the Keeper's Residence for the exclusive use of USCG personnel when at the Station. Under the Park Service's management, public visitation to the Key has been limited. However, a relatively constant presence has been maintained at the site through the NPS's Volunteer-In-Parks (VIP) program and various research initiatives. The former Kitchen building has generally been used to house volunteers while researchers and contractors have been accommodated within the Keeper's Residence.

In October 2008, Lord, Aeck & Sargent was contracted by the National Park Service to prepare a Historic Structure Report (HSR) for the resources of the Dry Tortugas Light Station.



Figure 1: Early 1920s view of Keeper's Residence taken during the final stages of construction.

It was decided that three documents would be prepared, the first would address the Lighthouse and Oil House, the second, the Keeper's Residence and the last document would address the remaining resources of the Light Station. This document addresses the Dry Tortugas Keeper's Residence.

During the first week of March 2009, a two member team from Lord, Aeck & Sargent (Rob Yallop and Glen Bennett) traveled to Loggerhead Key to undertake a physical inspection of the Light Station resources. In addition, Ms. Dorothy Krotzer of Building Conservation Associates also traveled to the site to collect mortar and paint samples for analysis (The results of this analysis are provided in Appendix A). Personnel from Lord, Aeck & Sargent spent a week on the island documenting the resources and collecting information to support preparation of the HSRs. A second brief visit was made to the site in June 2009 to collect some remaining information.

Field notes, measurements, material sampling and photographs were collected for all of the structures as a means to record the existing conditions. With the exception of the mortar and paint sampling, no destructive testing was performed and no historic fabric was removed to facilitate the collection of information. All portions of the Keeper's Residence were inspected during the review of existing conditions.

Historic research included two trips to the National Archives and Records Administration in Washington D.C. and one visit to the Southeast Region National Archives in Morrow, Georgia to review documents, drawings and photographs held primarily in Record Group 26. The files held in the archives of Everglades National Park were also reviewed and a visit was made to the USCG offices in Miami to review records pertaining to their management of the site. Numerous other secondary sources were consulted in preparation of the HSR.

The Park's General Management Plan has addressed treatment and use of the Light Station through the establishment of a Historic Preservation/Adaptive Use Management Zone in the center of Loggerhead Key. Without being specific, this management zone prescribes that the resource of the Light Station will be primarily reserved for interpretive and educational opportunities. The structures will also be adaptively used to accommodate critical functions such as housing for volunteers, staff and research personnel and the storage of utility components and equipment.

The Keeper's Residence has undergone a series of modifications over time. During the 1950s while under the management of the USCG, the floor plan was altered and the plumbing system was updated. A fire detection system was added in the early 1970's and the floor plan was altered again circa 1982. Major repairs took place in the mid-to-late 1980's, including additional floor plan changes, building rewiring and installation of new fixtures and outlets, replacement of the fascia, soffit and gutters and installation of new flooring. Also at this time, gypsum board was hung over the existing plaster walls and ceilings, and new baseboards were installed.

Additional changes to the Keeper's Residence have occurred since the National Park Service assumed management of the Light Station in 1992. The installation of centralized air conditioning, high efficiency appliances, and attic insulation occurred in 2002.
The windows were replaced with Pella architectural series thermopane windows in 2004. Although dates of installation are not known, other recent changes to the building include the installation of composition asphalt shingle roofing and metal hurricane shutters at each of the windows.

While many of these changes have resulted over time due to the deterioration and damage caused by the marine environment and intense storms that frequent this region, other changes have been implemented as building systems technology has advanced and residential living styles have changed.

Although the Keeper's Residence has undergone these changes, it has retained a substantial amount of its historic integrity and continues to express its historic residential character. The residence retains its one-story rectangular plan with Craftsman-style detailing and hipped roof form with overhanging eave.

The engaged front and side porches with tapered wood columns on brick piers with coral

cement detailing are intact with all wood elements painted white.

The residence retains its wood roof and floor framing systems and load-bearing brick masonry wall structure of buff yellow brick with contrasting red bricks alternating courses at building corners and diamond-shaped patterning.

Though the original doors and windows have been removed, the original configuration of exterior openings has been retained, and the most recent replacement windows closely replicate the appearance of the historic windows.

Despite the fact that non-historic materials have been installed at the interior ceilings, walls and floors, a portion of the historic plaster wall finish and wood crown molding remains visible above the gypsum board walls.

The desire of the National Park Service to provide greater use of the Keeper's Residence for continued residential purposes best suits the preservation of the building.

The existing condition of the Keeper's Residence does not present major obstacles to greater use, however there are several issues that should be addressed in order to correct deteriorating conditions and ensure preservation of the building.

These include replacing damaged roof shingles, installing gutters and downspouts, repairing damaged screening at eave, replacing deteriorated window lintels and repointing adjacent damaged mortar joints, sealing joints between the front stairs and cheek walls, repointing critical areas of mortar loss and masonry joint cracking in the front porch piers, repairing damaged porch flooring, conducting regulated materials analysis to quantify presence of asbestos and lead paint, and repairing plaster cracks at interior wall surfaces.

In addition, it is recommended that the building's exterior character be restored to its 1920s appearance to facilitate interpretation of the Light Station to this important period of modernization. Exterior character-defining features to be restored include replacing exterior doors to match character of historic doors and sidelights and installing wood shutters to match character of historic louvered wood shutters. It is also recommended that the building's interior be rehabilitated to provide the necessary elements and systems to accommodate its use as housing for visitors to the island.

## Summary of Recommendations

The following is a summary of the treatments recommended to preserve and rehabilitate the Dry Tortugas Keeper's Residence and to prepare it for continued use. The recommendations have been organized into three "Work Packages" in response to limits on the amount of cyclical maintenance funding that can be requested by Park in a given year. Further information about the Work Packages and a Cost Estimate are included in Appendix E.

### General

- Restore exterior of Keeper's Residence to its 1920s appearance.
- Rehabilitate interior for continued use.

### Work Package 1 – Priority Treatments including Masonry Repairs

- Replace deteriorated lintels and conduct masonry repointing and repair of the associated exterior masonry.
- Remove/replace corroded metal elements embedded within porch piers and conduct masonry repointing and stone repairs.
- Remove hurricane shutter brackets and repair damage to masonry and sills.
- Relocate tracks and install new hurricane shutter brackets with corrosion-resistant fasteners.
- Repair and repoint exterior masonry walls.
- Repair and repoint foundation walls.
- Repoint stairs and separation at cheek wall.

- Clean masonry.
- Install smoke detection system and extinguishers.
- Relocate passive solar water heater.
- Relocate propane tanks and enclosure from in front of crawl space access.

### Work Package 2 – Exterior Carpentry and Roofing Repairs

#### Roof

- Repair/replace damaged roofing shingles.
- Repair/replace damaged drip edge and soffit screening at eave. Repaint.
- Install gutters and downspouts.
- When replacing roofing in future, consider installing roofing material that matches the hexagonal pattern of original roofing.
- Protect attic vent from moisture infiltration.

#### Porches

- Repair/replace damaged porch flooring.
- Install hatch cover at side porch attic access.
- Restore porch balusters to match historic condition.
- Restore rear porch.
- Repaint porch ceiling, eave and floors

### Doors and Windows

- Replace non-historic doors with new doors matching character of historic doors.
- Replace plywood in front door surround with sidelights matching historic condition.
- Fabricate and install new wood louvered shutters matching those shown in historic images of the building.

### Work Package 3 – Interior Rehabilitation

#### Interior

- Repair cracking in plaster walls.
- Patch holes in gypsum board wall and ceiling finishes.
- Repair interior moldings.
- Repaint interior areas of deteriorated paint finishes.
- Remove carpeting and restore wood floor.
- If the existing vinyl floor tile are damaged or deteriorate to the point of replacement, it would be appropriate to remove the tile and restore the historic wood flooring.
- If the existing gypsum board ceiling finish is damaged or deteriorates to the point of replacement, it would be appropriate to remove the drywall to expose the historic wood ceilings.
- Develop an “alternative minimum” approach to accessibility.

#### Building Systems

- Better educate users of the Station’s housing facilities about the limits of the electrical system and energy saving measures that will help mediate demand during peak usage periods and reduce strain on the system.
- Repair/rewire faulty electrical outlets.
- Maintain in place existing light fixtures.
- Install new light fixtures at porch ceilings.

# Administrative Data

## Resource Names and Numbers

*Building Name:* Dry Tortugas Keeper's Residence
*Structure No.:* HS-24
*List of Classified Structures (LCS) No.:* 091388

## Resource Location

The Dry Tortugas Keeper's Residence is located on Loggerhead Key within Dry Tortugas National Park. Located 65 miles west of Key West Florida, Dry Tortugas National Park encompasses an area of approximately 100 square miles containing seven, small, sand and coral keys (islands) and the surrounding shoals and water. Loggerhead Key and Garden Key are the only inhabited keys within the Park. The Park's central cultural feature, Fort Jefferson, is located on Garden Key, approximately 2 ½ nautical miles east of Loggerhead Key. Access to the Park is by boat or seaplane. The visiting public generally travels to the Park on commercial ferries operated out of Key West. The primary public docking facilities and debarkation points are on Garden Key.

Loggerhead Key is the largest key in the Park measuring approximately 1 mile long and 700 yards across and containing approximately 35 acres. The Keeper's Residence is among several historically significant buildings at the Dry Tortugas Light Station. The Light Station complex is located in the approximate geographic center of Loggerhead Key.

*Location:*: Loggerhead Key, Dry Tortugas National Park
*Coordinates:* Latitude 24° 38' 00.021" N, Longitude 82° 55' 13.958" W
*County:* Monroe
*State:* Florida

## Cultural Resource Data

In 1984, a draft National Register nomination was prepared for the Dry Tortugas Light Station by National Park Service staff as part of a submission to the USCG, Department of Transportation. No further action was taken by the USCG regarding the nomination. The National Park Service subsequently conducted a review of the nomination in 1989 anticipating a potential transfer of the Light Station from the USCG. Based on this review, the nomination was updated in 1993 and submitted to the Acting Chief Historian of the National Park Service's Washington Support Office for a second review in 1995. No further action was taken with regard to the draft nomination.

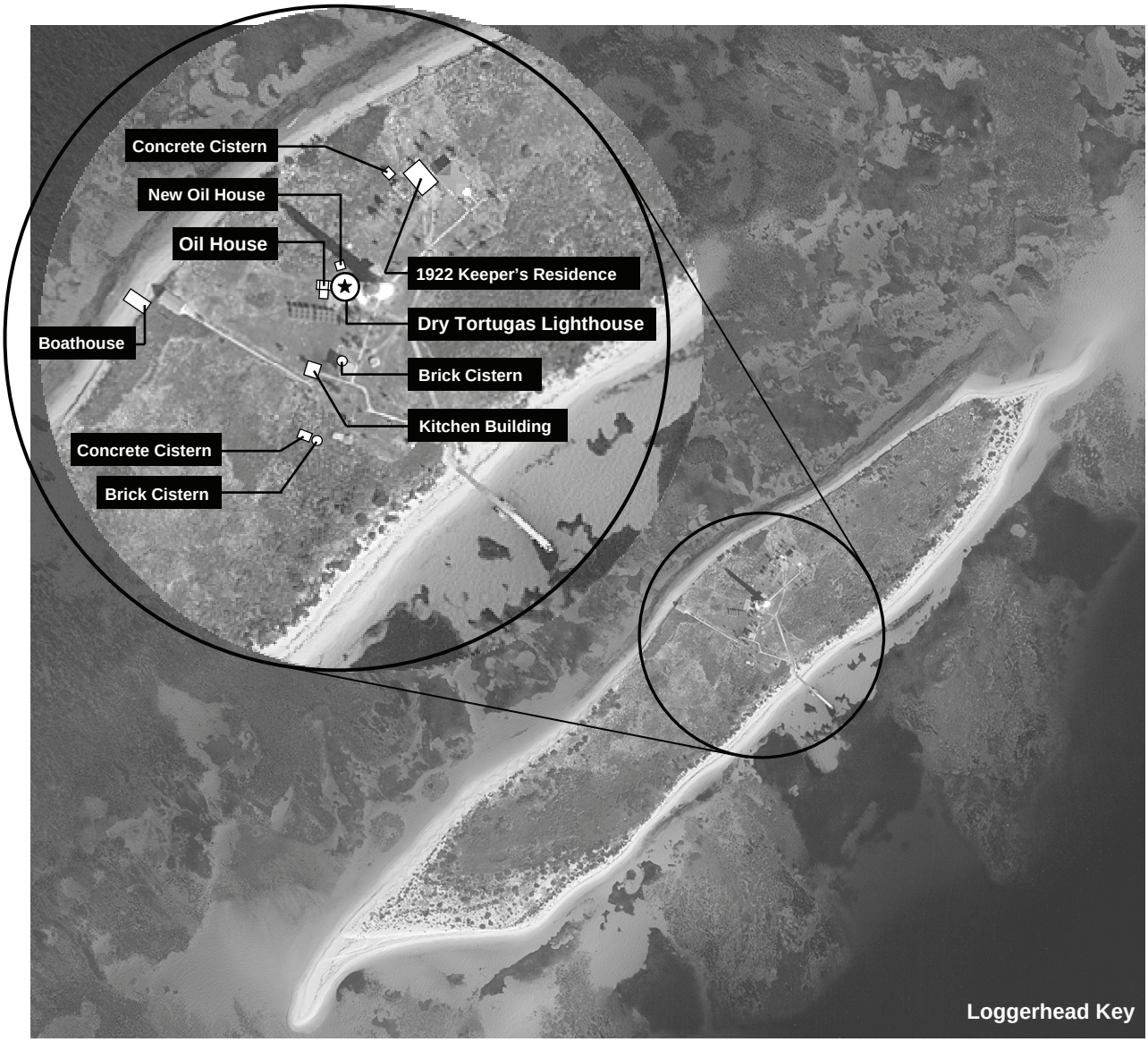
Dry Tortugas National Park was established in 1992 by Public Law 102-525 to "preserve and protect for the education, inspiration, and enjoyment of present and future generations nationally significant natural, historic, scenic, marine, and scientific values in South Florida." Under [36 CFR 60.1(b) (1)], historic units of the National Park System are automatically given National Register of Historic Places status by virtue of their incorporation into the park system. Thus, the Dry Tortugas Light Station was listed on the National Register of Historic Places as part of Dry Tortugas National Park.

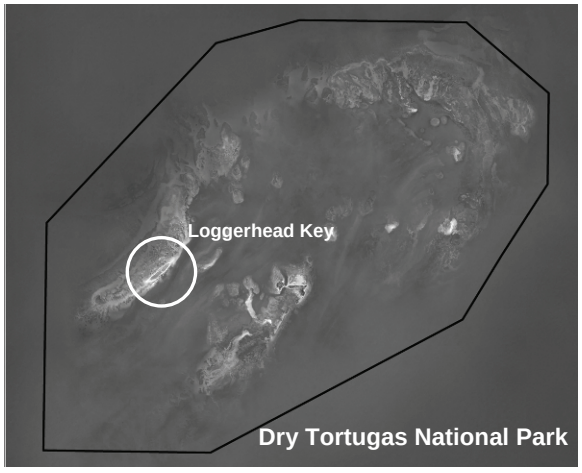
The following information is taken from the draft National Register nomination for Dry Tortugas Light Station completed in 1984 and updated in 1993.

*National Register Criteria* A and C
*Period of Significance:* 1855 – present (1995)
*Significant Dates:* 1856-1858, 1920s
*Acreage of Proposed District:* 1.85

## Significance

The draft national register nomination proposes a broad period of significance for the property spanning from its initial construction date through to the "present," or 1995, the year the draft nomination was submitted to the Washington Support Office. This approach



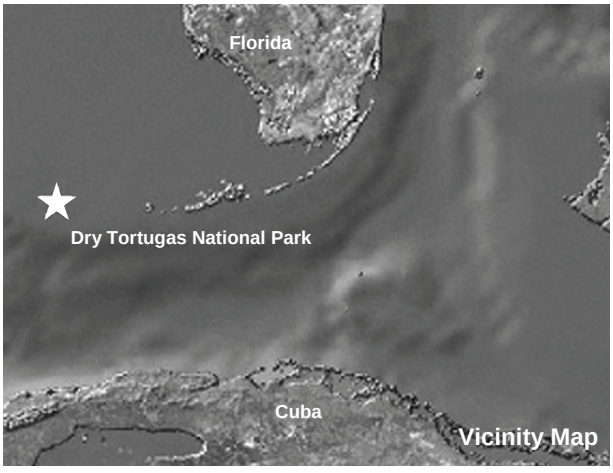




Figure 2: Maps showing location of Dry Tortugas National Park, Loggerhead Key and the individual structures of the Dry Tortugas Light Station.

suggests the Lighthouse derives its primary significance from its function as an aid to navigation and is inclusive of the entire period it has been active. This approach acknowledges all epochs of the Light Station's history including the National Park Service's management of the site during the last two decades.

Specifically, the draft nomination provides the following statement about the Light Station's significance.

> "The light station is significant primarily for its role in facilitating America's ocean-borne commerce and as a notable example of the kind of civilian public works project undertaken by Army engineers prior to the Civil War. While the Lighthouse is clearly the most important structure within the boundaries of the nominated area, there were several ancillary structures built at the same time as the lighthouse, and also from the 1920s, a period in which the station was extensively modernized."

It is recommended that the draft national register nomination be updated based on the research collected in preparing the HSRs and resubmitted for formal acceptance.

## Related Studies

Hellman, Robert and David M. Brewer. *Archeological Survey of Loggerhead Key, Dry Tortugas National Park*. Southeast Archeology Center (SEAC), National Park Service, 2003.

Kenneth Smith Architects Inc., and Bender & Associates, Architects P.A. for the State of Florida Department of State, Division of Historical Resources and Department of Community Affairs, Florida Coastal Management Program. *Florida Lighthouse Study* 2002

National Park Service *Draft National Register of Historic Places Registration Form* 1993

National Park Service. *General Management Plan Amendment, Dry Tortugas National Park.* 2002

National Park Service National Register Programs Division, Preservation Services Branch for the Department of Transportation, United States Coast Guard, Seventh District, *Rehabilitation Report and National Register Nomination for the United States Coast Guard Light Station, Dry Tortugas Lighthouse, Loggerhead Key Florida*. October 1984

# Historical Background and Context

The historical background of the Dry Tortugas Light Station is documented by historians, Love Dean in *Lighthouses of the Florida Keys* and Neil Hurley in *Lighthouses of the Dry Tortugas: An Illustrated History*. These along with Russ Holland's *America's Lighthouses: Their Illustrated History since 1716* and Edwin C. Bearss' *Shipwreck Study-The Dry Tortugas* contributed to the development of the historical background and context. The following narrative draws upon these histories and references them when cited. The historical background also relies on the "clipping files" and other primary sources related to the Dry Tortugas Light Station found in National Archives Record Group 26.

## Discovery and Early Exploration of the Dry Tortugas

Juan Ponce de Leon is credited with the discovery in 1513 of 11 sand and coral islands located at the southwestern tip of the Florida Keys. Because sea turtles were in abundance, he named the islands "Las Tortugas," meaning *the turtles*. At the time of Ponce de Leon's discovery, hundreds of turtles were present on the shores of these islands along with pelicans and the now-extinct Caribbean monk seal.[1] Several accounts describe Ponce de Leon's crews capturing over a hundred turtles in one night - turtles were a significant source of food for mariners.

The first recorded shipwreck in the area occurred in 1622 when the *Nuestra Senora del Rosario* ran aground on one of the keys of the Tortugas. The survivors and their rescuers reportedly camped on the island that would later be named Loggerhead Key.[2]

Florida was under Spanish rule from 1513 until 1763, when it was ceded to Britain. While under British rule, Las Tortugas were surveyed by T. Jefferys in 1763, by Bernard Romans in 1766, and by George Gauld in the 1770s. Gauld's maps, published in 1773, were used widely for navigation of the gulf coast off British West Florida. Due to the lack of fresh drinking water, or possibly "in contradiction to the vast tract of wet reef which at low water nearly reaches the surface," Las Tortugas eventually became known as the *Dry* Tortugas. On his charts, Gauld named the individual islands that made up the Dry Tortugas including Loggerhead "Turtle" Key.[3]

In 1783, following its participation in the American Revolution, Spain regained Florida, and maintained it as a colony until 1821. Spain encouraged settlement of the region through land grants, but Florida remained sparsely populated well into the nineteenth century. By 1845 when Florida became a state it had only 60,000 residents.

Given their location at the intersection of the Gulf of Mexico and the Atlantic Ocean where the swift Gulf Stream current flows though the Straits of Florida, the Dry Tortugas witnessed considerable shipping traffic. Westward expansion in the United States led to an increase in the transport of goods from the interior of the continent to the urban centers along the east coast. After passing through the open waters of the gulf, most ships heading east avoided the Dry Tortugas by taking a

[1] Bearss, Edwin C., *Shipwreck Study-The Dry Tortugas*, Washington, DC: Eastern Service Center-Office of History and Architecture, United States Department of the Interior, National Park Service, April 15, 1971,1.

[2] Hellmann, Robert and David M. Brewer, Archaeological Survey of Loggerhead Key, Dry Tortugas National Park,SEAC Accession No. 1341, 2003.

[3] Dean, Love, *Lighthouses of the Florida Keys,* Inc., Sarasota, Florida: Pineapple Press, 1998, 75.




Figure 3. Map produced in 1838 based on Gauld's earlier 1773 survey of the Dry Tortugas. Note the map identifies Loggerhead "Turtle" Key.

southerly route and navigating along the Cuban coastline. Stormy weather or a captain's inexperience could result in ships veering off course and foundering in the shallow reefs of the Keys. Not only did mariners have to be mindful of the hazardous sailing conditions, but they also had to keep a vigilant watch for pirates cruising these same waters in search of vessels they could exploit.

Salvaging, or wrecking as it was also known, became a lucrative business in the Florida Keys. Dozens of vessels and hundreds of men were active in the trade which became highly organized and regulated. Wreckers had to hold a license issued by the Federal Court to legitimately take part in salvaging activities. During the nineteenth century, the Keys claimed hundreds of ships carrying millions of dollars of cargo which was eventually salvaged and liquidated in the auction houses of Key West. In the Dry Tortugas, the natural harbor at Garden Key provided safe anchorage for the wreckers from where they could observe the surrounding keys and quickly respond to any ship running aground or needing assistance.[4]

## Aids to Navigation in the Dry Tortugas

On August 7, 1789, the new Congress of the United States, with its ninth act, assumed responsibility for managing the nation's lighthouses and navigational aids. Prior to this, each state sited, built, and managed lighthouses as needed. The U.S. Lighthouse Establishment was the body created by the government to oversee the construction and operation of the lighthouses. Initially, Secretary of the Treasury, Alexander Hamilton, directly appointed keepers and negotiated construction contracts. Even President Washington signed and approved lighthouse contracts during the first years of his presidency. In 1792 oversight of the lighthouses was passed to the Secretary of Revenue, and then back to the Secretary of Treasury in 1820 when Stephen Pleasonton became the Fifth Auditor of the Treasury.

During the early part of the nineteenth century, after the U.S. acquisition of the Louisiana Territory, shipping through the Florida Straits increased. Lieutenant Commander Matthew C. Perry was assigned to survey the Keys in 1821, after portions of Florida became a U.S. territory. Perry noted the difficult sailing conditions and reported to Congress that four light stations would be necessary to alleviate nautical risk within the Florida Keys. These included Southwest Key, Sand Key, Key Largo and Cape Florida. Congress responded with a recommendation to build lighthouses at Key West, Cape Florida and the Dry Tortugas. In the Dry Tortugas, Garden Key was selected as the most suitable location for a lighthouse. Construction of the



Figure 4. Undated nineteenth century view of Garden Key lighthouse within the parade ground of Fort Jefferson.

Garden Key lighthouse began in August of 1824 and continued until the lamp was lit on July 4, 1826. The focal plane of the light was 70 feet above sea level and the lantern was fitted with 23 lamps and 14-inch reflectors.[5]

Despite construction of a lighthouse on Garden Key, over the next two decades, mariners continued to complain about the inadequacy of navigational aids in the Dry Tortugas. The new light was not only difficult to see in the hazy conditions of the gulf, its location six miles from the outer southwest edge of the reefs, and another eight miles from the northeastern shoals, meant that ships would find themselves in dangerous waters before the light was visible. The light constructed on Garden Key was simply not tall enough to adequately mark the hazards of the Dry Tortugas.

[4] Ibid., 78

[5] Ibid., 77.

Numerous ship wrecks, including the *Concord* and *Florence* in 1831 and the *America* in 1836, were blamed on the poor visibility of the Garden Key lighthouse. In an 1836 interview with the *Key West Inquirer*, John Thompson, assistant light keeper at Garden Key, described the need for two additional lighthouses in the Dry Tortugas—one on the easternmost and the other on the westernmost keys.[6] The newspaper endorsed Thompson's position.

Others voiced their opinion directly to the Lighthouse Board. William Whitehead, the Collector of Customs at Key West, wrote to Stephen Pleasonton in1836:

> Should it not be thought advisable to have all the appropriations made in one year, I would designate as being worthy of attention first the two light houses recommended for the Tortugas in place of the one now there. Many vessels have grounded there during the last year in consequences of inadequacy of the present light which I have every reason to believe does not arise from any neglect of those in charge.[7]

Meanwhile, in 1842, twenty-six year old Captain Horatio Gouvenor Wright was selected and charged with leading the construction of a massive fortification planned for Garden Key. Following conflicts with Spain and England regarding border disputes, President Tyler and Congress were persuaded to set aside four million dollars for military installations at Key West, Key Biscayne and the Dry Tortugas. In June 1844, President Tyler signed appropriations for the initial phase of construction of the fortification that would later be named Fort Jefferson. With the capacity to house 1,500 men, arm three tiers with 450 weapons, and to stand 50 feet off the water, Fort Jefferson was designed to be the largest "Third System" fort in America. The walls of the proposed fort were to be laid out in a manner that would encompass the existing Garden Key lighthouse and keeper's dwelling.

Shipping activity in the Dry Tortugas escalated to an unprecedented level as supplies of men and material were sent to Garden Key. Complaints about the light continued until Pleasonton finally ordered several reconnaissance trips by his staff to assess the conditions. Adam Gordon, Lighthouse Superintendent at Key West, along with Captains William H. Chase and George Dutton of the Army Corps of Engineers, were sent to the Dry Tortugas to evaluate the light on Garden Key. They agreed the light was too low and dim to provide adequate aid to navigation and recommended that the light be relocated to Loggerhead Key. In the interim, Winslow Lewis was sent to inspect the lighthouse to see if anything could be done to improve its effectiveness. Lewis made minor adjustments to the lamp, but these proved to be ineffective and complaints continued.



Figure 5. Captain Horatio G. Wright.

## Lighthouse Illumination

American lighthouses of the nineteenth century, including the one at Garden Key, were lit primarily with Argand oil lamps. In 1781, Amie Argand developed a ring-shaped wick that allowed air to flow through and around the flame and thus produce a brighter, cleaner fire. The same Winslow Lewis that was

[6] Bearss, 14.
[7] Hurley, Neil E. *Lighthouses of the Tortugas, An Illustrated History*, Alexandria, Virginia: Historic Lighthouse Publishers, 1990, 18.

sent to make adjustments to the Garden Key light had developed and promoted a silver metallic, parabolic reflector assembly to be used with the Argand lamp. Lewis had successfully lobbied the Collector of Customs in Boston, Congress, and members of the Lighthouse Establishment, and his apparatus became the standard used in American lighthouses during first quarter of the nineteenth century. Lewis was paid $60,000 for a patent to the system, and most lighthouses were fitted with his apparatus by 1815.[8]

Lewis' system was an improvement on the various wicks and fuels previously used, but the Fresnel lens was concurrently being developed and would eventually surpass the Argand lamp and Lewis'parabolic reflector system in light quality and intensity.

Developed by Augustin Fresnel, a French physicist, the Fresnel lens resembled a large glass beehive surrounding a single lamp. Asked by the French Commission on Lighthouses in 1819 to help improve the illumination system, Fresnel worked with Claude Mathieu, his two brothers—Lenor and Fulgence, and Monsieur Talbouret to develop the new lamp technology. He also worked with Francois Soleil, Sr., a Parisian optician and glass manufacturer.

The design intent of the Fresnel lens was to refract all of the light emitted from the source into one concentrated horizontal beam. By compounding the light beams in the lens a stronger and brighter signal was produced. By 1821, Fresnel's design was refined into an assembly of eight panels of concentric circular lenses with catadioptric prisms at the top and bottom of the panels. The lenses were made with triangular shaped glass that concentrated the light into a narrow horizontal beam. In 1824, the first fixed Fresnel lens was constructed along with separate flash panels that were made to revolve around the light and produce two or four flashes per revolution. The flashes helped to distinguish the lights from stars or other lighthouses. This new Fresnel technology produced a bright, narrow sheet of concentrated light emitting from the lighthouse, which could be manipulated multiple ways for signaling sailors.[9]

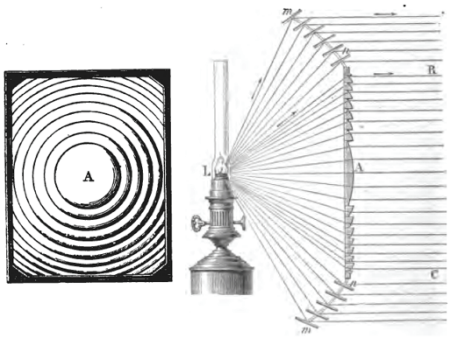



Figure 6. Schematic showing how the Fresnel lens concentrated light from a single source into a horizontal beam.

Under Pleasonton's guidance, the lighthouse system grew from 55 lighthouses in 1820, to 331 in 1852. Despite development of the French Fresnel lens and its widespread use in Europe, Pleasonton continued to favor the Argand lamps and parabolic reflector system. His reason for not using the newer Fresnel technology, he said, was based on budgetary considerations. It has also been suggested that Pleasonton's personal friendship with Winslow Lewis translated into a loyalty to Lewis' seemingly inferior system. Pleasonton's resistance to adopt the Fresnel technology resulted in mounting criticism of the Treasury Department's management of the lighthouse system. Eventually this led Congress to direct the Secretary of the Treasury to investigate the Lighthouse Establishment. Ultimately the decision was made to:

> discharge all the administrative duties of said office relating to the construction, illumination, inspection, and superintendence of light-houses, light vessels, beacons, buoys, seamarks, and their appendages, and embracing the security of foundations of works already existing, procuring illuminating and other apparatus, supplies, and materials of all kinds for building and for rebuilding when necessary, and keeping in good repair, the light-houses, light-vessels, beacons, and buoys of the United States.[10]

[8] Holland, Francis Ross, *America's Lighthouses: Their Illustrated History Since 1716*, Brattleboro, Vermont: Stephen Greene Press, 1972,15.

[9] Ibid., p. 18.

[10] *Light-house Appropriations Bill. Statutes at Large of the United States of America 1789-1873*, 32nd Congress, 1st sess., vol.10, August 1852, 119.

An outcome of the investigation was the creation of the U.S. Lighthouse Board. This newly formed body would be made up of four high ranking military officers, two from the Navy and two from the Army along with two civilians of "high scientific attainments." The Board would also divide the country into eight districts, expand inspection and engineering services, set up a central supply depot, begin publishing an annual "Light List", and encourage the use of new technology such as the Fresnel lens.

## A New Light in the Dry Tortugas

The Seventh District established by the Lighthouse Board included the Dry Tortugas, extending "from Cape Carnaveral [sic] light-house, Florida, to include Cedar Keys, Florida." The office of the Superintendent of the Seventh District was located at Key West.[11]

The newly formed Board began immediately equipping existing and new lighthouses with Fresnel lenses. In the Dry Tortugas, the focus of the Board was to respond to decades of complaints by providing additional navigational aids including the construction of a new lighthouse on Loggerhead Key.

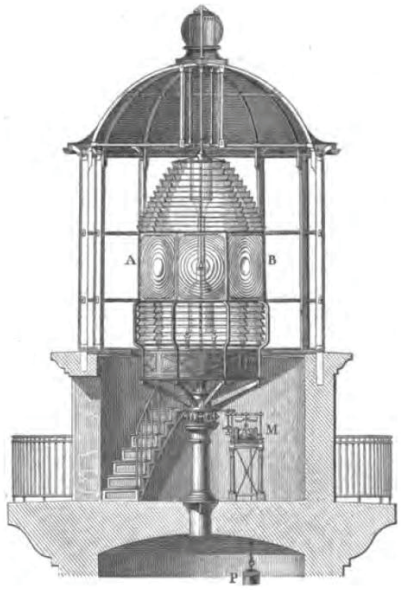



Figure 7. Section through a typical first-order lantern equipped with a Fresnel lens.

[11] *Organization and Duties of the Lighthouse Board: Regulations, Instructions, Circulars, and General Orders*, Washington DC: Government Printing Office,1871, 53.

Additionally, the light on Garden Key was slated for retooling including the installation of a fourth-order Fresnel lens to service the immediate harbor traffic. The new lighthouse proposed for Loggerhead Key was to be equipped with a first-order lens—the largest lamp available.

In 1855 Lieutenant T.A. Jenkins, United States Secretary of the Lighthouse Board, requested that Capitan H.G. Wright, overseer of construction at Fort Jefferson, submit a preliminary sketch and estimate for the new lighthouse. Wright provided a response to Jenkins on September 23rd, but it appears there was some confusion about the final location of the lighthouse, as his preliminary sketches, estimates, and letter are prepared for a project on Garden Key.

> It is proposed to first lay a grillage, as shown on the sketch, the top of which shall be on a level of those in the bastion of the fort. . ..I cannot make any satisfactory estimate for the keeper's dwelling, as I do not know what allowance of room for each person is authorized by the board, therefore none is submitted. There is now a wooden house, built for the keeper in 1847, which contains two lower rooms, with hall, two half attic rooms and a detached kitchen, which if sufficiently capacious, will answer the purpose for some years to come. . .The privy should be built over a vault communicating with the sewers of the work, the cost of vault which will be not far from $100.[12]

Ultimately the location for the new lighthouse was resolved and on August 18, 1856, Congress appropriated "for rebuilding the light-house, on a proper site, at Dry Tortugas and fitting it with first-order apparatus, thirty-five thousand dollars."[13]

In the same year, Wright was replaced by Captain Daniel P. Woodbury of New Hampshire. Woodbury who would now oversee construction of the fort and the lighthouse made several design changes to

[12] Dry Tortugas Light Station Clipping File, Appendix no. 17, H.G. Wright, Capitan of Engineers, Fort Jefferson, FL, to Lieutenant T.A. Jenkins, U.S.N., Secretary, Light-house Board, Washington, D.C., September 23, 1855, Record Group 26, NA.
[13] *Light-house and Appropriation Bill*, *Statutes at Large of the United States of America 1789-1873,* 34th Congress, 1st sess., August 1856, vol.11, 99.

Wright's original proposal. According to Love Dean, Woodbury modified the dimensions of the tower, construction of the steps, masonry detailing and connection details between the lantern and the tower. He also configured the brick to corbel out below the Watch Room, forming the floor of the galley above.[14]

Construction of the lighthouse on Loggerhead Key began in 1857 and within a year the tower was complete. The first-order Fresnel lens was manufactured by the L. Sautter & Company. During the conversion to Fresnel lenses, the U.S. Lighthouse Board generally divided their purchases equally between the two primary lens manufacturers; L. Sautter & Company and Henry LePaute.

In 1852, Louis Sautter bought the business started by Francois Soleil, Sr., with whom Fresnel worked to develop the Fresnel lens. Soleil's business passed to his son-in-law, Jean Jacques Francois and onto his son-in-law, Theodore Letrouneau before it finally left the Soleil descendants. Sautter & Company shipped their first lens to America in 1853 for the lighthouse at Alcatraz Island.

Sautter continued working with the glass manufacturer St. Gobain in Paris to make bigger and better glass pieces. Through acquisition and mergers, the company evolved to include electrical generators and searchlights. The company's lights were used to illuminate the Champs-Élysées and the Arc de Triomphe in the late nineteenth century.[15]

By 1858 the lighthouse and buildings of the Dry Tortugas light station were complete. The station consisted of several structures sited in the middle of Loggerhead Key including the 150- foot brick lighthouse, a detached two story oil house, a two-story keepers' dwelling, a separate two-story kitchen, and two brick cisterns and several privies. A boathouse would not be constructed until 1871.

## Keepers and their Duties

Benjamin Kerr was the first keeper assigned to the light station on Loggerhead Key. He was transferred from Garden Key in 1858 with a salary of $600 a year and brought with him, Henrietta his wife, and seven children. Kerr was employed at the Dry Tortugas light station until 1861, when he was replaced by James P. Lightbourn. Besides being named the first keeper of the Dry Tortugas Lighthouse, Kerr's notoriety stems from an incident in which both of his assistant keepers allied with his wife and one daughter to "make an attempt on his life."[16] According to G. Phillips who was stationed at Fort Jefferson at the time, Kerr and one of his daughters arrived at Garden Key in a small boat, after having escaped from Loggerhead Key. Kerr and his wife apparently reconciled and managed to finish their assignment with no further incidents.

The *Organization and Duties of the Lighthouse Board* set forth the requirements for lighthouse keepers. A few of the fundamental requirements established by the Board are listed below:

> LIV. Keepers were required to be over 18 and be able to read and write, and be in every respect competent to discharge the duties of the keeper….
> LV. Men of intemperate habits and those who are otherwise mentally or physically incapable of performing the duties of the light keepers, must not be nominated for appointment by superintendents of lights.
> LVII. Women and servants must not be employed in the management of lights, except by the special authority of the Department.[17]

Pay was established at the keeper's appointment and was begun when they entered their duties. The keepers were permitted to select their assistants, but keepers' families were allowed to be nominated only in "rare and exceptional cases."[18] The keeper's duties included keeping all aspects of the light station clean and in good working order, lighting and maintaining lamps, painting and maintaining all finishes both inside and out of all buildings, and maintaining clothing and accessories necessary to service and protect the light. Other duties included providing reports to the

[14] Dean, 84.
[15] Tag, Thomas, *The Sautter Lens Works Producers of the Fresnel Lens*, U.S. Lighthouse Society's, *The Keeper's Log*, Summer, 2005, www.uslhs.org.

[16] Dean, 87.
[17] *Organization and Duties of the Lighthouse Baord,* 60.
[18] Ibid.

district office, maintaining safe and dry places for cleaning supplies, and logging in and out supply deliveries. [19]

As one might expect, life on Loggerhead Key was particularly isolated. With a few exceptions, keepers remained at the light station for short durations. There were 10 keepers assigned to the Dry Tortugas station between 1858 and 1912.

During the 1860s, rations for each lighthouse keeper and assistant keeper, in addition to their salary, included:

> 40 pounds of salt pork, 52 pounds of salt beef, 100 pounds of flour, or 80 pounds of ship biscuit, 11 ½ pounds of brown sugar, 6 pounds of coffee, or 1 ½ pound tea, 5 pounds rice and 2 gallons beans or peas per quarter[20]

A break in the monotony came for the keepers and their families when on occasion they would be invited to socialize with the families of officers stationed at Fort Jefferson. Alternately at times the lighthouse keeper would host parties on Loggerhead Key, usually in conjunction with turtle turning expeditions. "Turtle turning" involved turning large turtles on their backs, thereby rendering them helpless and unable to escape. The turtle turning parties were often accompanied by the sharing of food, music, and dancing.

Later during the twentieth century, keepers were restricted to living on the island without their families. In a 1938 letter from the Superintendent of Lighthouses to the Commissioner of Lighthouses, the Superintendent advocates for familial visits for keepers during the summer months. Responding to a proposed change in policy that would eliminate this privilege, the letter emphasizes the remote and isolated conditions at the station:

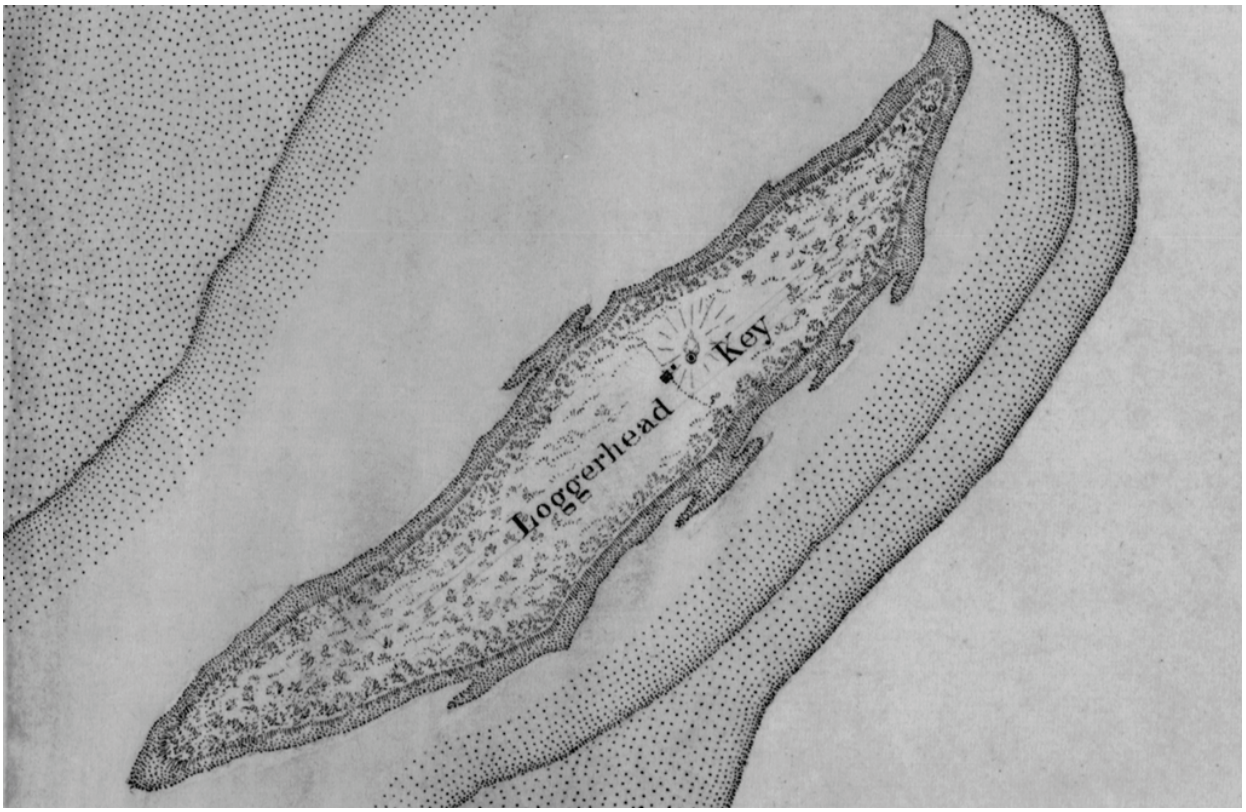
> Dry Tortugas Light station, Fla., is possibly one of the most isolated as well as attractive and efficient stations in the Service… There is no intention to make the station a resort; it is a condition that has existed for many years with nothing but beneficial results to the keepers and their families and this office believes that the best interest of the Service is being conserved in making no changes. With unrestricted privileges of this nature being enjoyed by the Carnegie Institutions Biological Station on the same reservation together with the other reasons it is recommended that no changes or restrictions in this respect be made….In reference to inquiry as to whether or not they be quartered in the station buildings, Bureau is advise that such is the case and the keepers and their families are perfectly satisfied to subject themselves to the slight inconvenience for the pleasure and privilege of having these relatives and friends with them as requested. It has been the experience of this office that these keepers feel that these dwellings are their homes, for which they pay more rent than they are worth, in addition to having to maintain homes elsewhere.[21]

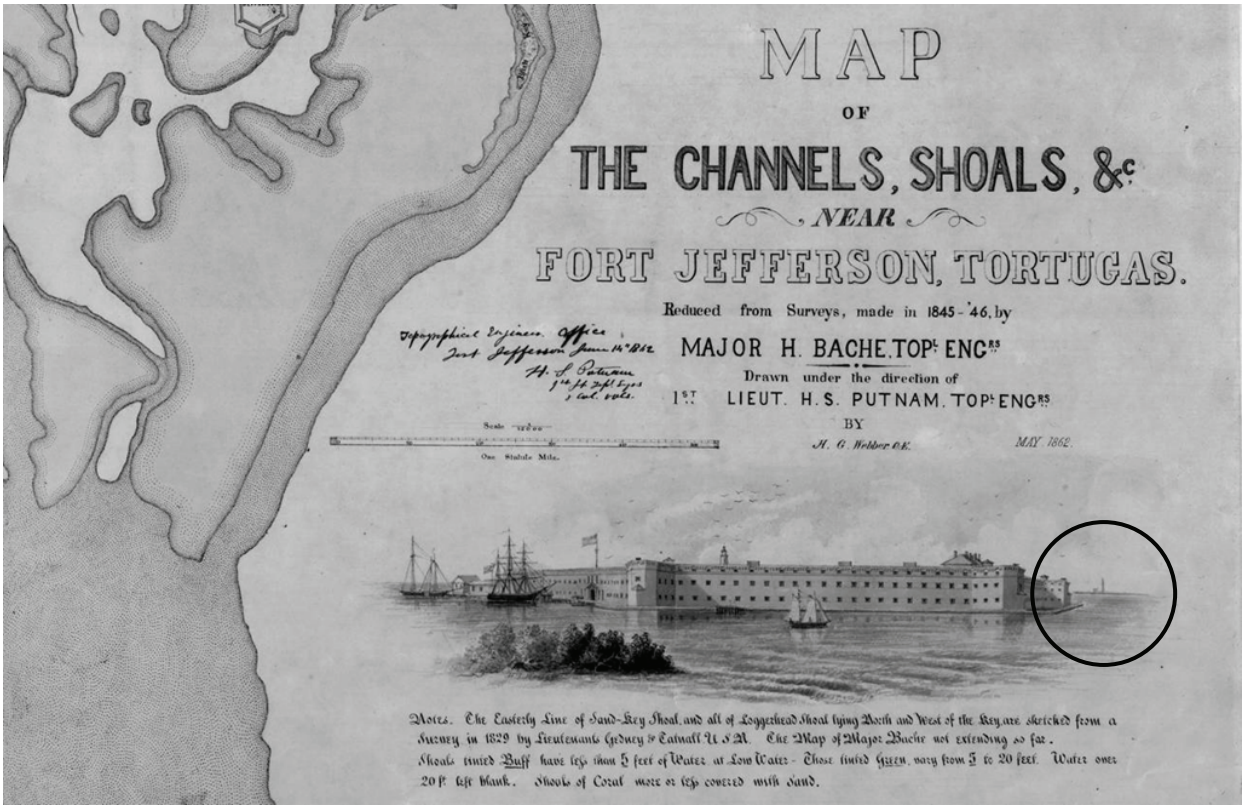
Even into the 1980s, lighthouse keepers with the Coast Guard reinforced the lonesome and isolated nature of their duties. Most assignments for unwed officers were for six weeks with three weeks on shore and assignments for married officers were typically four weeks with two weeks on shore. "The biggest complaint was the absence of women and having to cook for each other."[22]

## War and Disease

Florida seceded from the Union on January 10, 1861, but the Dry Tortugas remained under the command of Union forces throughout the War. The Union successfully blockaded St. Augustine, Jacksonville, Key West and Pensacola. Still, some smaller vessels were able to smuggle goods such as cattle, crops and salt to Confederate sympathizers. While most of the battles of the Civil War took place in other states, approximately 16,000 Floridians left home to fight in the war. The battles of Olustee (near Tampa Bay) and Natural Bridge (near Tallahassee) were both won by the Confederates and Tallahassee was the only state capital in the Confederacy not seized by Union Troops. [23]

[19] Ibid., 88-89.
[20] U.S. Lighthouse Board, *Registers of Lighthouse Keepers, 1845-1912*, National Archives Southeast Region, Morrow, Georgia.
[21] Superintendent of Lighthouses to Commissioner of Lighthouses, 08 June 1938, Record Group 26, NA, Washington, DC.
[22] Hurley, 59.
[23] Florida Center for Instructional Technology, College of Education, *Florida's Role in the Civil War: "Supplier of the Confederacy",* University of South Florida, 2009 http://fcit.usf.edu/Florida/lessons/cvl_war/cvl_war1.htm.




Figures 8 and 9. Portions of an 1862 map of Dry Tortugas showing the first depictions of the light station. Loggerhead Key is shown in plan (above) and the lighthouse can be seen in elevation beyond Fort Jefferson within the cartouche (below).

During the War, the 47th Regiment of the Pennsylvania Veteran Volunteers were stationed at Fort Jefferson and by 1865 nearly two thousand people were living on Garden Key. The installation was used primarily as a military outpost and prison during the war and was never fired upon or fired a shot in conflict.

A yellow fever outbreak in 1867 resulted in the Light Station falling into disrepair for several years. During the period between 1867 and 1871 Loggerhead Key was used as quarantine station for military personnel, which strained resources and impeded maintenance of the buildings. By 1871 the outbreak had subsided and various maintenance projects were again underway.

A second outbreak of yellow fever affected the Dry Tortugas in September of 1873, requiring all healthy soldiers on Garden Key to once again be relocated to Loggerhead Key. During the outbreak, thirty people were infected resulting in 12 casualties. The healthy were still on Loggerhead Key when the hurricane of 1873 hit the island.

## The Hurricane of 1873

The hurricane that struck the Dry Tortugas on October 6, 1873, initially formed near the Leeward Islands, drifted west towards the Yucatan Peninsula, then backtracked through the lower Gulf of Mexico, before it curved northward and passed over the towns of Punta Rassa and Melbourne on the east coast of Florida. Although the track of the hurricane took the eye north of the Dry Tortugas, it delivered a damaging blow to the Light Station.

The initial evaluation of the storm-damaged Light Station was bleak. The Lighthouse was reported to be in dangerous condition and it was initially recommended that the entire tower would need to be rebuilt.

Because Loggerhead Key was still under a yellow fever quarantine and contact with the island was limited, only temporary repairs could be made following the storm.

> The walk in front of the keeper's dwelling has been cemented and the water-conductors to the cisterns repaired. The cisterns have been cleaned and repaired, and wooden shutters for the tower-windows have been made, painted and hung. It is proposed, during the coming season, to make careful examination with a view to determining on plans for the foundation of a new tower.[24]

Congress appropriated $75,000 for repairs to the Lighthouse and plans were prepared for a new structure. In contrast to the existing masonry tower, the design of the replacement structure would be entirely of cast iron.

By 1875 the upper portion of the lighthouse had been extensively repaired, anchors were extended down through the lighthouse walls

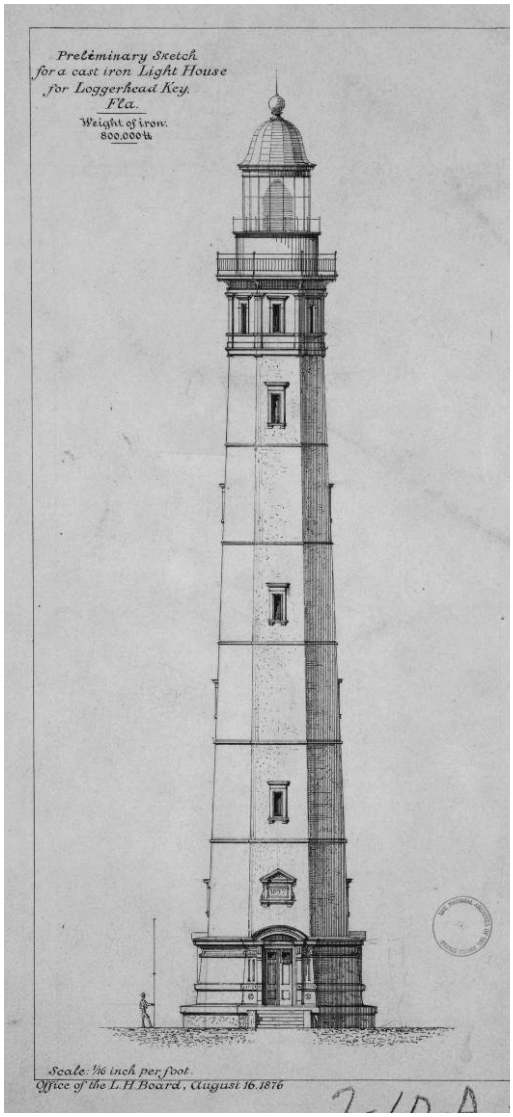



Figure 10. Elevation of iron tower proposed to replace storm-damaged masonry tower

[24] Ibid.

to secure the lantern and the tower received its distinctive daymark. The upper portion of the tower was painted black and the lower portion was painted white. The black color was supposed to help dampen reflections, contrast with the white clouds and show a distinct color pattern for sailors.[25]

The work was completed just as a second hurricane swept through the Dry Tortguas. The repairs held and were closely monitored during the ensuing years. Ultimately it was decided that a new lighthouse would not be necessary.

During this same period, discussions were held about the inadequacies of the Garden Key Lighthouse and its placement within the parade ground of Fort Jefferson. After another hurricane damaged the Garden Key Lighthouse, plans were made to replace it with an iron structure to be located on top of bastion C of the Fort. The original Garden Key Lighthouse was demolished and on April 5, 1876, the new cast iron light tower was lit.[26]

## Late Nineteenth-Century Development

Through the late 1870s, minor repairs were made to several of the Station's structures, and in 1880, a new boathouse was built. From 1888 to 1910, Prussian George Billberry served as keeper of the Light Station. During his service, many repairs and upgrades were made to the Station buildings. From 1880 through the 1890s, mineral lamps—otherwise known as Luchaire incandescent oil vapor lamps (i.o.v.)—became the method of illumination. New glass was installed in the lantern, wash houses were built, structures were painted and whitewashed, wire fence was installed, and on "April 30, 1893, the characteristic of the Loggerhead Key light was changed from fixed white to fixed white with a fixed red sector."[27] The implementation of red sector lighting was a navigational advancement for its time. A red pane of glass was installed on the side or sides of the lantern where the reefs or shoals were particularly dangerous. Shipmen knew not to



Figure 11. Undated nineteenth-century view of the Dry Tortugas light station looking northeast.

[25] Hurley, 39.
[26] Hurley, 41. The choice to construct the new tower out of iron was a strategic military decision. If the fort came under attack, a brick tower was considered more dangerous because of the heavy shrapnel produced if hit by shells.

[27] Hurley, 45.

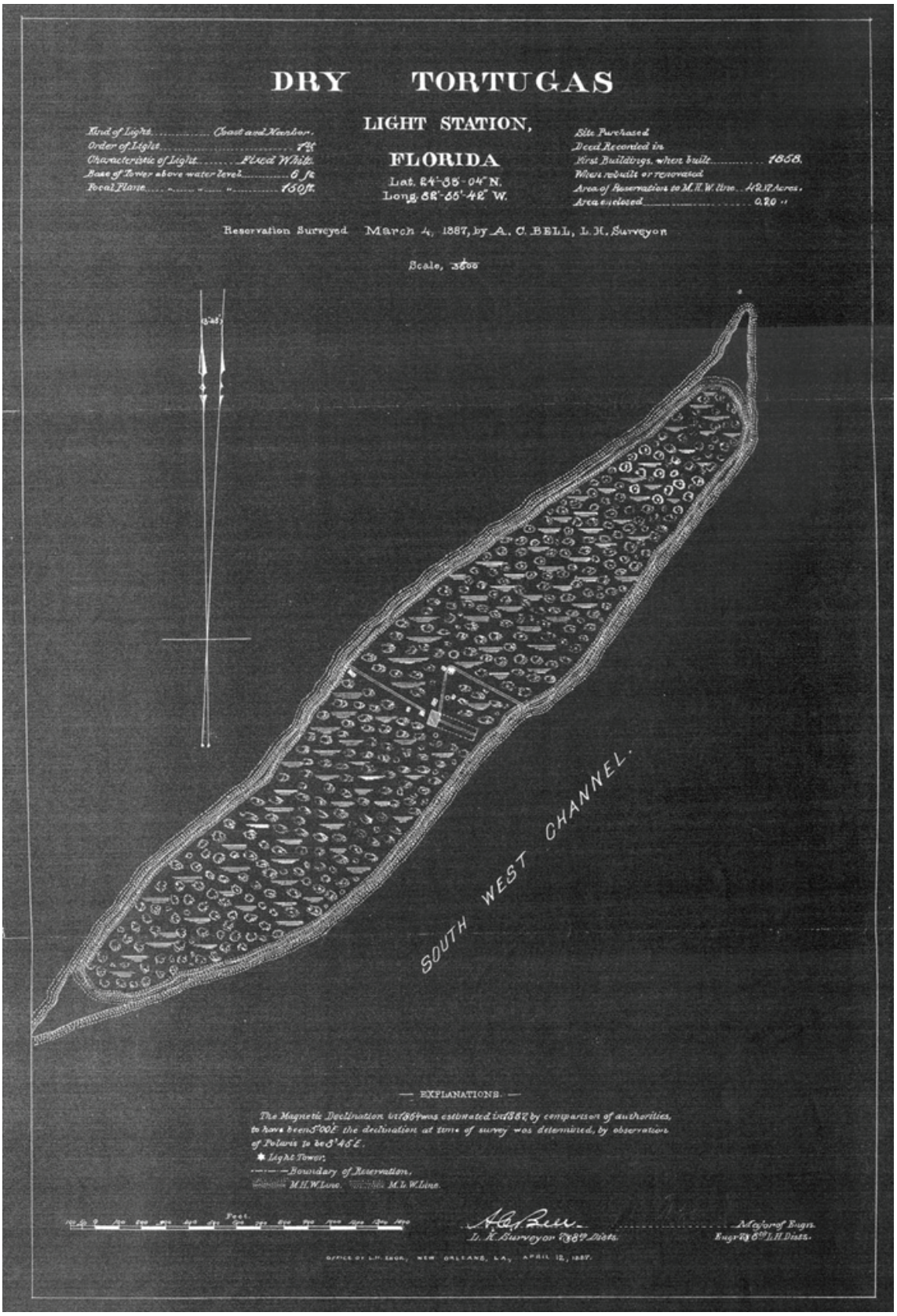



Figure 12. 1887 survey of Dry Tortugas Light Station by A. C. Bell.

navigate directly into the red light for this would signal imminently dangerous waters.

For most of the 1890s, once again Loggerhead and Garden keys were used as quarantine stations, this time for those suspected of being infected with small pox. Despite an order in 1893 from the War Department to discontinue the quarantine stations, the two keys would serve this purpose until 1900.

## The Spanish American War

In 1898, the United States entered into war with Spain over the liberation of Cuba. The Dry Tortugas served as a harbor and staging area for ships in the area. The most notable incident of the war occurred with the *U.S.S. Maine*. On January 24, 1898, the ship sailed to Havana and a few weeks later it suffered a massive explosion that killed 260 of its 350 sailors and sank the battleship. At the time, the explosion was blamed on an underwater Spanish mine, and as a result, the U.S. declared war against Spain on April 21. The war cry "Remember the Maine!" stems from this incident. The war was relatively short-lived and a treaty ending the conflict was signed in December 1898.

In 1976, a Navy panel concluded that the blast on the *Maine* was the result of an onboard fire in the coal storage area. It is possible that the fire may have originated while the ship was in the harbor at Garden Key.

## Bureau of Lighthouses

With the turn of the century, came a change in the management of the Lighthouse Board. In 1903, the Board was moved from the Treasury Department to the Department of Commerce. In 1910, it officially became known as the Bureau of Lighthouses. Congress intended to accomplish several objectives with this reorganization. First, it sought to demilitarize the lighthouse service. Both the Army and the Navy were not allowed a prominent role on the Board, the goal being to shed a civilian light on a primarily civilian service. Secondly, the reorganization allowed for an increase in districts to accommodate the growing number of light stations. In 1910, George R. Putnam was selected to lead the new Bureau of Lighthouses. Serving for 25 year, Putnam's most notable contributions include the introduction of radio beacons as an added means of navigation, electrification of many light stations and a retirement system for field employees.[28]

## The Carnegie Institution Marine Biology Laboratory

In 1904, a portion of the northern end of Loggerhead Key was granted through a revocable lease, to the Carnegie Institute for the establishment of a research laboratory to study marine life in the Atlantic. The Institute declared in their 1904 Year Book the establishment of the Marine Biological Laboratory at the Dry Tortugas, under the direction of Alfred G. Mayor.

Mayor was a Harvard educated biologist who initially studied butterfly pigmentation. However, due to a serious eye inflammation he was forced to pursue research that relied less on work with a microscope. Jellyfish offered the perfect specimen for him to study and he subsequently published a three volume work on the species. The Dry Tortugas offered an ideal location for collecting and observing jellyfish among other tropical plants and marine life.

The laboratory complex was constructed between 1904 and 1906 and was comprised of:

> a main laboratory building and sleeping porch, a detached lab, a kitchen, a windmill for pumping salt water and air to aquariums, a dock, a shipways, two small outhouses and a cistern. The labs and outhouses were built in New York and shipped to Loggerhead for assembly, while the rest of the buildings were built on site. About 50 palm trees were planted around the lab to shade the buildings and provide hurricane protection. All the buildings, chemicals, lab glassware and furniture cost only $4,800. The lab's research vessel was a 57-foot-long ketch, with a 20 horsepower auxiliary engine.[29]

A vast and diverse program of research was conducted at the laboratory. Some of the most notable accomplishments included ground-breaking research on coral reefs and

[28] Holland, 38.
[29] Hurley, 48. Carnegie Institute Yearbooks.

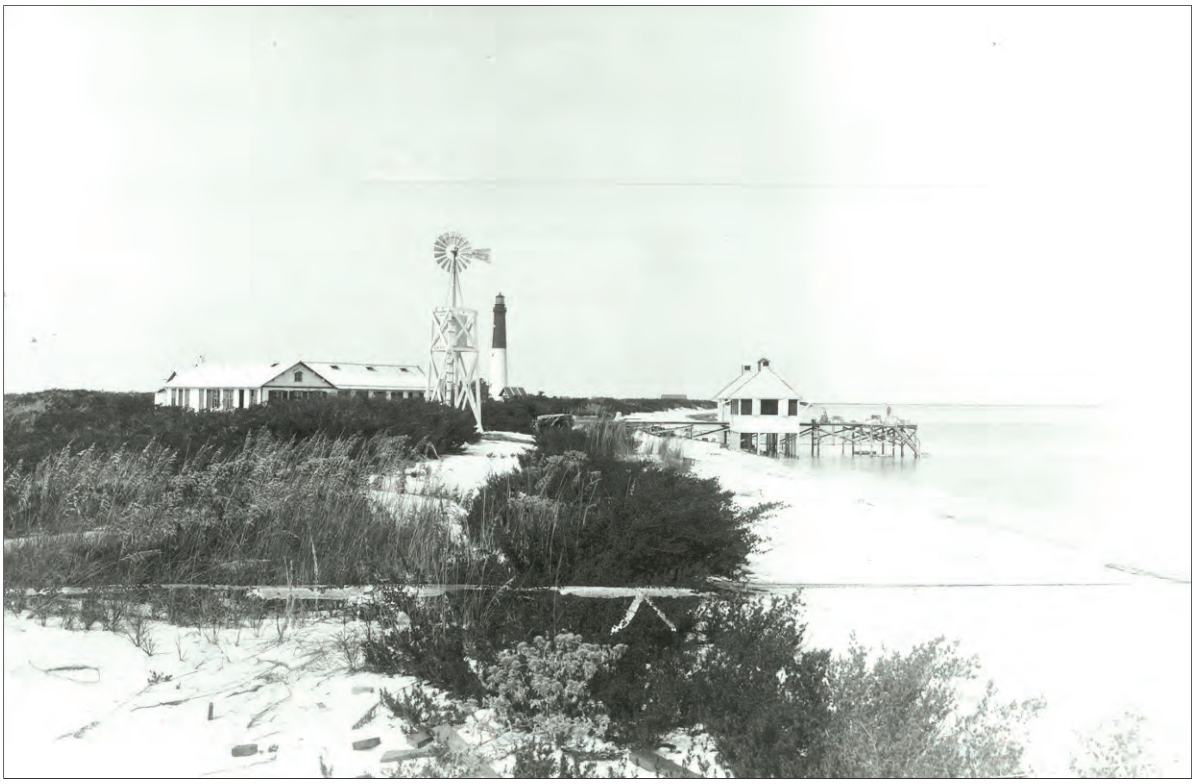


Figure 13. Undated view of the Carnegie Institute's Marine Biology Research Laboratory with the Dry Tortugas lighthouse in the distance.

mangrove communities, the establishment in 1908, of the Dry Tortugas as a wildlife refuge for the sooty tern, and the first underwater photographs—both black and white and color were taken there.

Although the Institute viewed Mayor as a promising individual, his selection of Loggerhead Key for the research laboratory was seen as a poor choice. It was too remote and difficult to access and receive support from the mainland. In addition, working around hurricane season left for a brief research period from May until July each year.

Mayor had some aspirations to relocate the lab to Jamaica to create a truly international biological station, but he suffered from tuberculosis and in June of 1922, his body was found face down on the shore of Loggerhead Key. He was 54 years old. The coroner ruled that Mayor died of "heart-failure and general debility contingent upon his tubercular condition."[30] A plaque erected in his honor in 1929 stands near the site of the former laboratory complex.

The Carnegie lab survived through the Great Depression and several hurricanes until 1939, when Carnegie President Vannevar Bush closed the laboratory. Reduced funding and a shift in philosophical focus from macro-biology to microbiology have been reasons stated for the closure.[31] During the thirty-five years of laboratory operation, more than 140 scientists visited and conducted research on, and in the waters surrounding Loggerhead Key.

## Early Twentieth Century Modernization

The early part of the twentieth century not only included the restructuring of national lighthouse management and the birth of modern marine biology with the establishment of the Carnegie laboratory, but also ushered in

[30] Calder, Dale R. and Lester D. Stephens. *Seafaring Scientist: Alfred Goldsborough Mayor, Pioneer in Marine Biology*, Columbia, South Carolina: University of South Carolina Press, 147.

[31] Hurley, 49.

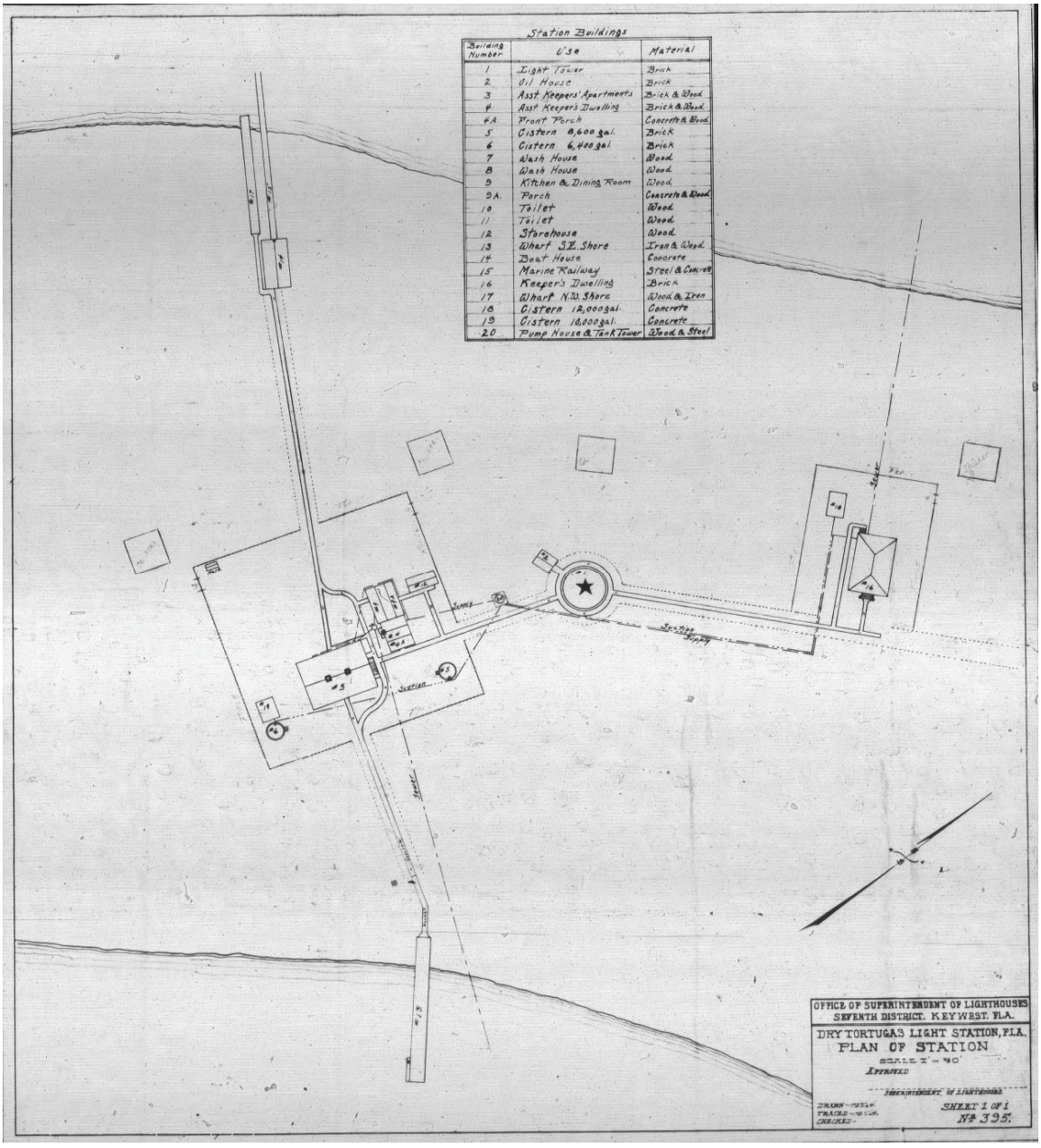



Figure 14. Ca. 1925 Plan of the Dry Tortugas Light Station.

modern technological advances at the Light Station. Radio beacons, electricity, concrete cisterns, a new lens and multiple construction projects were completed during this period.

Two significant hurricanes during the 1910s, once again, caused serious damage to the Light Station and the laboratory complex. The hurricane of October 10, 1910, (hurricanes were not named until the 1950s) damaged the wharf, shattered panes of glass in the tower, and severely damaged the dormitory and blew the roof off the main building at the Carnegie laboratory complex. The machine shop was moved off its foundations nearly five feet. On September 8, 1916, Congress allotted $2,800 and;

> a wrought-iron pile wharf with cast-iron caps and wooden girders, stringers, and decking was erected in place of the old wharf, which was destroyed. All work was



Figure 15. Undated view of the Garden Key Keeper's Residence with the iron lighthouse on bastion C in the distance.



Figure 16. View of Dry Tortugas Keeper's Residence shortly after completion.

> completed in May, 1917. Amount expended to June 30, 1917, $2,631.19.[32]

As a result of damage sustained in the 1910 hurricane, the original first-order lens was replaced with a second-order lens.

A second hurricane hit the island on September 10, 1919, severely damaging the laboratory by washing away snail breeding cages and resulting in damage to all the buildings.

Fort Jefferson experienced a massive fire in 1912 that destroyed the Garden Key light keeper's dwelling, as well as the fort's barracks, kitchen and latrine. The keeper's house was not rebuilt and some years later the harbor light was deemed unnecessary for navigational purposes and decommissioned. In 1921, the lighthouse on Loggerhead Key became the primary navigational beacon in the Dry Tortugas.

Following the decommissioning of the light on Garden Key, the Bureau of Lighthouses took several steps to upgrade and modernize the Light Station on Loggerhead Key. In 1922, a new dwelling for the primary keeper was constructed and two new concrete cisterns installed. Five years later when the original Oil House was converted to a radio beacon equipment room, it was connected to the tower by a reinforced concrete passageway. The marine radio beacon was installed in 1926 to assist ship traffic and provide basic communication. The new technology offered a means of communicating with mariners about weather, operations, and navigational issues. The marine radio beacons were able to transmit communications to ships in storms when the lighthouse was difficult to see.

The introduction of electricity to the island was another technological advancement that changed the way the Lighthouse and Light Station operated. Powered by generators, housed in a frame addition constructed on the south elevation of the former Oil House, the new electric light installed in the Lighthouse in 1931 had 3,000,000 candle-power, making the Dry Tortugas light the brightest in America. Several mariners reported that they could see the light up to 52 miles away. Before electrification, the Lighthouse had a range of approximately 19 miles. The existing incandescent oil vapor lamp was kept as a secondary system.

In 1935 Fort Jefferson was designated a National Monument by President Franklin Roosevelt and was transferred to the National Park Service.

## The U.S. Coast Guard

In 1939, the duties of the Bureau of Lighthouse were amalgamated into the operation of the United States Coast Guard. Light keepers were given the choice of becoming petty officers or remaining as civilian employees. During World War II keepers were utilized as lookouts for German U-Boats in the Florida Straits. The threat of attack by enemy U-boats was real as twenty-four American ships were sunk by German submarines during the war. Coast Guard keepers also took part in beach patrols and at times had to rescue or recover victims of U-boat attacks.

[32] Ibid.

During the war, there was some debate as to whether the lighthouse lights should be extinguished or dimmed. Exposing ships to enemies was considered less of a danger than running aground, so the Coast Guard implemented "dim-out" policies in which the intensity of the lamps was turned down.[33]

In March of 1945 a fire destroyed the original 1858 keeper's dwelling and damaged the adjacent kitchen building. As a result, the keeper's dwelling had to be demolished to its foundations. A second fire in 1964 destroyed several of the abandoned Carnegie laboratory structures.

Under management of the USCG the Dry Tortugas Light Station remained manned with a crew of from two, to as many as twelve personnel. From the mid-twentieth century to the 1990s, numerous projects were planned and implemented at the Station beyond the required routine maintenance and minor repairs that took up much of the time of those stationed on the island. A majority of the projects centered on upgrading and repairing the various systems that were critical to habitation of the island such as those that provided potable water, sanitary systems, and generation of electrical power. In 1967, extensive improvements were made to the tower including sandblasting the exterior and repainting the daymark.

Projects in the 1970s focused on the installation of fuel and water tanks, upgrading electrical service and providing fire protection in the 1922 Keeper's Residence or "barracks building" as it was referred to during this period. In 1975 during the construction of a new wharf on the eastern shore, a Seaman Apprentice, William H. Graves, was tragically killed. A small monument dedicated to Seaman Graves is located near the site of the accident.

In 1984, the USCG commissioned National Park Service personnel to prepare a rehabilitation report and national register nomination for the Dry Tortugas Light Station property. This project was undertaken to document the history of the Light Station and to make recommendations for the appropriate



Figure 17. Image taken from the top of the tower showing the burned remains of the original keeper's dwelling.

repair of the historic lighthouse and support structures in advance of a planned automation and modernization program. The document included recommendations focused on repairs to the Lighthouse as well as both mortar and paint analysis.

The following year an extensive program of repairs was completed on the Lighthouse, and in 1986, the USCG decommissioned the existing second-order bi-valve lens after aggregate from sand-blasting operations contaminated the mecury float mechanism. As a result the lens was no longer able to rotate and was replaced with an automated 24" Directional Code Beacon (DCB-24). The new lamp was programmed to create a flashing light every 20 seconds that could be seen up to 24 miles away. The bivalve lens was removed and placed on display at the National Aids to Navigation School in Yorktown, Virginia where it remains today.[34]

## The National Park Service

Following automation of the Lighthouse optic in 1986 the USCG continued to be challenged

[33] Hurley, 57.

[34] Dean, 99.

by mounting deferred maintenance and limited funding for repair or capital improvements. In an effort to reduce their burden, consideration was given to demolishing several non-essential structures including the boat house and original kitchen building. In addition, advancements in the Long Range Navigation (LORAN) system and GPS (Global Positioning System) technology, as well as the expanded use of Satellite Navigation (SATNAV) resulted in diminishing reliance by mariners on visual aids such as lighthouses and beacons.

About the same time, the National Park Service, and at least two other groups, expressed interest in taking over management of Loggerhead Key and the Light Station property from the USCG. The other groups vying for the property included the Key West Ports and Transportation Authority who was interested in establishing a marine hatchery and science camp on the island, and the Key West Art and Historical Society who expressed an interest in managing the lighthouse, but had not submitted a formal proposal.

In 1991, the Coast Guard determined that the National Park Service presented the most viable proposal and several meetings were held between the two entities to evaluate the condition of the existing resources and to discuss the logistics of a transfer. Negotiations focused on resolution of several utility issues regarding the electrical generators and septic system and also a requirement for the USCG to remove all hazardous materials from the island as a condition of transfer. Despite their desire to divest themselves of the Light Station completely, the USCG would continue to maintain the light as an active aid to navigation and provide logistical support to the Park Service as part of the agreement. Transfer of the light station also provided opportunity for the USCG to eliminate permanent staff on the island and limit its obligation to routine site visits to maintain the optic. Establishment of Dry Tortugas National Park the following year provided the ideal mechanism for formally transferring Loggerhead Key and the Light Station to the National Park Service.

Dry Tortugas National Park was created in 1992 to "preserve and protect for the education, inspiration, and enjoyment of present and future generations nationally significant natural, historic, scenic, marine and scientific values in South Florida." The Park boundaries established at the time encompassed all of the seven small islands that make up the Dry Tortugas as well as the coral reefs, shoals and waters within an approximately 100 square-mile area. As part of the enabling legislation for the Park, the USCG lands, including all of Loggerhead Key were formally transferred from the USCG to the National Park Service. The establishment of Dry Tortugas National Park also resulted in the Light Station resources being listed on the National Register of Historic Places.

Through its Volunteers-In-Parks (VIP) program, the Park Service has been able to maintain a consistent presence on Loggerhead Key for much of the last two decades. The volunteers, who stay on the island for one to several months at a time, are housed in the former kitchen building and perform limited repair and maintenance of the resources. More importantly their presence provides a level of security for the island that serves as a deterrent to those that may seek to damage or cause harm to cultural or natural resources.

Since the National Park Service assumed management of the Light Station they have had the additional challenge of dealing with Cuban refugees making landfall at Loggerhead Key. The Dry Tortugas have become a primary landing point for the refugees due to their proximity to Cuba and remote location.

Since adoption of the "wet foot/dry foot" policy in the mid-1990s, the influx of refugees has been steady. The wet foot/dry foot policy generally states that if a refugee is able to make landfall on U.S. soil they will be allowed to stay and can pursue citizenship, on the other hand, if they are intercepted in the waters between Cuba and the United States, they will be sent back to Cuba or to a third country.

Generally arriving at night, during periods of calm weather, the refugees cross the open waters between the two countries in make-shift boats referred to as "chugs." These chugs accumulate on the keys and intermittently have to be removed to the mainland for disposal.



Figure 18. Chug used by Cuban refugees to land at Loggerhead Key in 2008.

After the Mariel Boatlift in 1980, the numbers of Cuban refugees attempting to enter the United States peaked again in 1994 and 2005. Refugees that make landfall within the Park are temporarily detained by the National Park Service until USCG officials can transfer them to the mainland for processing. Historic resources, primarily the Boathouse on Loggerhead Key and the casemates within Fort Jefferson on Garden Key, are occasionally used to temporarily house landed refugees. In recent years the USCG has increased its patrols in the waters around the Park reducing the number of refugees making landfall on the Keys.

The National Park Service has also recently completed an extensive landscape restoration program to remove the Australian Pine and other exotic plants from Loggerhead Key. These invasive species were introduced by Carnegie Institute personnel during the first half of the twentieth century dramatically changing the landscape character of the island. The program has been successful in removing the trees and returning the island to its pre-Carnegie appearance.

With the exception of the Lighthouse which continues to function as an active aid to navigation, the resources of the Dry Tortugas Light Station are primarily used for housing and also to shelter critical components of the island's utility systems. Volunteers from the



Figure 19. Graffiti left by Cuban refugees on wall of Boathouse.



Figure 20. Aerial view of Loggerhead Key showing density of Australian Pine growth prior to de-vegetation project.

VIP program occupy the former original kitchen building for most of the year and the 1922 Keeper's Residence is reserved for intermittent use by National Park Service personnel, researchers or contractors. The USCG also maintains a room in the Keeper's Residence for its use during routine visits to service the light. Visitation to the Park is limited by the Park's General Management Plan Amendment currently limits the numbers of visitors allowed on the island to 24. It also establishes permissible activities allowed on the island which include hiking, picnicking and exploring. The GMPA currently restricts access to the Lighthouse and Light Station buildings by the visiting public until such time as they can be made safe for this level of use.

# Chronology of Development and Use

Historical research conducted in the federal records of the Lighthouse Service, Coast Guard, and National Park Service and investigation of the existing building during the course of the present study provide an understanding of the broad patterns of development and use of the Keeper's Residence at the Dry Tortugas Light Station.

Constructed in 1922-23, the Keeper's Residence was built to provide much-needed residential living space for the principal lighthouse keeper and his family during a period of modernizing the Light Station. The residence underwent several changes during the period of Coast Guard oversight of the Light Station. The floor plan was altered and plumbing system updated in the early 1950's, including the addition of a water line from an elevated tower near the Lighthouse and installation of a hot water heater flue, bathroom fixtures and a kitchen sink. A fire detection system was added in the early 1970's and the interior floor plan altered c. 1982. Major repairs took place in 1985, including additional floor plan changes, rewiring and installation of new fixtures and outlets, replacement of eave fascia & soffit and gutters, as well as installation of new flooring, gypsum board over the walls and ceilings, and new baseboards.

Additional changes have occurred since the National Park Service assumed management of the Station in 1992. The installation of centralized air conditioning, high efficiency appliances, and attic insulation occurred in 2002 as part of a larger project to eliminate environmental problems associated with the use of diesel fuel on the island. The windows were replaced with Pella architectural series thermopane windows in 2003. Although dates of installation are not known, evidence of additional alterations to the building include the installation of a fiberglass shower and new vanity unit in the bathroom as well as the existing composition asphalt shingle roof and metal hurricane shutters on the exterior of the building.

Although the Keeper's Residence has undergone these changes over time, it has retained a substantial amount of its historic materials and continues to express a majority of its historic residential character.

## Original Construction

There were three keepers – the principal keeper and two assistants -- and their respective families residing at the Dry Tortugas Light Station by January of 1917. All three keepers and their family members lived in the original 1858 two-story brick keeper's dwelling. [35]

The earliest correspondence regarding the need for a new Keeper's Residence began in 1916 with a letter from the Office of Lighthouse Inspector



Figure 21: Rear elevation of original 1858 Keeper's Dwelling.

[35] Department of Commerce, Recommendation for Repairing Aids to Navigation, January 3, 1917. Record Group 26: National Archives, Washington, DC.

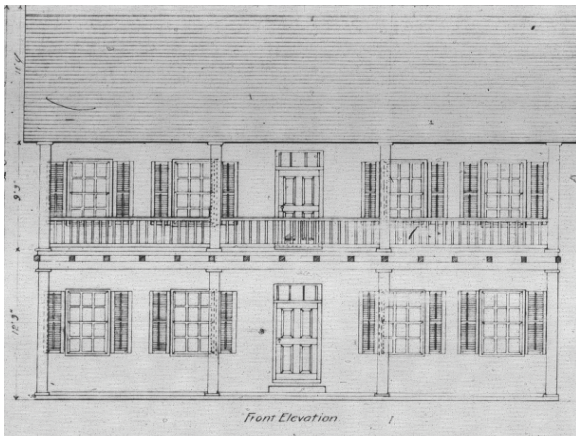



Figure 22: Front elevation of proposed new wood frame Keeper's Residence (1916).

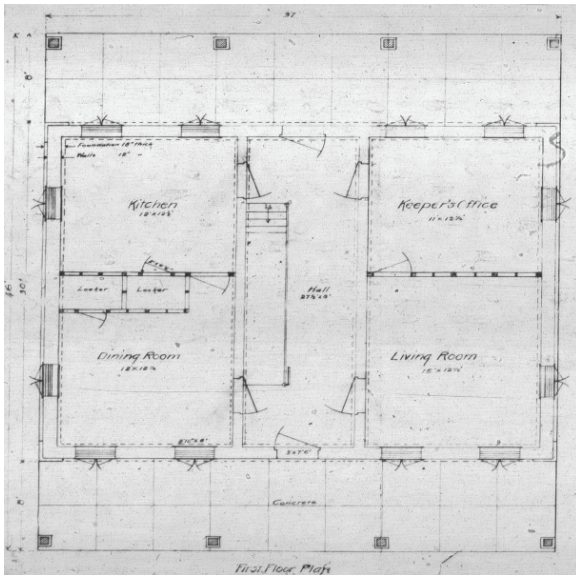



Figure 23: First floor plan of proposed new wood frame Keeper's Residence (1916).

to the Commissioner of Lighthouses in Washington. This letter stated that "the only dwelling that is necessary for light keepers in this district at the present time is one for the Keeper of Dry Tortugas Light Station, Fla." The letter went on to state that "it should be a substantially constructed reinforced concrete or brick structure in order to safely withstand the destructive tropical storms that frequently visit that locality." [36]

Correspondence from the Lighthouse Inspector to the Lighthouse Commissioner in early 1917 indicates that all three keepers and their families were living in the original dwelling. These cramped quarters were considered inappropriate by the lighthouse district superintendant:

> All three keepers and their respective families at present live in the same dwelling, a two-story brick eight-room house with slate roof. The two assistant keepers and their families occupy the lower floor, each having one large room and one small room. The Keeper and family occupy the upper story, which has four rooms, two large and two small. Each keeper has a kitchen in a detached building, and there are two wash houses, also detached. The quarters are entirely inadequate for the number of persons to be housed, and are very inconvenient. The crowding of three families into the same building, which is not designed with a view of keeping them separate, leads to ill-feeling and quarrelling and encourages improper conduct. [37]

## Early Plan Development

George R. Putnam, first Commissioner of the newly organized Bureau of Lighthouses, endorsed the idea of constructing additional quarters at the Dry Tortugas Light Station.

The initial intent of the Lighthouse Board was to build a fireproof concrete building to house multiple keepers and their families that was similar in appearance to the original keeper's dwelling. Schematic drawings and specifications for a new dwelling were published by the Lighthouse Service in late 1916. These plans illustrate a structure very much like the original dwelling, but instead of the two room over two room plan with central hall and stair of the original dwelling, the plans for the new residence reflected a four room over four room layout. The dining room, kitchen, keeper's office and living room are shown on the first floor and four bedrooms with one bathroom on the second floor. The plans were prepared by the Office of the Lighthouse Inspector-Seventh District.

[36] Correspondence from Office of Lighthouse Inspector to Commissioner of Lighthouses, December 5, 1916. Record Group 26: National Archives, Washington, DC.

[37] Department of Commerce, Recommendation for Repairing Aids to Navigation, January 3, 1917. Record Group 26: National Archives, Washington, DC.

Correspondence between the Lighthouse Service and the Seventh District office resulted in several plan changes. It was determined that the structure should be constructed fully of concrete. The first floor walls were to be 8" thick poured-in-place concrete and the second floor walls 6" thick. The interior walls were to be "ribbed metal lath plastered with cement". [38] The project budget was set at $6,500.00.
Over the next several years the drawings and specifications were further developed. Shortly after comments were received on the 1916 set of plans, a second set was published in 1917 that incorporated the changes requested. Concrete was used as a building material based on its fire resistance. Testing of sand samples from the island indicated that with the proper aggregate, it could be used for concrete foundations and posts.

By March of 1920, the wall design changed from poured-in-place concrete to hollow concrete blocks. [39] Anticipating that construction costs would exceed the budget, value engineering strategies were suggested by W.W. Demerritt, the Seventh District Superintendent of Lighthouses, in a letter to the Commissioner of Bureau of Lighthouses:

> In view of the comparatively small appropriation for dwelling at the present high prices, in order to avoid any possibility of over running the allotment, it is proposed to undertake these works in the order mentioned below until funds are exhausted, the other works to be finished with funds from General Expenses, when available: Dwelling; Cistern; Plumbing, including concrete water tower; Concrete walks; and Fence. [40]

In June of the same year, there is further correspondence that most of the plumbing — including fixtures and piping — should be removed from the project to help bring the cost down. [41] By August 1920, Superintendent




Figure 24: Revised front elevation of proposed new concrete Keeper's Residence (1917).

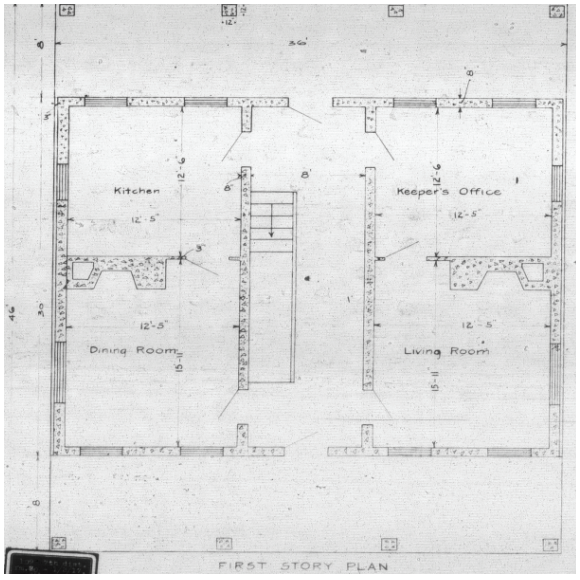



Figure 25: Revised first floor plan of proposed new concrete Keeper's Residence (1917).

Demerritt appears willing to put the project on hold to request additional funding at a later date.

It appears that based on the funding shortage however, the original scope of constructing a residence to house multiple keepers and family members was reduced to building a smaller building to house only the principal keeper and his family. A subsequent set of undated plans was developed based on this change to a single-family residential use. The plans are for a small, square concrete block house with two bedrooms, a dining room, bathroom, pantry and kitchen.

[38] Comments on preliminary plans for Keeper's Dwelling at Dry Tortugas Lt. Sta., January 3, 1917. Record Group 26: National Archives, Washington, DC.
[39] Department of Commerce, Dry Tortugas, Fla., Keeper's Dwelling, March 20, 1920. Record Group 26: National Archives, Washington, DC.
[40] Superintendent of Lighthouses to Commissioner of Lighthouses, March 31, 1920. Record Group 26: National Archives, Washington, DC.
[41] Correspondence from Acting Commissioner of Lighthouses to Superintendent of Lighthouses, June 23, 1920; August 11, 1920. Record Group 26: National Archives, Washington, DC.

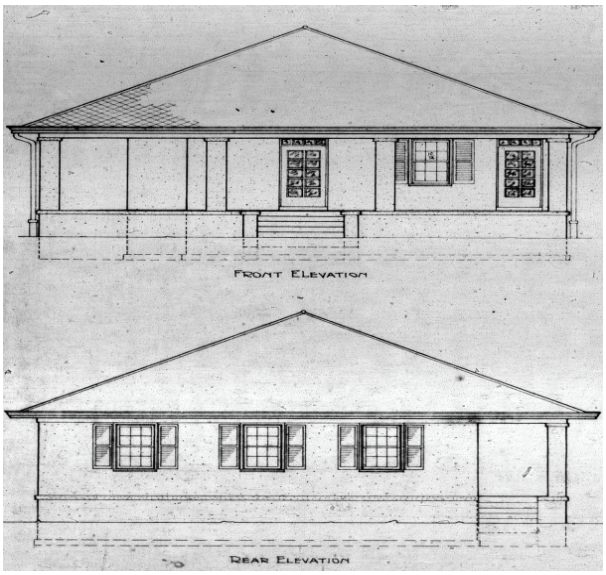



Figure 26: Undated front & rear elevation of proposed new single story concrete Keeper's Residence.

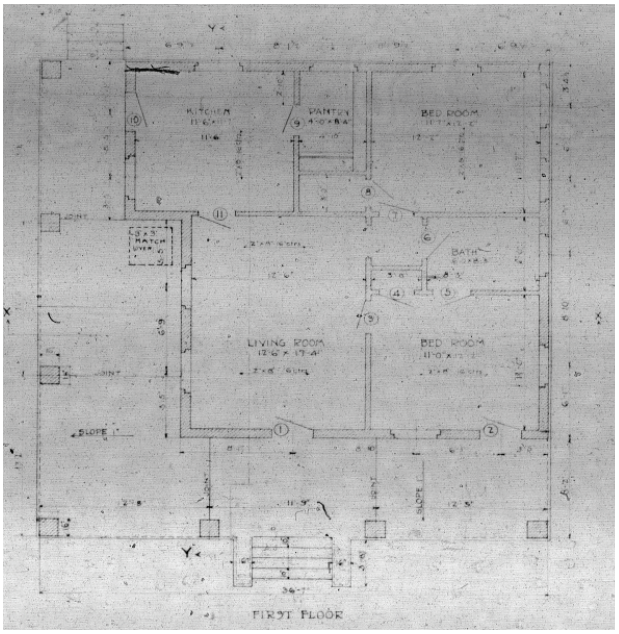



Figure 27: Undated floor plan of proposed new single story concrete Keeper's Residence.

These plans for a smaller residence did not meet approval with Superintendent Demerritt. In correspondence relating to this set of plans, the superintendent commented:

> After comparing the dwelling shown on attached blueprints with other dwellings for keepers in this district, it is the opinion of this office that it is too small for the purpose intended and does not compare favorably with existing accommodations at Dry Tortugas L.S., nor even with the dwellings furnished some assistant keepers of the district. The rooms are too small for comfort in this climate, and there are not enough rooms for some of our keepers with large families. The two bedrooms and the kitchen should be 1-1/2' to 3' larger in length and in width, and an additional room should be furnished, but this latter could be made to the building in the rear of the kitchen with funds from General Expenses, the addition to be used as a kitchen and the present kitchen as a dining room. If this would not be permissible, it would be to the ultimate interest of the Service, and to the keepers of the station, to ask for additional appropriation and wait until sufficient funds were authorized for a more suitable dwelling for the Keeper at this, the most important and finest land station in the district. [42]

The drawings that Demerritt refers to were likely a set of small dwelling plans archived with the remainder of drawings from this period in the National Archives. The plans were never dated or signed as approved but they fit as a logical link in the evolution of the design from the initial large concrete dwelling to the brick bungalow that was ultimately built. The drawings show the concrete block wall construction intended for the larger dwelling while the plan layout resembles a smaller version of what was actually built.

Demerritt's grievances may be easily inferred from the concrete dwelling plans and subsequently resolved with the new plans for the brick bungalow. As constructed, the design for the new Keeper's Residence appears to have incorporated Demerritt's comments – the bedrooms were two feet wider than originally planned and a dining room was added to the building.

While Demerritt was voicing his concern over the plans for the Keeper's Residence, the Lighthouse Service issued an advertisement for bid (No.3344) in August 1920. The specifications associated with this bid indicate the mixes for

[42] Correspondence from Superintendent of Lighthouses to Commissioner of Lighthouses, August 11, 1920. Record Group 26: National Archives, Washington, DC.

the concrete blocks, cement, sand, mixing and placing instructions, mortar mix, and stucco to be used on the concrete blocks. Plaster is specified for interior walls. The framing lumber was to be long-leaf yellow pine as were the floor and subfloor. The subfloor material was to be ⅞" x 6" boards laid diagonally and the floor material ⅞" x 3- ½" prime grade flooring. The ceiling framing was to be long leaf yellow pine of various sizes. The interior mouldings were specified to be cypress. Shelving was specified for the pantry and the kitchen was to receive a china cabinet. The plumbing specification is set up so that the contractor is to rough in all the connections and extend pipes beyond foundations; however, the plumbing fixtures are specifically called out as a separate line item. [43]

No bids are available from this time period, but it appears the price may have exceeded the appropriated limit. Correspondence alludes to internal estimates that imply the design continued to exceed the stated appropriation. By August 18, 1920, the Bureau of Lighthouses had agreed with Demerritt and deferred further action regarding the construction of a new residence at Dry Tortugas "until such time as the allotment can be adequately increased, or until you are otherwise advised in this matter." [44]

## The Keeper's Residence is Funded

Over a year later there is evidence of a shift in construction from concrete to load-bearing brick masonry. The Lighthouse Service prepared a cost estimate in December 1921 with face brick and common brick "to construct a brick dwelling for keeper." [45] Despite allusions to the escalated cost of the residence, every available estimate for the Keeper's Residence — whether it be concrete or brick — from the period of 1916 to 1921 totals $6,500.

In addition to the cost estimate, the 1922 fiscal year appropriations request signals a material change in construction to brick as Superintendent Demerritt described the appropriation for a "brick dwelling for the keeper." In the "Description of Need" section of the appropriations request, Demerritt indicates a renewed need for additional living quarters as the number of keepers present at the Light Station had increased from three to four since the last appropriations request.

> All four keepers and their respective families live in the same dwelling, a two story brick eight-room house, four of the rooms are about 8' x 10'. The quarters are absolutely inadequate for the number to be housed, and now there are four, hence the urgent necessity for additional accommodations for these employees. The overcrowding of four families into the same building which is not designed with a view to keeping them separate and according them a reasonable degree of privacy, leads to ill-feeling and quarreling and encourages improper conduct. It is recommended that funds be reallocated in order that this urgent work can be immediately undertaken. [46]

The Bureau of Lighthouses approved the appropriations request on December 24, 1921. Demerritt then requested that an additional appropriation of $9,200 be issued from the General Expenses, Lighthouse Service for the 1922 and 1923 fiscal years. The funding strategy that he initially suggested in 1920 materialized with a request:

> To afford proper living conditions for the keepers and their families the existing building are to be rearranged, remodeled and fitted with more modern accommodations. A supply of running water will be furnished to all dwellings while sanitary sewers will be constructed to serve them. A systematic arrangement of walks is desirable to facilitate work and improve the general appearance of these grounds. Additional cistern capacity is desirable to conserve the rain water supplied from the available roof areas. [47]

[43] Specifications for Single Dwelling for Keeper. Record Group 26: National Archives, Washington, DC.
[44] Bureau of Lighthouses to Superintendent of Lighthouses, August 18, 1920. Record Group 26: National Archives, Washington, DC.
[45] Estimate of Cost of Proposed Works, Lighthouse Service, Department of Commerce, December 12, 1921. Record Group 26: National Archives, Washington, DC.
[46] Request for Appropriations (Form 80), Superintendent of Light Houses to Bureau of Lighthouses, December 12, 1921. Record Group 26: National Archives, Washington, DC.
[47] Recommendation as to Aids to Navigation, Superintendent of Light Houses to Commissioner of Lighthouses, April 28, 1922. Record Group 26: National Archives, Washington, DC.



Figure 28: Early view of Keeper's Residence.

It appears from this sequence of appropriations requests that the Keeper's Residence was built without plumbing and that this later appropriation provided those systems.

## Construction

After evolving through these design iterations, the Keeper's Residence was constructed with a configuration smaller than originally planned. It is assumed that Keeper Charles H. Johnson, appointed in 1919, and his family occupied the house upon its completion in 1923.

An undated site plan of the Light Station shows the proposed dwelling for keeper to be located approximately the same distance from the Lighthouse as the 1858 keeper's dwelling but on the northeast side of the station.

In plan the new structure was laid out parallel to the existing keeper's dwelling so that the main entrance and porches of both buildings faced the same eastern direction.

The bungalow building type with Craftsmen elements was typical of residential bungalows being constructed throughout America's suburbs during this period. The completed building is a single story brick building with a hipped roof with a slight flair at the roof edge. As constructed, the residence did not resemble the first drawings for the Keeper's Residence, but did resemble the small concrete dwelling shown in Figures 25 and 26. The plan, roughly 50' x 35', consisted of front steps centered on a central door.

The original floor plan in the 1921 architectural plans was typical of bungalows of this period. The original plans show the Living Room, Dining Room, Pantry and Kitchen on the southwest side of the building and the Porch, Bedroom, Bathroom and another Bedroom on the northeast side. The Living Room and Dining Room were separated by a wall with a cased opening. A door on the northwest side of the rear wall of the Dining Room led to the Pantry. A small vestibule was directly opposite the Pantry and led to a bathroom between the bedrooms. The front bedroom had direct access to the front porch through door D2. [48]

[48] Architectural Drawing, "Floor Plan for Keeper's Brick Dwelling," December 2, 1921. Record Group 26: National Archives, Washington, DC.

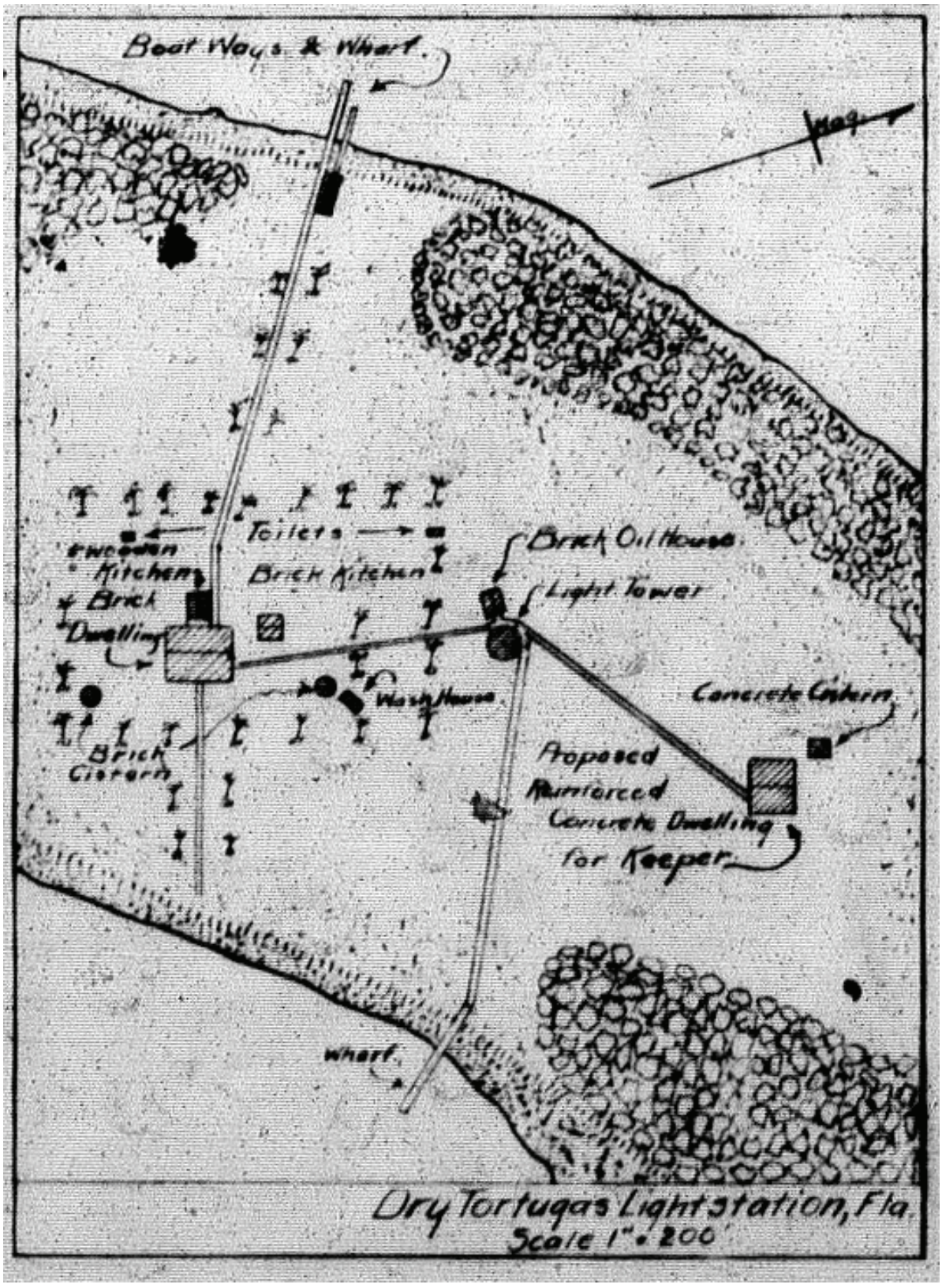



Figure 29: Undated Light Station Site Plan – note proposed site of new Keeper's Residence to the northeast of the lighthouse.

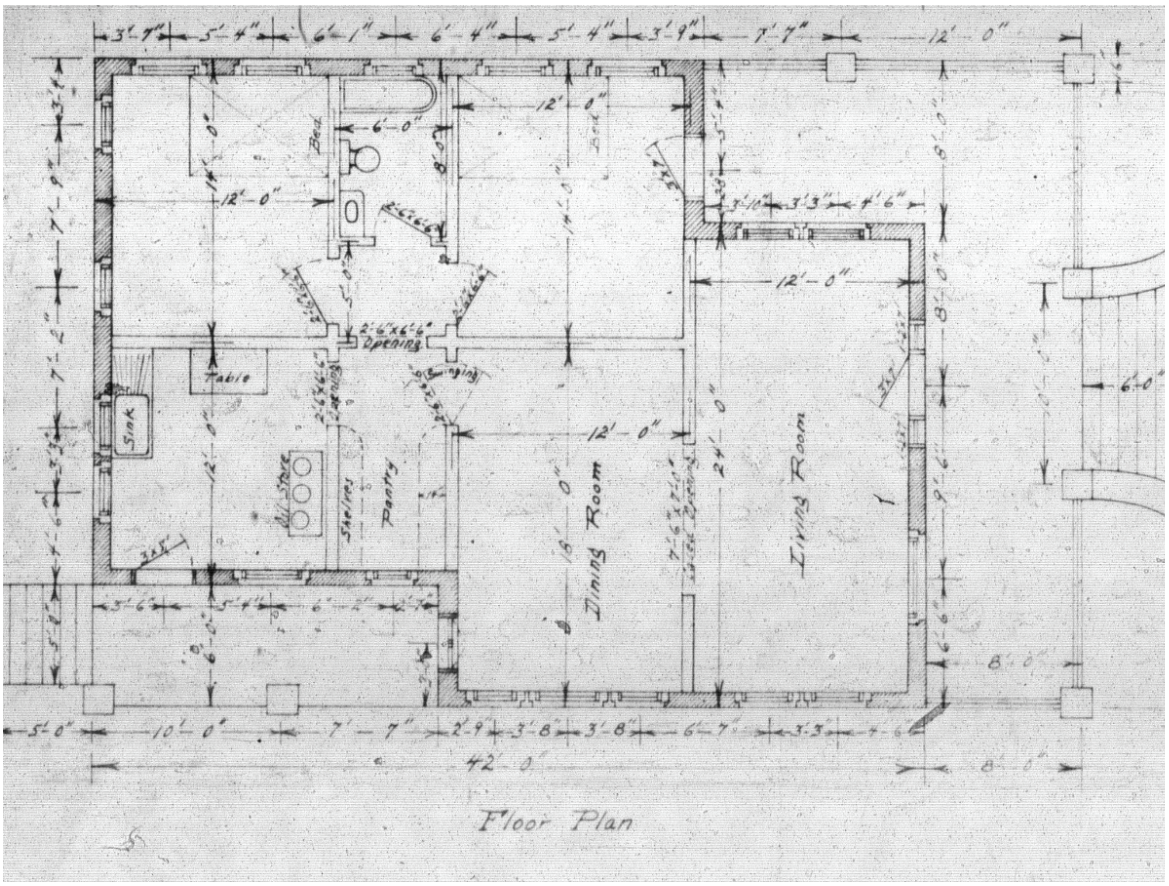



Figure 30: Floor plan of Keeper's Residence as it was constructed (1921).

The 1920 construction specifications and 1921 architectural plans indicate that 14 of the windows were six-over-six double-hung wood windows with sash and frames constructed of yellow pine and a single casement window of eight-light casements located on the northwest elevation. The specifications and historic images further indicate that the windows of the Keeper's Residence included operable wood shutters. Some shutters were Bahama-style shutters that were hinged at the window head and opened out from the sill while others were standard shutters hinged along the window jambs that opened flat again the outside walls. The specifications and historic images indicate that the window sash and frames were painted white and the shutters green. [49]

The architectural plans indicate that the original roofing and sheathing for the Keeper's Residence were hexagonal asbestos shingles and tongue and groove wood, respectfully. The *Items, Quantities, and Unit Prices* in the December 12, 1921 *Estimate of Cost of Proposed Works* includes "14 squares" of "hex asbestos shingles at $19 per square". In addition, architectural drawings dated July 19, 1985 indicate that the roofing was asbestos shingles and sheathing was 1" x 4" tongue and groove wood at that time.

The plans also indicate that the building was intended to have gutters and downspouts, with the downspouts located in the middle of the northwest elevation and at the juncture of the front porch and masonry wall on the northeast and southwest elevations. Historic photographs dating from the period of construction indicate that the house originally had fascia-hung gutters and downspouts at these locations. The

[49] "Specifications for a Single Dwelling for Keeper at Dry Tortugas Lightstation, Florida," August 10, 1920. Record Group 26: National Archives, Washington, DC, 7.

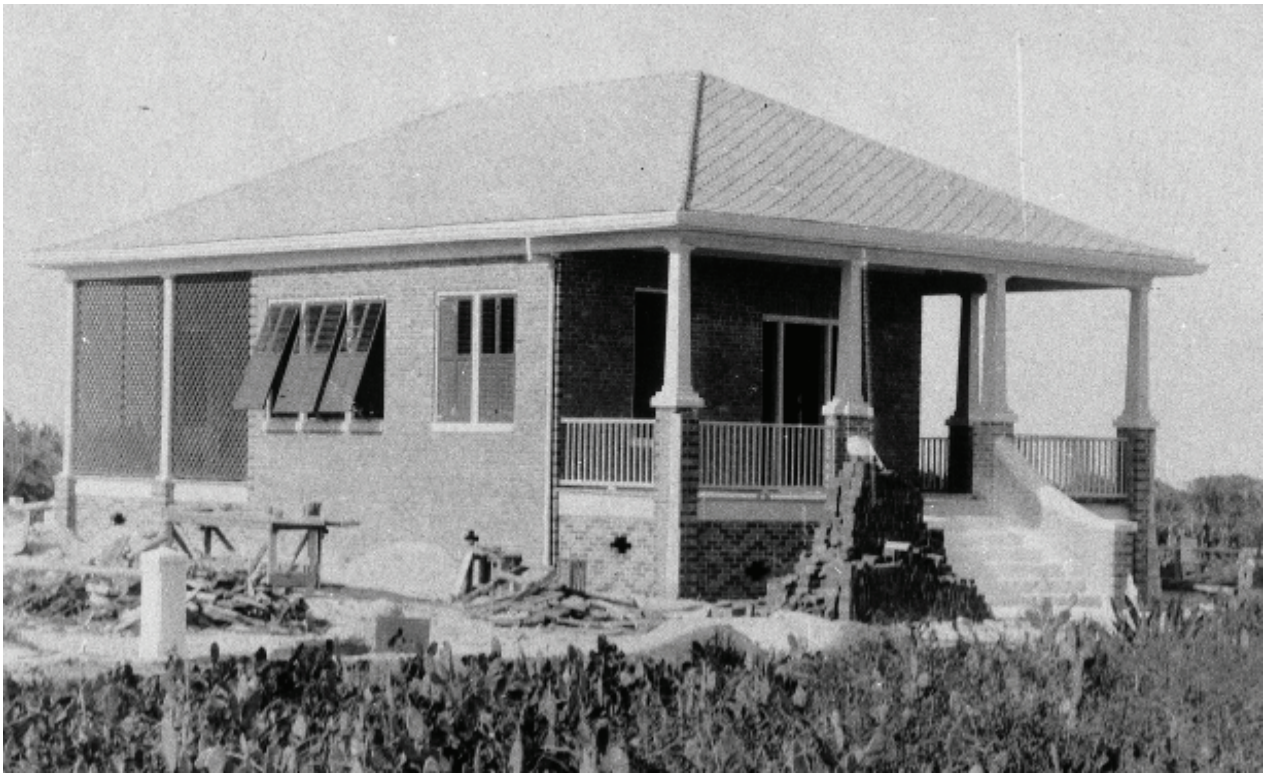


Figure 31: Early view of Keeper's Residence

specifications indicate that gutters and leaders shall be No. 26 gage "Armco" iron or equal, heavily galvanized. Leaders shall be 4 inches in diameter, joints riveted and well soldered. Leaders shall be well supported and secured to swelling with substantial galvanized iron fittings."

The specifications also outlined the characteristics of interior moldings, including that all interior trim would be of cypress; window and door trim and base board would be of plane section with rounded edge or edges; molding at intersection of ceiling and side walls would be of a plain strip, ¾ x 3 inches with lower edge rounded, and a 1 inch quarter round molding; door and window casings and apron would be approximately 7/8 x 4¼ inches and baseboard 7/8 x 7½ inches; and joint at base and floor would be finished with 1 inch quarter round molding. [50]

[50] "Ibid,,4.

## The Keeper's Residence Undergoes Gradual Changes

The Coast Guard and National Park Service were able to provide drawings of projects that were completed at the Keeper's Residence over time. These drawings give us a glimpse into the types and timing of changes that took place to the building.

The U.S. Bureau of Lighthouses was amalgamated into the operations of the U.S. Coast Guard in 1939. After the Coast Guard acquired oversight of the Light Station, the function of the Keeper's Residence changed from a single family dwelling to more of a bunkhouse as crews of officers began manning the island. The number of officers stationed increased to between seven and twelve per month, but family members were not allowed to live on the island during this period.

Before the 1950s, there appear to have been no significant changes to the building. The wood elements of the house were certainly repainted during this early period, probably maintaining

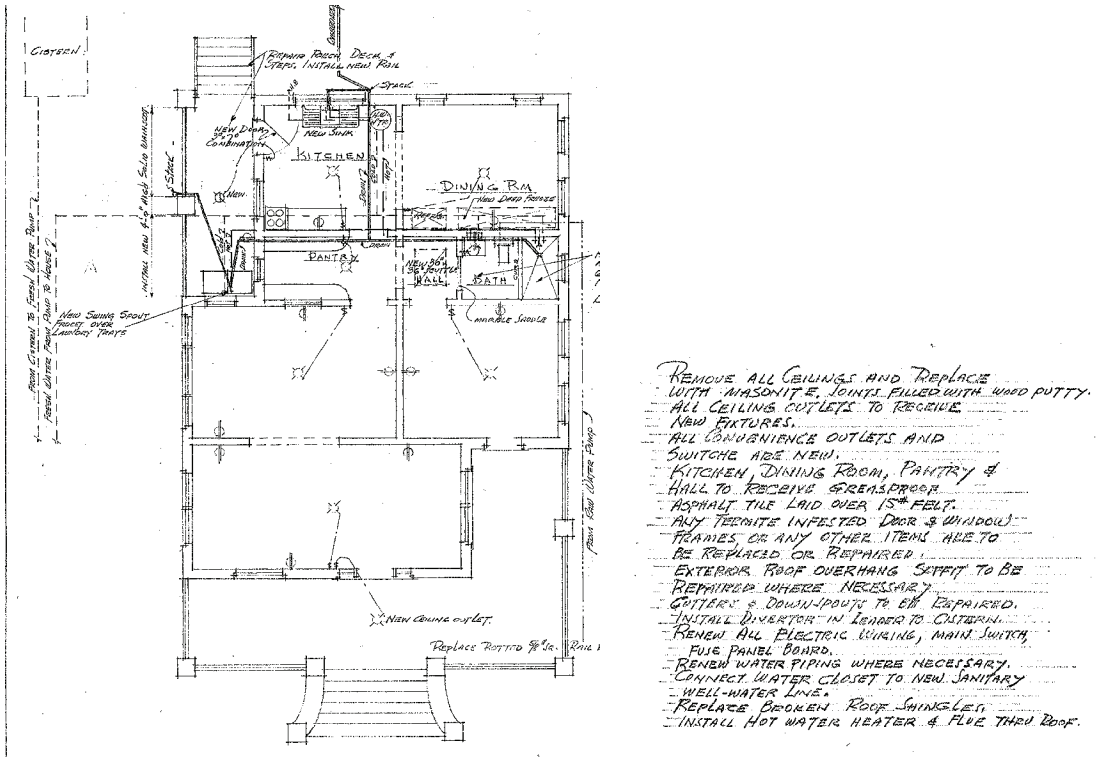



Figure 32: "Quarters Building" from 1951 Improvements to Sanitary Facilities (dated 8/27/51).

the original colors, which were described as white trim with green blinds.

In 1951 the Keeper's Residence was renovated under the scope of a project entitled *Improvements to Sanitary Facilities*. A 1-1/2" water line was planned to run from elevated water tanks near the Lighthouse to the northeastern elevation of the residence. The project included removing and replacing all ceilings with masonite and providing new ceiling fixtures. There is currently no physical evidence that masonite was installed, though it could have been removed at a later date. The kitchen, dining room, pantry and hall were to receive "greasproof [sic] asphalt tile laid over #15 felt." [51] Windows or doors that were termite infested were to be repaired or replaced. The exterior elements — gutters, downspouts, soffits and roof shingles were to be repaired as necessary. The drawings instruct that wiring and plumbing should be "renewed where necessary." [52] A new sink was to be installed in the kitchen and a water heater flue installed through the roof. A new tile floor and wainscot was to be installed in the bathroom and new plumbing fixtures added. A lead pan was to be installed under the shower.

In addition, two changes to the floor plan were implemented at this time. A portion of the wall between the kitchen and original bedroom (now dining room) at the northeast end (rear) of residence was removed to create a combination kitchen/dining room and a door opening between the bathroom and rear bedroom (now dining room) was enclosed to create a square hall.

## Changes in the 1960s and 1970s

Air conditioning was installed in the Keeper's Residence in 1969. The project included instillation of five window units (1-8,000 BTU and 4-13,000 BTU), a ceiling exhaust fan for the kitchen and glass fiber insulation in the attic. [53]

[51] Architectural Drawing, "Improvements to Sanitary Facilities, Dry Tortugas Light Station, Loggerhead Key, Florida," August 27, 1951, Archives, United States Coast Guard 7th District, Miami, FL.
[52] Ibid.

[53] Architectural Drawing, "Barracks Building Air Conditioning, Dry Tortugas Light Station, Loggerhead Key, Florida," April 10, 1969, Archives, United States Coast Guard 7th District, Miami, FL.

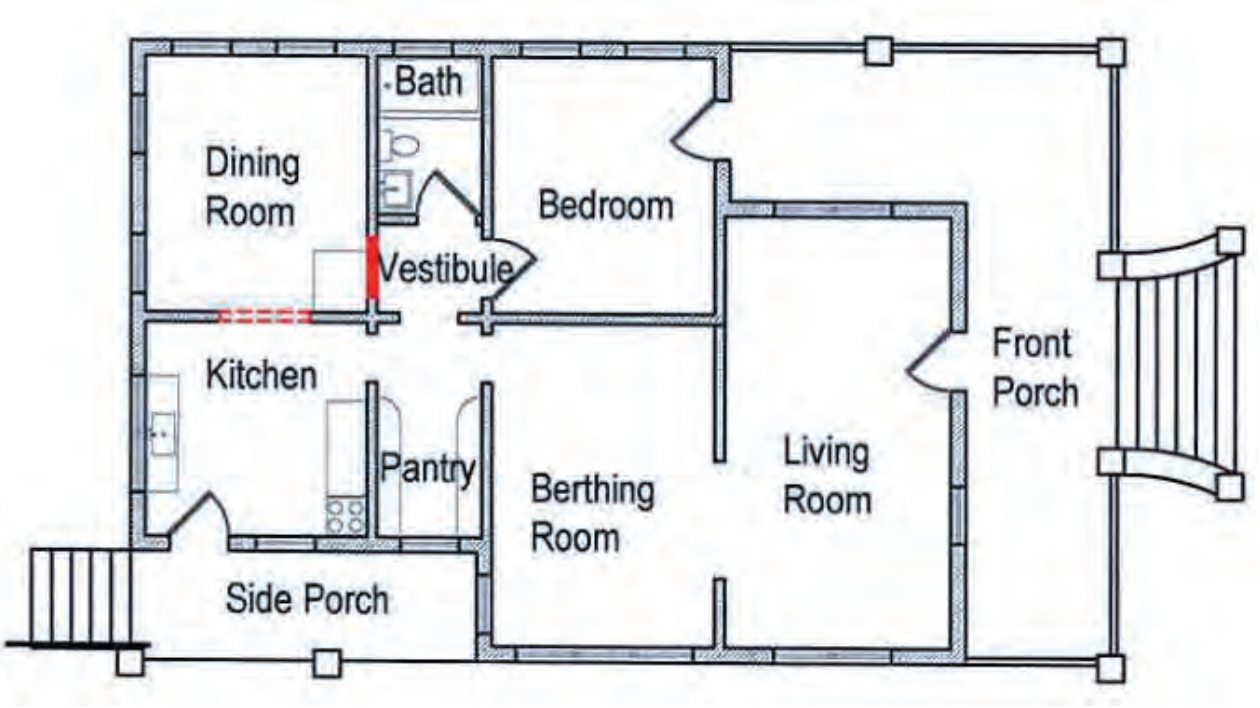



Figure 33: Changes in floor plan following 1951 project *Improvements to Sanitary Facilities*.

Based on a review of available architectural drawings, it appears that a lay-in suspended acoustical tile ceiling was installed on the interior sometime between 1969 and 1989. The original double-hung windows were also removed during this period, and replaced with awning and jalousie windows. It is likely that the original Bahamian style exterior shutters were removed when the original windows were replaced.

A fire detection system was installed in 1971 in the Keeper's Residence. Surface mounted ionization detectors were installed in the front rooms and thermal detectors were placed in the kitchen, dining, pantry and hallway. A control panel was located in the pantry and three manual switches installed — one each in the private bedroom, living room and kitchen. [54]

## Modifications in the Late 1980s

Additional changes to the Keeper's Residence took place in the mid-to-late 1980s. The interior floor plan was altered c. 1982 by adding interior walls to separate the front room into two separate spaces with a corridor between them. Drawings dated August 22, 1985 illustrate as-built conditions for a rehabilitated Keeper's Residence and these new walls are shown as "existing work to be removed."

The floor plan was altered again c. 1989 based on "as-built" drawings dating from that year. The walls added in the early 1980s are shown as removed, and a new wall was provided to create a second private bedroom in what was originally the dining room —subsequently shown in later plans as the berthing room.

The new wall formed a hall that leads from the Living Room at the front of the house to the Kitchen/Dining Room at the rear, with a bedroom and laundry room on the southwest side and the front bedroom, vestibule, and bathroom along the northeast side of the house. The existing plan configuration is different from the original layout, but offers roughly the same

[54] Architectural Drawing, "Barracks Building Fire Detection System, Dry Tortugas Light Station, Loggerhead Key, Florida," April 6, 1971, Archives, United States Coast Guard 7th District, Miami, FL.

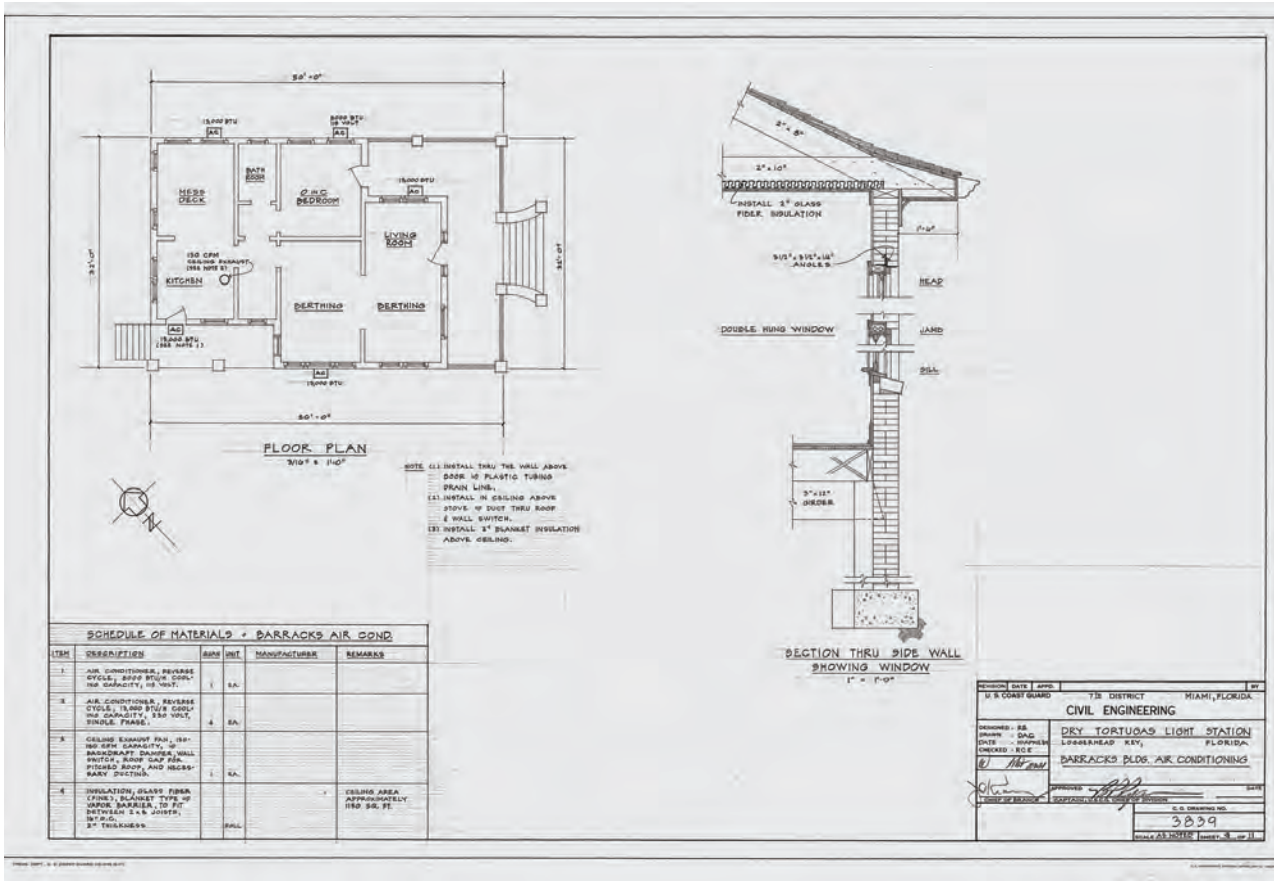


Figure 34: Changes in floor plan following 1951 project *Improvements to Sanitary Facilities*.

type and quantity of spaces as originally planned. [55]

The drawing at right (Figure 38) is a composite showing the evolution of changes to the Keeper's Residence floor plan over time. The house was completely rewired during this period. Except for the main service to the distribution panel, all existing wiring was removed and replaced with non-metallic conduit (NMC). Existing fixtures and outlets were removed and replaced with fluorescent light fixtures in the house and incandescent fixtures on the porches. Both the fire alarm and electrical panels were replaced. [56]

Also in the late 1980s in a letter from the Commander of Coast Guard Group Key West to the Commander of the Seventh Coast Guard District, the following observations were made, "failure of the mortar in the masonry at the main house is contributing to the collapse of both the front and rear porches" and "the rear area of the main house is infested with termites and the entire structure is overdue for tenting." [57] Based on information in a "Dwelling/Lighthouse Condition Survey" for the Crew's Quarters completed in November 1991, the structural issues with the front and back porch foundation walls were corrected in 1989. [58]

[55] Architectural Drawing, "Crew's Quarters Floor Plan, Dry Tortugas Light Station Rehabilitation, Dry Tortugas Light Station, Loggerhead Key, Florida," August 22, 1989, Archives, United States Coast Guard 7th District, Miami, FL.
[56] Architectural Drawing, "Electrical Plans, Dry Tortugas Light Station, Loggerhead Key, Florida," August 22, 1989, Archives, United States Coast Guard 7th District, Miami, FL.
[57] Letter, Commander of Coast Guard Group Key West to Commander of Seventh Coast Guard District, May 4, 1989; Archives: National Park Service, Everglades National Park, Homestead, FL.
[58] Dwelling/Lighthouse Condition Survey of Crew's Quarters, November 10, 1991; Archives: National Park Service, Everglades National Park, Homestead, FL.

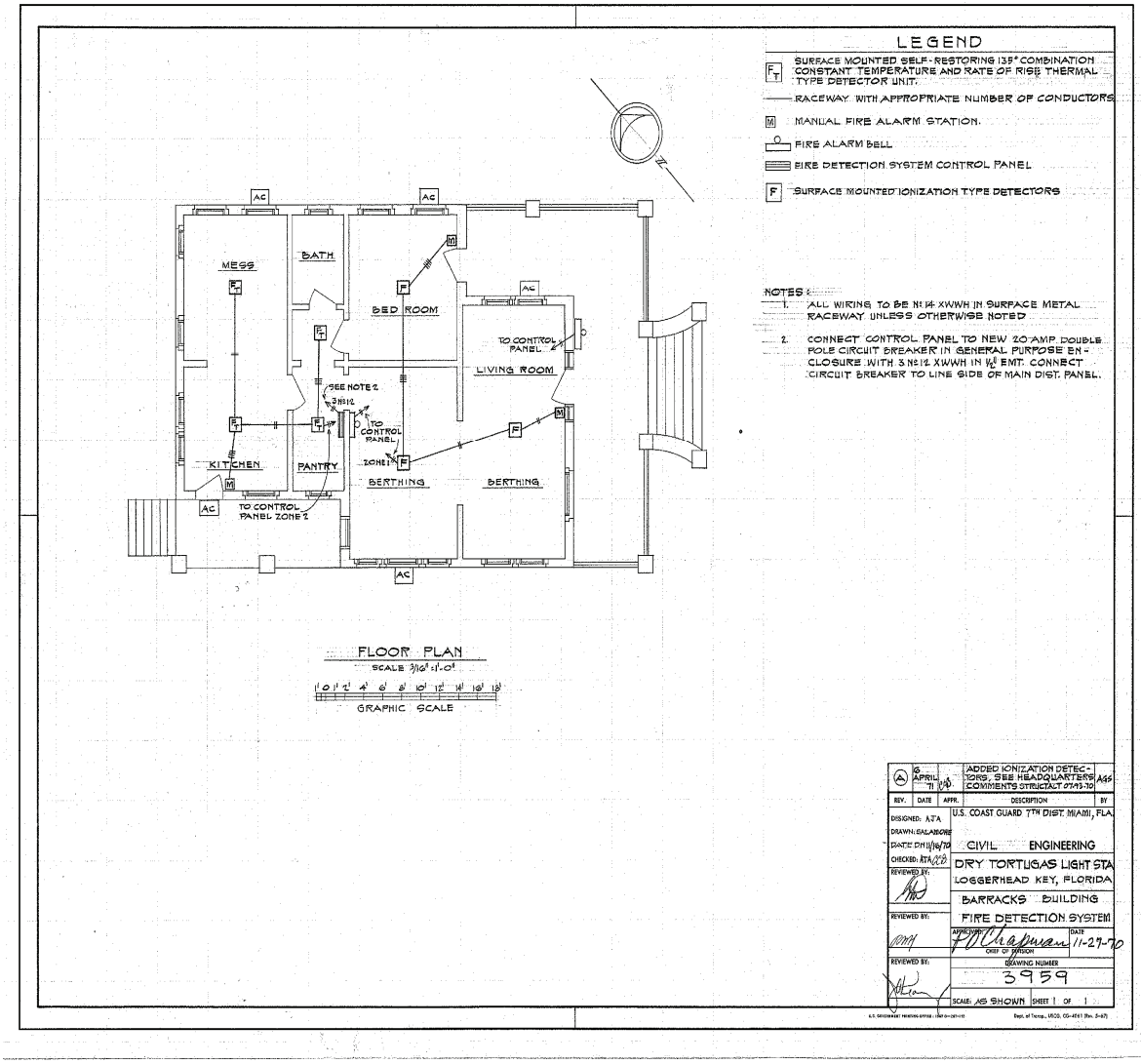



Figure 35: Barracks Building Fire Detection System from 1969 (dated 6 April '71).

In addition, the following changes to the exterior and interior of the building took place during the late 1980's.

- Original eave fascia and soffit components removed to repair rafters and joist tails – replaced with new ½" x 14" plywood soffit, 4" continuous fiber glass screen, quarter round wood molding, and 1" x 8" wood fascia.
- New PVC gutters installed at eave
- Existing 1" x 12" cornice fascia retained and 7/8" x 3¾" molding removed.
- Exterior side door at rear of residence replaced.
- Vinyl asbestos tile (VAT) installed in Rooms front room, hallway, pantry, bathroom, and kitchen/dining room.
- Half-inch gypsum wall board and 1" x 2" furring strips installed over plaster walls.
- Removal of existing lay-in suspended **ceiling revealing historic crown molding** concealed within and installation of gypsum board over the original pine ceilings.
- Original 7/8" x 7½" base board removed and new ¾" x 4" wood baseboard and

shoe molding installed throughout the residence. [59]

## National Park Service Modifications

There have been several changes to the Keeper's Residence since the NPS acquired oversight of the station in 1992. In 2002, power on the island was converted from the diesel powered generators to photovoltaic electric generation and battery storage. Part of the project included equipping the Keeper's Residence with high efficiency appliances, installing a centralized air handling unit and adding insulation. The ceiling was dropped above the hallway to accommodate the new unit and the compressors are visible on the exterior of the residence. [60]

Soon thereafter, in 2003, the existing windows were replaced with Pella architectural series thermo pane windows because the existing windows would not close and were not keeping the elements out of the structure. The six-over-six pane sash of the new windows matches the pane configuration of the original windows. The PMIS 48292 with the cost of $22,500 notes that the replacement windows were approved by the National Park Service Southeast Regional Office and the Florida State Historic Preservation Officer. [61]

Although dates of installation are not known, evidence of additional alterations to the Keeper's Residence includes the installation of a fiberglass shower and sink and cabinet unit in the bathroom and metal storm shutters and tracks at window exteriors.

Currently, the Keeper's Residence consists of the living room; central hallway; bedroom added in the original dining room; Coast Guard office located in the former front bedroom; laundry room added in the original pantry; bathroom; and kitchen/dining room (at the original rear bedroom).

The building is currently used to provide housing for contractors and visitors to the Light Station. The living room is used as general living space and bunk room. The pantry and vestibule have been modified to accommodate electrical panels, a washer/dryer unit and the dropped ceiling for the HVAC duct work. Considerable thought and planning went into building a new Keeper's Residence on Loggerhead Key. From 1916 to 1921 the plans were reduced from a large two-story, four bedroom concrete structure to a single story brick bungalow due to budgetary constraints.

Over time, the plan of the bungalow has changed and the systems, windows and doors have been replaced. The Keeper's Residence standing today has been through several renovations but maintains a majority of its historic residential character.

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[59] Architectural Drawing, "Crew's Quarters Floor Plan, Dry Tortugas Light Station Rehabilitation, Dry Tortugas Light Station, Loggerhead Key, Florida," August 22, 1989, Archives, United States Coast Guard 7th District, Miami, FL.

[60] "Convert From Diesel to Photo-Voltaic Electric Generation - Loggerhead Key, PMIS 71050," April 23, 2008 (date of last update), National Park Service, Southeast Regional Office, Atlanta, GA.

[61] "Replace Windows – Lighthouse Keepers Quarters - Loggerhead Key, PMIS 48292," September 13, 2006 (date of last update), National Park Service, Southeast Regional Office, Atlanta, GA.

## Dry Tortugas Keeper's Residence Timeline

| | |
|---|---|
| 1916 | Early correspondence regarding the need for a new Keeper's Residence. |
| 1917 | Preliminary plans for new Keeper's Residence prepared. |
| 1919 | Charles H. Johnson appointed Principal Keeper |
| 1920 | $6,500 authorized for a two-family residence |
| 1922 | June – Materials and construction crew arrive to complete new residence. |
| 1923 | New Keeper's Residence 90% completed – interior trim work remains to be completed. |
| 1939 | U.S. Bureau of Lighthouses amalgamated into the operations of the U.S. Coast Guard. |
| 1951 | Keeper's Residence renovated under scope of "Improvements to Sanitary Facilities Project" - scope included removing a portion of the wall between the kitchen and original bedroom (now dining room) at the northeast end (rear) of residence to create a combination kitchen/dining room; enclosing door opening between bathroom and rear bedroom (now dining room) to create a square hall; addition of water line; removal and replacement of ceilings with masonite; new ceiling light fixtures; greaseproof asphalt tile installed in kitchen, dining room, pantry, and hall; windows and doors repaired or replaced as necessary; gutters, downspouts, soffits, and roof shingles repaired as necessary; new sink installed in kitchen; hot water heater flue installed through the roof; new tile floor and wainscot installed in bathroom; new plumbing fixtures added; and a lead pan installed under the shower. |
| 1969 | Five window air conditioning units, ceiling exhaust fan, and 2" glass fiber insulation in the attic installed in the residence. |
| 1969-1989 | Lay-in suspended acoustical tile ceiling installed on the interior and awning windows installed to replace original double-hung wood windows. |
| **1971** | Fire detection system installed in the residence, with surface-mounted ionization detectors placed in the front rooms and self-restoring 135 degree combination constant temperature and rate of rise thermal detectors installed in the kitchen, dining room, pantry, and hallway. |
| **1982** | The original interior floor plan was altered by adding interior walls to separate front room into two separate spaces with a corridor between them. |
| **1985-1989** | Rehabilitation of Crew's Quarters<br>■ New PVC gutters installed at eave<br>■ Original eave fascia and soffit components removed to repair rafters and joist tails – replaced with new ½" x 14" plywood soffit, 4" continuous fiber glass screen, quarter round wood molding, and 1" x 8" wood fascia.<br>■ Existing 1" x 12" cornice fascia retained and 7/8" x 3¾" molding |

removed.

- Exterior side door at rear of residence replaced.
- Floor plan altered by removing the walls installed ca. 1982 and new stud partition wall constructed to create a central hallway and second bedroom.
- Vinyl asbestos tile (VAT) and carpeting installed as flooring finish in all rooms.
- Half-inch gypsum wall board and 1" x 2" furring strips installed over the plaster walls.
- Removal of existing lay-in suspended ceiling revealing historic crown molding concealed within and installation of gypsum board over the original pine ceilings.
- Original 7/8" x 7½" base board removed and new ¾" x 4" wood baseboard and shoe molding installed throughout the residence.
- Residence rewired – main service to panel retained; all existing wiring removed and replaced with non-metallic conduit (NMC); existing fixtures and outlets removed and replaced with fluorescent light fixtures in the house and incandescent fixtures on the porches; electrical panel and fire alarm replaced.

**Post 1989** Installation of existing gray composition asphalt shingle roofing.

**March/April 2002** HVAC, insulation and high efficiency appliances installed; hallway ceiling lowered to improve HVAC; and residence connected to solar power unit.

May 2002 Underground passive solar water heater installed.

December 2004 Windows replaced with six-over-six, double-hung Pella architectural series thermo-pane windows.

2009 Development of HSR

# Physical Description

## Dry Tortugas Keeper's Residence

The Keeper's Residence was constructed in 1922-23 during a period when the Dry Tortugas Light Station was being modernized. It was built as living quarters for the principal lighthouse keeper and his family. Prior to this, the principal keeper as well as two assistant keepers and their families were living in the original 1858 keeper's dwelling. The original kitchen building was also converted into living quarters during the 1920s modernization of the Light Station.

Several years of correspondence regarding the need for and design of a new keeper's residence ensued following initial requests for a new residence in 1916 by the principal keeper. Though it is unknown if there was a standard design for keeper's residences in the early twentieth century, most residences were constructed in an architectural style similar to that of other modest homes in the surrounding areas. [1]

This was true of the new Keeper's Residence, as it was a bungalow house type designed with elements of the Craftsman style that was popular in America's developing suburban residential areas during the first part of the twentieth century. The one-story brick bungalow was designed in a rectangular plan and measured 32' x 51' (overall outside dimensions). The building has load bearing brick masonry walls and wood-frame floor and roof structural systems. The building's hipped roof is covered with composition asphalt shingles. The exterior wall finish is buff yellow brick laid in a modified Flemish stretcher bond with contrasting red bricks at the building corners.

An engaged L-shaped front porch wraps approximately half-way around the northeast side of the residence. The porch roof structure is supported by tapered wood columns resting on brick piers trimmed at the corners with coral stone buttresses. The brick piers are a mixture of yellow and red brick. An engaged rear porch provides access to the rear entry into the residence. Foundation piers, porch foundations, and brick balustrade for the porch steps are faced with the same yellow brick as used on the rest of the residence. In addition, these masonry elements have contrasting red brick arranged to create a diamond-shaped pattern.

Generally, significant changes to the building since its construction include replacement of the original double-hung wood windows, first with metal jalousie windows and then with modern double-hung thermo pane window units. The louvered wood shutters originally installed on the building have been removed. Original exterior doors have been replaced with wood panel doors and the front door surround has been removed and replaced with plywood.

The original porch balustrade has been removed and replaced with turned balusters that are not in keeping with the architectural character of the building. The original interior floor plan was altered and the ceiling and wall surfaces covered



Figure 43: 2009 View of Keeper's Residence and surrounding landscape.

[1] Ray Jones, *The Lighthouse Encyclopedia: The Definitive Reference*. Guilford, Connecticut: The Globe Pequot Press, 2004, 95.

with modern gypsum board. A more detailed description of existing building characteristics follows below.

## Character Defining Features

Character-defining features of the Keeper's Residence are those elements of the building that significantly contribute to the building's character and therefore should be maintained and preserved.

Despite the changes to the residence described above, the building retains the overall historic architectural character. These character-defining features include:

- Isolated and sparsely vegetated subtropical setting – The character of the surrounding landscape is one of the Light Station and Keeper's Residence most unique and important features contributing greatly to the resources sense of place.
- Relationship between the residence and tower as well as other associated structures of the Light Station
- Southeast to northwest siting of the building with the primary façade facing Fort Jefferson
- Craftsman Style form and detailing
- Rectangular plan and one-story height
- Wood roof and floor framing systems and load-bearing brick masonry wall structure
- Hipped roof with overhanging wood eave and slight flair at the soffit
- White paint color of exterior wood trim and other elements -- results from paint sampling from the exterior woodwork show eleven layers of white and cream paint.
- Exterior masonry wall finish of buff yellow brick with detailing of contrasting red bricks alternating courses at building corners and diamond-shaped patterning
- Portland Cement Mortar – results from mortar sampling from exterior masonry show mortar consisting of one part Portland cement and 2.4 parts local carbonate sand (contains no lime or natural cement)
- The original configuration of exterior door and window openings on all sides of the building
- Concrete stairs and brick/coral stone cheek walls leading to front porch/entrance
- Unique coral stone buttressing at building corners
- Windows are considered character-defining features of the residence -- the existing modern units that were installed in 2003 replicate the appearance and pane configuration of the original windows
- Exterior window trim with flat casings and concrete sills
- Engaged front (east) wrap-around porch with tapered wood columns on brick piers with coral stone caps and detailing, narrow-board ceiling, tongue and groove flooring, and cement stairs with brick and cement cheek walls



Figure 44: 2009 view of Keeper's Residence with concrete walkway in foreground.

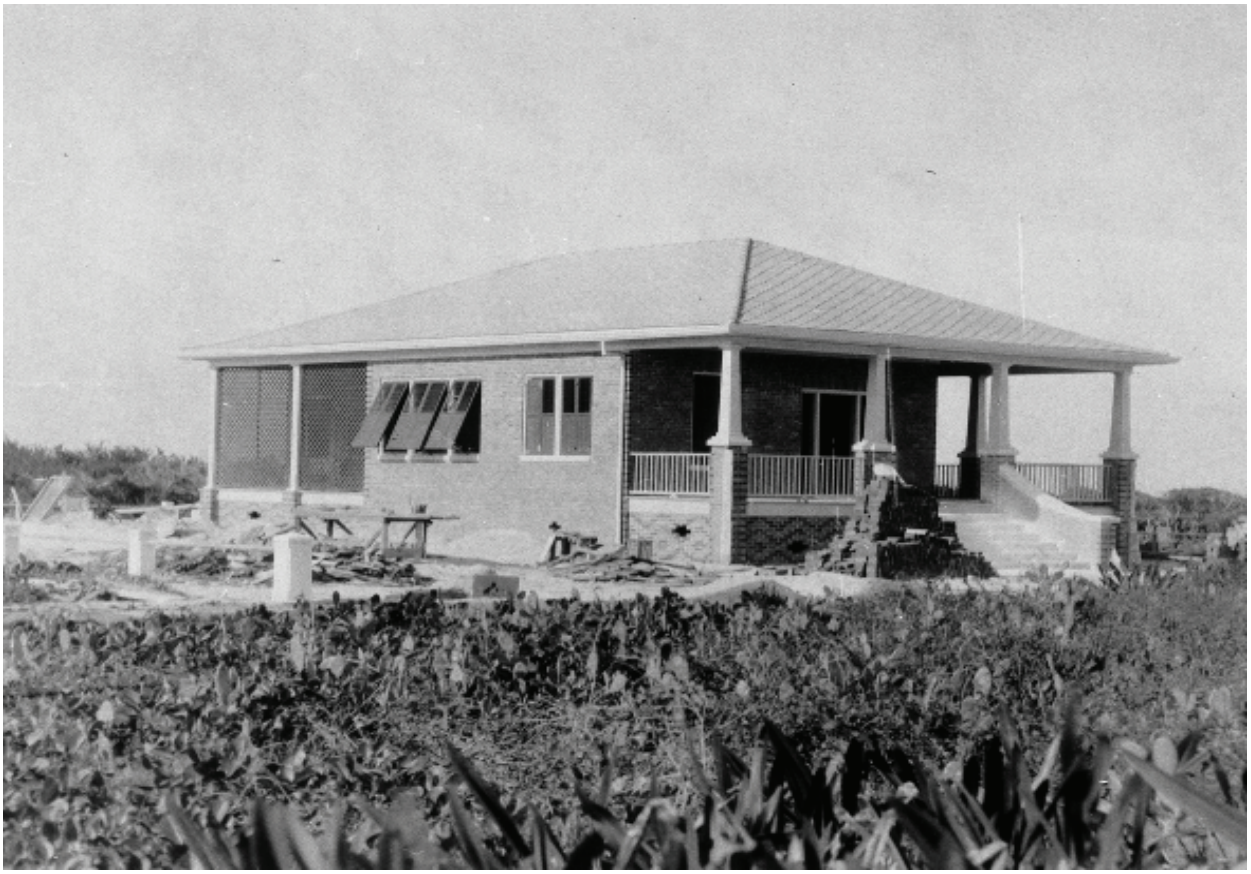


Figure 45: Circa 1923 view of Keeper's Residence nearing completion.

- Unique coral stone buttresses at building corners on the main elevation
- Engaged rear (south) porch with square wood post supports, narrow-board ceiling,
- tongue and groove flooring, and concrete stairs
- Interior plaster on wood lathe wall finish – results from plaster sampling from interior plaster show two-coat system with a gypsum and sand-based scratch coat and gypsum-based finish coat gauged with lime
- Interior wood ceiling covered with non-historic gypsum board ceiling finish
- Wood crown molding located at the juncture of the original plaster walls and ceilings
- Interior wood flooring covered with non-historic vinyl composition tile and carpeting
- Interior door and window trim with flat casings at the heads and jambs

## Site

The Dry Tortugas Keeper's Residence was constructed in 1922-23 during a period of modernization of the Light Station. The Keeper's Residence is located approximately 150 feet northeast of the Lighthouse. It is sited southeast to northwest with its primary façade facing southeast toward Fort Jefferson.

The surrounding landscape is comprised of sand, scrub grass and several palm trees. Existing site features include a series of intersecting concrete walkways that connect the Keeper's Residence to the light house and other buildings at the station. These walkways also connect the front of the residence to the rear along the



Figure 46. Lowest two courses of reddish-brown brick of exterior walls above grade.



Figure 47: One of three interior brick piers supporting the Keeper's Residence.



Figure 48: Cross-shaped vent in the foundation walls providing ventilation.

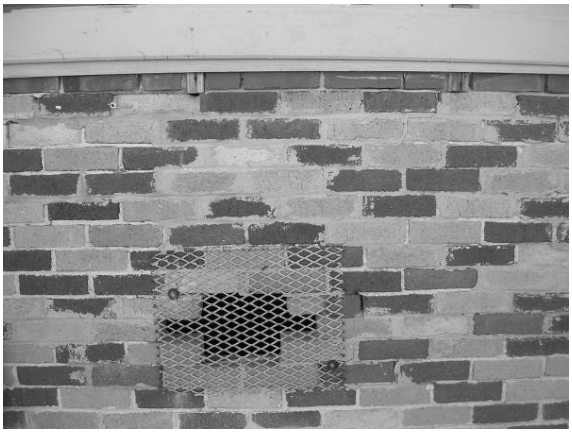


Figure 49: Typical past repointing efforts at the exterior face of foundation walls.



Figure 50: Loss of mortar in horizontal and vertical masonry joints at southwest front porch wall.

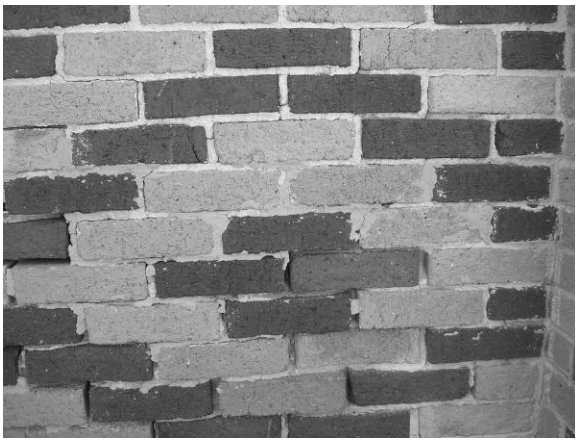


Figure 51: Loss of mortar in masonry joints and evidence of past repointing efforts at left side of front porch foundation wall on southeast elevation.

southwest elevation. A concrete cistern is located adjacent to the residence, approximately 25' from the south corner of the house.

Based on historic photographs produced at the time of construction, fencing was constructed around the southwest, northwest, and northeast sides of the residence. This fence appears to have been approximately 2-3' in height and comprised of individual concrete piers with a single wood or metal railing extending between piers. This fence is no longer extant. It is not know when it was removed from the site.

## Structural Systems

***Foundation:*** The level of grade around the perimeter of the Keeper's Residence did not permit access to the building's foundation. The exterior load-bearing masonry walls extend below grade without interruption. Information on the original 1921 architectural plans shows load-bearing brick masonry walls extending below grade to concrete footings. The interior face of the foundation walls are a reddish-brown common brick, as are the lowest exposed two courses of the exterior walls. (Figure 46) The remainder of the exterior foundation walls is constructed of the buff yellow brick used on the remainder of the residence.

The first floor is raised above grade approximately 28" on wood joists with a 2'-4" crawl space below. The floor structure is supported by the exterior walls and by three interior brick piers. The interior piers are 20½" square and extend 27-28" above grade to the underside of the floor framing. These piers are formed with the same reddish-brown common brick used on the interior face of the foundation walls (Figure 47).

Cross-shaped vents in the exterior load bearing masonry walls provide air circulation to the crawlspace. (Figure 48) There are two vents in both the northwest and southeast foundation walls, though one vent on the northwest wall has been infilled with concrete to accommodate an exterior spigot. There are five vents on each of the northeast and southwest walls, though one on the southwest wall has been infilled with concrete.

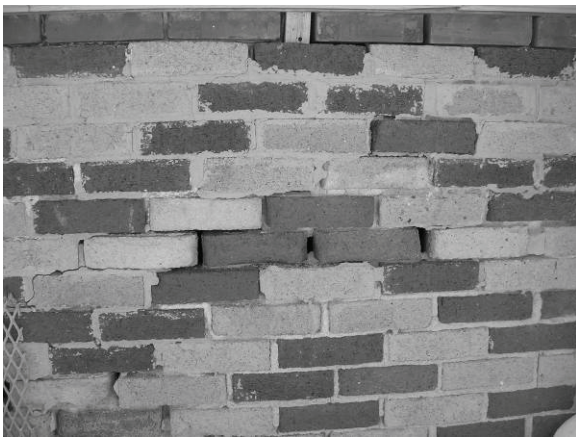


Figure 52: Loss of mortar in masonry joints and evidence of past repointing efforts at right side of front porch foundation wall on southeast elevation.



Figure 53: Floor framing including 11' – 11" wood girders spanning width of residence.



Figure 54: Wood girders bearing in a pocket in the top three courses of exterior wall on wood ledger board.



Figure 55: Overlap of wood joists on top of girders.



Figure 56: Hatch in ceiling of side porch providing access to attic.



Figure 57: Roof framing at hip ridges.

**Existing Condition:** The foundation walls of the main house appear sound with no signs of past or active settlement or movement of the foundation walls. Localized mortar loss and evidence of repointed masonry joints indicate previous mortar loss due to weathering at all foundation walls. (Figure 49)

Several condition issues were identified with the porch foundation walls. These include erosion of mortar in masonry joints; past repointing with mortar that does not match the historic mortar in color and texture; and spalling of face brick. Specific areas of damage are identified below.

- Southwest wall of front porch exhibits loss of mortar in horizontal and vertical masonry joints. (Figure 50)

- Left side of the porch foundation wall on the southeast elevation (when facing the residence) (Figure 51)

- Right side of the porch foundation wall on the southeast elevation (when facing the residence) (Figure 52)

- Porch foundation wall on the southwest elevation (when facing the residence)

***Floor Framing:*** The first floor structure of the Keeper's Residence is raised above grade on a wood frame structure. Three girders of paired 3" x 12" wood members span the width (northeast to southwest) of the residence. The girders are 11'-11" long and are supported by brick buttresses at the exterior walls and set in mortar atop the brick piers. (Figure 53)

Girders support 2" x10" wood floor joists spaced at 16" on center. Joists are notched and bear in a pocket in the top three courses of the exterior wall and rest on a 1" x 5" wood ledger board attached to the face of the girders. Four brick courses below the plate are corbelled out from the wall face to support the load. (Figure 54)

The walls are 8" thick with each successive corbelled course extending out 1" to provide wall widths of 9, 10, 11 and 12" respectively.



Figure 58: Ceiling joists and decking from the attic.



Figure 59: V-shaped struts and collar ties of roof trusses.



Figure 60: Vertical struts of roof truss extending from mid-span of the rafters to joists.

Joists are approximately 139.5" in length and are sistered with a 22" overlap at the girders. (Figure 55)

The joists are braced by wood cross bridging. The bridging is 1" x 3" wood members 16-16.5" in length nailed to the joists. The first floor decking, as observed from the crawlspace, is 1" x 5" tongue and groove wood that runs diagonally (north to south) to the joists.

**Existing Condition:** Though the floor framing was observed to be generally in sound condition, some signs of deterioration and damage were noted from the crawlspace. Typical deterioration of the framing members from moisture and termite activity is evident in Figure 51 above. The fasteners used in securing the flooring framing showed some signs of corrosion, however no evidence of loosening or shifting of the members was observed. The finished floor prevented the visual inspection of the floor framing and decking from the interior of the residence.

***Roof Framing:*** Access to the attic of the Keeper's Residence is provided through two hatches, one located in the ceiling of the interior vestibule and the second located in the ceiling of the rear porch. (Figure 56)

The hipped roof of the Keeper's Residence is framed with 2" x 8" circular-sawn rafters spaced



Figure 61: Batt insulation in the attic.

at 16” on center with a 2” x 12” main ridge board and 2” x 10” hip ridges. The fasteners of the roof framing system in some locations showed minor signs of corrosion but generally appeared in good condition. No signs of failed fasteners was observed and all joinery appeared tight (Figure 57).

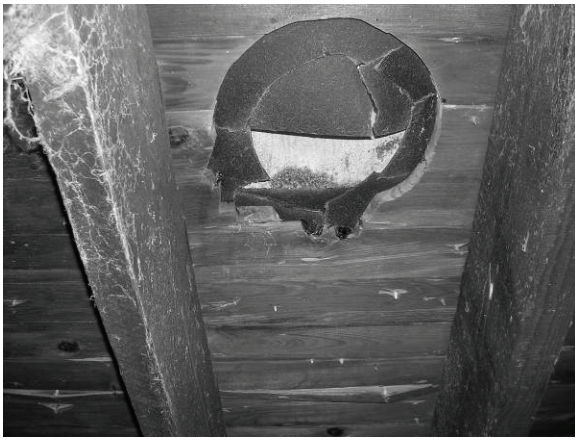


FIgure 62. Attic vent open though the roof.



Figure 63: 2009 view of façade (east elevation).



Figure 64: 2009 view of south elevation.

The ceiling joists are 2” X 10” circular-sawn boards at 16” on center spanning the width of the structure. The joists are fastened to the rafters at the inside face of the eave fascia and bear on the exterior brick wall. The patina of the rafters and joists are dark brown unfinished wood. (Figure 58)

The roof structure also includes a series of trusses that are a variation of the Howe Truss. These trusses consist of 2” x 8” V-shaped struts extending from the ceiling joists to the rafters on either side of the ridgpole and are braced laterally with 2” x 6” collar ties spaced 16” on center. (Figure 59)

Two rows of vertical 2” x 8” struts extend from the ceiling joists to the rafters at mid-span, with one row of struts on each side of the V-shaped struts. The roof framing members are attached with round-headed common nails that are exhibiting some corrosion but generally appear in good condition. This roof framing was designed to resist wind loads. (Figure 60)

The roof sheathing, as observed from the attic space, consists of 1” x 3” tongue and groove wood. The eave of the hipped roof has a slight flair at the soffit. Batt insulation has been installed in the attic for energy efficiency. Insulation is present between the attic floor joists with additional insulation laid in several layers over the base layer. (Figure 61)

**Existing Condition:** The attic space was dry at the time of inspection and no evidence of active or past leaks was observed. A circular opening, most likely for an attic vent, is open through the roof framing and roofing and does not have a cover or screening. This opening could allow moisture to infiltrate the roof and attic of the residence (Figure 62). The fasteners used to secure structural roofing members appear to be in relatively good condition. Some fasteners are exhibiting signs of surface corrosion while others have not corrosion at all. All of the structural roofing members appeared well secured.

## Exterior Features

***East Elevation:*** The southeast elevation of the Keeper's Residence is the front elevation and faces towards Fort Jefferson. The residence has an engaged porch that extends the full width of the east elevation and wraps around the northwest corner and extends approximately 25 feet along the north elevation. The porch roof is supported by tapered wood columns set on brick piers. The piers are trimmed with decorative coral stone buttresses. These buttresses are unique features of the residence that seem to be an attempt by the designers to acknowledge the tropical setting of the structure. The main wall of the house at the southeast elevation is load-bearing brick masonry consisting of unpainted buff yellow face brick laid in a Flemish stretcher bond with

contrasting red bricks alternating courses at the building corners. The main entrance to the Keeper's Residence is located on this elevation, as is the original side entrance into Room KR104, currently used as quarters for Coast Guard personnel when on the island. This elevation also contains one window opening located southwest of the main entrance when facing the house. This window is a single six-over-six double-hung window. (Figure 63)

***South Elevation:*** The south elevation faces toward the Lighthouse. The engaged porch with wood post supports, narrow-board ceiling, and tongue and groove flooring and the side entrance to the residence are located on this elevation. This elevation contains four windows openings. Two openings have single six-over-six double hung windows; the third opening has three (3) six-over-six double hung windows; and the fourth opening has two (2) six-over-six double hung windows. There are five cross-shaped foundation vents located on this elevation, two venting the side porch, two venting the crawlspace of the residence, and one venting the area under the front porch. An HVAC compressor is located on this elevation at the side porch. (Figure 64)

***West Elevation:*** The west elevation is the rear of the residence and faces the Gulf of Mexico. The



Figure 65: 2009 view of west elevation.



Figure 66: 2009 view of north elevation, with Light Tower in background.



Figure 67: Torn and missing asphalt roofing shingles.



Figure 68: View of single PVC downspout at north elevation



Figure 69: Weather paint finish, rusted nail heads, and torn/missing quarter-round and screening at the eave soffit.



Figure 70: Separation of frieze board at east corner of building.

side porch is accessed at this elevation via concrete steps. This elevation contains four windows openings. Two of the openings have single six-over-six double hung windows; the third opening has two (2) six-over-six double hung windows; and the fourth opening has a casement window with eight panes in each casement. The northern (far left) and southern (far right) windows as you face the building were covered with metal hurricane shutters during the time of the inspection. This elevation also contains the access to the crawlspace under the residence, which is located behind two propane gas tanks that are chained to the building. (Figure 65)

***North Elevation:*** The north elevation faces toward the site of the former Carnegie Marine Institute. The short leg of the front wrap-around porch is located on this elevation. This elevation contains six window openings. Four of the openings have single six-over-six double hung windows; the fifth opening has a smaller six-over-six double hung window; and the sixth opening has a two (2) six-over-six double hung windows and is located in the inset of the side porch. The two eastern-most windows were covered with plywood on the exterior during the time of the inspection. There are four cross-shaped foundation vents located on this elevation, two venting the space under the front porch and two venting the crawlspace underneath the main portion of the residence. An HVAC compressor is located on this elevation. (Figure 66)

***Roofing:*** The roof is clad with gray composition asphalt shingles. While the exact date of the installation of the existing roofing and sheathing is not known, it appears to have been installed post-1989. [2]

**Existing Condition:** The existing asphalt shingle roofing is in sound condition and is functioning satisfactorily as there was no indication of moisture infiltration or damage. However, there are several roof shingles torn and missing that need to be repaired and/or replaced. (Figure 67)

[2] Architectural Drawing, "Crew's Quarters Floor Plan, Dry Tortugas Light Station Rehabilitation, Dry Tortugas Light Station, Loggerhead Key, Florida," August 22, 1989, Archives, United States Coast Guard 7th District, Miami, FL.

***Gutters and Downspouts:*** The original construction drawings indicate that the building was intended to have gutters and downspouts. Historic photographs dating from the period of construction also indicate that the house originally had fascia-hung gutters and downspouts. Architectural drawings from 1989 indicate that new PVC gutters were installed at that time. The Keeper's Residence currently has no gutters, and a single PVC downspout remains on the northeast elevation. (Figure 68)

***Roof Eave and Cornice:*** The 1920 construction specifications state that all exterior trim shall be prime grade yellow pine. The roof rafters were constructed to terminate at the load bearing masonry wall. The lookouts are sistered to the rafter ends and extend beyond the end walls to form the slight flare in the eave.

The original 1921 architectural drawings for the residence indicate that the boxed eave was comprised of a 1" x 18" soffit and 1" x 8" wood fascia. This drawing also shows the cornice consisting of a 1" x 12" wood fascia with a 7/8" x 3¾" molding. The architectural drawings for the residence entitled *Barracks Building Air Conditioning* dated April 10, 1969 confirm the existence of the original eave and cornice details at that time.

Architectural drawings entitled *Crew's Quarters Floor Plan* dated August 22, 1989 indicate that the eave fascia and soffit were to be removed completely to repair rafters and joist tails. The removed materials were replaced with new ½" x 14" plywood soffit, 4" continuous fiberglass-screened venting, quarter round wood molding, and 1" x 8" wood fascia. The cornice molding appears not to have been replaced. Visual inspection confirms the characteristics and dimensions of the replacement materials described above. The eave fascia is overlapped at the top by metal drip edge. A wood frieze board covers the top courses of the brick wall.

**Existing Condition:** The eave and cornice are generally sound and attached. No rot or other deterioration was observed. The painted finish on existing wood features is weathered and



Figure 71: View of tar coating the interior face of the exterior brick viewed through hole in the bathroom wall.

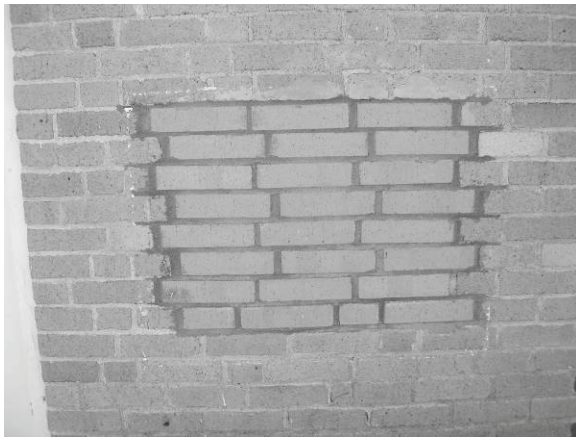


Figure 72: Replacement brick and mortar not matching historic materials located to the right of the main door on the east elevation



Figure 73: Erosion of mortar and brick spalling at north elevation.

deteriorating. The metal flashing and nails are rusted. The quarter-round wood molding and screening at the eave soffit is torn and missing in select locations. (Figure 69)



Figure 74. Spalling brick at west elevation.



Figure 75: Spalling brick at west elevation.



Figure 76. Vent opening infilled for hose bib at west elevation.

The sheet metal flashing is pulling away from the eave at the southeast (front) elevation and east corner of the residence. The cornice at the east corner of the building is separating with an approximate ½" gap at the mitered corner. (Figure 70)

***Exterior Walls:*** The exterior walls of the Keeper's Residence are load-bearing brick. The solid walls are two wythes thick. The interior wythe, visible from the crawlspace, is reddish-brown smooth-face common brick. The exterior wythe of the masonry walls is unpainted light-colored buff brick with a coarse texture. The dimensions of the high-fired exterior brick are 3¼" wide x 2¼ high x 7½" long, and the coursing is a Flemish stretcher bond with contrasting red bricks at building corners. The interior face of the brick walls is coated with tar and the interior walls are finished with plaster board and a finish coat of plaster. The tar applied to the brick wall was observed through a hole in the plaster wall of the bathroom. (Figure 71)

Test results of a mortar sample from the exterior wall of the Keeper's Residence revealed that it consists of one part Portland cement and 2.4 parts local carbonate sand. The analysis indicated that the Keeper's Residence mortar did not contain any lime or natural cement. The Keeper's Residence is the only structure at the Light Station that does not contain natural cement in its mortar. The use of Portland cement exclusively in the mortar mix is in keeping with a building constructed during the early 1920s.

Archival research supports the use of Portland cement and local sand in the construction of the Keeper's Residence. The 1920 specifications call for mortar to be composed of "I part [Portland] cement and 2-1/2 parts sand. Hydrated lime not to exceed 10% by volume of the cement shall be used for tempering." [3] Although the mortar specifications were written for concrete block and not brick, the information can certainly be applied to the brick. In fact, the ingredients and proportions documented in the current lab analysis are almost identical to those included in the specifications.

[3] "Specifications for a Single Dwelling for Keeper at Dry Tortugas Lightstation, Florida," August 10, 1920. Record Group 26: National Archives, Washington, DC, 3.

**Existing Condition:** The exterior walls have experienced moderate erosion of mortar and face brick due to weathering caused by the extreme weather conditions of heat, wind, water, and sand. Evidence of past repointing with mortar not matching the historic mortar indicates that these conditions have existed for some period of time. For example, portions of brick located to the right of the main door on the east elevation and at the northwest elevation have been replaced with brick and mortar that does not match historic brick and mortar. The new brick is 9" long with a smoother texture than the original 8" brick with a rougher texture. The mortar joints are wider than the historic joints; the mortar is dark grey in color rather than the lighter gray of the historic mortar; and the new mortar has a smooth consistency rather than the more textured consistency of the historic mortar, indicating that the later mortar does not contain the local carbonate sand as the historic mortar. (Figure 72)

The areas of damaged masonry are identified below.

- Loss of mortar and spalling brick at lower portion of wall on north elevation (Figure 73)
- Spalling brick and inappropriate repointing on west elevation (Figure 74)
- Spalling brick at west elevation (Figure 75)
- Infill of crawlspace vent for hose bib on west elevation (Figure 76)
- Cracking in mortar joint on northwest elevation
- Spalling brick to right of Window 15 at south corner on southwest elevation
- Loss of mortar at lower wall section below Window 15 on south elevation

The wall areas above and between the windows have experienced masonry joint cracking extending from the top corners of the windows horizontally across the face brick of the exterior



Figure 77: Mortar joint cracking due to oxide jacking.



Figure 78: Mortar joint cracking due to oxide jacking.

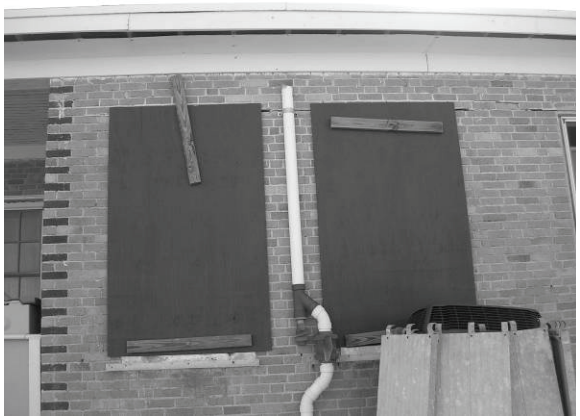


Figure 79: Mortar joint cracking due to oxide jacking between windows 3 and 4.



Figure 80: Mortar joint cracking due to oxide jacking between windows 4 and 5.



Figure 81: View of boxed eave and cornice at east corner of residence.



Figure 82: Dorothy Krotzer of Building Conservation Associates, Inc. (BCA) works to obtain a paint sample from the Porch trim of the Keeper's Residence.

walls. These conditions are caused by jacking from oxidation and associated expansion of the steel lintels embedded in the masonry walls. This

damage is occurring in multiple locations that are identified by elevation below.

***South Elevation***

- Above and between Windows 14 and 15 (Figure 77)

***West Elevation***

- Above and between Windows 8, 9 and 10 (Figure 78)

***North Elevation***

- Above and between Windows 3 and 4 (Figure 79)

- Above and between Windows 4 and 5 (Figure 80)

***Front Porch Roof, Eave, Cornice, and Supports:***

The L-shaped front porch extends approximately 25' along the north elevation of the residence and is engaged within the main roof.

The boxed eave has a slight overhang and is formed by the 12" soffit comprised of a 1"x 8" plywood with the outer 4" section screened to provide ventilation to the attic space. The top portion of the 1" x 4" eave fascia is overlapped by metal drip edge. The header for the porch roof is formed by a 1" x 4" fascia board and 1" x 6" soffit with quarter-round wood molding. (Figure 81)

The porch roof is supported by five tapered, boxed, wood columns with wood plinths. The columns are supported by yellow and red brick piers with concrete caps and are trimmed in coral stone along their outside vertical edges. The columns taper from 10½" at the bottom to 7&½"at the top.

Results from paint sampling from the exterior woodwork of the Keeper's Residence indicate that the building was originally painted white.

Samples removed from the front porch trim show 11 layers of white and cream paint. (Figure 82)

In addition, historic photographs of the residence show white-colored trim and the preliminary specifications dating to 1917 state that all woodwork was to be painted white.

**Existing Condition:** There is masonry damage in multiple locations at the front porch piers. There are multiple cracks in the mortar joints, bricks, and concrete caps of the porch piers. This damage is almost certainly related to the corrosion and expansion of tie rods and anchor plates embedded in the piers to secure the porch roof. There is also evidence of past cracks that have been filled with epoxy filler. The specific areas of masonry damage to the porch piers are identified below.

No 1: Crack in the southwest side of the plinth on the far left porch pier on the southeast elevation (facing residence) (Figure 83)

No. 2: Crack in the east side of the plinth on the far left porch pier on the east elevation (facing residence) (Figure 84)

No. 3: Crack in the east side of the plinth on the far right porch pier on the south elevation and vertical crack between the brick and coral stone buttress (facing residence) (Figure 85). The buttresses are experiencing some weathering but are in good condition.

No. 4: Crack in the north side of the plinth on the far left porch pier on the north elevation and cracks between the brick and coral stone buttress (facing residence)

No. 5: Cracks in the brick and mortar joints at the top of the far right pier on the north elevation (facing residence) (Figure 86)

No. 6: Crack in the west side of plinth and top three courses of the second pier from the left on the south elevation (facing residence) (Figure 87)

No. 7: Past repair of crack in the west side of plinth of the second pier from the right on the east elevation (facing residence)

No. 8: Crack in brick and masonry joints on the west side of the far left pier on the east elevation (facing residence)



Figure 83: Crack in the concrete plinth on the far left porch pier on the southeast elevation.



Figure 84: Crack in east side of plinth on the far left porch pier at east elevation.



Figure 85: No. 3: Crack in the east side of plinth on the far right porch pier at east elevation.

No. 9: Crack in the plinth, brick, and masonry joints on the south side of the far right pier on the north elevation (facing residence)

The paint on wood elements of the porch is at the end of its life span as exhibited by flaking and weathering of the paint, particularly along the eave, cornice, and wood columns. For example, paint finish at the far right porch column at the east elevation is deteriorated due to weathering. (Figure 88)

***Front Porch Ceiling:*** The porch ceiling is 1" x 2½" wood painted white with ½" space between boards to provide attic ventilation. There is a hole cut in the ceiling for a light fixture but no fixture existed at the time of inspection. (Figure 89)



Figure 86: Cracks in brick and mortar joints at the top of the far right pier on the north elevation.



Figure 87: Crack in the west side of plinth and top three courses of the second pier from the left on the south elevation.

**Existing Condition:** The front porch ceiling has multiple layers of paint. The outer layers are chipping and flaking. The heads of the nails used to secure the ceiling boards are corroded due to exposure to salt. (Figure 90)

***Front Porch Railing:*** The non-historic porch balustrade is constructed of wood. The top and bottom rails are 2" x 4" boards painted white. The stock balusters are 28½" long. (Figure 91). The original porch balusters shown in historic images of the Keeper's Residence were closely spaced square wood members. At least one other generation of balusters was installed on the building. Mid-twentieth century images of the building show widely spaced rectangular balusters with angled balusters at the piers.

**Existing Condition:** Generally, the wood is sound and nails are secure. The baluster post at the south corner of the house on the southwest elevation is separating and the face board is detached. (Figure 92)



Figure 88: Weathered paint finish on the far right porch column at east elevation.

***Front Porch Floor:*** The porch flooring is 1" x 5" tongue and groove wood painted blue-green and running east to west. The V-joint and 5"-wide boards are atypical features of flooring materials, even for the 1920s, suggesting that the existing flooring could be a later addition.

**Existing Condition:** The porch flooring is generally sound structurally. There are multiple individual floor boards that are damaged at their outside ends. This damage includes broken boards, split & cracking ends and rot damage to boards.

Counting from the south corner across the front of the porch, the damaged boards are outlined below.

- Boards 8 & 9 -- broken ends
- Board 12 -- joint separating on left side
- Board 42 -- broken end (Figure 93)
- Board 47 -- joint separating
- Board 62 -- joint separating
- Board 68 -- split and cracked
- Board 71 -- split and joint separating at right side

Counting from the southeast corner along the northeast side of the porch, the damaged boards include:

- Board 5 – rot damageBoard 8 – rot damage (Figure 94)
- Boards 14, 15 & 17 – rot damage

The fascia below the porch decking is 1" x 4" wood painted blue-green with a simple bead ogee profile along its top edge. This trim is cracked and loose at various locations across the east and north elevations of the front porch.

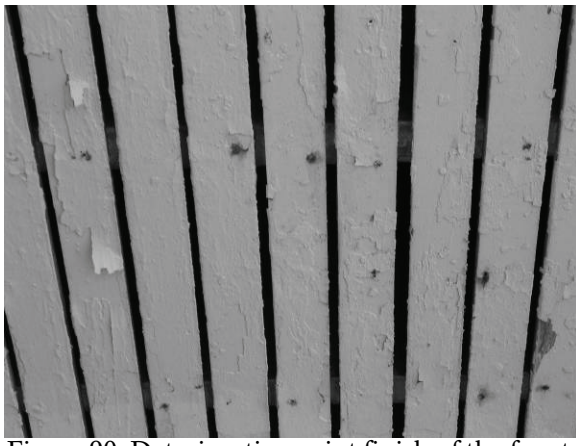


Figure 90: Deteriorating paint finish of the front porch ceiling.



Figure 91: View of front porch railing with wood top and bottom rails and balusters.

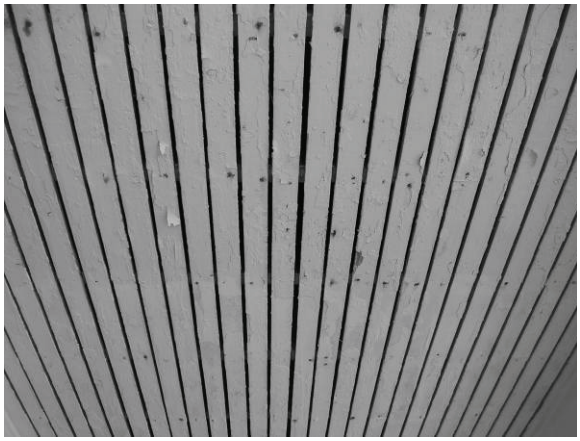


Figure 89: View of front porch ceiling with ½" gap between boards for attic ventilation.



Figure 92: Damage to baluster post at the south corner of the porch.



Figure 93: Broken tongue and groove flooring of front porch.



Figure 94. Rot damage to tongue and groove flooring of front porch.



Figure 95: View of concrete steps and brick cheek walls at front entrance.

Areas where this condition occurs are identified below.

- East elevation between south corner of building and stairs
- East elevation at top left of stairs at southeast elevation
- North elevation between first and second porch piers (from left to right)
- North elevation between second porch pier and east corner of house (from left to right)

***Front Porch Stairs:*** The porch is accessed from the front by concrete steps consisting of six (6) risers and six (6) treads from the concrete sidewalk to the porch floor. The treads measure 11½" and risers measure 7". The steps are painted the same blue-green color as the porch floor. Brick cheek walls flank the stairs and splay out from the porch to the bottom step. The cheek walls are topped with a coral concrete cap. (Figure 95)

**Existing Condition:** The porch stairs are in sound condition. The stair cheek walls, however, exhibit signs of deterioration including spalling brick and separation between joints of the cheek



Figure 96: Separation of joint between cheek wall and pier at top of stairs.

walls and front porch piers. Individual conditions are illustrated below.

- Spalling of brick due to weathering
  - At the southwest side of the left cheek wall
  - At the northeast side of the right cheek wall
  - At top left stair pier
- Separation of the joints between the cheek wall and porch piers due to settlement of the stairs away from the residence
  - Between the left cheek wall and porch pier at the top of the porch stairs on the southwest elevation
  - Between cheek wall and pier at top of stairs on the north elevation (Figure 96)
- Separation of joint between the stairs and inside face of cheek wall (Figure 97)



Figure 97: Separation of joint between stairs and cheek wall.

***Side Porch:*** The side porch measures 18' – 1" long and 6' – 6" wide, and is accessed from the west elevation and extends along the south elevation. The current porch configuration conforms to the 1921 architectural plans. Historic photographs dating to the period of construction show that the side porch originally had wood lattice between the supporting posts. The wood lattice has been removed at some point in the past and the space between the posts is open.



Figure 98: View of side porch – eave screening is torn and missing; metal anchors and brackets are corroding and staining the exterior paint.

***Side Porch Roof, Eave, Cornice, and Supports:*** The side porch is engaged within the main roof of the residence and the porch eave is the same as that around the house. The eave and drip edge are the same as that on the front porch (described above). The porch roof is supported by two 8" x 8" chamfered posts. Porch posts have a 1" x 8" base trim at the bottom, and a 2" x 11½" wood cap at the top of the posts.

**Existing Condition:** The wood elements of the roof, eave, cornice and posts are sound. The screening of the eave soffit is torn and missing in sections. In numerous locations along the side porch cornice, metal anchors and brackets are attached to the exterior of the cornice. These items are corroding and staining the exterior paint. (Figure 98)



Figure 99: View of side porch ceiling with ½" gap between boards.

***Side Porch Ceiling:*** The side porch ceiling is 1" x 2½" boards with ½" space between boards to provide attic ventilation. A 23½" x 28" access hatch to the attic space is located in the ceiling of the porch. The hatch opening has a 3" beadboard trim on all sides. A porcelain light fixture with metal junction box is located in the center of the porch ceiling. (Figure 99)



Figure 100: Deteriorating paint finish and rusted nail heads on side porch ceiling.



Figure 101: Hairline cracks in masonry joints at the northwest porch wall.

**Existing Condition:** The side porch ceiling has multiple layers of paint which is chipping and flaking. Heads of nails used to secure the ceiling boards are corroded. (Figure 100)

***Side Porch Walls:*** The porch walls are the south and west walls of the residence. The porch foundation walls are the same yellow and reddish-brown face brick used on the rest of the residence.

***Side Porch Walls***: The porch walls are the south and west walls of the residence. The porch foundation walls are the same yellow and reddish-brown face brick used on the rest of the residence.

**Existing Condition:** The west masonry porch wall has cracks in the mortar joints extending seven courses down from the bottom of the cornice. (Figure 101)

The side porch foundation wall also has cracks in the mortar joints. (Figure 102) The wood fascia board under the floor at the masonry foundation wall is missing.

***Side Porch Floor:*** The porch flooring is ¾" x 5" tongue and groove wood flooring running south to north. The floor boards, painted a blue-green color, are 78" long with 3% slope from the side of the residence and extend 9½" beyond the face of the brick foundation wall. This long overhang



Figure 102: Eroded and cracked mortar joints in side porch foundation wall.

is presumably due to a non-historic addition to the porch that has since been removed.

**Existing Condition:** The porch floor structure is generally in sound condition. However, there are multiple individual floor boards that are damaged at their outside ends. This damage includes broken boards, split & cracking board ends, and joint separation between boards. From the left side facing the porch, the damaged boards include:

- Boards 5, 6, 7, 8, 10, and 20 (Figure 103)
- Boards 35 and 39 (Figure 104)

***Side Porch Stairs:*** The porch is accessed by concrete stairs consisting of six (6) risers and treads from the concrete walkway at grade to the porch floor. The treads measure 11½" and risers 6¾". The steps are painted white. The stair railing has upper and lower 2" x 4" wood rails nailed to a 4" x 4" wood post. (Figure 105)

**Existing Condition:** The stair and porch railings are generally sound. The nails are loose and there is some separation between the 1" x 4" and 2" x 4" wood forming the porch rail support post at the northwest wall of the porch. (Figure 106)

***Doors:***The Keeper's Residence has three exterior doors.

*Front Door (D-1):* The front door is located on the east or primary elevation. This doorway has been altered since the residence was constructed, possibly at the same time as the floor plan changes were made in the mid-1980s. The single wood door shown on the 1921 architectural plans had two vertical rectangular panels below a six-light glazed upper panel. Flanking the door on both sides were sidelights that included a single vertical wood panel below a six-light glazed upper panel. The elevations also show a simple head detail of a single soldier course of buff yellow brick.

The door frame is still intact, but the existing door is a non-historic single six-panel wood door measuring 6'-10" x 3'-0" wide x 1¾" thick with a metal door knob and butt hinges. The sidelight frame is still in place but the sidelight sash and panel below have been removed and



Figure 103: Damage to outside ends of side porch flooring – boards 5, 6, 7, 8 and 10.



Figure 104: Damage to outside ends of side porch flooring – boards 35 and 39.



Figure 105: View of side porch concrete stairs.

replaced with plywood painted white. (Figure 107) A steel lintel supports the brick above the door frame and the brick header is intact.

The existing front door jamb and sidelight frame are comprised of wood members, as detailed in the profile sketch below. (Figure 108)
The threshold at the front door is thought to be original. It is a 3½" piece of wood on top of a 6'-3" long continuous sill of concrete that extends the width of the rough opening. The concrete sill has as 10% slope and the threshold is painted blue/green. (Figures 109 & 110)



Figure 106: Separation between the wood porch rail post at northwest wall.



Figure 107: Non-historic door and sidelights infilled with plywood at the front entrance (D-1).

***Side Door (D-2):*** A second door is located in the east elevation and provides access from the porch to Room KR104. This door has been altered since the residence was constructed. The single wood door shown on the 1921 architectural plans had two vertical panels above and two vertical panels below a single horizontal middle panel. The existing door is a non-historic single four-panel wood door measuring 6'-10" x 2'-10" wide x 1¾" thick with a metal door knob. The door frame is wood with a steel lintel carrying the masonry above the door opening. (Figure 111)

***Rear Door (D-6):*** The rear door is located on the south elevation. This door has been altered since the residence was constructed. The single wood door shown on the 1921 architectural plans had two vertical panels above and two vertical panels below a single horizontal middle panel. The existing door is a single six-panel wood door measuring 6'-10" x 3'-0" wide x 1¾" thick with a metal door knob and steel butt hinges. (Figures 112 & 113)

The wood threshold at the back door is 3¼" wide over a 3'-4" long x 4" high block of coral concrete. The coral concrete has a 5% slope. The threshold is painted blue/green. Profiles of the back door jamb and threshold are illustrated in the details attached to the finish schedule. (Figure 114)

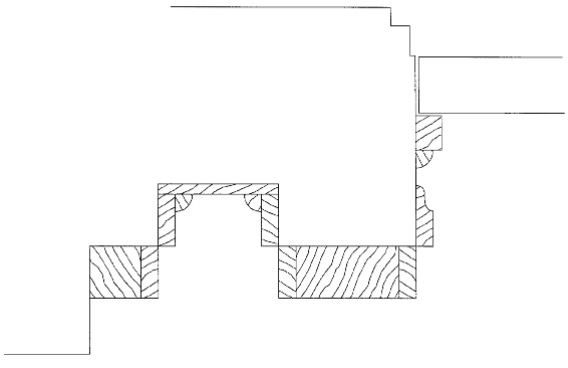


Figure 108: Profile of the existing door jamb and sidelights at the primary entryway (D-1).

**Existing Condition:** The doors and frames are generally in good condition. The wood is solid and the joints are sound. The finish on the exterior face of all doors is slightly weathered due to exposure to the elements. The steel lintels above the door frames show minor corrosion. (Figure 115)

The paint finish on the threshold at the secondary front door (D-2) is chipped and cracked in select locations. Heads of nails used to fasten weather stripping to the secondary front door are rusted. (Figure 116)

*Windows:* **There are fifteen windows in the Keeper's Residence. One window is located at the east elevation; four windows at each of the south and west elevations; and six windows at the north elevation**.

Available records from the National Park Service indicate that the windows were replaced in 2004. The existing windows are six-over-six, double-hung, Pella, architectural-series, thermo=pane windows. [4] The original louvered wood shutters shown in historic images of the building have been removed from the residence. Metal hurricane shutters and guide tracks are secured to the brick masonry and concrete sills with metal screws. Several windows were covered with the hurricane shutters at the time of inspection.

All windows have a steel lintel spanning the openings at the head. Each window also has a coral concrete sill measuring 44½" long x 4" high with a wood sub sill. The individual panes are 9" wide x 16" high with 1" muntins. At the interior of the windows, a 1" x 6" wood sill and 1" x 3½" wood apron are typical. All windows also have 1" x 4" flat wood trim at the head and jamb casings. The jamb trim is joined to the head trim with butt joints. (Figure 117)

Brief descriptions of each window are provided below organized by building elevation. The windows are numbered for ease of reference on the existing floor plan drawing.



Figure 109: Threshold at primary entryway (D-1) with wood atop a continuous stone sill.

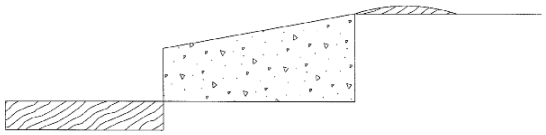


Figure 110: Profile of the existing threshold at the front entrance (D-1).



Figure 111: Non-historic door at side entrance on east elevation (D-2).

[4] "Replace Windows – Lighthouse Keepers Quarters - Loggerhead Key, PMIS 48292," September 13, 2006 (date of last update), National Park Service, Southeast Regional Office, Atlanta, GA.

*East Elevation*

- Window 1 (W-1) is located to the left of the main entrance (facing the residence) in the
- living room (KR101). This window is six-over-six double-hung sash measuring 6'-2" high x 3'-8"wide.



Figure 112: Interior face of non-historic door at side entryway (D-6).

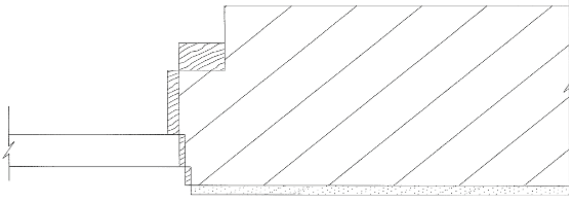


Figure 113: Profile of the existing door jamb at the back door (D-6).

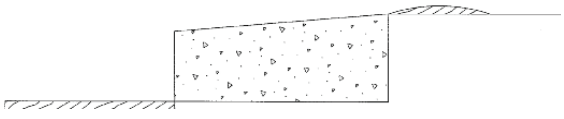


Figure 114: Profile of the existing threshold at the back door (D-6).

*North Elevation*

- Window 2 (W-2) is a pair of six-over-six double-hung sash inset within the side porch in the living room (KR101) that measure 5'-5" high x 6' wide.
- Window 3 (W-3) and Window 4 (W-4) are each six-over-six double-hung sash in the Coast Guard Quarters room (KR104) measuring 6'-2" high x 3'-2" wide.
- Window 5 (W-5) is six-over-six double hung sash in the bathroom (KR106) that measures 4'-5" high x 3' wide.
- Window 6 (W-6) and Window 7 (W-7) are each six-over-six double-hung sash in the dining section of the kitchen (KR107) measuring 6'-2" high x 3'-2" wide.

*West Elevation*

- Window 8 (W-8) and Window 9 (W-9) are each six-over-six double-hung sash in the dining section of the kitchen (KR107) measuring 4'-5" high x 3' wide. A drawing of interior of Window 8 is illustrated in the details attached to the finish schedule.Window 10 (W-10) is a pair of double-hung sash in the kitchen (KR107) measuring 5-5" high x 6' wide.
- Window 11 (W-11) is casement with eight-light sash in the bedroom. (KR103)



Figure 115: Steel lintel above primary door (D-1) exhibits minor corrosion.

*South Elevation*

- Window 12 (W-12) is six-over-six double-hung sash in the kitchen (KR107) measuring 5'-5" high x 3-6" wide.
- Window 13 (W-13) is six-over-six double-hung sash in the laundry room (KR105) measuring 5'-5" high x 2'-6" wide.
- Window 14 (W-14) is a set of three six-over-six double-hung sash in the bedroom (KR103) measuring 5'-5" high x 10' wide.
- Window 15 (W-15) is a pair of six-over-six double-hung sash in the living room (KR101) measuring 5'5" high x 6' wide.

**Existing Condition:** While the window units themselves are in sound condition, the steel lintels and coral concrete sills are in a deteriorating condition. As described above in the *Exterior Wall* section of this report, the steel window lintels over the windows are severely rusted causing extensive jacking of brick along the window heads and extending between windows. (Figure 118)

It is recommended that new wood louvered shutters that match the historic condition be fabricated and installed on the building (See Figure 45). It should be noted that both awning (Bahamian Style) and side hinged shutters were used on the building depending on the window configuration. These variations in shutter type should be matched as part of the restoration of these features.



Figure 116: Rusted lintel and nail heads at secondary front door (D-2).



Figure 117: View of interior window with typical sill, apron and casings.



Figure 118: Rusted steel lintel above the opening for Window 2.



Figure 119: Damage to concrete sill of Window 2 from the metal shutter track.



Figure 120: Cracks in the masonry and mortar joints below Window 7.



Figure 121: Damage to concrete sill of Window 9.

In addition, the aluminum tracks for the hurricane shutters installed at the window heads and sills have caused cracking and chipping of the brick heads and concrete sills and cracking along the brick mortar joints. The individual instances of masonry damage to window elements are outlined below.

Window 2 – chipping and cracking of the concrete sill (Figure 119)

Window 7 – cracking of bricks and along mortar joints below window sill (Figure 120)

Window 9 – chipping of concrete sill (Figure 121)



Figure 122. Cracked concreted sill of Window 15.

## Interior Features

***Schedule of Existing Finishes:*** The following Schedule of Finishes documents the finishes and their characteristics identified in the Keeper's Residence. A Summary Description of Interior Conditions follows the Schedule of Finishes. (below)

**Figure 123:**
**Keeper's Residence Schedule of Finish Characteristics (Original Finish -- Existing Finish)**

| Ident. # | Location | Floor | Walls | | | |
|---|---|---|---|---|---|---|
| | | | Southeast | Southwest | Northwest | Northeast |
| KR101 | Living Room | Wood --VCT | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster |
| KR102 | Hallway | Wood--VCT | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster |
| KR103 | Bedroom | Wood -- Carpeting | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster |
| KR104 | Coast Guard Quarters | Wood -- Carpeting | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster |
| KR105 | Laundry Room | Wood -- VCT | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster |
| KR106 | Bathroom | Ceramic Tile | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster |
| KR107 | Kitchen/Dining Room | Pine T&G --VCT | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster | Plaster -- Gypsum/Plaster |

| Ident. # | Location | Ceiling | Moldings | | Fixture |
|---|---|---|---|---|---|
| | | | Crown/Cornice | Base | |
| KR101 | Living Room | Plaster -- Gypsum | C4 | B1 | 1 |
| KR102 | Hallway | Plaster -- Gypsum | C1 | B1 | 1 |
| KR103 | Bedroom | Plaster -- Gypsum | C3 | B2 | 1 |
| KR104 | Coast Guard Quarters | Plaster -- Gypsum | C4 | B2 | 1 |
| KR105 | Laundry Room | Plaster -- Gypsum | C2 | None | 1 |
| KR106 | Bathroom | Plaster -- Gypsum | C2 | None | 1 |
| KR107 | Kitchen/Dining Room | Plaster -- Gypsum | C2/C5 | B1/B1 | 1 |

LEGEND

**Flooring**
**VCT** 12" x 12" square vinyl composition tile
**Ceramic Tile** 8" x 8" square white ceramic tile
**Carpeting** Low-cut orange carpeting
**Wood** 3/4" x 5" tongue & groove pine flooring

**Walls**
**Gypsum/Plaster** 1/2" gypsum board walls over historic plaster (original plaster exposed above top of gym board walls)
**Gypsum** 1/2" gypsum board wall

**Fixtures**
**1** Two-bulb fluorescent ceiling fixture -- Detail F1

**Ceiling**
**Gypsum** **1/2" g**ypsum board ceiling finish

**Crown**
**C1** 5 & 1/8" two-piece quarter-round, double-ogee crown mold -- C1 Detail
**C2** 1 & 1/4" one-piece ovolo crown mold -- C2 Detail
**C3** 4 & 1/2" two-piece ovolo, fascia crown mold -- C3 Detail
**C4** 4" two-piece ovolo crown mold and picture rail -- C4 Detail
**C5** 4 & 7/8" two-piece ovolo crown mold and picture rail -- C5 Detail

**Base**
**B1** 4 & 1/4" two-piece rounded baseboard with 3/4" base shoe molding
**B2** 4 & 1/4" two-piece fascia baseboard with 3/4" base cap molding

**Moldings**

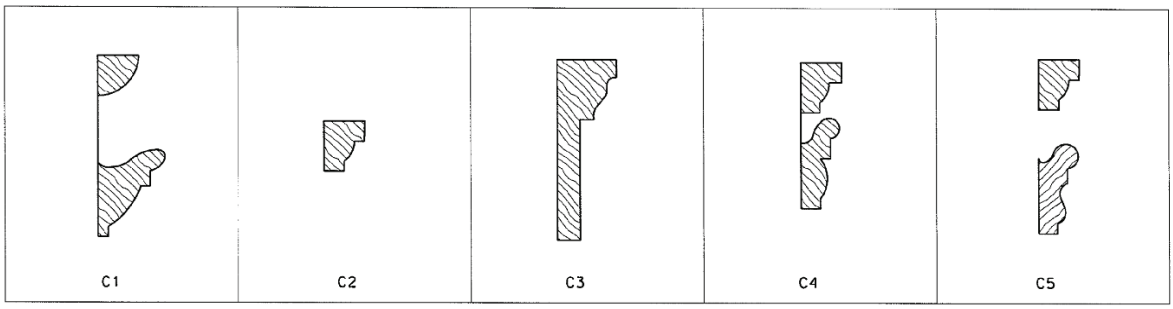



Figure 123: Interior crown moldings Types C1 – C5.

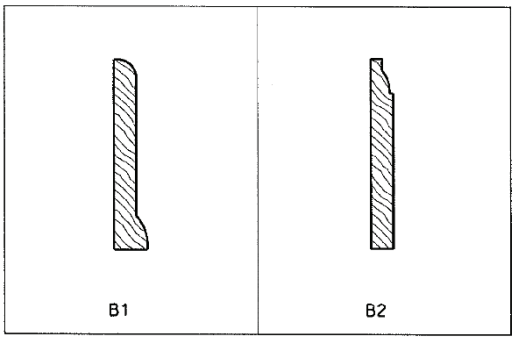



Figure 124: Interior crown moldings Types C1 – C5.

## General

***Flooring:*** The original flooring for all rooms of the Keeper's Residence was yellow pine. As described in the 1920 specifications, the "finish floor shall be 7/8 x 3-1/4 inch prime grade, edge grain, long leaf yellow pine, closely driven up, and blind nailed." The original flooring was covered with tile or carpeting in the mid-to-late 1980s. According to Coast Guard architectural plans entitled *Crew's Quarters Floor Plan* dated August 22, 1989, vinyl asbestos tile (VAT) was installed in Rooms KR101, KR102, KR105, KR106, and KR107 as part of this project. Carpeting was installed in Rooms KR103 and KR104. It is likely that the tile and carpeting were laid directly over the original pine flooring. Visual inspection cannot determine the presence or absence of asbestos in the floor tile. Given the possibility that the tile could contain asbestos, it should be tested and if asbestos is found, removed and abated.

***Walls:*** Gypsum wall board covers the original plaster and wood lathe walls throughout the residence. According to architectural plans *Crew's Quarters Floor Plan* dated August 22, 1989, ½" drywall was installed on 1" x 2" furring strips at 16" on center over the original plaster. The gypsum wall board extends from the floor to a height approximately 12" below the ceiling, revealing the top portion of the historic plaster walls and original crown molding.

Test results from samples of original interior plaster revealed that the typical interior plaster finish is a two-coat system, with a gypsum and sand-based scratch coat and gypsum-based finish coat gauged with lime. The finish coat is consistent with a Keene's cement mixture. Keene's cement is a slow-setting, hard-finish plaster produced by burning very pure gypsum at high temperatures and treating the material with alum or other chemicals during the manufacturing process. [70] These findings indicated that a different plaster was used than originally outlined in the 1920 specifications, which called for a scratch coat comprised of one part cement, two parts sand, and 1/10$^{th}$ part hydrated lime and a finish coat composed of a cement plaster similar to the U.S. Gypsum Company's "'Adamant," a fire-resistant type of early drywall.

***Ceilings*:** The ceiling in all rooms of the residence is gypsum board, most likely ½" or 5/8" thick. The original ceiling material, as outlined in the 1920 specifications, was 7/8" x

[70] Edwin C. Eckel. *Cements, Limes and Plasters: Their Materials, Manufacture and Properties*. Michigan: Donhead Publishing Co., 2005 (originally published 1905), 78.

3¼" tongue and groove yellow pine. The original pine ceiling boards are visible below the insulation in the attic. Architectural drawings from the 1951 project entitled *Improvements to Sanitary Facilities* indicate that the existing ceilings were to be removed and replaced with masonite. It appears that this work was not completed.

Architectural drawings entitled *Barracks Building Air Conditioning,* April 10, 1969, indicate that the original pine ceilings and wood crown molding are intact. The project called for installation of 2" glass fiber insulation in the attic.

According to architectural plans entitled *Crew's Quarters Floor Plan* dated August 22, 1989, the existing ceiling at that time was a lay-in suspended acoustical tile ceiling. These drawings call for retention of the lay-in suspension structure and 100% replacement of the acoustical tile panels. These drawings also show existing 6" blanket insulation within the suspended ceiling. The lowered gypsum board walls approximately 12" below the original plaster wall and ceiling joint indicate that the suspended ceiling was installed in the residence at some point after the building was constructed and likely removed circa 1985 - 1989 and replaced with the existing gypsum board applied directly over the original pine ceilings. This is further supported by the slight overlap of the gyp board ceiling over the top of the historic crown molding.

***Moldings*:**
Most rooms have wood baseboards, moldings at the top of the gypsum board walls, and crown molding at the juncture of the plaster wall and ceiling joint. Specific molding characteristics are summarized below by room.

## Living/Berthing Room (KR101)

***Flooring:*** The existing flooring of Room KR101



Figure 125: View of Living/Berthing Room facing north.



Figure 126: Uneven vinyl tile in living room.



Figure 127: Hairline crack in the plaster wall at the east corner in living room.



Figure 128: Peeling paint at the southeast wall just below the ceiling.

is 12" x 12" square vinyl asbestos tile (VAT) in an off-white color with brown speckles. The tile appears to have been laid directly over the tongue-and-groove flooring. The floor tile is a potential source of asbestos from the materials used to create the tile and likely the mastic used to secure the tile in place.

***Walls:*** The original plaster walls in Room KR101 are covered with ½" gypsum wall board. An HVAC vent has been cut into the historic plaster of the southeast wall approximately 4" below the historic crown molding.

***Ceiling:*** The existing ceiling in Room KR101 is gypsum board, most likely 1/2" or 5/8" thick.

***Moldings*:** A typical 4¼" wood baseboard with a ¾" base shoe molding painted white are present in Room KR101. A wood molding is located at the top of the gypsum board walls below the historic plaster wall. The historic crown molding is a 4" two-piece ovolo crown mold and picture rail. The door opening in the east elevation and window openings in this room have a 7/8" x 4¼" flat wood trim at the head and jamb casings. The jamb trim is joined to the head trim with butt joints. The moldings in Room KR101 are in sound condition and appropriately attached. The baseboard (B1) and crown molding (C4) are illustrated in Figure 124 above.

***Fixture*:** There is a single fluorescent light fixture located in the center of the ceiling of this room.

**Existing Condition:** The condition of the finishes in Room KR101 is generally good. Items noted:

- The tile is uneven just inside the front door. This is most likely due to poor underlayment and/or moisture infiltration from below (Figure 128)
- There is a narrow hairline crack in the visible portion of the plaster wall at the east corner of this room. The diagonal crack begins at the corner and runs northwest down the length of the visible portion of the plaster wall. (Figure 129)

## Central Hallway (KR102)

***Flooring*:** The existing flooring in Room KR102 is the same white and brown 12" x 12" vinyl asbestos tile (VAT) characteristic found throughout the residence. The floor tile is a

potential source of asbestos from the materials used to create the tile and likely the mastic used to secure the tile in place.

***Walls*:** The wall finish in Room KR102 is the same ½" gypsum wall board characteristic found throughout the residence. As noted below, the ceiling in the central hallway was lowered to conceal the HVAC ductwork. The historic plaster wall finish and crown molding remain intact above the dropped ceiling.

Sampling and microscopic analysis of the wall finish and crown molding in the central hall above the dropped ceiling revealed that the walls were originally painted a pale gray-green and the molding was painted white after having been sealed with a clear coat. Testing further revealed that the three-coat paint system outlined in the 1920 specifications was followed, though the paint color used was the pale gray-green instead of the white called for in the specifications.

***Ceiling*:** The existing ceiling in Room KR102 is the same gypsum board (most likely 1/2" or 5/8" thick) characteristic found throughout the residence. The ceiling in Room KR102 was lowered in 2002 to conceal the HVAC air handler and ductwork above. The dropped ceiling structure is wood frame. The earlier ceiling remains intact above the dropped ceiling and is visible from the hatch access to the attic. The earlier ceiling in this area appears to be a fiber board material such as Homasote.

***Moldings*:** A typical 4¼" wood baseboard with a ¾" base shoe molding painted white are present in Room KR102. There is no crown molding at the wall/ceiling juncture of the dropped ceiling. However, the historic crown molding is intact above the dropped ceiling and visible from the hatch access to the attic. The historic crown profile is a 5&1/8" two-piece quarter-round, double-ogee crown mold. The moldings in Room KR102 are in sound condition and appropriately attached. The baseboard (B1) and crown molding (C1) are illustrated in Figure 124 above.




Figure 129: View of Central Hallway facing west toward Kitchen.



Figure 130: View of Bedroom facing west.



Figure 131: View of Bedroom facing southeast.



Figure 132: Peeling paint on the southwest wall along the door frame.

*Fixture*: There is a single fluorescent light fixture located in the center of the ceiling of this room.

**Existing Condition:** The condition of the finishes in Room KR102 is generally sound. Items noted include peeling paint at the southeast wall at its juncture with the ceiling. (Figure 130)

## Bedroom (KR103)

***Flooring*:** The existing flooring in Room KR103 is low-cut orange carpeting. According to Coast Guard architectural plans entitled *Crew's Quarters Floor Plan* dated July 19, 1985, the flooring installed in this room at that time was carpet. The carpeting was most likely installed over the original pine flooring.
***Walls*:** The wall finish in Room KR103 is the same ½" gypsum wall board characteristic found throughout the residence. The gypsum board has been applied over the plaster of the three original walls in this room and was used to finish the northeast wall when it was constructed ca. 1985. An HVAC vent has been cut into the historic plaster of the northeast wall approximately 4" below the historic crown molding.

***Ceiling*:** The existing ceiling in Room KR103 is the same gypsum board (most likely 1/2" or 5/8" thick) characteristic found throughout the residence.

***Interior Door*:** The existing door to this room (D-3) is a hollow-core wood door that measures 82" high x 34" wide x 1¾" thick and has a metal door knob and butt hinges.

**Moldings:** A typical 4¼" wood baseboard with a ¾" base shoe molding painted white are present in Room KR103. A wood molding is located at the top of the gypsum board walls below the historic plaster wall. The historic crown molding is 4½" two-piece ovolo, fascia crown mold. The door opening in this room has 1" x 2½" wood trim at the head and jamb casings with mitered corners. The windows have 7/8" x 4¼" flat wood trim at the head and jamb casings. The jamb trim is joined to the head trim with butt joints. The moldings in Room KR103 are in sound condition and appropriately attached. The

baseboard (B2) and crown molding (C3) in Room KR103 are illustrated in Figure 124 above.
***Fixture*:** There is a single fluorescent light fixture located in the center of the ceiling of this room.

**Existing Condition:** The condition of the finishes in Room KR103 is generally sound. Items of concern regarding condition include peeling paint on the southwest wall along the door frame. (Figure 134)

There is a narrow crack in the visible portion of the plaster wall above the drywall at the south corner of the bedroom. The diagonal crack begins just below the historic crown molding and runs down the visible portion of the plaster wall. (Figure 135)



Figure 133: Hairline crack in the plaster wall at the south corner.



Figure 134: Torn gypsum wall board at the southeast wall.

## Coast Guard Quarters (KR104)

***Flooring:*** The existing flooring in Room KR104 is the same low-cut orange carpeting found in Room KR103.

***Walls:*** The wall finish in Room KR104 is the same ½" gypsum wall board characteristic found throughout the residence.

***Ceiling*:** The existing ceiling in Room KR104 is the same gypsum board (most likely 1/2" or 5/8" thick) characteristic found throughout the residence.

***Interior Door*:** The existing door opening to this room is historic wood casing and door (D-4). The door is a four paneled wood door with two vertical panels above two vertical panels below. The door measures 82" high x 36" wide x 1¾" thick and has historic metal door knob hardware and metal butt hinges at the interior face of the door.

***Moldings*:** A typical 4¼" wood baseboard with a ¾" base shoe molding painted white are present in Room KR103. A wood molding is located at the top of the gypsum board walls below the historic plaster wall. The historic crown molding is 4½" two-piece ovolo, fascia crown mold. The door opening in this room has 1" x 2½" wood trim at the head and jamb casings with mitered corners. The windows have 7/8" x 4¼" flat wood trim at the head and jamb casings. The jamb trim is joined to the head trim with butt joints. The moldings in Room KR103 are in sound condition and appropriately attached. The baseboard (B2) and crown molding (C3) in Room KR103 are illustrated in Figure 124 above.

The same 4¼" wood baseboard and ¾" quarter-round base molding painted white found in Room KR103 is present in Room KR104. A wood molding is located at the top of the gypsum board walls below the historic plaster wall. The historic crown molding is a 4" two-piece ovolo crown mold and picture rail. The



Figure 135: View of Laundry Room facing south.



Figure 136: Gouges and holes in the gypsum wall board in the Laundry Room.

windows have 7/8" x 4¼" flat wood trim at the head and jamb casings. The jamb trim is joined to the head trim with butt joints. The baseboard (B2) and crown molding (C4) in Room KR104 are illustrated in Figure 124 above.
***Fixture*:** There is a single fluorescent light fixture located in the center of the ceiling of this room.

**Existing Condition:** The condition of the finishes in Room KR104 is generally sound. Items of concern regarding condition include:

- Peeling and flaking paint at the exterior door threshold and door jamb trim.
- The gypsum wall board is torn at several locations at the southeast wall. (Figure 136)

## Laundry Room (KR105)

***Flooring*:** The existing flooring in Room KR105 is the same white and brown 12" x 12" vinyl asbestos tile (VAT) characteristic found throughout the residence. The floor tile is a potential source of asbestos from the materials used to create the tile and likely the mastic used to secure the tile in place.

***Walls*:** The wall finish in Room KR105 is the same ½" gypsum wall board characteristic found throughout the residence. The gypsum board has been applied over the plaster of the three original walls in this room. The top portion of the northeast wall of this room has been cut out to allow for the routing of the ductwork for the HVAC system that is located within the dropped ceiling of the adjacent hallway.

***Ceiling*:** The existing ceiling in Room KR105 is the same gypsum board (most likely 1/2" or 5/8" thick) characteristic found throughout the residence.

***Moldings*:** There is no baseboard in Room KR105. A wood molding is located at the top of the gypsum board walls below the historic plaster wall. The historic crown molding is a 1¼" single-piece ovolo crown mold. The window opening is this room is has a 7/8" x 4¼" flat wood trim at the head and jamb casings. The jamb trim is joined to the head trim with butt joints. The moldings in Room KR105 are in sound condition and appropriately attached. The historic crown molding (C2) is illustrated in Figure 124 above.

***Fixture*:** There is a single fluorescent light fixture located in the center of the ceiling.

**Existing Condition:** The condition of the finishes in Room KR105 is generally sound. Items noted include isolated gouges and holes in the gypsum wall board. (Figures 138)

## Bathroom (KR106)

***Flooring*:** The existing flooring in Room KR106 is 8" x 8" white ceramic tile. According to Coast Guard architectural plans entitled "Crew's Quarters Floor Plan" dated July 19, 1985, vinyl asbestos tile (VAT) was installed in the bathroom in the mid-1980s as part of the rehabilitation of the residence. Given the presence of the VAT in other rooms of the residence, it is likely that the VAT was installed in the bathroom at that time as well, and the existing ceramic tile was installed at a later, unknown, date.

***Walls*:** The wall finish in Room KR106 is the same ½" gypsum wall board characteristic found throughout the residence. The gypsum board has been applied over the plaster walls. As described above, sampling of the interior finish at the historic plaster in the bathroom revealed that the walls were originally painted a pale green.

***Ceiling*:** The existing ceiling in Room KR106 is the same gypsum board (most likely 1/2" or 5/8" thick) characteristic found throughout the residence.

***Interior Door*:** The existing door to this room (D-5) is a hollow-core wood door that measures 82" high x 34" wide x 1¾" thick and has a metal door knob and butt hinges.

***Moldings* :** There is no baseboard in Room KR106. The historic crown molding is present at the joint of the historic plaster wall and ceiling. The crown molding is a 1¼" single-piece ovolo crown mold. The door and window openings in this room have 7/8" x 4¼" flat wood trim at the head and jamb casings. The jamb trim is joined to the head trim with butt joints. The moldings in Room KR106 are in sound condition and appropriately attached. The historic crown molding (C2) is illustrated in Figure 124 above.



Figure 137: Plaster damage at west corner of bathroom.



Figure 138: Plaster damage and peeling paint at northwest wall or bathroom.

***Fixture*:** There is a single fluorescent light fixture located in the center of the ceiling.

**Existing Condition:** The condition of the finishes in Room KR106 is generally poor. Items noted include:

- Torn and missing drywall at east corner of bathroom
- Missing plaster and holes in plaster at west corner (Figure 139)
- Missing plaster and holes in plaster at north corner
- Cracked and missing plaster at east corner
- Missing plaster and peeling paint at northwest wall (Figure 140)



Figure 139: Peeling and flaking paint from southwest wall above Window 12.



Figure 140: Peeling and flaking paint from plaster at southeast wall above Window 8.

## Kitchen/Dining Room (KR107)

***Flooring*:** The existing flooring in Room KR107 is the same white and brown 12" x 12" vinyl asbestos tile (VAT) characteristic found throughout the residence. The floor tile is a potential source of asbestos from the materials used to create the tile and likely the mastic used to secure the tile in place.

***Walls*:** The wall finish in Room KR107 is the same ½" gypsum wall board characteristic found throughout the residence. Two metal HVAC vents have been cut into the northwest wall of this room. One vent is located in the kitchen section of the room above the entry from the hall. The second vent is located in the dining room section of the room. Both vents are location approximately 6" from the ceiling.

***Ceiling*:** The existing ceiling in Room KR107 is the same gypsum board (most likely 1/2" or 5/8" thick) characteristic found throughout the residence.

***Moldings*:** A typical 4¼" wood baseboard with ¾" quarter-round shoe molding painted white is present in Room KR107. A wood molding is located at the top of the gypsum board walls below the historic plaster wall. The historic crown molding is present at the joint of the historic plaster wall and ceiling. In the kitchen section of the room, the crown profile is a 1¼" single-piece ovolo crown mold. In the dining section of the room, the crown profile is a 4 & 7/8" two-piece ovolo crown mold and picture rail. The door opening in the south elevation and window openings in this room have 7/8" x 4¼" flat wood trim at the head and jamb casings. The jamb trim is joined to the head trim with butt joints. The moldings in Room KR107 are in sound condition and appropriately attached. The baseboard (B1) and crown molding (C2 and C5) are illustrated in Figure 124 above.

***Fixture*:** There is a single fluorescent light fixture located in the center of the ceiling in both the kitchen and dining sections of this room.

**Existing Condition:** The condition of the finishes in Room KR107 is generally good. Items noted include:

- Peeling and flaking paint from plaster in kitchen section at southwest wall above Window 12 (Figure 141)
- Peeling and flaking paint from plaster in dining section at southeast wall above Window 8 (Figure 142)
- Cracked plaster in dining section at southwest wall between Windows 6 and 7

## Utilities

***Electrical System*:** As noted in the *Chronology of Development and Use* section above, the residence has undergone several updates of its electrical system. Most recently, between 1985 and 1989, the building was rewired, the electrical

panel and fire alarm replaced, and fluorescent interior fixtures and incandescent exterior fixtures were installed.

Currently, electrical power is provided to the Keeper's Residence by the photovoltaic (PV) system installed by the National Park Service in 2002. Prior to installation of the PV system, electricity was produced by two diesel-powered generators. Fuel for these generators was provided by the USCG, however due to the cost and hazards associated with delivering fuel to the island, the Coast Guard installed solar panels on the tower to power the Lighthouse. Shortly thereafter, the National Park Service installed an expanded PV system to service all of the structures of the Light Station.

Power for the Light Station utility systems and structures is generated by the large photovoltaic array located west of the tower. A bank of batteries, located in the rear addition of the oil house stores power from the system for use at night and for times when the array cannot provide enough current for demand during the day. The system's controllers and conversion panels are located on the south wall of the oil house and the distribution load centers are located in the south addition. From here electricity is delivered to the Light Station structures through underground conduits.

The electrical service for the Keeper's Residence is routed underground through a concrete "pull" hatch on the southwest side of the residence and into the crawlspace of the residence. (Figure 143) The wiring is then routed through the flooring to the surface-mounted distribution panel on the northwest wall of Room KR105. (Figure 144)

The house wiring runs from the distribution panel through the ceiling of Room KR105 into the attic. The wiring to and from the distribution panel is housed in gray plastic conduit. (Figure 145)

The wiring in the attic is sheathed in white plastic and attached to the framing with plastic fasteners as it is routed to the individual rooms. In addition, an older generation of fabric-clad wiring (in black sheathing) is present in the attic. (Figure 146)



Figure 141: Concrete "pull" hatch on the south side of the residence.



Figure 142: Surface-mounted distribution panel on northwest wall of Room KR105.

The distribution panel indicates 120/240 V service and is a 16-circuit panel with a 125A main circuit breaker. The 16 circuits are:

| | |
|---|---|
| Ckt. #1 | Birdbath (20-10kA) |
| Ckt. #2 | Microwave/Sink (20-10kA) |
| Ckt. #3 | Master Bedroom (20-10kA) |
| Ckt. #4 | Back Porch/Kitchen (20-10kA) |

Ckt. #5 Empty
Ckt. #6 Refrigerator/Stove (20-10kA)
Ckt. #7 Indoor AC Unit (20-10kA)
Ckt. #8 Dining Room/Bedroom (20-10kA)
Ckt. #9 Empty
Ckt. #10 Dryer (20-10kA)
Ckt. #11 Outdoor AC Unit (20-10kA)
Ckt. #12 Living Room/Front Porch (20-10kA)
Ckt. #13 Empty



Figure 143: Conduit from distribution panel to the attic.



Figure 144: White –sheathed wiring in the attic and older generation of fabric-clad wiring (in black sheathing).

Ckt. #14 Hot Water Heater (30-10AIC)
Ckt. #15 Empty
Ckt. #16 Empty

There are 24 electrical outlets, ten switches, six identical interior overhead fluorescent light fixtures, and two exterior incandescent light fixtures. Descriptions of electrical system components per room are summarized below.

- The living room (KR101) has six outlets, a double switch, and a double-tube fluorescent light fixture mounted in the ceiling. (Figure 147)
- The hallway (KR102) has two outlets, two single switches, and an electrical box (but no fixture) mounted in the ceiling.
- The bedroom KR103) has four outlets, a single switch, and a double-tube fluorescent light fixture mounted in the ceiling.
- The laundry room (KR105) has two outlets, a single switch, and a double-tube fluorescent light fixture mounted in the ceiling.
- The bathroom (KR106) has one outlet, a single switch, and a double-tube fluorescent light fixture mounted in the ceiling.
- The kitchen portion of Room KR107 has four outlets, two single switches, a double switch, and a double-tube fluorescent light fixture mounted in the ceiling.
- The dining portion of Room KR107 has five outlets, a double switch, and a two-tube fluorescent light fixture mounted in the ceiling.
- The back porch has a modern metal electrical box mounted in the ceiling with a porcelain fixture, but no light bulb. There is an additional square cut-out in the back porch ceiling with existing electrical wiring visible. The side porch light fixture is controlled by a switch in the kitchen just inside the side door.
- The front porch has a square cut-out in the ceiling for a fixture, but no electrical box, wiring, fixture, or bulb is present.

**Existing Condition:** The photovoltaic array has an anticipated useful life of 20 years, which leaves a minimum of 13 years before it will need to be replaced. However, the lifespan of the individual components of the system and the batteries range from eight to ten years. Regular maintenance of the system is required primarily due to the effects of the environment on individual system components.

The existing system has sufficient capacity to service the demand required by a general level of use. However, at certain times when the housing units are filled and demand for cooling is high the system is required to operate near its capacity. It has been suggested that better educating those that use the housing facilities about the limits of the system and energy saving measures would help to mediate these periods of peak demand and reduce strain on the system.

The electrical system of the Keeper's Residence is generally in sound condition. The plastic conduit, plastic sheathed wiring, distribution panel, and electrical switches, fixtures and outlets appear intact and in operable condition. However, the older generation of fabric-clad wiring shows signs of wear and the sheathing is frayed as viewed from the attic.

**Gas:** The Keeper's Residence has a propane gas supply system to provide fuel for cooking. Two steel gas supply tanks are located at the exterior of the northwest elevation adjacent to the kitchen. (Figure 148) The steel gas supply pipe penetrates the northwest foundation wall and extends southeast along the underside of the floor joists to a point where it turns up to connect to the oven in the kitchen.

**Existing Condition:** The gas system is in operable condition, however, the gas tanks themselves exhibit rust and corrosion. The roof of the shed covering the tanks is also deteriorated, with missing roofing shingles. (Figure 149)

**HVAC:** The Keeper's Residence was historically not air-conditioned. Air conditioning was installed in the residence in 1969. The system consisted of five (5) window-mounted air conditioning units, a ceiling exhaust fan, and glass fiber blanket-type insulation. Of the five



Figure 145: Double-tube fluorescent light fixture mounted in the ceiling.



Figure 146: Two steel gas supply tanks located at the west elevation.



Figure 147: Propane tanks exhibit rust and corrosion.

units installed, four were 13,000 BTU units and the fifth was an 8,000 BTU unit. [71]

As noted in the *Chronology of Development and Use* section of this report, an HVAC system was installed in the residence in 2002. During a project to convert the power source for the Light Station from diesel generators to photovoltaic electric generation and battery storage, a centralized air handling unit and two air compressors were installed at the residence.




Figure 148: Trane air handler located in the laundry room (KR105).

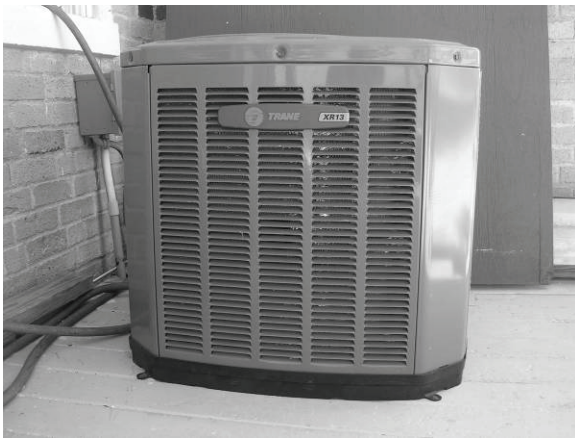



Figure 149: Trane air compressor located on the side porch.

The HVAC system has an air handler located in the laundry room (KR105). The Trane equipment (model # TWE031E13FB1; serial # Z501SXK1V) is a 200-230 volt, 4.3 amp unit that was manufactured in December 2001. (Figure 150)

Two Trane air compressors are associated with the residence. A Trane XR13 (model # 2TTR3018A1000AA; serial # 8374L8E3F) manufactured in September 2008 is located on the back porch. (Figure 151)

A Trane XL16i (model # 4TTX6048B1000BA; serial # 7311PBC1F) manufactured in July 2007 is located at the northeast side of the residence. (Figure 152)

During this project, the ceiling in the hall was lowered to accommodate the ductwork. (Figure 153)

The ductwork runs the length of the hall encased in the dropped ceiling and provides air supply to each adjacent room through vents at the upper portion of the common walls. (Figure 154)

**Existing Condition:** The HVAC system is in reliable operating condition. The air conditioning function of the system was in working order during the time of inspection. The air handler unit and compressors appear to be intact. The portion of ductwork visible from the interior of the residence and within the dropped ceiling is in sound condition, with no holes or tears evident.

**Plumbing System:** According to the 1920 specifications for the Keeper's Residence, a plumbing system was installed in the building at the time of construction. The specifications outline the following requirements for the original plumbing system:

- Rough in all necessary connections for kitchen sink, bath tub, lavatory and water closet.

[71] Floor Plan by the U.s. Coast Guard Civil Engineering Division: Barracks Building Air conditioning project, Dry Tortugas Light Station; Dated April 10, 1969.

- Two separate lines of ¾ inch galvanized wrought iron pipe to extend from sink, bath tub and lavatory, connecting into two common runs of 1 inch galvanized wrought
- iron pipe which shall extend beyond the foundations of dwelling not more than six feet.
- A 3 inch cast iron pipe, with proper connections for waste pipes from sink, lavatory, bath tub and water closet, shall be suspended securely from the bottom of floor joists and extend through foundation wall and terminate with Y-branch and cleanout plug.
- The plumbing fixtures were bid separately and were to be installed and connected to waster and supply pipes.
- One cast iron roll rim kitchen sink, 36 by 20 inches, integral back with hollow space for pipe connections
- One rectangular pattern, 20 by 18 inch, enameled iron, integral back roll rim lavatory, with oval bowl, apron, and open integral overflow
- One 5 foot, enameled, cast iron, roll rim bath tub supported on cast-iron ball feet
- One vitreous ware, flushing rim, siphon jet water closet, with pedestal base and molded in trap, provided with substantial, well finished seat and cover and low-down, vitreous ware flushing tank
- Faucets are to be standard grade, well finished nickel plated of Fuller type

Visual inspection reveals that additional plumbing lines and fixtures have been installed, although the date if installation is not known. These more recent plumbing lines are 16" PVC piping located under the house in the crawlspace and on the northeast side of the residence adjacent to the bathroom. (Figure 155) Remnants of the older generation of iron piping are still in place in the crawlspace as well. (Figure 156)

Water is supplied to the residence via a reverse osmosis potable water system. From the holding



Figure 150: Trane air compressor located at the north elevation behind the walk boards.



Figure 151: View of dropped ceiling and ductwork in the hall.

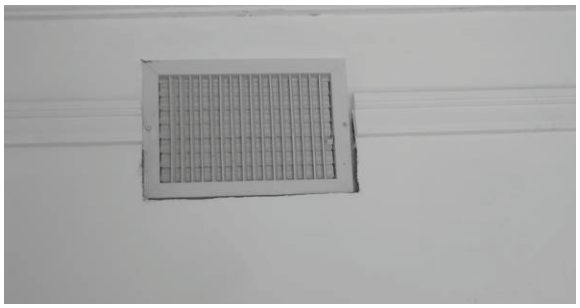


Figure 152: Typical metal vent in rooms.



Figure 153: View of PVC plumbing lines located in the crawlspace.



Figure 154: View of older generation iron plumbing piping.



Figure 155: Existing sink in kitchen (KR107).

tanks located in the south Oil House addition water is pumped to the residence via an underground PVC supply line. Hot water is provided by a passive hot water heater located to the north of the residence.

Plumbing fixtures have been installed in the kitchen, laundry room, and bathroom. The fixture in the kitchen is a stainless steel double sink. The 1921 architectural plans show that the original sink was installed at the northwest (rear) wall of the kitchen. The existing sink is located at the southeast wall. (Figure 157)
A plumbing connection is provided in the laundry room for a washing machine that is part of a stacked system. (Figure 158)

There are three plumbing system fixtures in the bathroom, including a sink/lavatory, molded plastic shower, and toilet. The 1921 architectural plans show the original sequence of fixtures in the bathroom of lavatory and water closet along the left side of the room and tub at the northeast wall. The existing sequence of fixtures is sink, molded-plastic shower, and toilet along the left side of the room. (Figure 159)

**Existing Condition:** The plumbing system is generally in reliable operating condition. No signs of active or past leaking from the piping were observed under the residence at the time of inspection.

## Summary of Conditions

The following is a summary of the condition issues observed during inspection of the Keeper's Residence.

### Structural

- Localized mortar loss and joint cracking at foundation walls and piers.
- Floor framing exhibits no sign of settlement or deterioration.
- Roof framing exhibits no signs of significant past or active moisture damage. Existing open attic vent is potential source of moisture infiltration. Fasteners appear in generally good condition.

- Although no active termites where observed, isolated areas of damage from previous termite activity are present.

### Exterior

- Existing composition asphalt shingle roofing exhibits no signs of moisture infiltration, though several individual shingles are torn or missing.
- Gutters and downspouts, which were original features of the residence, have been removed.
- The eave and cornice exhibit general weathering and deterioration of painted finish to wood elements; metal flashing and nails are rusted though still functional; and localized damage to the wood molding and screening at the eave soffit.
- Moderate erosion of mortar and face brick at exterior walls due to weathering. Several areas of deteriorated masonry have been repaired with replacement brick and mortar not matching historic materials.
- Extensive localized mortar joint and masonry cracking at exterior masonry walls due to jacking from corrosion and associated expansion of the steel lintels embedded in masonry walls.
- Localized damage to mortar joints, brick, and concrete caps at front porch piers due to corrosion and expansion of embedded anchors.
- General weathering and deterioration of the painted finish of front porch columns, eave and cornice and side porch posts, eave and cornice.
- Multiple layers of paint build-up and chipping and flaking of the outer layers at front and side porch ceilings and flooring.
- The existing non-historic front porch railing is not compatible with the historic character of the building. Front porch balustrade at south corner of house is separating and face board is detached from wall.
- Front and rear porch floor boards are damaged at their outside edges, including broken boards, split & cracking board ends, joint separation between boards, and rot damage to boards.
- Localized damage to wood molding and screening at the eave soffit at the front and side porches.
- Separation at joint between cheek walls and cement steps at front porch stairs due to settlement of stairs.
- Finish on the exterior face of all doors is slightly weathered due to exposure to the



Figure 156: Existing washing machine and dryer in the laundry room (KR105).



Figure 157: Plumbing fixtures in the bathroom (KR106), including sink, shower and toilet (beyond shower).

elements; heads of nails used to fasten weather stripping to the secondary front door are corroded.

- Removal of historic doors and modification of primary entrance surround.
- Steel lintels above the door frames show minor corrosion.
- Paint finish on the threshold at the primary front door is chipped and cracked at select locations.
- Aluminum tracks for hurricane shutters installed at the window heads and sills have caused cracking and chipping of the brick masonry and concrete sills.
- Removal of historic louvered wood shutters.

### Interior

- Tile flooring is uneven and in Room KR101, most likely due to poor underlayment and/or moisture infiltration from below.
- Diagonal hairline cracks in plaster wall at east corner of Room KR101, south corner of Room KR103, and southwest wall between Windows 6 and 7 in room KR107. These cracks appear to be dormant.
- Peeling and flaking paint from plaster at southwest wall above Window 12 and southeast wall above Window 8 in Room KR107; at the southeast wall at its juncture with the ceiling in Room KR102; and at the southwest wall along the door frame in Room KR103.
- Isolated gouges and holes in the gypsum wall board in Room KR105 and at the east corner in Room KR106.
- Missing plaster and holes in plaster walls at west corner, north corner, east corner, and northwest wall of Room KR106; cracked plaster in southwest wall between Windows 6 and 7 of dining section of Room KR107.
- Separation/minor crack between drywall panels at ceiling of dining section of Room KR107.

### Utilities

- The electrical system appears in sound condition. The plastic conduit, plastic sheathed wiring, distribution panel, and electrical switches, fixtures and outlets appear intact and in operable condition. The older generation of fabric-clad wiring shows signs of wear and the sheathing is frayed as viewed from the attic.
- The gas system is in operable condition, however, the gas tanks themselves exhibit rust and corrosion.
- The HVAC system is in reliable operating condition. The air conditioning function of the system was in working order during the time of inspection. The air handler unit and compressors appear to be intact. The portion of ductwork visible from the interior of the residence and within the dropped ceiling is in sound condition, with no holes evident.
- The plumbing system is generally in reliable operating condition. No signs of active or past leaking from the piping were observed under the residence at the time of inspection. However, the older generation of wrought and cast iron piping located in the crawlspace exhibits signs of corrosion.

# Requirements for Treatment and Use

The treatment and use of the Dry Tortugas Keeper's Residence must be considered within a framework of applicable laws, policies and agreements. These various mandates govern a wide range of management issues beyond the preservation, protection and interpretation of the Park's cultural resources. They extend to issues of visitor and staff use, safety, and universal accessibility among others. Because the National Park Service has agreed to reserve a room in the Keeper's Residence for the exclusive use of U.S. Coast Guard personnel and provide water and power to the residence under a cooperative agreement between the two agencies, treatment and management will in part be bound by this and future agreements between the NPS and USCG.

## The National Historic Preservation Act

Section 106 of the National Historic Preservation Act mandates that Federal agencies, including the National Park Service take into account the effects of their actions on properties listed or eligible for listing in the National Register of Historic Places. The goal of this directive is to encourage agencies to avoid or minimize adverse impacts to cultural resources and to make sure preservation is fully considered as part of the planning process. The Section 106 process also requires consultation with parties outside the National Park Service that may have an interest in the property.

In 1995, in an effort to expedite the review process, a programmatic agreement was made between the Advisory Council and the NPS that allows for programmatic exclusion of some activities from the full Section 106 review process. These excluded activities are limited to routine repairs and maintenance that do not alter the appearance of the historic structure or involve widespread or total replacement of historic features or materials.

## Accessibility

The National Park Service is committed to providing persons with disabilities the highest feasible level of physical access to historic properties.

The Architectural Barriers Act of 1968, the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 set forth the federal mandate for making buildings and facilities more accessible. The guidelines that accompany these Acts as well as the Uniform Federal Accessibility Standards (UFAS; 41 CFR 19.6; 49 FR 31528) provide design direction for accessibility modifications to historic structures in the national park system. With regard to outdoor developed areas such as trails, beaches and picnic and camping areas, the National Park Service has adopted the U.S. Access Board's Outdoor Environments guidelines.

Given that full compliance with these mandates in many cases would require alteration of significant features of a historic property, provisions have been made within the Acts for achieving alternative means of compliance. Given that the Keeper's Residence will be used as housing, options for providing full accessibility should be explored.

In addition to building and site related accessibility issues, the primary challenge at the Dry Tortugas Light Station is accessing the site itself. Although at least one of the commercial vessels used to transport visitors to the park is accessible and equipped to accommodate a wheelchair, currently the only debarkation point within the park is on Garden Key. There are currently no public docking facilities provided at

Loggerhead Key. Thus there is currently no accessible route that could bring a mobility-impaired visitor to Loggerhead Key or the Light Station. If accessible access to the island could be established, improvements to the wharf and walkways would have to be completed to access the Light Station itself. Due to the topography of the Key, providing an accessible route from the dock to the Light Station may require significant alteration of the historic landscape.

Recognizing its obligation to make the Park accessible to the widest audience possible, the Park has outlined its management direction in the General Management Plan Amendment.

Make visitor and management facilities as accessible as practicable, depending on the nature of the area and of the facility, to persons with visual, hearing, mobility, and mental impairments. Strive to provide the highest level of accessibility possible to facilities, programs, and services consistent with the nature of the area, the conservation of resources and the mandate to provide a quality experience for everyone.

Meet accessibility standards on visitor transportation vessels and aircraft with the limits of marine and aircraft design and safety requirements. Work with organizations that encourage and enable use of the park areas by special populations, which will increase awareness o f the needs of these populations and help to ensure that potential visitors with particular needs are aware of the opportunities offered at the Dry Tortugas.

## International Building Code

As a matter of policy, the National Park Service has adopted the International Building Code which establishes minimum regulations for the design and installation of building systems with an emphasis on preserving public health and safety. Its requirements are applicable to both new construction and the repair and alteration of existing buildings.

Full compliance with IBC requirements is not mandatory for historic buildings where there is no threat to life safety.

> 3407.1 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].

Alternatives to full code compliance can be sought where compliance would needlessly compromise the integrity of the historic building.

## DO #58 and NFPA Code 914

Among many other issues, the National Park Service Management Policies address the protection of historic resources against fire. Section 5.3.1.2 of the policy document states that:

In the preservation of historic structures and museum and library collections, every attempt will be made to comply with national building and fire codes. When these cannot be met without significantly impairing a structure's integrity and character, management and use of the structure will be modified to minimize potential hazards rather than modifying the structure itself.

NFPA Code 914, "Fire Protection of Historic Structures" has been adopted by the National Park Service.

Since the Keeper's Residence is to be used for housing, the addition of a sprinkler system to provide fire suppression is recommended. Further assessment should be conducted to determine the feasibility of installing a sprinkler system in the building. If it's not feasible, alternative means of providing fire protection should be explored.

## The Secretary of the Interior's Standards

Treatment of historic resources associated with the Light Station is to be guided by The Secretary of the Interior's Standards for the Treatment of Historic Properties. These

standards provide a framework for planning and implementing responsible preservation practices and ensuring there is a philosophical consistency to the work. A series of guidelines have been developed to accompany the standards and assist with their interpretation.

Additionally, the Preservation Briefs published by the National Park Service provide technical guidance for the appropriate treatment of a variety of materials, features and conditions found in historic buildings.

## Cooperative Agreements with USCG

When Dry Tortugas National Park was established in 1992 the U.S. Coast Guard determined the facilities on Loggerhead Key to be "excess to its needs" and transferred the property (the entire key) to the National Park Service. The transfer of property excluded the Lighthouse with the stipulation that the USCG would continue to "maintain and utilize" the structure for its own purposes, primarily as an active aid to navigation.

In 2007 the USCG and National Park Service entered into a cooperative agreement regarding the use of facilities and utilities on Loggerhead Key. This agreement requires the NPS to reserve a room within the Keeper's Residence for the exclusive use of USCG personnel and provide water and power to the building. Among other minor items the USCG agreed to provide propane and gasoline storage tanks to the island and to refrain from making modifications to the Keeper's Residence with the exception of rehabilitating the rainwater collection system.

In 2008 a Memorandum of Agreement was prepared between the USCG and the NPS that establishes the parameters for the formal transfer of ownership of the Lighthouse to the NPS. Transfer of the Lighthouse is contingent upon several requirements, one being completion of this Historic Structure Report. Upon transfer of the Lighthouse the USCG will retain ownership of the lens and associated equipment and require continued access to the Lighthouse to maintain this equipment.

# Ultimate Treatment and Use

## Use

The Dry Tortugas Light Station has served continuously as an aid to navigation since its light was first lit in 1858. Likewise, the Keeper's Residence has continuously served as housing for Lighthouse Board, USCG and NPS personnel and visitors to the Key for more than 80 years.

As discussed in the previous section, current cooperative agreements with the USCG affect the use of the Keeper's Residence, requiring at least a portion of the building to be used for housing. Under these agreements, the NPS has agreed to maintain a room in the Keeper's Residence for the exclusive use of USCG personnel when on the Key. In addition, the agreements stipulate that the USCG will not make any modifications to the building except to rehabilitate the rainwater collection system.

Further, the Park's General Management Plan Amendment (GMPA) calls for the resources of the Light Station to be preserved and protected according to the Park's authorizing legislation and also that they be managed to support operational needs and visitor use. An important outcome of the GMPA has been the establishment of management zones that prescribe the types and levels of visitor use and the amount of manipulation of the natural or cultural setting that is appropriate for different areas of the Park.

The GMPA has addressed treatment and use of the Light Station resources through the creation of a Historic Preservation/Adaptive Use (HP/AU) Management Zone. One of four management zones established within the Park, the HP/AU Zone applies to those areas that contain historic and cultural resources and where the visitor experience will be primarily focused on educational and interpretive opportunities.

Two management zones have been applied to Loggerhead Key. The HP/AU Zone encompass the resources of the Light Station in the center of the Key with the remainder of the island falling within a Research Natural Area Zone.

The parameters established by the GMPA for Loggerhead Key, limit the number of visitors that can be on the island to 24 (12 originating from the commercial carriers and 12 from private vessels). This number has been established as an initial baseline that may be adjusted in the future pending the results of a monitoring program and the completion of the re-vegetation project.

Permissible uses within Loggerhead Key's HP/AU zone include unrestricted picnicking, hiking, and exploring. However, the GMPA currently restricts visitor access to the buildings until such time as the structures can be made safe and the appropriate programs are in place to support this level of use.

Since the transfer of Loggerhead Key and the Light Station to the National Park Service in 1992, public visitation to the Key has been limited. Existing concession agreements do not include provisions for transporting visitors from Garden Key to Loggerhead Key. Therefore the site has only been accessible to those reaching the island by private vessel.

Looking forward however, the Park is exploring ways that it can improve public access to the Key through renewed concession agreements. In addition, consideration is being given to utilizing the Light Station resources as a "base of operations" for an expanded program of scientific investigation and research associated with the areas status as a Research Natural Area (RNA). This

designation covers a 46 square mile area that is designated as a marine reserve designed to restore ecological integrity and capacity for self-renewal by minimizing human disturbance. The RNA complements the adjacent Tortugas Ecological Reserve of the Florida Keys National Marine Sanctuary (FKNMS). Together the RNA and the larger Tortugas Ecological Reserve will help to ensure the success of both marine and terrestrial ecosystems while offering outstanding opportunities for scientific research and public education.

Under these scenarios, the use of the Keeper's Residence is not anticipated to change, however its intensity of use may be increased. The Keeper's Residence will continue to serve as residential housing for Coast Guard and National Park Service personnel as well as contractors and researchers while visiting the Key.

The Keeper's Residence should be interpreted as a historic component of the Light Station and a good example of an early-twentieth century light keeper's residence. While the exterior of the Keeper's Residence can contribute to the interpretive experience of visitors to the Light Station, NPS personnel have indicated that the interior of the residence will be used for housing and will thus not be open to visitation by the general public.

## Building Fabric

While the Keeper's Residence has received modifications over time, the building retains a majority of its historic integrity. Some of the existing building elements date to the building's construction while others have been replaced with non-historic materials. The

Keeper's Residence is a bungalow style structure with a masonry wall structure and three door and fifteen window openings. The building has a wood frame hipped roof structure with asphalt shingle roofing. There have been changes to these elements over time, including repair and replacement of materials that have deteriorated due to the extreme weather conditions at the Key or that have been upgraded due to technological improvements in materials (such as the composition asphalt roofing shingles) and systems (installation of HVAC, electrical and passive solar systems).

The building's load-bearing brick masonry walls remain intact though they have been repaired and repointed over time. The existing six-over-six double-hung windows in the residence were installed in 2003, replacing non-historic windows installed at an earlier date. The size and pane configuration of the existing windows accurately replicate that of the windows that were present in the residence historically. The wood shutters that were originally installed over the windows have been removed at an unknown date and metal hurricane shutters and tracks installed over the windows. In addition, the historic exterior doors and the entry surround at the front door have been removed and replaced with non-historic components. While the asphalt roofing is not historic to the residence, the wood frame roof structure is historic and intact.

The interior of the residence has experienced changes in its floor plan and finishes. The floor plan was first altered in the early 1950s, and twice again in the 1980s. Also in the 1980s, new flooring and baseboards as well as gypsum board over the plaster walls and wood ceilings were installed. The residence underwent several changes to its mechanical systems. The plumbing system was updated in the early 1950's and a fire detection system was added in the early 1970's. The building was rewired and new electrical outlets and fixtures were added during the 1980s.

Centralized air conditioning and high efficiency appliances were added to the residence in 2002.

## Recommended Ultimate Treatment and Use

It is recommended that the ultimate treatment and use of the Light Station resources remain consistent with the guidelines established in the GMPA for the HP/AU Management Zone. As the name implies, this zone calls for the preservation, protection and interpretation of

cultural resources yet recognizes the need to adaptively use these resources to accommodate critical functions, such as housing, sheltering essential equipment and utility components and the maintenance of the lighthouse optic as an active navigational aid.

The Recommended Ultimate Treatment for the Keeper's Residence is restoration of the exterior character of the building to its historic appearance to enhance interpretive programming and rehabilitation of the interior spaces and finishes to accommodate the needs for continued use as housing.

The historic character of the building's exterior appearance should be maintained and restored where appropriate during future rehabilitation projects to correct condition issues. Exterior components that should be restored include the exterior doors and primary entry sidelights, wood shutters, wood lattice at rear porch, and fencing around site.

Given that the Keeper's Residence will continue to be used to provide housing to personnel at the Light Station, the interior should continue to be adaptable to the needs of modern living while preserving existing historic character.

This treatment approach would maintain and restore the exterior of the building to the period of its original construction, and thereby facilitate interpretation to that period of modernization at the Light Station in the early 1920's. This approach would maintain the existing interior character and allow for necessary material and system upgrades to accommodate residential use of the building. This approach would also allow for future interpretation of the evolution of changes to the interior of the building.

This approach has the following advantages:

- Addresses deferred maintenance and needed repairs to prevent further deterioration or loss of historic fabric
- Preserves in place for interpretation, building fabric from a broad spectrum of the building's history.
- Removes modifications made during the recent past that are not in keeping with the building's historic character (such as non-historic doors).
- Restores character defining features such as the exterior doors and louvered wood shutters that were historically present on the building.

This approach has the following disadvantages:

- Misses the opportunity to restore and interpret the interior floor plan and finishes, such as the plaster wall finishes, wall finishes and wood ceiling finishes.

# Alternatives for Treatment and Use

## Use

The Dry Tortugas Keeper's Residence was designed for the single purpose of providing residential housing for the principal keeper and family while stationed at the Light Station. While the Keeper's Residence no longer provides housing for a keeper, it continues to be used for the purpose of housing for visitors to the Light Station.

While the intent of the NPS is to continue to use the Keeper's Residence to provide housing for staff and visitors to the Key, the building could be adaptively used for other purposes in the future. Consideration for potential alternative uses could include adapting the building as a visitor center should the level of visitation rise to a point where a visitor center is warranted and/or the need for residential housing on the Key is reduced.

## Treatment

The proposed ultimate treatment recommends restoration of the exterior of the Keeper's Residence to its 1920's appearance. Potential exterior elements for restoration include the exterior doors and entry sidelights, wood shutters, wood lattice at rear porch, and fencing around site.

An alternative treatment approach would be to restore both the exterior and interior of the building. While this approach would best facilitate full interpretation of the building and its use as a Keeper's Residence and would not necessarily preclude it from being used for housing, it would not best serve the ongoing need for the Keeper's Residence to provide comfortable and functional housing for visitors to the island.

Another alternative treatment approach would be to restore the exterior of the building to its historic appearance and rehabilitate the interior while restoring certain interior character defining features. Through this approach, several non-historic interior finishes could be removed to recapture the historic finishes of the residence, including the vinyl asbestos tile and carpeting, gypsum board wall and ceiling finishes. This alternative approach is similar to the recommended treatment and restoration of these select interior material features could be pursued in future rehabilitation projects as the existing non-historic materials deteriorate or are removed.

Another alternative treatment approach would be to preserve all existing fabric regardless of its aesthetic character in order to represent and interpret the full evolution of changes to the Keeper's Residence throughout its entire history.

# Recommendations for Treatment and Use

The 1922 Keeper's Residence at the Dry Tortugas Light Station was well-designed, well-constructed, and generally well-maintained. The building has remained in sound condition throughout periods of oversight by the Bureau of Lighthouses, U.S. Coast Guard, and the National Park Service. While the building has undergone interior plan and material changes over time, it retains its historic character as a residence for keepers and their family members and later visitors to the Light Station.

## Foundation

While the house foundation walls show no signs of significant deterioration, the porch foundation walls exhibit loss of mortar in the masonry joints, past repointing with mortar that does not match the historic mortar, and weathering and spalling of brick.

**Recommendation:** Where its removal will not result in damage to the brick, it is recommended that incompatible replacement mortars be removed, damaged brick replaced, and deteriorated joints repointed. All deteriorated joints with a loss of mortar to a depth of more than 5/8" should be repointed. Based on inspections made during the development of the HSR, it is estimated that approximately 35% of the porch foundation walls should be repointed.

Formulate repointing mortar to match as closely as is practicable, the composition of the original mortar. The mortar analysis identified ordinary gray Portland cement as the original binder with natural carbonate sand at a component ratio of 1:2.4. Given that modern Portland cements differ in character from their early-twentieth century counterparts it is recommended that the repair mix be tempered with lime. Consideration should also be given to using a Type II or Type V (sulfate resistant) Portland cement given the salt laden environment. Mock-ups should be prepared to ensure the most accurate match possible between the replacement and historic mortars. Brick to be replaced should also match existing brick in size, color, and texture.

## Roof

The roof of the Keeper's Residence is performing well and is not currently in need of replacement. However, it is recommended that the few missing and damaged asphalt shingles be replaced with shingles matching the existing roofing material. In addition, the existing attic vent that is currently open to the elements should be protected so that moisture cannot infiltrate into the attic. As the roofing materials deteriorate and replacement becomes necessary, consideration should be given to installing a roofing material that matches the hexagonal pattern of the original roof.

**Recommendation:** It is recommended that the rusted metal drip edge and nails be replaced, damaged wood quarter-round and soffit screening be replaced, gap in the drip edge at the south elevation be repaired, gap in the frieze board at the east corner be repaired, and the weathered painted finish be repainted white based on results of the Materials Analysis.

## Gutters & Downspouts

While the residence originally had galvanized metal gutters and downspouts, PVC gutters and downspouts were installed in 1989. There are currently no gutters and only a single

disconnected PVC downspout remaining on the residence.

**Recommendation:** It is recommended that K-style gutters with round downspouts be installed on the residence. Sizing of these components will depend on rainfall analysis and required capacities. Despite reference to half-round gutters in some of the specifications, application of K-style gutters is consistent with early drawings and historic images of the residence.

## Exterior Walls

The exterior walls have experienced moderate erosion of mortar and face brick due to weathering caused by the extreme conditions at the site.

Evidence of past repointing campaigns conducted with incompatible mortars and of varying levels of workmanship indicates that erosion of the historic mortar has been occurring for some time.

In addition, areas of the exterior walls along the tops of windows and between windows have experienced cracking of the mortar joints and brick caused by jacking of the steel lintels. This damage extends from the top corners of the windows horizontally around most of the perimeter of the building. The result is that the top eight to ten courses of brick at the top of the exterior walls has been shifted out of alignment.

Where its removal will not result in damage to the brick, it is recommended that incompatible replacement mortars be removed, damaged brick replaced, and deteriorated joints repointed.

The areas of past mortar replacement (as outlined in the Exterior Walls section of the Physical Description) are indicated by mortar that is darker grey in color, has a smoother consistency, and wider joints than the lighter gray, more textured, and narrower joints of the historic condition.

**Recommendation:** Based on inspections made during the development of the HSR it is estimated that approximately 25% of the exterior walls should be repointed.

Prior to repointing, the steel window and door lintels should be removed and replaced with 316 grade stainless steel lintels. The new stainless steel lintels should be painted with a colored top coat to match the color of the historic lintels.

Formulate repointing mortar to match as closely as is practicable, the composition of the original mortar. The mortar analysis identified ordinary gray Portland cement as the original binder with natural carbonate sand at a component ratio of 1:2.4. Given that modern Portland cements differ in character from their early-twentieth century counterparts it is recommended that the repair mix be tempered with lime. Consideration should also be given to using a Type II or Type V (sulfate resistant) Portland cement given the salt laden environment. Mock-ups should be prepared to ensure the most accurate match possible between the replacement and historic mortars. Brick to be replaced should also match existing brick in size, color, and texture.

## Front Porch Piers

The brick, mortar joints and concrete caps at the front porch piers are cracked in multiple locations. These cracks appear to be the result of internal stresses caused by corrosion of iron components embedded within the piers. Although it could not be confirmed during the site inspection that metal components are present, historic documentation suggests that anchor rods were extended down through porch columns and into the piers as a means to secure the porch roof from uplift during hurricanes.

**Recommendation:** It is recommended that the damaged piers be disassembled and the corroded anchors be removed and replaced if significantly deteriorated or blasted and coated with a protective finish. The damaged pier caps should be repaired through stone conservation measures by doweling the pieces together and securing with adhesive.

Replacement brick should match existing brick in size, color, and texture and repointing

mortar should consist of Portland cement as the binder with natural carbonate sand at a component ratio of 1:3 (as recommended in the finish analysis.)

## Front and Rear Porch Flooring

While the porch floors are generally sound structurally, there are individual boards that are damaged, including broken ends, split and cracking ends, and rot damage. The individual instances of this damage are outlined in the condition assessment above. In addition, the floor boards and structural members of the rear porch have been reoriented during a previous repair.

**Recommendation:** It is recommended that damaged boards be repaired as possible and replaced as necessary. Treatment should include application of borate wood preservative to arrest any active rotting, followed by application of epoxy consolidation of affected wood and epoxy putty filler of missing wood. If use of epoxy products is not warranted, replace damaged portion of floor boards with in-kind materials. Install ledger board at rear porch or reorient floor structure to replicate original construction. In lieu of reorienting the flooring and structure, installation of the missing ledger board would conceal the original joist pockets and make the rear porch appear largely as it had originally. It is also recommended that the lattice screening that originally enclosed the rear porch be fabricated and reinstalled.

## Front Porch Railing

The turned balusters of the porch railing were installed in the relatively recent past and are not in keeping with the character of the Craftsman influenced architecture. It is recommended that the porch railing be restored to its original appearance with closely-spaced square balusters as shown in historic photographs.

## Front Porch Stairs

There is separation between the concrete stairs and brick cheek walls at the front porch stairs. It is recommended that this gap be pointed to prevent moisture infiltration.

## Front and Rear Porch Ceiling, Eave, Cornice, and Flooring

The painted finish on the wood elements of the porches is at the end of its life span. With multiple layers of paint, the outer layers are chipping and flaking, particularly along the eave, cornice, and wood columns.

These painted finishes likely contain lead and therefore consideration should be given to their removal. Alternatively however, it is recommended that the historic finishes be preserved in place and that the porch ceiling, eave and floors be repainted.

## Doors

As described above in the “Exterior Wall” section, remove existing deteriorating steel lintels above door openings prior to repointing. Following replacement of the lintels, it is recommended that the existing non-historic exterior doors be replaced with new doors replicating the appearance of the historic entrance doors and surrounds.

At the primary front door opening, restore the single wood door with flanking sidelights as indicated in historic images. At the side and rear door openings, restore the historic single wood doors as shown in historic images and drawings.

## Windows

The existing windows installed in 2004 are in good condition and generally match the site lines of the historic units. However, it is recommended that the existing deteriorating steel lintels above all window openings be removed and replaced with new 316 grade stainless steel lintels as described above in the “Exterior Wall” section.

In addition, it is recommended that damage to the concrete window sills and surrounding brick caused by the hurricane shutter guide tracks be repaired or the sills be replaced as necessary. Given that it will be necessary to

remove and remount the existing hurricane shutter tracks in a secure fashion that minimizes damage to the historic fabric, the new hurricane shutters should be designed in a manner that will accommodate the installation of the historic louvered wood shutters. In the event of a hurricane, the wood shutters would be closed and the steel hurricane shutters would be installed over the wood shutters. The design of the louvered wood shutters should match those shown in historic images.

## Floor Plan

Given that the building will continue to be used for residential purposes as has been initially indicated by Park staff, the existing floor plan can be retained as evidence of the evolution of changes to the building's layout.

Should the decision be made in the future that the structure is to be used to interpret the lives of Dry Tortugas Lighthouse keepers, restoration of the historic floor plan should be considered.

## Interior Floors

Given its relatively good condition, it is recommended that the existing vinyl floor tile be maintained in place. It is less practical however to maintain the existing carpeting and therefore it is recommended that the carpeting be removed and the historic wood flooring be restored in these spaces.

Given the possibility that the vinyl floor tile and/or mastic could contain asbestos, these materials should be tested as part of a regulated materials test. (See "Regulated Materials" section below). If the test results are positive, the tile can remain in place until it is damaged or becomes friable at which time it should be removed and the historic wood floors restored.

## Interior Walls

It is recommended that the existing upper sections of the plaster walls and wood crown molding be retained and repaired as necessary. If the existing gypsum board wall finish is damaged or deteriorates to the point of replacement, it would be appropriate to remove the drywall to expose the historic plaster wall finish.

## Interior Ceilings

If the existing gypsum board ceiling finish is damaged or deteriorates to the point of replacement, it would be appropriate to remove the drywall, and expose and repair the historic wood ceilings.

## Interior Moldings

It is recommended that the existing historic crown molding present above the non-historic gypsum board walls be retained and repaired as necessary. In addition, the historic casings at the interior door and window jambs and heads should be retained.

## Interior Plaster Wall Conditions

Hairline plaster cracks identified in the remaining top portion of the historic plaster walls above the gypsum board wall sections should be repaired with a gypsum-based patching material compatible with the historic finish. The locations of plaster damage are summarized below:

- Living/Berthing Room (KR101)
- Bedroom (KR103)
- Bathroom (KR106)
- Kitchen/Dining Room (KR107)

## Interior Gypsum Board Conditions

Patch holes in the gypsum board wall and ceiling finishes. The locations of gypsum board damage are summarized below:

- Laundry Room (KR105)
- Bathroom (KR106)

## Interior Paint Conditions

Deteriorated paint finishes identified on the interior surfaces should be scraped and repainted using a feather-edge technique and light sanding to reduce the paint thickness at

the edges. The rooms where this repair will be necessary are summarized below:

- Hallway (KR102)
- Bedroom (KR103)
- Bathroom (KR106)
- Kitchen/Dining Room (KR107)

## Electrical System

The electrical system is in sound operating condition. When the electrical system is updated or replaced in the future, it would be appropriate to reuse existing conduit where possible to minimize damage to existing historic finishes. Replace faulty receptacles and switches as needed and minimize installation of additional receptacles and devices which typically have a negative impact on a building's historic character. If the Keeper's Residence will be continue to be used for residential purposes and not be open to the public, the existing non-historic fluorescent light fixtures can be maintained and reused where possible.

It is also recommended that users of the Station's housing facilities be better educated about the limits of the electrical system and energy saving measures that will help mediate demand during peak usage periods and reduce strain on the system.

## Propane Gas System

The propane gas system is in sound operating condition. Ongoing maintenance and periodic replacement of propane tanks is recommended. It is also recommended that the propane tanks be relocated from in front of the crawlspace access to facilitate regular inspections of the foundation and floor framing systems. The existing shed roof can be reused and roofing shingles repaired or replaced to provide protection to the gas tanks.

## HVAC System

The HVAC system is in sound operating condition and it is recommended that the existing system be maintained to provide necessary climate control for the residence.

## Plumbing System

The plumbing system is in sound operating condition. In addition to ongoing maintenance of the plumbing system, it is recommended that the passive water heater be moved closer to the residence in order to reduce the amount of water wasted while waiting for heated water to reach the fixtures.

## Fire Suppression System

Installation of a fire suppression system in the Keeper's residence may not be practical based on the effects of the salt-laden environment would have on system components and the lack of available fresh water. It is recommended that protection of the building and occupants be provided through a smoke detection system and accessible extinguishers.

## Accessibility

Providing increased public access to Loggerhead Key carries with it several limitations and challenges. Assuming that transportation to the Key is resolved, visitors to Loggerhead would likely disembark onto the main dock on the east shore of the island and then walk a short distance on concrete walkways to the Light Station. The incline from the dock to the Light Station is gradual but in certain areas exceeds permissible slope limits for wheelchair use. In addition, wind-blown sand often covers the surface of the concrete walks. Given this difficulty of providing barrier-free access to Loggerhead Key and the Light Station buildings, providing full access to the interior of the Keeper's Residence may not be a practicable expectation.

In the event an accessible route to the building is established it would be necessary to construct a ramp to provide access to the first floor. Given the first floor's height above grade, the ramp would have a substantial footprint and therefore a significant visual impact on the character of the building.

## Regulated Materials

Based on the likely presence of asbestos in the vinyl asbestos floor tile and lead in the paint, it

is recommended that an environmental survey of the building be conducted to define the content, location and quantity of identified hazardous materials.

# Sources of Information


Bearss, Edwin C. *Historic Structure Report, Historical Data Section, Fort Jefferson: 1846-1898 Fort Jefferson National Monument.* 1983.

_____. *Shipwreck Study-The Dry Tortugas*. Washington, DC: Eastern Service Center-Office of History and Architecture, Department of the Interior, National Park Service, 1971.

Calder, Dale R. and Lester D. Stephens. *Seafaring Scientist: Alfred Goldsborough Mayor, Pioneer in Marine Biology,* Columbia, South Carolina: University of South Carolina Press, 2006.

Cipra, David L. *Lighthouses, Lightships, and the Gulf of Mexico*. Alexandria, Virginia: Cypress Communications, 1997.

Dean, Love. *Lighthouses of the Florida Keys*. Sarasota, Florida: Pineapple Press, 1998.

Ebert, James D. "Carnegie Institution of Washington and Marine Biology: Naples, Woods Hole, and Tortugas." Washington, DC: Carnegie Institute of Washington, 1985.

Florida Center for Instructional Technology, College of Education. "Florida's Role in the Civil War: 'Supplier of the Confederacy'." University of South Florida. http://fcit.usf.edu/Florida/cvl_war1.htm.

Holland, Jr., Francis R. *America's Lighthouses: Their Illustrated History Since 1776*. Brattleboro, Vermont: Stephen Greene Press, 1972.

Hurley, Neil E. *Lighthouses of the Dry Tortugas, An Illustrated History*. Aiea, Hawaii: Historic Lighthouse Publishers, 1998.

Johnson, Stuart and Richard Ramsden. *Rehabilitation Report and National Register Nomination for the United States Coast Guard Light Station Dry Tortugas Light Station, Loggerhead Key, Florida*. National Park Service, 1984.

Manucy, Albert. *A Constructional History of Fort Jefferson 1846-1874*. Atlanta, Georgia: National Park Service Southeast Region, 1961.

*Organization and Duties of the Light-House Board and Regulations, Instructions, Circulars, and General Orders of the Light-House Establishment of the United States,* Washington, DC: Government Printing Office, 1871.

Tag, Thomas. "The Early Development of the Fresnel Lens." U.S. Lighthouse Socieity, *The Keeper's Log,* Summer, 2005. www.uslhs.org.

_____. "The Sautter Lens Works Producers of the Fresnel Lens—Parts 1 and 2" U.S. Lighthouse Society, *The Keeper's Log,* Summer, 2005. www.uslhs.org.

U.S. Congress. *Light-house and Appropriation Bill. Lighthouse Board.* 32nd Congress, 1st sess., *Statues at Large of the United States of America, 1789-1873*. vol. 10, August, 1852.

_____. *Light-house and Appropriation Bill.* 34th Congress, 1st sess., *Statues at Large of the United States of America, 1789-1873*. vol. 11, August, 1856.

U.S. Lighthouse Board. *Registers of Lighthouse Keepers, 1845-1912*. National Archives and Records Administration Southeast Region, Morrow, Georgia.

_____.List of General Correspondence, 1791-1900. National Archives and Records Administration, Washington, DC. Record Group 26. NC-31. Series 38.

United States Coast Guard. Records Concerning Illuminating Apparatus, 1839-1960. National Archives and Records Administration, Washington, DC. Record Group 26. NC-31. Entry 59.

_____. Logbook of Lightstations. National Archives and Records Administration, Washington, DC. Record Group 26. NC-31. Entries 5, A1 330E, A1 330M, A1 330T, A1 330S, A1 330Z, A1 330AF,159D-159I.

_____. Studies and Surveys. National Archives and Records Administration, Washington, DC. Record Group 26. NC-31. Entry A1 345.

_____. Boards of Survey (Real Property) Case Files. National Archives and Records Administration, Washington, DC. Record Group 26. NC-31. Entries A1 99 and 99a.

_____. Light Station Files. National Archives and Records Administration, Washington, DC. Record Group 26. NC-31. Entry 381.

United States Department of Commerce. Recommendations as Aids to Navigation. National Archives and Records Administration, Washington, DC, Record Group 26 (These forms are filed within NC-31. Entry 51. Boxes 408 and NC-31. Entries A1 99 and 99a and occasionally among other records. They are standard appropriation request forms.)

United States Lighthouse Board. Dry Tortugas Clipping File. National Archives and Records Administration, Washington, DC. Record Group 26. NC-63. Entry 13.

United States Bureau of Lighthouses. National Archives and Records Administration, Washington, DC. Record Group 26. NC-31. Entry 51. Boxes 408 and 862.

## APPENDIX A

# Draft National Register Nomination

Museum Curator

H3223 (SER-OCR)

Memorandum

To: Acting Chief Historian, WASO

From: Deputy Associate Regional Director, Cultural Resources, Southeast Region

Subject: Submittal of National Register Nomination for Dry Tortugas Light Station, Dry Tortugas National Park

This nomination was initially prepared in 1984 by the Southeast Regional Office for the United States Coast Guard (USCG). The draft nomination was sent to the Seventh District Office of the Coast Guard that year. The USCG took no further action regarding the nomination. In 1989 the Superintendent of Everglades National Park requested that we seek a review of the nomination because the Coast Guard had expressed an interest in the National Park Service (NPS) assuming management of the Dry Tortugas Light Station on Loggerhead Key. In November 1989 a copy of the draft nomination was sent to the Chief Historian with a request for review by his office and the National Register. It was returned in early 1990 with specific comments and suggestions. For a variety of reasons nothing was done with the nomination until early 1993.

At that point we contacted the USCG and were able to retrieve the original photographs taken in 1984 and sent to their Miami office. Historian Len Brown went over the comments from the National Register staff, made the suggested changes, and updated it in accordance with National Register Bulletin 16A. We also field checked the photographs and determined that they still represented existing conditions. Marilyn Harper of the Register staff suggested this. Because the process of transfer of the property from USCG to the NPS had not been completed the nomination was not pursued for another year and a half. In November of 1994, the Superintendent of Everglades and Dry Tortugas National Parks indicated that we could submit the nomination.

Since it was reviewed five years ago, we ask that it be given a second review and, unless there are major problems, that it be entered on the National Register of Historic Places.

bcc:
Supt. EVER

LBrown: LB: 2/14/95

NPS Form 10-900
(Rev. 10-90)

OMB No. 1024-0018

United States Department of the Interior
National Park Service

NATIONAL REGISTER OF HISTORIC PLACES
REGISTRATION FORM

This form is for use in nominating or requesting determinations for individual properties and districts. See instructions in How to Complete the National Register of Historic Places Registration Form (National Register Bulletin 16A). Complete each item by marking "x" in the appropriate box or by entering the information requested. If any item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions. Place additional entries and narrative items on continuation sheets (NPS Form 10-900a). Use a typewriter, word processor, or computer, to complete all items.

## 1. Name of Property

historic name: Dry Tortugas Light Station

other names/site number: NA EVER

## 2. Location

street & number: NA _..cation ___
city or town: Loggerhead Key Dry Tortugas_____ _____ vicinity ___
state: Florida _____ code 12_ county: monroe_____ code 087____
zip code 33130___

## 3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act of 1986, as amended, I hereby certify that this ____ nomination ____ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property ____ meets ____ does not meet the National Register Criteria. I recommend that this property be considered significant ___ nationally ___ statewide ___ locally. ( ___ See continuation sheet for additional comments.)

_____ _____
Signature of certifying official Date

_____
State or Federal agency and bureau

In my opinion, the property ____ meets ____ does not meet the National Register criteria. ( ___ See continuation sheet for additional comments.)

_____ _____
Signature of commenting or other official Date

_____
State or Federal agency and bureau

## 4. National Park Service Certification

I, hereby certify that this property is:

____ entered in the National Register _____ _____
___ See continuation sheet.
____ determined eligible for the _____ _____
National Register
___ See continuation sheet.
____ determined not eligible for the _____ _____
National Register
____ removed from the National Register _____ _____

____ other (explain): _____

_____ _____ _____
Signature of Keeper Date of Action

## 5. Classification

Ownership of Property (Check as many boxes as apply)

___ private
___ public-local
___ public-State
X__ public-Federal

Category of Property (Check only one box)

___ building(s)
X__ district
___ site
___ structure
___ object

Number of Resources within Property

| Contributing | Noncontributing | |
|---|---|---|
| _5____ | 0___ | buildings |
| _1___ | _____ | sites |
| _4___ | _2___ | structures |
| _____ | _____ | objects |
| 10___ | 2___ | Total |

Number of contributing resources previously listed in the National Register _____

Name of related multiple property listing (Enter "N/A" if property is not part o a multiple property listing.) _____

## 6. Function or Use

Historic Functions (Enter categories from instructions)

| Cat: | Sub: |
|---|---|
| TRANSPORTATION | Water-related |
| DOMESTIC | Institutional |

Current Functions (Enter categories from instructions)

| Cat: | Sub: |
|---|---|
| TRANSPORTATRION | Water-related |
| DOMESTIC | Institutional |

## 7. Description

Architectural Classification (Enter categories from instructions)

LATE 19TH/EARLY 20TH CENTURY AMERICAN MOVEMENT--Bungalow

OTHER--Lighthouse

Materials (Enter categories from instructions)

foundation Not Known

roofs Copper/Asphalt; Sheetmetal; Asphalt Shingle; Metal Shingle

walls Brick

other

Narrative Description (Describe the historic and current condition of the property on one or more continuation sheets.)

## 8. Statement of Significance

Applicable National Register Criteria (Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing)

_X__ A Property is associated with events that have made a significant contribution to the broad patterns of our history.

____ B Property is associated with the lives of persons significant in our past.

_X__ C Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components lack individual distinction.

____ D Property has yielded, or is likely to yield information important in prehistory or history.

Criteria Considerations (Mark "X" in all the boxes that apply.)

____ A owned by a religious institution or used for religious purposes.
____ B removed from its original location.
____ C a birthplace or a grave.
____ D a cemetery.
____ E a reconstructed building, object,or structure.
____ F a commemorative property.
____ G less than 50 years of age or achieved significance within the past 50 years.

Areas of Significance (Enter categories from instructions)
_TRANSPORTATION_____
_ENGINEERING_____
_____
_____
_____
_____
_____
_____

Period of Significance ____1855 to Present_____
____1856 to 1858_____
____1920s_____

Significant Dates _1856-58_____
_1920s_____
_____

Significant Person (Complete if Criterion B is marked above)
_____NA_____

Cultural Affiliation _____NA_____
_____
_____

Architect/Builder _Captain Daniel P. Woodbury, U.S. Corps of Engineers_____

Narrative Statement of Significance (Explain the significance of the property on one or more continuation sheets.)

## 9. Major Bibliographical References

(Cite the books, articles, and other sources used in preparing this form on one or more continuation sheets.)

Previous documentation on file (NPS)
_NA preliminary determination of individual listing (36 CFR 67) has been requested.
NA_ previously listed in the National Register
NA_ previously determined eligible by the National Register
NA_ designated a National Historic Landmark
NA_ recorded by Historic American Buildings Survey # _____
NA_ recorded by Historic American Engineering Record # _____

Primary Location of Additional Data
___ State Historic Preservation Office
___ Other State agency
_X_ Federal agency
___ Local government
___ University
___ Other
Name of repository: __U.S. Coast Guard__Miami, FL._____

## 10. Geographical Data

Acreage of Property __1.85_____

UTM References (Place additional UTM references on a continuation sheet)

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| 1 | 17 | 305600 | 2725500 | 3 | __ | _____ | _____ |
| 2 | __ | _____ | _____ | 4 | __ | _____ | _____ |

___ See continuation sheet.

Verbal Boundary Description (Describe the boundaries of the property on continuation sheet.)

Boundary Justification (Explain why the boundaries were selected on a continuatio sheet.)

11. Form Prepared By

name/title__Stuart Johnson, Historian (1984) _Updated Len Brown ,Hist. (1993)_

organization__SE Region,__National Park Service_____ date__January__1995_____

street & number__75__Spring__St.__SW_____ telephone_404-331-5989____

city or town____Atlanta_____ state_GA_ zip code __30303_____

Additional Documentation

Submit the following items with the completed form:

Continuation Sheets

Maps

A USGS map (7.5 or 15 minute series) indicating the property's location.
A sketch map for historic districts and properties having large acreage or numerous resources.

Photographs

Representative black and white photographs of the property.

Additional items (Check with the SHPO or FPO for any additional items)

Property Owner

(Complete this item at the request of the SHPO or FPO.)
name _____

street & number_____ telephone_____

city or town_____ state_____ zip code _____

Paperwork Reduction Act Statement: This information is being collected fo applications to the National Register of Historic Places to nominate propertie for listing or determine eligibility for listing, to list properties, and to amen existing listings. Response to this request is required to obtain a benefit i accordance with the National Historic Preservation Act, as amended (16 U.S.C. 47 et seq.).

Estimated Burden Statement: Public reporting burden for this form is estimate to average 18.1 hours per response including the time for reviewing instructions gathering and maintaining data, and completing and reviewing the form. Direc comments regarding this burden estimate or any aspect of this form to the Chief Administrative Services Division, National Park Service, P.O. Box 37127 Washington, DC 20013-7127; and the Office of Management and Budget, Paperwor Reductions Project (1024-0018), Washington, DC 20503.

The

Dry Tortugas are located approximately 65 miles west of Key West, Florida, and 90 miles north of Cuba. These islands are the last in the 150 mile string of reefs and islands that make up the Florida Keys. There is no fresh water on the islands.

Loggerhead Key, one of the ten islands in the Dry Tortugas group, is approximately 4,200 feet long and 700 feet wide at its widest point (photo no. 1, maps 1--USGS Quad. and 2). Early reports indicate that vegetation on this island, as in the rest of the Dry Tortugas, was sparse consisting of scrub brush, cacti, and grass. At present, however, the island has a relatively thick vegetative cover. This is likely attributable to the fact that scientists from the Carnegie Institute introduced a variety of non-indigenous plants in the first decade of this century including coconut palms, azaleas, date palms, rubber trees, bananas, and ornamental cacti.

Historically there have been only two complexes of structures on Loggerhead Key. The main complex, the Dry Tortugas Light Station, is the subject of this nomination and is described in detail later in this section. However, from 1904 to 1939, the Carnegie Institute of Washington, D.C. maintained several buildings and structures at the northern tip of the island which were used during the summers as a marine biology laboratory (drawing 5). This site is heavily overgrown and, except for one ruined frame building, no structures survive. There are still several very deteriorated concrete specimen tanks and a plaque erected in honor of the first director of the laboratory, Alfred G. Mayer. The property lacks physical integrity and it does not appear that it would meet National Register criteria. Therefore it is not included in this nomination. However it should be assessed under Criteria D as an archeological property.

The Dry Tortugas Light Station is situated near the center of the island. Within the boundaries of that portion of the Station being nominated to the National Register are 12 structures (drawing 3). Of these two post-date World War II, and are considered to be intrusions. The rest of the structures date from 1856-58, the period of original construction, and the 1920s, a period in which the Lighthouse Service modernized the station to a considerable extent. A description of each structure (including intrusions) within district boundaries follows. One building outside the district is also described. This is the generator building that was constructed in the early 1960s.

A. **Lighthouse** Drawings: 2 to 5

Built in 1856-58, the Dry Tortugas Lighthouse is a conical shaped brick tower that is 150 feet in height and topped by a lantern containing a first order lens. Walls at the base of the lighthouse are approximately 8 feet 9 inches thick, and the diameter of the tower at that point is approximately 28 feet. From the base a winding staircase of cut granite blocks leads to a watch room

beneath the lantern. The diameter of the tower at this point (to the exterior surface of the watch room walls) is approximately 13.5 feet. Beginning approximately 12 feet beneath the watch room, the exterior of the tower is corbelled out to form the floor of an exterior gallery around the watch room. Resting atop the watch room is an iron lantern with a polygonal arrangement of windows. The roof and finial are of copper and have been coated with roofing asphalt. There is a narrow gallery around the lantern. The bottom half of the tower is painted white, while the upper half is painted black. This color scheme is not original, but apparently dates to about 1984.

U.S. Corps of Engineers Captain H.G. Wright, the officer in charge of construction of Fort Jefferson on Garden Key, developed schematic plans for the lighthouse in 1855. More detailed drawings of the lighthouse as well as other structures in the complex were produced in 1857, apparently by Wright's successor at Fort Jefferson, Captain Daniel P. Woodbury. These drawings show that the lighthouse has changed little since originally constructed.

Aside from routine maintenance, the only substantive repair of the facility came as a result of an 1873 hurricane which necessitated in 1875 the virtual reconstruction of a nine foot section of the tower directly beneath the lantern. This was accomplished by cutting out the existing masonry in narrow vertical sections and rebuilding each section before moving on to the next. Other repairs included the extension of the lantern anchors downward into the masonry being reconstructed to better secure the lantern to the tower. These repairs cost $75,000.

Construction of the Dry Tortugas Lighthouse was completed in 1858 with the installation of a first order Fresnel lens supplied by L. Sautter and Company of Paris, France. This lens was illuminated by oil lamps and its range was 20 miles. Initially the character of the light was fixed white, but in 1893 the character was changed to fixed white with a fixed red section. In 1909 the Lighthouse Service purchased a new first order bivalve lens from Henry Lepaute of Paris, France. The next year the character of the light was changed from fixed to flashing, and in 1922 parallel screens for the bivalve lens were installed. Sometime after World War II, the Coast Guard converted the illuminating apparatus for the lens to electricity. The light had a nominal range of 28 miles. The Coast Guard removed the classical lens in February 1987 and replaced it with a new automated system consisting of a rotating 24" high intensity lens with two emergency lights. The original lens is at the National Aids to Navigation School USCG Reserve Training Center, Yorktown, Virginia.

B. **Bosun's Workshop** (Former Oil Storage Building) Drawings 3 and 8

This 16' by 14' one story structure of formed concrete was built in 1926 to replace the original oil storage building that had been converted to house radio equipment. The roof is gabled and covered with corrugated metal. The single rear window has been filled in, the only apparent change to the building. Despite its

utilitarian nature, this structure is clearly linked to the modernization effort at the light station during the 1920s. In addition, its simple rectangular form and flat door and window sills and lintels give this structure an appearance that is very similar to the original oil house and kitchen.

C. **Radio Room** (Original Oil Storage Building) Drawings: 3, 5, and 8.

Built in 1856-58, this two story, brick structure measures 16' by 14' and originally served as a storage building for the oil used to illuminate the lamps in the lighthouse. The roof is gabled and covered with sheet metal. The c. 1900 photograph of the light station shows the building unpainted and with an internal chimney (since removed) against the south wall. Originally freestanding, this building was connected to the lighthouse in 1926 by a 12' by 6'4" passageway of formed concrete during the same time that it was converted to house radiobeacon equipment. It is interesting to note that original 1857 construction drawings for the lighthouse and other buildings in the complex called for the oil storage building to be connected to the lighthouse tower. After World War II, additional poured concrete additions were built against the south and west walls of the structure. Other changes to the exterior of this structure include the relatively recent installation of metal jalousie windows. On the interior, wooden stairs (presumably original) along the north wall lead to the second floor. On the walls and ceiling, 1" by 4" beaded panelling remains although it has been partially obscured on the walls by the subsequent installation of modern artificial panelling. Despite changes to this building it is still clearly identifiable as one of the original structures in the light station complex.

D. **Crew's Quarters** (Former Keeper's Residence) Drawings: 3 and 8.

Built in 1922 as the residence for the principal lighthouse keeper and his family, this building is a one story brick bungalow with a hipped roof covered with asphalt shingles. A front porch partially wraps around the northeast side of the house. Its roof is supported by tapered wooden columns resting on brick piers trimmed in coral stone. The piers themselves, the porch foundations, and the brick balustrade for the porch steps are all built of the same yellowish brick as the rest of the house except that a diamond pattern of contrasting red brick was "woven" into the masonry at the time of construction. A small rear porch serves as an outdoor service area for the kitchen. It has a shingled side wall, and its foundation is patterned in a fashion similar to that of the front porch. The buildings's exterior is apparently unaltered with the exception of the metal jalousie windows which have been substituted for the original double hung wooden windows. In addition, air conditioning units have been placed in several windows. The interior plan has been altered and wallsurfaces (originally plaster) have been covered with modern sheet panelling. The building is an excellent example of the bungalow style, one of the most common suburban housing types of the period. The choice of this style by the Light House Service was part of the overall modernization of the station which took place during the 1920s.

E & K. **Concrete Cisterns** Drawings: 4, 5, and 8.

These cisterns were built in 1922 to replace the original brick cisterns at the light station. Each measures 16′ by 10′ by 8′6" with approximately 4′ extending above the ground level. Cistern K collected rainwater from the original keeper's quarters, and Cistern E collected water from the new keeper's quarters built in 1922. These cisterns played an important role in the 1920s modernization of the light station. Unlike the older brick cisterns, water from the new cisterns was pumped to the plumbing systems which were installed in the light station buildings at this time.

F. **Fiberglass Water Tanks** INTRUSION

These tanks were installed between 1951 and 1977 and have replaced the concrete cisterns in function. They are noncontributing elements.

G. **Paintlocker** INTRUSION

This concrete block structure was built about 1951 and is used to store paint and flammable liquids. A noncontributing structure.

H. **Guest House** (Original Kitchen Building) Drawings 4, 5, 7, and 8.

Built in 1856-58, this two story brick structure measures approximately 20′ by 17′. It has a gabled roof covered with metal shingles. On the front of the building, the roof extends out from the building some 9′ and is supported on brick columns to form a porch. This was added when the building was renovated in 1922, and it is not known if the present porch replaced an earlier one. The building was unpainted originally, but is now painted white. Jalousie windows have replaced the original wooden, double-hung sash and the rear door has been filled in by concrete block. The interior has been changed considerably and the only remaining original feature appears to be the stairs leading to the second floor. The 1922 renovation plans for the building show that there was a bake oven built into the base of the chimney. This was modified for use as a closet, and the chimney stack above the roof was removed. The upstairs may have served as quarters for one of the assistant keepers. The building is now used to house visitors and work parties. Despite changes, this building retains the original form and character evident in the c. 1900 historic photographs.

I. **Foundation of Original Keepers Quarters** Maps/Drawings: 3 to 5 and 8.

Built in 1856-1858, this structure originally housed the principal lighthouse keeper, his two assistants, and their families. The 1857 construction drawing for the light station called for a frame dwelling, but brick was the actual construction material. As revealed by the c. 1900 historic photograph and a 192 renovation plan this structure was a two story, brick dwelling with Greek Revival features. Each floor had two rooms off a central stair hall, and there were two

nterior chimneys, one for each side of the house. Galleries ran across the front nd back of the structure with the rear gallery being partially enclosed. This uilding burned in 1945, and the site was razed several years later leaving only he outline of the foundation. Although the building itself is gone, its site is till significant in terms of understanding the original layout of the light tation.

& L **Brick Cisterns** Drawings: 5 and 8.

hese structures were built in 1856-58 to collect rainwater for general use by the ight station keepers and their families. Each cistern is 14' in diameter and xtend 4' above the ground. As seen in the c. 1900 photograph, cistern J ollected rainwater via the guttering system of the lighthouse keepers house. istern L collected water in a similar manner from the kitchen building. Although he cisterns have apparently been unused since the 1920s, when new concrete isterns were built, they are nevertheless important original features of the ight station. They show how a constant water supply was maintained in an area ithout natural water, and they are also important in defining how the original ight station was laid out and how it functioned.

**Generator Building**

he metal building lies just outside the district boundaries. It was excluded rom the district due to its recent construction date--post 1960.

Summary Paragraph

The Dry Tortugas Light Station on Loggerhead Key has been in continuous operation since 1858 serving as an aid to navigation for vessels cruising the Florida Straits between the Gulf of Mexico and the Atlantic Ocean. Officers of the U.S. Corps of Engineers who were in charge of the construction of Fort Jefferson on nearby Garden Key also planned and supervised the erection of the 150 foot brick lighthouse and several support structures in 1856-58 for the U.S. Lighthouse Board. Thus the Dry Tortugas Light Station is significant primarily for its role in facilitating America's ocean-borne commerce and as a notable example of the kind of civilian public works projects undertaken by Army engineers prior to the Civil War. While the lighthouse is clearly the most important structure within the boundaries of the nominated area, there were several ancillary structures built at the same time as the lighthouse, and also from the 1920s, a period in which the station was extensively modernized.

Loggerhead Key, the westernmost island in the Dry Tortugas group, is located approximately 65 miles west of Key West, Florida, and 90 miles north of Cuba. The Dry Tortugas are the last in the 150 mile string of coral reefs and islands that make up the Florida Keys. The Spanish explorer, Ponce de Leon, discovered the islands in 1513 during his first Florida expedition and called them "Las Tortugas" for the large number of green sea turtles he found there. Over time, the islands became known as the Dry Tortugas due to the absence of fresh water.

By mid-sixteenth century, homeward bound Spanish ships carrying silver mined in Peru and New Spain sailed a standard course across the Gulf of Mexico and through the Florida Straits and the Bahama Channel in order to take advantage of the Gulf Stream which would carry them into the Atlantic and north along the east coast of Florida. Later on, ships sailing to and from the colonial ports that were established on the Gulf Coast added to this traffic. Speed was the advantage of this route, but there were hazards as well. Once ships passed the Dry Tortugas at the entrance to the Florida Straits, they were vulnerable to pirate attack and could be driven onto hidden reefs and shoals by tropical storms and hurricanes.

The first advance in navigation in the Dry Tortugas came while the British controlled Florida. George Gauld surveyed the islands in the early 1770s for the Board of Admiralty and published a chart of the Tortugas in 1773 that mariners relied on for the next 75 years. Gauld also named the islands, including Loggerhead (originally Loggerhead Turtle) Key.

Additional improvements to navigation in the Dry Tortugas did not come until Spain ceded Florida to the United States in 1821. By this time trade between Atlantic and Gulf Coast ports was burgeoning, and the number os ships passing through the Florida Straits was increasing. Loss of ships and their cargoes due

o storms in the Florida Keys, by then considered to be within the territorial aters of the United States continued to be a problem. This was compounded by reckers who carried on a lucrative and sometime illegal, business of salvaging recked American ships which they sold along with their cargoes in the British ahamas. Attacks by Caribbean based pirates still occurred with regularity. o protect American shipping interests in the Keys, the United States purchased he island of Key West in January 1822 as a base of operations. In March of hat year, Lt. Commander Matthew C. Perry took formal possession of the island nd reconnoitered the surrounding area. in his report to the Secretary of the avy, Perry emphasized the need to halt piracy and to curb the excesses of the reckers. He also recommended that four lighthouses be built in the Keys ncluding one in the Dry Tortugas.

ater in 1822, Captain David Porter sailed to Key West with a small squadron of hips to combat piracy in the Caribbean, and by 1828 a U.S. District Court had een established in Key West to license wreckers and to require them to sell alvaged cargoes and vessels in U.S. ports.

n regard to the need to build lighthouses in the Keys, Congress acted promptly y allocating funds for this endeavor in 1822, but the overall objective of uilding enough lighthouses to make the keys genuinely safe for shipping proved o be a difficult and lengthy task that was not completed until after the Civil ar. Nevertheless, by the end of 1826, three lighthouses were in service ncluding one in the Dry Tortugas, a 65 foot high brick tower with fixed light n Bush Key, three miles east of Loggerhead Key. It was soon apparent that it as not adequate to warn mariners of the shoals and reefs in the area. Ship recks continued, and ship captains complained that in stormy weather it was mpossible to safely gauge their distance from the light. In 1836, Captain John hompson, the keeper of the light, recommended that two other lighthouses be uilt in the Tortugas. Article published in the American Coast Pilot, a popular ournal about maritime issues, also singled out the Bush Key light for riticism.

o steps were taken to correct the situation until 1845 when Simon Pleasonton, ifth Auditor of the Treasury, ordered Adam Gordon, the Lighthouse uperintendent at Key west to determine if complaints about the Dry Tortugas ight were valid. Gordon took advantage of the fact that the U.S. Corps of ngineers was studying the Dry Tortugas to determine what kinds of ortifications to build there, and he secured the recommendations of Engineer aptains William H. Chase and George Dutton who both agreed that to be ufficiently visible the Dry Tortugas light should be relocated to Loggerhead ey and that the new lighthouse should be 120 feet high. The Lighthouse Board, owever, took no action aside from having the existing light adjusted.

s part of a 1851 study of United States lighthouses, the Lighthouse Board sent circular letter to captains of packets and mail boats for recommendations.

he responses regarding the Dry Tortugas light were not positive. Some captains eplied that they routinely avoided the Tortugas altogether, preferring to use he better marked Cuban coast as their point of reference. Others said that nly a new first order light would make the Tortugas safe.

inally, the Lighthouse Board took action in August 1855 when the Secretary of he Board, Naval Lieutenant T.A. Jenkins, wrote to U.S. Corps of Engineers aptain H.G. Wright, the officer in charge of the on-going construction of Fort efferson on Garden, formerly Bush, Key. Jenkins requested that he provide onstruction cost estimates and preliminary plans for a new Dry Tortugas ighthouse. Wright responded in September by submitting to the Lighthouse Board ost estimates, a description of materials, and a sketch of a 150 foot brick ighthouse tower designed to accommodate a first order Fresnel lens. The next ear Congress allocated $35,000 for the project and construction was begun. By his time Wright had been reassigned to another duty station, and Captain Daniel . Woodbury had been placed in charge of the continuing work at Fort Jefferson s well as the new lighthouse on Loggerhead Key. The brick lighthouse as well s several support structures including a two-story residence for the lighthouse eeper, a kitchen building, an oil storage building, and two cisterns--all built f brick--were completed in 1858. The lighthouse was officially placed in ervice on July 1 of that year. The 1826 lighthouse on Garden Key was reduced o the status of a fourth order harbor light. An 1873 hurricane damaged the lder structure severely and in 1876 the Lighthouse Board erected a new wrought ron tower on one of the bastions of Fort Jefferson. This lighthouse, still tanding today, was also designed and built under the supervision of Army ngineers.

he fact that the U.S. Corps of Engineers played a major role in the onstruction of the Dry Tortugas Light Station on Loggerhead Key was not an solated occurrence. The U.S. Corps of Engineers, first organized in 1802, had ajor responsibilities in regard to improving navigation on rivers and streams nd developing America's harbors including the construction of a significant umber of lighthouses. Other lighthouses in the Florida Keys that were either esigned and/or built by the engineers include the Carysfort Reef Lighthouse 1848-1852), the Sand Key Lighthouse (1851-53), and the Sombrero Key Lighthouse 1854-58).

ne Dry Tortugas remained in Union hands during the Civil War, and the operation f the new lighthouse on Loggerhead Key was not hindered in any way. In 1867 nd 1873, Loggerhead Key served as a quarantine station for military personnel uring yellow fever epidemics at Fort Jefferson. Again the operation of the ight station was apparently not affected.

n the post-Civil War period, one of the most notable features of the operation f the Dry Tortugas Light Station was the continual round of maintenance ctivities and repairs needed to keep the lighthouse and other structures in a

sable condition despite frequent storm damage and the day-to-day problems ssociated with the harsh marine environment. Congressional appropriations for epairs were frequent. The most serious threat to the lighthouse resulted from he 1873 hurricane. In 1875 the virtual reconstruction of a nine foot section f the tower immediately beneath the lantern was completed at a cost of $75,000. ven after the repairs were finished, the Lighthouse Board considered the ossibility of building a new tower, but the ability of the lighthouse to eather several subsequent storms convinced the board that a new tower was not eeded.

.C. Bell, surveyor of lighthouses for the seventh and eighth districts, mapped oggerhead Key and the light station in 1887. His work showed that the station ad changed very little since its construction thirty years earlier. This emained true until the 1920s. The major changes on Loggerhead Key from 1880 o 1910 were administrative in nature and had little impact on the station tself. In 1888, the War Department approved a request by the Treasury epartment to reserve Loggerhead, Garden, and Bird Keys as possible sites for uarantine stations, presumably in case of future Yellow Fever outbreaks. It oes not appear that the islands were actually used for this purpose in ubsequent years. In 1900 the military reservation of Dry Tortugas, including oggerhead Key, was transferred to the Navy Department from the Army who had ontrolled the area since 1842. This came about, because Fort Jefferson was no onger an active army post, but was used instead by the Navy as a coaling tation for ships of war. Four years later the Carnegie Institution of ashington was permitted to build a marine biology research station on the orthern tip of the island. Until the outbreak of World War II, this facility erved as a summer laboratory for scientists who studied marine flora and fauna n the Keys. In 1908 Loggerhead Key was recognized as a bird sanctuary by xecutive Order of President William H. Taft.

epairs to the Dry Tortugas Light Station were constant and frame structures uch as the wash house, privies, boathouse and docks had to be replaced on everal occasions. During 1920s, however, the Lighthouse Service undertook the irst major building program on the island since the station's original onstruction. The original keepers quarters and the kitchen building were efurbished and a brick bungalow was erected as the residence of the lighthouse eeper. The oil storage building was equipped with an electrical generator and adio equipment, used primarily to monitor and respond to calls from ships in istress. Electricity does not appear to have been supplied to other buildings n the island at this time. Other new construction during the 1920s included formed concrete addition to the former oil storage building to connect it to he lighthouse tower, a new storage building, and a boathouse. The original rick cisterns were apparently capped at this time and new cisterns of formed oncrete were constructed..

In administrative change of some importance was the inclusion in 1935 of Loggerhead Key within the boundaries of Fort Jefferson National Monument. In 1939 the Lighthouse Service merged with the U.S. Coast Guard, and the following year the Coast Guard and the National Park Service entered into a formal agreement in which the Coast Guard retained all management responsibilities for Loggerhead Key and the Dry Tortugas Light Station.

Additional changes to the Dry Tortugas Light Station did not come until the completion of World War II. In 1945, the original keepers quarters burned and its ruins were razed several years later. Other changes in the post-war period included the construction of a metal generator building, the erection as a 365 foot high antenna, the addition of modern communication equipment to the lighthouse tower, and the construction of two formed concrete additions to the original oil storage building. Despite these and more recent changes, the light station still retains the basic qualities it possessed in the 1920s when the Lighthouse Service upgraded the original 1856-58 station to meet more modern needs.

MAJOR BIBLIOGRAPHICAL REFERENCES

earss, Edwin C. Historic Structure Report, Historical Data Section, Fort Jefferson, 1846-1898. Washington, DC: U.S. Department of Interior, National Park Service, 1982.

earss, Edwin C. Shipwreck Study--The Dry Tortugas. Washington, DC: U.S. Department of Interior, National Park Service, 1971.

arnegie Institution of Washington. Yearbooks. Washington, D.C.: Carnegie Institution of Washington, 1904-1939.

ean, Love. Reef Lights, Seaswept Lighthouses of the Florida Keys. Key West, Florida: The Historic Key West Preservation Board, 1982.

eneral Services Administration. National Archives and Records Service. Record Group 26, U.S. Coast Guard Records, Site File Florida No. 16.

anucy, Albert C. "A Handbook for Fort Jefferson History," St. Augustine, Florida: Fort Marion National Monument, 1942.

auer, Carl Otwin. Sixteenth Century North America. Berkeley: University of California Press, 1971.

**ection 10**

erbal Boundary Description:

roceed from center of lighthouse base 65 feet due east to a point on the istoric District boundary. From that point proceed 114 feet due north; 122 eet due east; 141.5 feet due north; 239 feet due west; 343 feet due south; 20 feet due east; 220 feet due north; 45 feet due east; and 87.5 feet north o point of beginning.

oundary Justification:

he boundary selected encompassess the historic buildings that comprise the istrict as shown on Map 3 and described above.

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OMB No. 1024-0018

nited States Department of the Interior
ational Park Service

ATIONAL REGISTER OF HISTORIC PLACES
ONTINUATION SHEET

ection ____ Page __

Dry Tortugas Light Station___
name of property
__Monroe, Florida_____
county and State

==========

IST OF PHOTOGRAPHS

ith a few exceptions these photographs were taken by Stuart Johnson, National ark Service, in January 1984. The original negatives are filed with the United tates Coast Guard, Seventh District Office in Miami, Florida. Though taken ten ears ago these photos were field tested in 1993 and were determined to ccurately portray existing conditions.

hotograph #

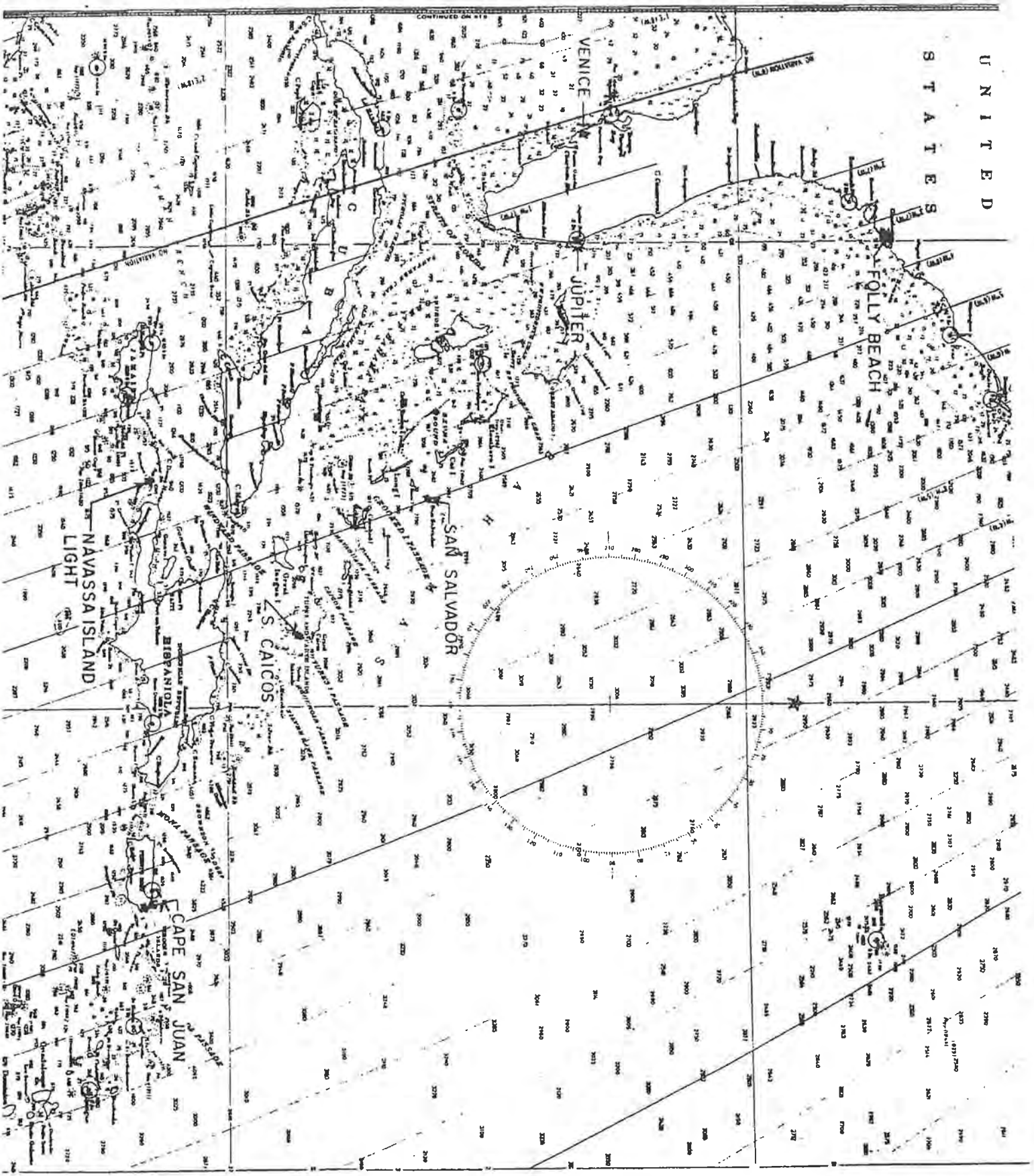
1. Loggerhead Key--aerial view looking northwest. Lighthouse is in right center of the picture. Photographer: Richard Ramsden, NPS. Negative filed with U.S. Coast Guard, Seventh District Office.
2. Not included.
3. Dry Tortugas Lighthouse and Radio Room, looking NW. Dry Tortugas Light Station. Buildings A and C.
4. Watchroom and lantern of lighthouse, looking NW. Building A.
5. Interior of lighthouse showing spiral granite steps.

6. Entry at base viewed from connector with radio room.
7. Dry Tortugas lighthouse, iron door from watchroom to gallery at top of lighthouse. Building A.
8. Bosun's Work Shop (formerly the Oil House), looking west. Dry Tortugas Light Station. Building B.
9. Bosun's Work Shop (formerly the Oil House). looking southwest
10. Radio Room at Dry Tortugas Light Station, looking NE.

11. Radio Room, looking NW. Building C.
12. Crew's Quarters (formerly Keeper's Residence), Dry Tortugas Light Station, looking west. Building D.
13. Crew's Quarters (formerly Keeper's Residence), looking east.
14. " " " " " , looking north.
15. Brick cistern at former kitchen building, Dry Tortugas Light Station, looking SE. Structure L.

16. Brick cistern and concrete cistern that served original Keeper's Residence. Looking south. Structures J and K.
17. Guest House, primary facade, facing west. Dry Tortugas Light Station. Building H
18. Guest House, original kitchen, Building H. Facing west.
19. Guest House, note remnants of chimney, facing north.
20. Interior stairs of guest house (Building H).

21. Dry Tortugas Light Station Complex showing original features. Looking South. Guest House and cistern that served original kitchen are in right foreground.
22. Metal Generator Building, looking north. Dry Tortugas L.S. Located outside of historic district. Noncontributing structure.
Photograph by Richard Ramsden, NPS. Filed USCG, Miami, FL.




Dry Tortugas Light Station Area Map
Loggerhead Key, Florida
Map #2

1 Keepers Residence
2 Asst Keepers Residence
3 2d & 3d Keepers Residence
4 Radio
5 Oil House
6 Boat House
OFFICE OF SUPERINTENDENT OF LIGHT-HOUSES
SEVENTH DISTRICT, KEY WEST, FLA.
BAY TORTUGAS LIGHT STATION
PLAN
Scale 1"=80'
Approved June
Superintendent
Washington, D.C.
No 701

## APPENDIX B

# Materials Analysis

# Dry Tortugas Light Station

## Materials Analysis

Dry Tortugas, Florida

**Prepared For**

Lord Aeck & Sargent Architecture
Ann Arbor, Michigan

**Prepared By**

Building Conservation Associates, Inc.
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APPENDICES

Appendix A: Sample Stratigraphies and Photomicrographs

Appendix B: Mortar and Plaster Analysis Report (Testwell, Inc. 2009)

Appendix C: *Rehabilitation Report and National Register Nomination for the United Stated Coast Guard Light Station, Dry Tortugas Lighthouse, Loggerhead Key, Florida,* 1984

## 1.0 INTRODUCTION

At the request of Rob Yallop of Lord Aeck & Sargent Architecture (LAS), Building Conservation Associates, Inc. (BCA) prepared an analysis of select building materials removed from buildings associated with the Dry Tortugas Light Station, including the Dry Tortugas lighthouse. The light station is located in the Dry Tortugas National Park in Florida. The materials investigated as part of this study include mortar and paint finishes. The buildings investigated as part of this study include: the lighthouse, original oil house, kitchen building, keeper's residence and the south brick cistern. The primary goal of the materials analysis is to document the buildings' original mortars and paint finishes for inclusion in a Historic Structure Report (HSR). A secondary goal is to provide recommendations for future restoration work based on the findings of the analysis. (*Figures 1-5*)

The report summarizes the findings of both the mortar analysis and the finishes study. Following the introductory information regarding the site and study methodology, the report discusses the findings of the research and then makes recommendations for appropriate restoration mortar mixes and paint colors. All mounted cross-sections have been labeled and permanently housed and will be archived at BCA's Philadelphia office unless otherwise requested by the client.

All work required for the execution of this study was performed by Dorothy S. Krotzer, BCA Regional Director, with assistance from Testwell, Inc. for completion of the laboratory portion of the mortar analysis. Mortar and paint samples were taken from the site in March 2009 and laboratory analysis was performed in April and May 2009.



**Figure 1.** Lighthouse, March 2009. Photograph by author.



**Figure 2.** Oil house, March 2009. Photograph by author.



**Figure 3.** Original kitchen building. March 2009. Photograph by author.



**Figure 4.** Keeper's residence. March 2009. Photograph by author.



**Figure 5.** South brick cistern. March 2009. Photograph by author.

## 2.0 METHODOLOGY

Prior to the site visit and removal of samples, information related to the history of the Dry Tortugas Light Station provided by LAS was reviewed. Portions of the draft HSR, including historic images and information on the construction chronology and materials, were studied in order to gain a general understanding of the history of the site and any information related to the buildings' paint finishes and masonry construction. The archival information included a 1984 *Rehabilitation Report and National Register Nomination* that contained paint and mortar analysis of the lighthouse. (*Appendix C*)

Once the relevant historical documentation was reviewed, a site visit was made and the buildings were physically examined for areas from which representative samples of mortar and paint finishes could be removed. Once these intact areas were identified, samples were removed. Mortar and plaster samples were removed using a small masonry chisel or five-in-one tool and a hammer. Paint samples were removed using a scalpel. A total of eleven mortar and plaster samples and sixteen finish samples were removed from the buildings and taken back to the laboratory for analysis.

### 2.1 Finishes Analysis

All finish samples were initially examined in reflected light using a Nikon high-resolution stereomicroscope SMZ-1500 with variable magnification (16x-160x) to identify which samples would be embedded and sectioned for analysis. The selected samples were then mounted in a commercial polyester/methacrylate resin polymerized with a methyl ethyl ketone peroxide catalyst (Bioplast®). Embedded samples were sectioned on a Leco® VC-50 micro-saw for microscopic examination. The sectioned samples were dry-polished using a series of fine Micromesh® polishing cloths ranging from 6,000 to 12,000 grit. Sectioned samples were observed under a Nikon 50i compound microscope in both visible light filtered through a daylight correction filter and ultraviolet light. The ultraviolet light was generated by a mercury illumination system filtered through a violet filter cube (EF4 V-2A Ex400/40 Dm430 Bar 450). Photomicrographs of representative samples were taken using a five megapixel Nikon DigiSight color digital camera system and are included in this report to illustrate specific observations.

All paint samples were viewed in cross-section and their paint layering sequences, or stratigraphies, recorded. These stratigraphies are included in Appendix A. Once the stratigraphies of every sample were deciphered, significant paint layers were identified and raw samples were manipulated in order to expose these layers for color matching purposes. Once the target layers were exposed, they were subjected to a bleaching process in order to reverse any yellowing that may have occurred over time. It is well documented that linseed oil-based paints (especially pale-colored paints) darken and yellow over time if not exposed to sunlight. This even affects oil-based finishes that have been covered with

subsequent paint layers. In order to diminish this yellowing of paint layers, they were exposed to an ultraviolet light source for approximately two weeks.

Following the bleaching process, the exposed layers were subjected to a portable spectrophotometer, a GretagMacbeth X-Rite *EyeOne*®, in order to generate a CIE L*a*b* value for each sample. Then, each sample was visually matched to two different color systems, the standardized Munsell color system and the commercial Benjamin Moore paint palette. The spectrophotometer was then used to generate CIE L*a*b* values for each of the color matches.

A color in the CIE L*a*b* system is defined according to three axes. The L*-axis (from 0 to 100) is the light-dark axis. The a*-axis (from –100 to +100) is the green-red color axis. The b*-axis (from –100 to +100) is the yellow-blue axis. Delta E is a measurement of the color difference between the original paint surface color and the closest color matches that BCA has identified. A perfect match would have a Delta E value of 0.00. Delta E equals the square root of $[(L^*_1 – L^*_2)^2 + (a^*_1 – a^*_2)^2 + (b^*_1 – b^*_2)^2]$. Where $L^*_1$, $a^*_1$, $b^*_1$ are the original paint surface values and $L^*_2$, $a^*_2$, $b^*_2$ are the commercial paint values. Consequently, the lower the value of Delta E, the closer the match. Although several commercial colors were tested for each element, only the closest match has been presented. All color matches are included in Section 4.1 of this report.

Finish samples were removed from the following locations:

| | | |
|---|---|---|
| **LOKE.F.1** | Oil house | Exterior, east wall (now enclosed), finishes on brick. |
| **LOKE.F.2** | Passageway between oil house & lighthouse | Interior, south wall, finishes on concrete. For comparison with LOKE.F.1. |
| **LOKE.F.3** | Oil house | Exterior, east wall (exposed), finishes on brick. |
| **LOKE.F.4** | Oil house | Exterior, east wall (now enclosed), door frame, finishes on wood. |
| **LOKE.F.5** | South brick cistern | Exterior, west wall, finishes on brick. |
| **LOKE.F.6** | Lighthouse | Exterior, west elevation (now enclosed), finishes on brick. |
| **LOKE.F.7** | Lighthouse | Exterior, west wall (now enclosed), door frame, finishes on wood. |
| **LOKE.F.8** | Lighthouse | Exterior, west wall (now enclosed), door to lighthouse, finishes on wood. |
| **LOKE.F.9** | Lighthouse | Interior, ground floor level, finishes on brick. |
| **LOKE.F.10** | Kitchen building | Exterior, east elevation, finishes on brick. |
| **LOKE.F.11** | Oil house | Exterior, south elevation (now enclosed), finishes on brick. |

| | | |
|---|---|---|
| **LOKE.F.12** | Keeper's residence | Interior, hallway outside bathroom, original west wall (covered by drop ceiling), finishes on plaster. |
| **LOKE.F.13** | Keeper's residence | Interior, hallway outside bathroom, original west wall (covered by drop ceiling), original wood cornice, finishes on wood. |
| **LOKE.F.14** | Keeper's residence | Interior, bathroom, original west wall, finishes on plaster. |
| **LOKE.F.15** | Keeper's residence | Exterior, east elevation, front door frame, finishes on wood. |
| **LOKE.F.16** | Keeper's residence | Exterior, east elevation, front porch beam above columns, back face, finishes on wood. |

## 2.2 Mortar and Plaster Analysis

Cursory visual examination of the mortar samples was performed by D. Krotzer and subsequent laboratory analysis was executed by John Walsh of Testwell Laboratories, Inc. in Ossining, New York. John Walsh specializes in the analysis and identification of historic mortar materials. Testwell's laboratory work included: petrographic examination; chemical analysis (gravimetric analysis and atomic absorption spectroscopy); statistical point counting (used instead of acid digestion to gain information on the quantity of aggregate since it is an acid-soluble carbonate sand); and water-soluble chloride analysis. The goal of Testwell's analysis was to identify the binder and aggregate components of each mortar, as well as the original component ratio and any deterioration due to salt crystallization or hydration.

Although Testwell's findings are discussed in Section 3.2 of this report, the full mortar analysis report has also been included in Appendix B.

Samples of brick mortar and plaster were removed from the following locations:

| | | |
|---|---|---|
| **LOKE.M.1** | Oil house | Exterior, east elevation, mortar. Taken from protected wall now enclosed. Sample from interior of wall (from an area where a hole was cut through wall for a pipe). |
| **LOKE.M.2** | South brick cistern | Exterior, east elevation, mortar. |
| **LOKE.M.3** | South brick cistern | Interior, parging. Taken from upper portion of interior wall. |
| **LOKE.M.4** | Lighthouse | Exterior, west elevation, mortar. Taken approx. 8-feet from ground. |
| **LOKE.M.5** | Lighthouse | Exterior, west elevation, mortar. Taken from former exterior wall now enclosed, adjacent to entrance to lighthouse. |
| **LOKE.M.6** | Lighthouse | Interior, mortar. Taken from wall at ground floor level. |
| **LOKE.M.7** | Lighthouse | Interior, mortar. Taken from wall below watch level (supposedly rebuilt in 19th century). |
| **LOKE.M.8** | Oil house | Interior, south wall, plaster. Taken from behind modern wood paneling and earlier beadboard wall; three-layer plaster system applied over brick. |
| **LOKE.M.9** | Kitchen building | Exterior, north elevation, mortar. Sample from interior of wall. |
| **LOKE.M.10** | Keeper's residence | Exterior, west wall, mortar. |
| **LOKE.M.11** | Keeper's residence | Interior, bathroom, west wall, plaster. Two-coat plaster system. |

# 3.0 SUMMARY OF FINDINGS

## 3.1 Finishes Analysis

The paint finishes of five historic buildings at the Dry Tortugas Light Station were examined as part of this study. The majority of paint samples were removed from exterior brick and wood trim elements. However, samples of interior paint were also removed from the keeper's residence and the lighthouse.

MASONRY

The exterior brick masonry surfaces of the oil house, south brick cistern and lower half of the lighthouse all seem to share a similar finish history. Each of these buildings has been painted a version of cream or white throughout its history, although the total number of layers varies. In addition, the earliest finish appears to be a white lime wash, followed by paint finishes (presumably oil-based) that are also white/cream in color. The brick masonry of the kitchen building was examined and found to only have four layers of modern white paint. The upper portion of the lighthouse (currently painted black) was not accessible at the time of the field investigation.

Although the brick masonry of the oil house, kitchen building, lighthouse and south brick cistern is currently painted, historic documentation indicates that originally the brick on these buildings was left unpainted. An undated historic photograph shows both the kitchen building and the oil house as exposed brick structures. (*Figure 6*) Although the date of this photograph is unknown, it must pre-date 1892 because a photograph taken circa 1892 clearly shows the oil house painted. (*Figure 7)* In the same circa 1892 photograph, the brickwork of the kitchen building, barely visible through the palm trees, remains unpainted. In addition, there are several written descriptions of the lighthouse dating from 1858 that refer to it as being a "natural color brick" or as a "brick-color tower."[1]

Physical evidence confirms the historical documentation. The surface of the brick in samples removed from these buildings appears somewhat weathered and uneven, suggesting it was worn by exposure to the elements before being painted. The only structure that may have always been painted was the south brick cistern. As evidenced in Figure 9 the sample removed from the brickwork of the cistern shows a relatively clean brick surface, suggesting it has always been protected from the weather. (*Figures 8-9*)

[1] "Loggerhead Key Lighthouse, Dry Tortugas, Florida." Printed October 21, 1993. PP. 1-2



**Figure 6.** Historic image showing the oil house and kitchen building as unpainted brick masonry buildings. The Lighthouse has been painted black and white but the oil house is not yet painted, dating this photograph to some time between 1870 and 1892.



**Figure 7.** Historic image showing the lighthouse, oil house and old keeper's residence circa 1892. Note that the oil house has been painted white in this photograph. Photograph courtesy of LAS.

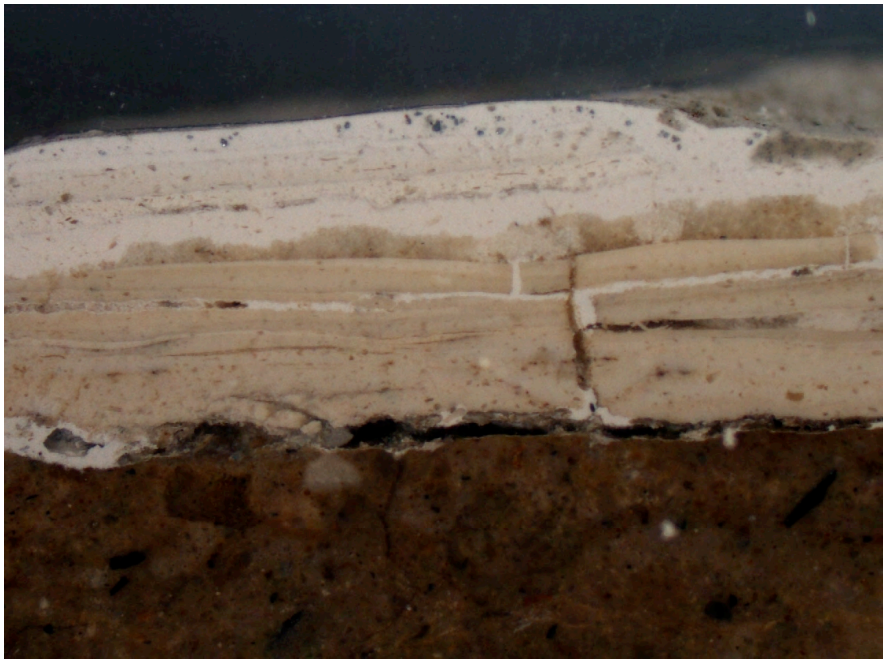


**Figure 8.** Oil house. Photomicrograph of painted exterior brick showing numerous layers of cream and white-colored paint. (40x magnification, visible light).



**Figure 9.** South brick cistern. Photomicrograph of earliest finish applied to brick wall of cistern. Note first layer is more translucent than the others and appears to be a limewash. Also, the surface of the brick is relatively unsoiled. (100x magnification, visible light).

Although archival documentation indicates that the lighthouse was not originally painted, records document that it has been painted black and white at least since 1875, when an inspection log states that "The black portion of the tower has been painted, and the remainder whitewashed."[2] Interestingly, this reference illustrates the use of two different types of paint finishes on the brick structures of the Dry Tortugas Light Station, a practice that may have been applied to not only the lighthouse but to the other buildings as well. For the lighthouse, it would have been necessary for the black finish to be a paint (presumably oil) instead of a lime wash, as achieving a truly black-colored lime wash would have been difficult if not impossible.

A *Rehabilitation Report and National Register Nomination* on the Dry Tortugas lighthouse from 1984 included materials analysis of the paint by Law Engineering Testing Company. One paint sample from the lighthouse was provided for analysis. Although the location of the sample was not indicated, it is assumed that the sample was removed from the exterior of the lighthouse. According to the 1984 report, the paint sample consisted of two paint layers, both found to be an acrylic-polyvinyl acetate mixture with lead and zinc-based pigments. A recent in situ examination of the lighthouse exterior for this report confirms the presence of only a few layers of modern white paint on the exposed portion of the lighthouse exterior. This number of paint layers is far fewer than the approximately 30 paint layers documented for the paint sample removed from a protected area of the lighthouse exterior (from a wall inside the connector building) as part of the current study. This discrepancy in number of paint layers can most likely be attributed to the fact that the exterior of the lighthouse was sandblasted in 1967. The blasting would have removed any early coatings, explaining why the sample examined in 1984 had only two paint layers and why the recent in situ investigation revealed only a few paint layers on the exposed portion of the lighthouse exterior. The paint sample removed from the protected area inside the connector is more representative of the complete finish history of the lighthouse exterior and provides insight into the building's earliest finishes.

### WOODWORK & METALWORK

The exterior woodwork of the four buildings (oil house, lighthouse, kitchen building and keeper's residence) was also examined. The exterior door and doorframe of the lighthouse, currently enclosed by the link to the original oil house, contain between 30-35 layers of paint. The doorframe contains more paint layers than the door, suggesting it may pre-date the door. The earliest paint layers on the frame are cream-colored paint. After these, the frame was painted various shades of grays approximately 30 times. The door contains slightly fewer layers (approximately 30), all of which are various shades of gray. The doorframe of the original oil house was also painted numerous times (approximately 40 paint layers). The earliest finish is a medium gray. Subsequent layers are predominantly gray with a few creams later in the sequence. The wood trim of the kitchen building

[2] LAS, Draft Historic Structure Report (HSR), "Background" section.

contains only a few layers of modern paint, indicating the woodwork is relatively modern or that it has been stripped. (*Figures 10-11)*

The historic photographs provide some insight into the color palette of the exterior woodwork of these buildings. In both photographs, the window sash and frames of all of the buildings appear to be a pale color (likely white or cream) and the shutters are a dark color. However, at the time of this study, there was no access to historic windows in these buildings, as many have been replaced with modern units and the shutters have been removed. This prevented a positive identification of the actual color of the pale paint visible in the photographs.

In the historic images shown in *Figures 6* and 7, the doors of the buildings are typically open in the photographs, preventing the color of the doors from being seen; they could have been painted the light color of the windows or the dark color of the shutters. As discussed above, the physical evidence indicates that the door frame (and possibly the door) of the lighthouse was originally painted white, followed by numerous layers of gray paint. It is not know when the transition from white to gray occurred for the lighthouse. By contrast, the door frame of the original oil house was always painted gray. Again, there is no photographic evidence to corroborate either of these observations.

There is, however, written historic documentation regarding paint for the metalwork and woodwork of the lighthouse. In an 1862 document entitled "Instructions and Directions for Light-House and Light-Vessel Keepers of the United States", paint colors and paint types are carefully specified for the interior and exterior metal and wood work of the lighthouse. All paint is linseed-oil based and generally glossy in sheen. The interior of the lighthouse lantern is to be painted white, while the exterior is to be painted black or red. Black seems to be the most prevalent color called for, although there are also references to "lead", "gray", "yellow", "straw", "brick", "oak wood" and "Portland stone." In addition, all ironwork is supposed to be primed with red lead.[3] Although the metal components of the lighthouse were not examined as part of this study, the colors found on the existing woodwork (white and gray) are in keeping with the colors specified in 1862.

The exterior woodwork of the keeper's residence was originally painted white, a conclusion based on both physical and archival documentation. Samples removed from the front porch trim show 11 layers of white and cream paint. In addition, historic photographs of the house show white-colored trim and the preliminary specifications for the building that date to 1917 state that all woodwork was to be painted white. (*Figure 12*) The original hurricane blinds, which appear a dark color in the historic photographs, do not remain on the building and could therefore not be sampled to confirm

[3] Instructions and Directions for Light-House and Light-Vessel Keepers of the United States, 4th edition, 1862. Pages 106-110.

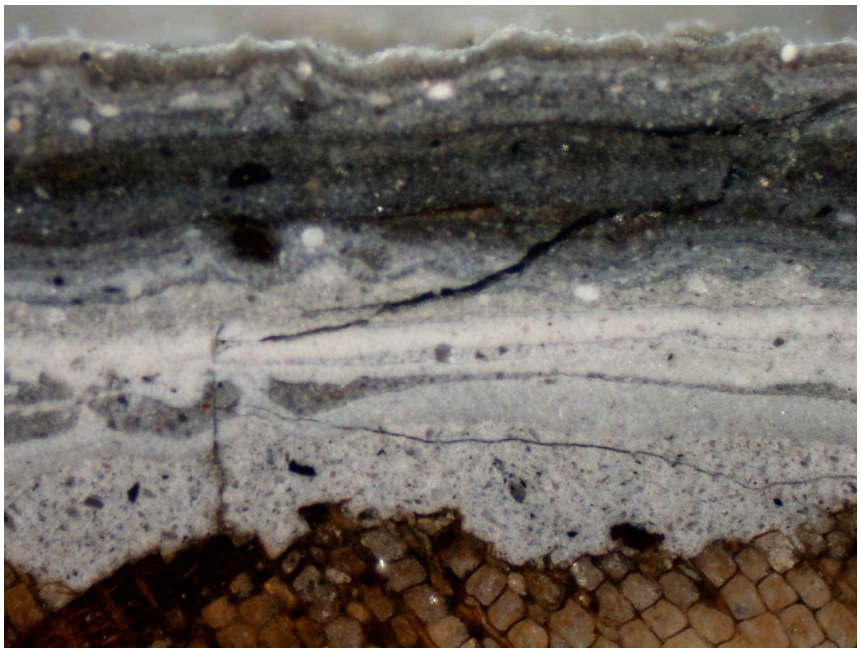


**Figure 10.** Oil house. Photomicrograph of a paint sample removed from the exterior door of the oil house showing numerous layers of gray paint applied to the frame over time. (100x magnification, visible light).



**Figure 11.** Lighthouse. Photomicrograph of a paint sample removed from the exterior door frame of the lighthouse showing a similar range of gray paint colors as the sample above, although the earliest paint color was cream. (40x magnification, visible light).

their original color. However, the preliminary specifications state that they are to be painted green. (*Figure 13*)

Select interior finishes of the keeper's residence were also examined. Samples were removed from the plaster walls of the hallway and bathroom and the wood cornice of the hallway. The walls of both the hall and bathroom were painted a pale gray-green originally and the cornice was painted white, after having been sealed with a clear coat. The preliminary specifications call for the wood to be sealed with shellac and for a three-coat paint system (1 primer and 2 finish coats), all white in color. While the sealer layer and three-coat system seems to have been employed, the color varied from that included in the specification. (*Figure 14)*



**Figure 12.** Historic image showing the exterior of the keeper's residence. Note light-colored trim on most exterior woodwork with the exception of the hurricane blinds.

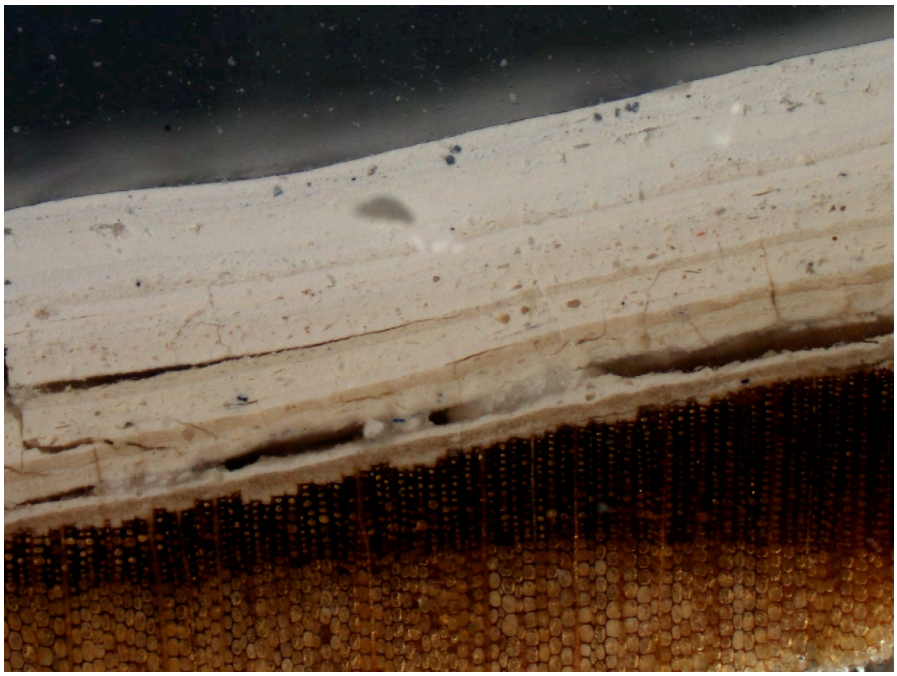


**Figure 13.** Keeper's residence. Photomicrograph of a paint sample removed from the exterior porch trim contains only cream and white-colored paint. (100x magnification, visible light).

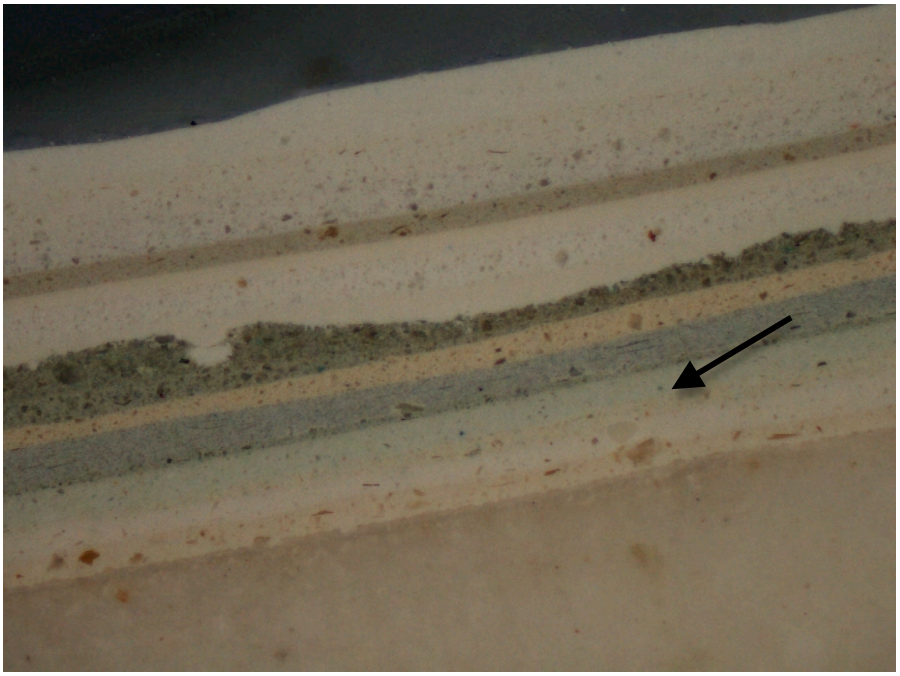


**Figure 14.** Keeper's residence. Photomicrograph of a sample of paint removed from the plaster wall's of the bathroom. Note original three-layer paint system of two primers topped by a pale gray-green. (100x magnification, visible light).

## 3.2 Mortar & Plaster Analysis

MORTAR

Laboratory analysis indicates that the majority of mortars used historically at the Dry Tortugas Light Station are composed of natural cement and local carbonate sand. Lime, which would have been added to the mortars as a gauging material to improve workability, was not documented in any of the historic mortars analyzed as part of this study. The natural cement and sand mortars were found at the lighthouse, the oil house, the original kitchen building and the south brick cistern. In addition, samples of mortar removed from four different locations within the lighthouse, including the portion of brick masonry directly below the watch room floor plate, were as natural cement and carbonate sand mortars that ware virtually indistinguishable from one another. The similarity of these mortars makes it difficult to draw any conclusions about the date of installation or type of mortars used for the numerous repair campaigns made to the lighthouse, which were documented in extensive written material. However, the physical evidence suggests that, although there were numerous repairs campaigns, the same mortar mix and ingredients were used consistently for the majority of the re-pointing campaigns in the 19th century. (*Figure 15*)

The natural cements in these mortars were identified as American natural cements, typical of those manufactured in Rosendale, New York or Louisville, Kentucky. The sand in all mortar samples was identified as a natural carbonate sand containing coral and shell fragments, presumably the same sand found along the shore of Loggerhead Key. The sand is fairly narrowly-graded, with the bulk of the material falling between a No. 16 and a No. 30 sieve. Given the remote location of the key, use of materials at hand such as beach sand for the construction of these buildings would have been practical as well as commonplace.

Establishing original component proportions for these mortars was challenging due to the acid-soluble carbonate sand. Instead of dissolving the binder through chemical means and extracting the insoluble sand, a different approach involving microscopical point-counting of sand and binder components and bulk chemical analysis of representative mortar samples had to be preformed. Using this non-traditional two-tiered approach revealed that the original binder to aggregate ratio of the Dry Tortugas Light Station mortar samples is approximately 1 part natural cement to 1.5 parts sand, by volume. This is a fairly typical mix for historic natural cement mortars. A more in-depth discussion of the methodology used to determine this ratio is discussed in Appendix B.

A natural cement is defined as an eminently hydraulic lime that is typically derived from the burning of highly impure limestone. It is these impurities that give the lime the characteristic of hydraulicity, or the ability to set by reaction with water (no air is needed, unlike with pure high calcium limes). Natural cements differ from Portland cements, which were produced later, in that the latter are artificially produced. Portland cements of the 19th century were made by grinding together chalk and

clay and then heating the mixture at high temperatures to produce a simulated natural cement. Both natural and Portland cements can have quite high strength and durability. Natural cement based mortars were quite common in the mid to late 19th century and would have been readily available when these buildings were constructed. [4]

The use of natural cement and carbonate sand mortars is, of course, not surprising given what we know about the construction of nearby Fort Jefferson, which dates to roughly the same period and is associated with the same builders. In fact, Captain H.G. Wright, who oversaw the construction of Fort Jefferson, wrote a proposal to the Light House Board for the construction of the Dry Tortugas lighthouse in which he calls specifically for the use of cement mortars with no lime. Writing in 1855, he states: "I am disposed to believe that the mortar for both brickwork and concrete should be made of cement and sand without any admixture of lime, and in the proportion of two parts of the latter to one of the former in powder."[5] Note that the ratio Wright calls for is quite close to that documented in the current lab analysis.

Although Wright does not specifically call for "natural cement", there was no other commercially available cement in the United States until Portland cement was introduced in the 1870s. So, the mortar Wright was specifying was indeed meant to be a natural cement based mortar. There were many subsequent repair campaigns that involved re-pointing weathered brick joints as well as significant reconstruction of a portion of the masonry below the lighthouse lantern in 1875. Natural cement mortars were specified for some of the re-pointing repairs, namely those made to the lighthouse in 1868.

The *Rehabilitation Report* from 1984 also included chemical analysis of a mortar sample taken from the Dry Tortugas lighthouse. The results of this report conflict with the findings presented here. The report identified the mortar sample as a lime-based mortar with a small percentage of Portland cement and possibly gypsum as the binder mix, and fine silica sand and shell fragments as the aggregate. Because the aggregate contains calcium carbonate-based shell fragments, the acid in the chemical analysis will dissolve the aggregate as well as the binder, and will therefore not provide an accurate reflection of the mortar proportions. In addition, it also may cause the binder to be misidentified as lime. The author of the 1984 report does note that because of the shell content of the mortar, precise identification of the binder to aggregate ratio is impossible, but they still provide an approximate ratio of 1part cement, 3 parts lime and 12 parts sand.

[4] Eckel, Edwin C. *Cements, Limes and Plasters. Reprinted Third Edition.* Dorset: Donhead Publishing, 2005. Page 242.



**Figure 15.** Lighthouse. Area of historic mortar removed for analysis. Note characteristic carbonate sand inclusions.



**Figure 16.** Oil house. Area of early plaster, discovered behind later wall finishes, removed for analysis.

[5] LAS, Draft Historic Structure Report (HSR), "Background" section. [Reference: Dry Tortugas Light Station clipping file, Appendix no. 17, H.G. Wright, Capitan of Engineers, Fort Jefferson, FL, letter to Lieutenant T.A. Jenkins, U.S.N., secretary, Light-house Board, Washington, D.C., September 23, 1855, Record Group 26, NA.]

The only mortar analyzed as part of this study that did not contain natural cement was the mortar removed from the exterior brickwork of the keeper's residence, which dates from 1922-23. This mortar is composed exclusively of Portland cement and the same local carbonate sand; no lime was detected in this mortar either. The estimated cement to sand ratio, by volume, is 1 part cement to 2.4 parts sand.

Archival research supports the use of Portland cement and local sand in the construction of the keeper's residence. The 1920 specifications for the construction call for mortar to be composed of "1 part [Portland] cement and 2-1/2 parts sand. Hydrated lime not to exceed 10% by volume of the cement shall be used for tempering."[6] Although the mortar specifications were written for concrete block and not brick, the information can certainly be applied to the brick. In fact, the ingredients and proportions documented in the current lab analysis are almost identical to those included in the 1920 specifications.

The mortars were also examined for the presence of any deterioration due to salt crystallization or salt hydration. This examination was performed petrographically, looking for signs of microcracking, and chemically, looking for elevated levels of water-soluble alkali salts (sodium, potassium and chloride). In general, most mortar samples exhibit "good microstructural integrity", with no evidence of deterioration from salts. Although some minor sulfate deposits and chlorides were detected, they are not related to any significant cracking distress. In addition, the presence of alkali salts is most likely due to the original mortar mix and the use of unwashed sands, an not from subsequent deposits of salt from the environment.

PLASTER

Interior plaster of two of the historic buildings was also examined. In the oil house, a sample of a three-coat plaster system, discovered behind a layer of modern wood paneling and a bead board wall, was removed for analysis. The plaster is composed of: a lime and carbonate sand scratch coat gauged with natural cement, a natural cement and carbonate sand brown coat, and a lime-based finish coat that is gauged with gypsum (no sand). Although it is unclear when this plaster dates from, it is possible that it is original to the building and dates to the 1850s. The sand used in the scratch and brown coats is the same as that used in the brick mortar of the same building, a local carbonate sand. (*Figure 16)*

The other interior plaster examined for this study was removed from the keeper's residence, and presumably dates to the original 1922-23 period of construction. The plaster is a two-coat system, with gypsum and sand-based scratch coat and a gypsum-based finish coat gauged with lime. The brown coat is consistent with a Keene's cement mixture. Keene's cement is a slow-setting, hard-

[6] 1920 specification, page 3.

finish plaster produced by burning very pure gypsum at high temperatures and treating the material with alum or other chemicals during the manufacturing process.[7] The current lab findings indicate that a different plaster was used than what was originally specified. The preliminary specifications for the keeper's residence, which date to 1920, call for the use of cement and lime plaster and not gypsum. However, the finish plaster was to be "cement plaster equal to the US Gypsums Co's Adamant"', a fire-resistant type of early drywall.

For a more in depth discussion of the specific findings of the mortar and plaster analysis performed as part of this study, including detailed characterization of the aggregate and binder as well as annotated photomicrographs, refer to *Appendix B.*

[7] Edwin C. Eckel. *Cements, Limes and Plasters: Their Materials, Manufacture and Properties*. Michigan: Donhead Publishing Co. 2005 (originally published 1905), 78.

# 4.0 CONCLUSIONS AND RECOMMENDATIONS

## 4.1 Finishes

MASONRY

The recommendation for an appropriate paint finish for the masonry of the historic buildings at the Dry Tortugas Light Station is fairly straightforward. The white finish on the brick masonry portions of the lighthouse, oil house, south brick cistern and kitchen building should be maintained (note that the masonry portions of the keeper's residence were never painted). Even though archival and physical evidence indicates that these buildings were not originally painted (possibly with the exception of the cistern), a white finish was applied early enough in their history that it can be considered historically significant. For instance, the oil house was painted white by circa 1892 and the lighthouse was painted with its current black and white scheme by 1875. In the case of the lighthouse, not only is the black and white paint scheme historic, but it also defines the lighthouse's appearance and its identity. In addition to being historically appropriate, the use of a finish on the brick masonry of these buildings also affords a level of protection for the brick substrate by protecting it from wind and moisture that would no doubt take a toll on the surface of the brick over time, possibly eroding away the fire skin and making the brick even more susceptible to weathering.

Although the brick of these buildings should be maintained white, the type of finish used to achieve this white color should be carefully considered. Archival evidence indicates that both limewash and oil paints were used historically on the buildings at the Dry Tortugas Light Station, although where each of these finishes was used is not always made clear. Physical evidence, however, suggests that white limewash was used on the brick portions of these buildings, with the exception of the black paint on the top half of the lighthouse, and oil paint was used on the wood elements. The use of limewash on masonry structures was commonplace throughout history and into the early 20th century. It was an inexpensive and readily available finish. From a preservation perspective, limewash is a perfect finish for masonry substrates because it forms a good bond, it is moisture-permeable and it resists biological growth. It could also be renewed both easily and cheaply.

The majority of the white finishes currently on the brick buildings at the Dry Tortugas Light Station appear to be modern acrylic- or oil-based paints. While the color of the finish is appropriate, the finish type is not. These modern finishes, which in some cases appear to be trapping moisture in the wall, should be removed and white limewash applied instead. Of course, care should be taken to carefully remove the modern paint layers in a way that does not damage the brick substrate (this would exclude the use of many abrasive blasting techniques). In addition, the existing paint should be tested to determine any lead content prior to removal. The materials analysis included in the 1984 rehabilitation report cites that the paint on the exterior of the lighthouse is an acrylic-polyvinyl acetate mixture with lead and zinc-based pigments. It is likely this paint still remains on the lighthouse

and that other buildings of the light station were painted with the same lead-based paint. Further testing would be required to identify lead content in any of the paint coatings on the buildings.

Once the modern coatings are successfully removed from the brick masonry, the limewash will bond well to the brick, the mortar and any traces of earlier limewash. The limewash will allow any moisture present in the brick walls to escape without compromising the limewash finish (as opposed to the less permeable modern paints which can fail when moisture gets trapped behind them). Performing a mock-up of such a finish is strongly advised in order to assess the longevity of this type of finish in the environmental conditions associated with the island.

The only masonry surface that should not get painted with a lime wash is the top half of the day mark, which is painted black. Achieving a truly black limewash is difficult if not impossible, so some other type of finish will have to be used in this location. Although oil paints were most likely used historically, a better paint may be currently available. Modern paints such as those based on potassium silicate or even some highly permeable acrylic paints designed for historic masonry should be considered for the lighthouse.

WOODWORK & METALWORK

Recommendations for appropriate restoration finishes for the woodwork and metalwork of the oil house, lighthouse and keeper's residence are included in the chart below; no paint colors are provided for the kitchen building because no historic paint was found on the wood trim of this building. Wherever surviving physical evidence remains, a color match to the historic paint color is provided. Color matches are made to both the Munsell and Benjamin Moore color systems. However, in cases where there is no longer any physical paint evidence or access to a particular element was not permitted during the study, recommendations for appropriate restoration colors are provided but are based solely on archival information (written or photographic). In the latter case, a general recommendation is provided but a specific color match is not. The basis for each color match is provided in the "Source" column of the chart below.

The recommended restoration paint colors are provided below. Specific color matches have been made to both the standardized Munsell color system and the commercial Benjamin Moore paint palette. CIE L*a*b values for the actual color as well as the color matches are also provided so that the difference between the actual color and the matches can be determined. Please note that, although there was subtle variation in the color of the limewashes on the different buildings, a single color match to the limewash is provided.

It should also be mentioned that the recommended colors for the lighthouse and oil house door trim (which are based on physical evidence) may represent original paint colors that were on the buildings when the brick masonry was exposed and not once the brick was painted white. Unfortunately, it is

not possible to determine the paint color on the wood door trim when the brick was first painted white.

Any attempt to reproduce the following pages, including printing from the electronic version of the report, will distort the color of the provided chips. Only the actual color chip or notation should be used for paint replication purposes.

| Building | Component | Date | Description | Source | Color Match | CIE L*a*b* Values | Color Chip |
|---|---|---|---|---|---|---|---|
| **Lighthouse** | Brick masonry | 1858-1870 | Exposed brick | Written archival references, physical evidence | Not Provided - not a paint color | | |
| | Brick masonry | 1870 | Bottom half white limewash and top half black paint | Written archival references, historic photographs, physical evidence | *Munsell Match: N 9.5*<br><br>*B. Moore Match: OC-45*<br><br>*Access to white limewash only* | *Sample:*<br>L*89.7 a*0.1 b*4.4<br>*Munsell Match:*<br>L*96.7 a*-0.7 b*1.1<br>Delta E = 7.8<br>*B. Moore Match:*<br>L*93.0 a*-0.5 b*5.4<br>Delta E = 3.5 | B. Moore OC-45 |
| | Window sash and frames | circa 1892 | Pale-colored paint, possibly cream or white | Historic photograph | Not Provided - no physical evidence | | |
| | Door | possibly 1858 | Gray paint | Physical evidence | *Munsell Match: N 5.75*<br><br>*B. Moore Match: HC-161* | *Sample:*<br>L*56.3 a*-2.3 b*0.7<br>*Munsell Match:*<br>L*59.0 a*-1.0 b*0.4<br>Delta E = 3<br>*B. Moore Match:*<br>L*54.4 a*-5.0 b*-1.8<br>Delta E = 4.1 | B. Moore HC-161 |

| Building | Component | Date | Description | Source | Color Match | CIE L*a*b* Values | Color Chip |
|---|---|---|---|---|---|---|---|
| | Door frame | possibly 1858 | Cream paint | Physical evidence | *Munsell Match: 2.5Y 9/2*<br>*B. Moore Match: 1149* | *Sample:*<br>L*83.6 a*2.3 b*13.8<br>*Munsell Match:*<br>L*92.0 a*2.2 b*16.1<br>Delta E = 8.7<br>*B. Moore Match:*<br>L*89.5 a*3.9 b*11.1<br>Delta E = 6.7 | B. Moore 1149 |
| | Lantern exterior | 1862 | Black paint | Written archival reference | Not Provided - not a paint color | | |
| | Lantern interior | 1862 | White Paint | Written archival references, | Not Provided - not a paint color | | |
| **Oil house** | Brick masonry | 1858 | Exposed brick | Historic photographs, physical evidence | Not Provided - not a paint color | | |

| Building | Component | Date | Description | Source | Color Match | CIE L*a*b* Values | Color Chip |
|---|---|---|---|---|---|---|---|
| | Brick masonry | circa 1892 | White limewash | Historic photographs, physical evidence | *Munsell Match: N 9.5*<br><br>*B. Moore Match: OC-45* | *Sample:*<br>L*89.7 a*0.1 b*4.4<br>*Munsell Match:*<br>L*96.7 a*-0.7 b*1.1<br>Delta E = 7.8<br>*B. Moore Match:*<br>L*93.0 a*-0.5 b*5.4<br>Delta E = 3.5 | B. Moore OC-45 |
| | Window sash and frames | circa 1892 | Pale-colored paint, possibly cream or white | Historic photograph | Not Provided - no physical evidence | | |
| | Door frame | 1858 | Gray paint | Physical evidence | *Munsell Match: 10Y 6/1*<br><br>*B. Moore Match: 1483* | *Sample:*<br>L*50.5 a*-1.4 b*1.1<br>*Munsell Match:*<br>L*35.2 a*-0.4 b*0.2<br>Delta E = 15.3<br>*B. Moore Match:*<br>L*33.4 a*-0.6 b*-1.5<br>Delta E = 17.3 | B. Moore 1483 |
| **Kitchen building** | Brick masonry | 1858 | Exposed brick | Historic photographs, physical evidence | Not Provided - not a paint color | | |

| Building | Component | Date | Description | Source | Color Match | CIE L*a*b* Values | Color Chip |
|---|---|---|---|---|---|---|---|
| | Brick masonry | unknown | White limewash | Physical evidence | *Munsell Match: N 9.5*<br>*B. Moore Match: OC-45* | *Sample:*<br>L*89.7 a*0.1 b*4.4<br>*Munsell Match:*<br>L*96.7 a*-0.7 b*1.1<br>Delta E = 7.8<br>*B. Moore Match:*<br>L*93.0 a*-0.5 b*5.4<br>Delta E = 3.5 |  <br>B. Moore OC-45 |
| **South brick cistern** | Brick masonry | 1858 | White limewash | Physical evidence | *Munsell Match: N 9.5*<br>*B. Moore Match: OC-45* | *Sample:*<br>L*89.7 a*0.1 b*4.4<br>*Munsell Match:*<br>L*96.7 a*-0.7 b*1.1<br>Delta E = 7.8<br>*B. Moore Match:*<br>L*93.0 a*-0.5 b*5.4<br>Delta E = 3.5 | <br>B. Moore OC-45 |
| **Keeper's dwelling exterior** | Door surround and porch trim | 1917 | White paint | Written archival references, historic photographs, physical evidence | *Munsell Match: 5Y 9/1*<br>*B. Moore Match: 974* | *Sample:*<br>L*88.3 a*-0.4 b*11.2<br>*Munsell Match:*<br>L*92.1 a*0.2 b*10.3<br>Delta E = 3.9<br>*B. Moore Match:*<br>L*89.0 a*0.1 b*8.4<br>Delta E = 2.9 |  <br>B. Moore 974 |
| **Keeper's dwelling interior** | Plaster walls of hallway and bathroom | 1917 | Pale gray-green paint | Written archival references, physical evidence | *Munsell Match: 10Y 7/1*<br>*B. Moore Match: 1486* | *Sample:*<br>L*78.5 a*-2.0 b*4.9<br>*Munsell Match:*<br>L*71.9 a*-1.6 b*8.7<br>Delta E = 7.6<br>*B. Moore Match:*<br>L*76.9 a*-0.5 b*7.3<br>Delta E = 3.3 |  <br>B. Moore 1486 |

| Building | Component | Date | Description | Source | Color Match | CIE L*a*b* Values | Color Chip |
|---|---|---|---|---|---|---|---|
| | Wood cornice of hallway | 1917 | White paint | Written archival references, physical evidence | *Munsell Match: 5Y 9/1*<br><br>*B. Moore Match: 974* | *Sample:*<br>L*87.2 a*0.0 b*12.7<br>*Munsell Match:*<br>L*92.1 a*0.2 b*10.3<br>Delta E = 5.5<br>*B. Moore Match:*<br>L*89.0 a*0.1 b*8.4<br>Delta E = 4.7 |  <br>B. Moore 974 |

## 4.2 Mortar

Analysis of the brick mortars of the buildings at the Dry Tortugas Light Station indicates that the original mortars were composed of natural cement. Such mortars were typical for the period, especially for maritime construction. The mortar has generally held up well through the years, even in the harsh environment of wind and salt-laden sea air; although exceptions can be seen at the lighthouse, where the mortar is friable in many areas and paint loss occurs regularly at the mortar joints. However, as previously discussed, this deterioration is most likely a factor of moisture permeating through the wall and inappropriate paint films and not failure of the original material. A more comprehensive evaluation of this aspect of the masonry construction falls outside of the scope of this research.

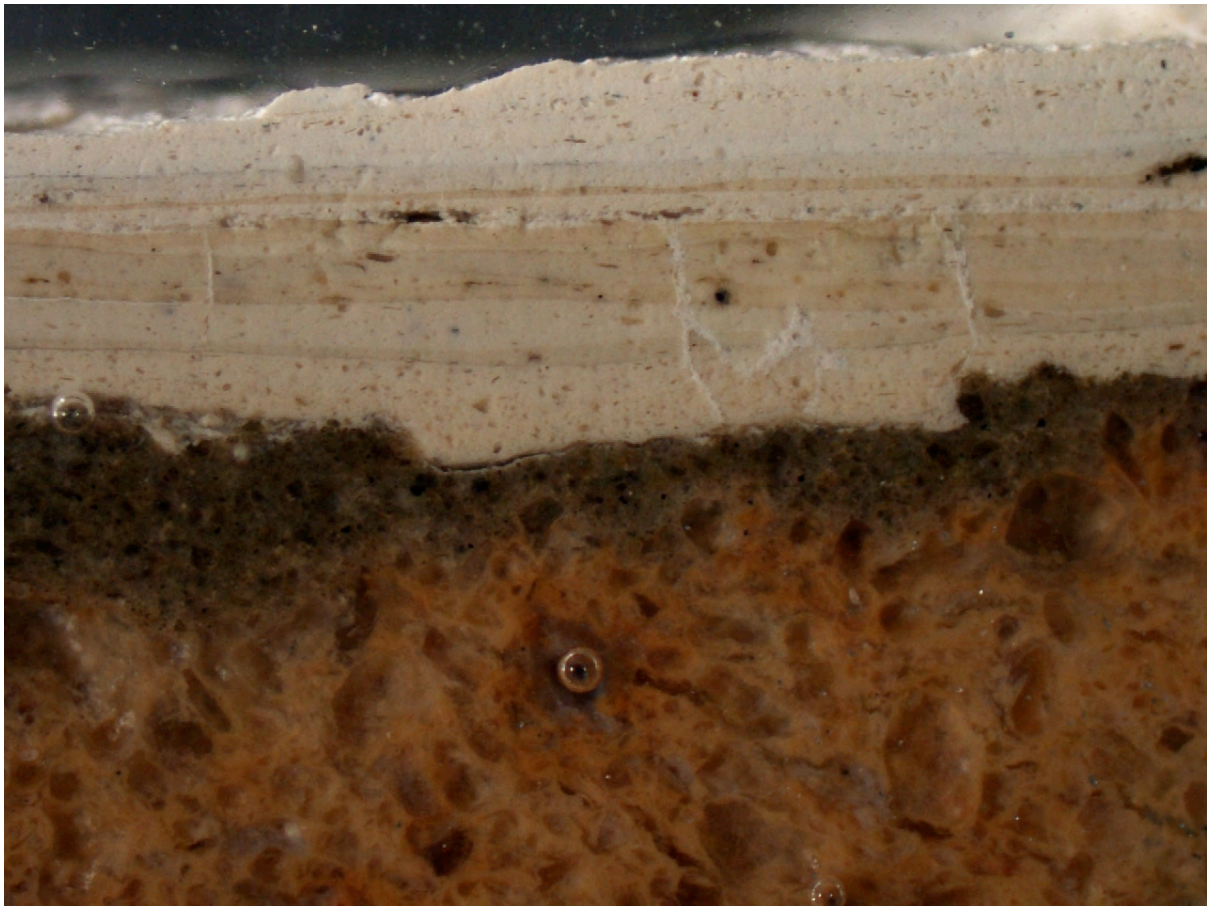
For future re-pointing campaigns, it is important that the correct mortar be used. It may also be prudent to replace existing repair campaigns with a more appropriate mortar. Mortars based on large amounts of Portland cement are typically too strong and dense to be used in combination with the type of low-fired brick found on most of these buildings. Although, the keeper's residence, which was built later, is an exception, as it is constructed of high-fired modern brick and Portland cement mortar. In general, the use of a high calcium or hydraulic lime mortar would also be inappropriate for these buildings. Therefore, the recommended restoration mortar for the historic buildings at the Dry Tortugas Light Station is as follows:

<u>Lighthouse, Oil House, Kitchen Building & South Brick Cistern</u>
*Binder*: natural cement
*Sand:* natural carbonate sand (to match existing)
*Component Ratio (binder: sand):* 1:1.5

<u>Keeper's Residence</u>
*Binder*: Portland cement
*Sand:* natural carbonate sand (to match existing)
*Component Ratio (binder: sand):* 1:3 (note this mix is slightly less binder-rich than the original)

# APPENDIX A.

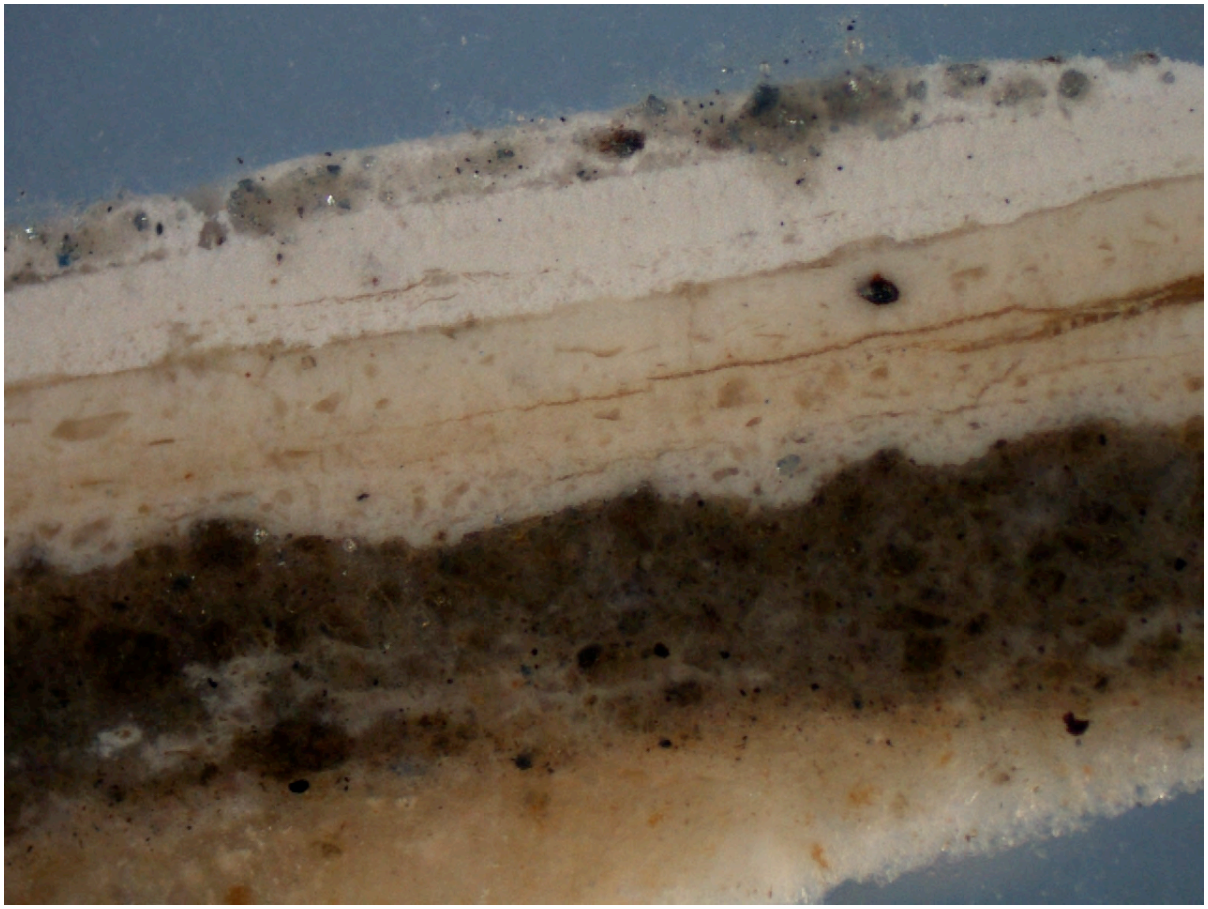
# PHOTOMICROGRAPHS AND STRATIGRAPHIES



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.1 (40x, Visible Light) |
| **LOCATION:** | Oil House, exterior, east elevation now enclosed, finishes on brick. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Brick | Surface looks weathered and soiled, suggests exposure prior to painting |
| **1** | Cream | All finishes look like paint, missing early limewash layer visible in LOKE.F.9 |
| 2 | Off-white | |
| **3** | Off-white | |
| **4** | Cream | |
| **5** | Cream | |
| **6** | Cream | |
| 7 | Off-white | |
| **8** | Cream | |
| **9** | Off-white | |
| **10** | Off-white | |
| **11** | Off-white | Current finish |

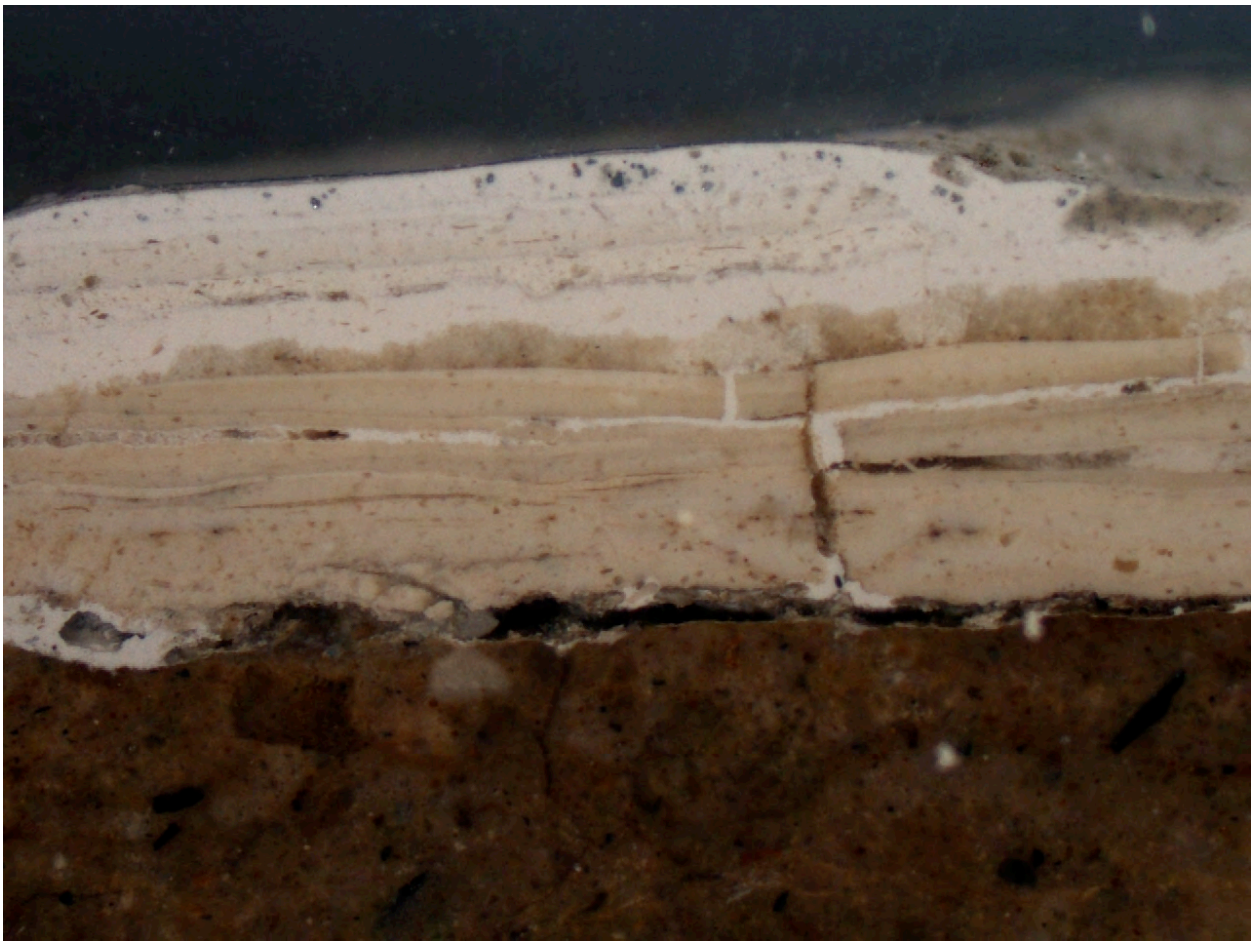
* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.2 (100x, Visible Light) |
| **LOCATION:** | Passageway between Oil House & Lighthouse, south wall, finishes on concrete. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Concrete | |
| 1 | Off-white | |
| **2** | Cream | |
| **3** | Cream | |
| 4 | Off-white | |
| **5** | Off-white | Modern paint |
| **6** | Off-white | Current finish |

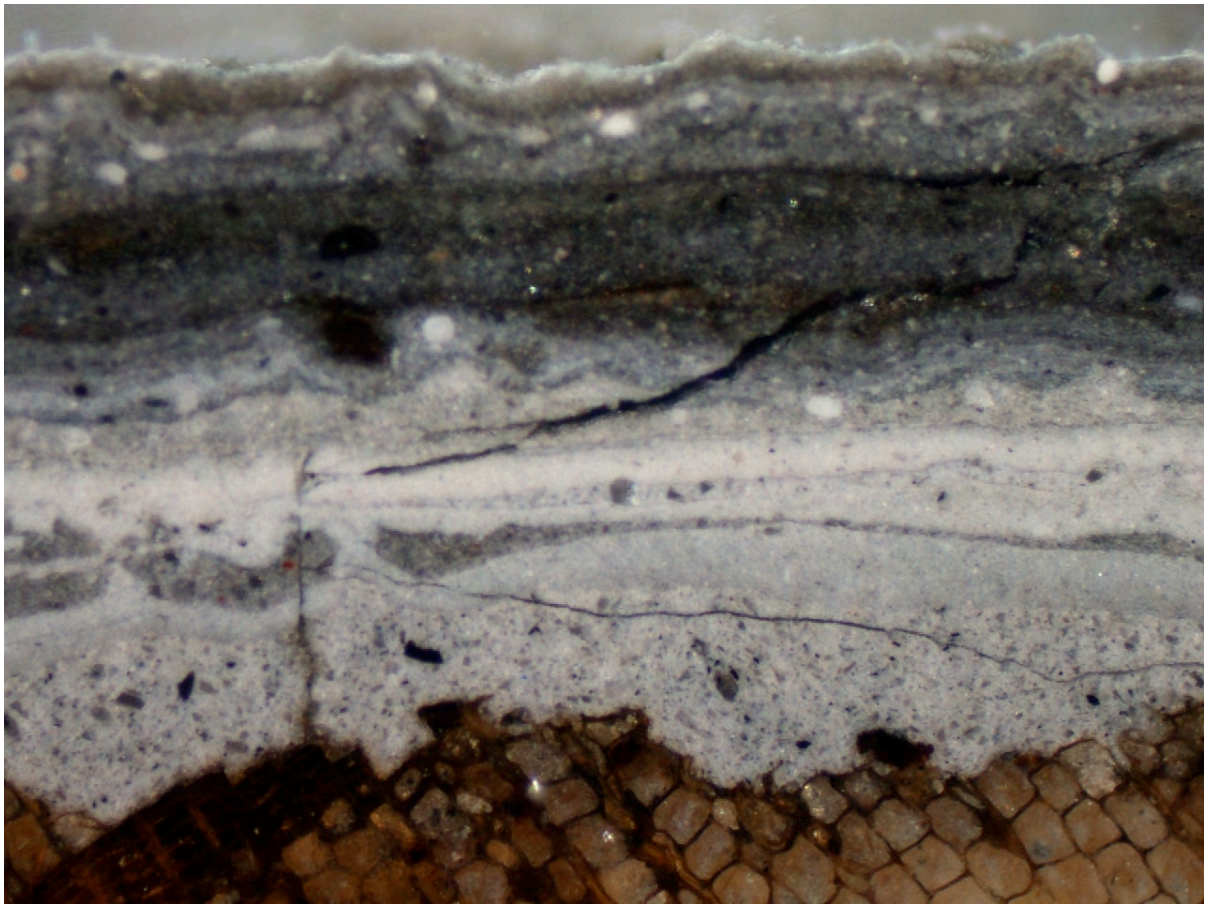
* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.3 (40x, Visible Light) |
| **LOCATION:** | Oil House, exterior, east elevationl, finishes on brick. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Brick | Fracture at surface suggests weathering prior to painting |
| **1** | Cream | |
| **2** | Cream | |
| **3** | Cream | |
| **4** | Cream | |
| **5** | Cream | |
| **6** | Cream | |
| **7** | Cream | |
| **8** | Cream | |
| **9** | Cream | |
| **10** | Cream/tan | Translucent |
| **11** | White | |
| **12** | Off-white | |
| **13** | Off-white | |
| **14** | Off-white | |
| **15** | White | Current finish |

* **bold** indicates a finish layer and not a primer

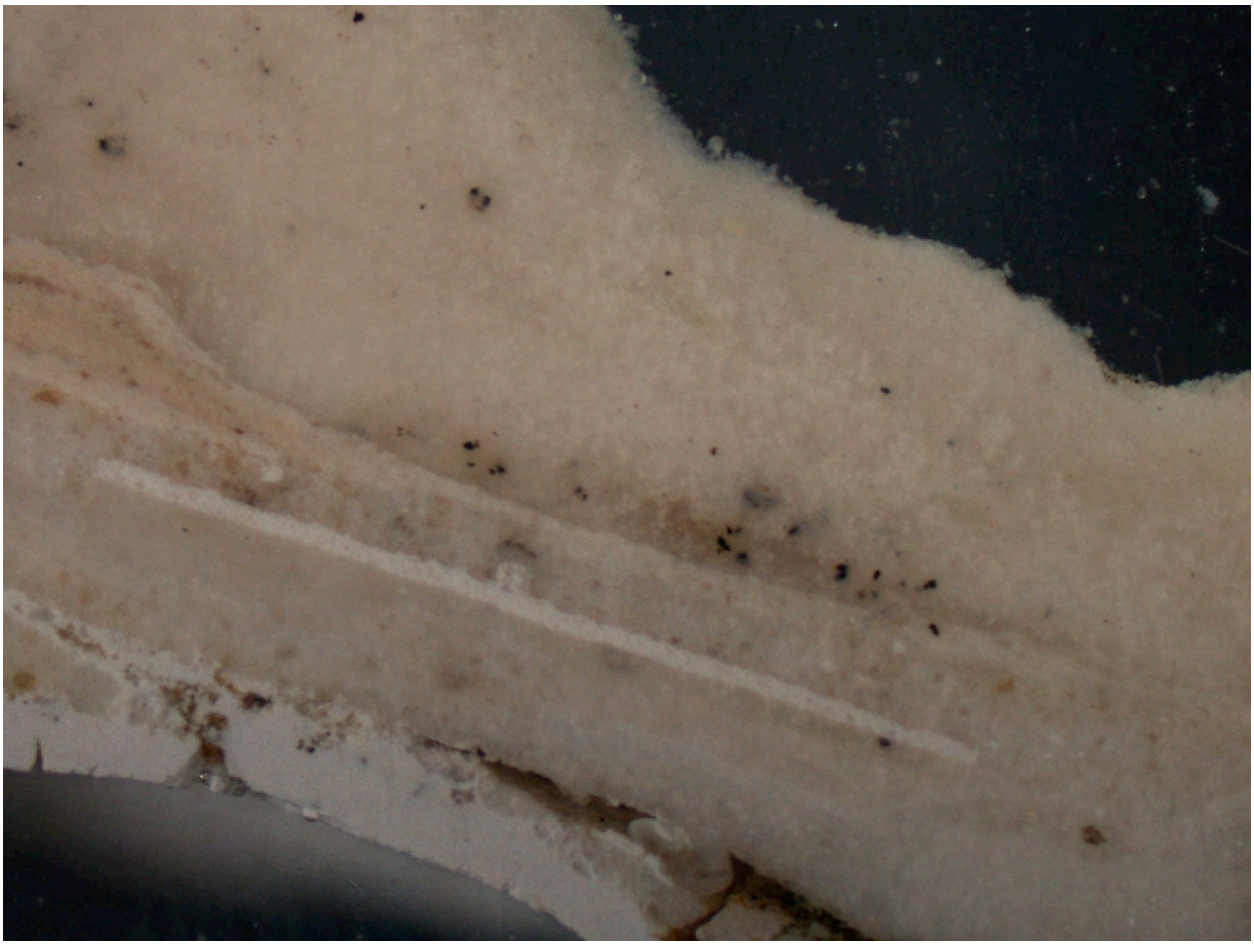


| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.4 (100x, Visible Light, only earliest layers visible in photo) |
| **LOCATION:** | Oil House, exterior, east elevation, door frame, finishes on wood. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Wood | |
| 1 | Pale gray | |
| **2** | Pale gray | |
| **3** | Pale gray | |
| 4 | Gray-green | Translucent |
| **5** | Pale gray | |
| **6** | Pale gray | |
| **7** | Pale gray | |
| **8** | Pale gray | |
| **9** | Medium gray | |
| 10 | Pale gray | |
| **11** | Medium gray | |
| **12** | Medium gray | |
| **13** | Medium gray | |
| **14** | Pale gray | |
| **15** | Medium gray | |
| **16** | Off-white | |

| | | |
|---|---|---|
| **17** | Gray-green | |
| 18 | Gray-green | |
| **19** | Light gray-green | |
| **20** | Pale gray | |
| **21** | Off-white/ pale gray | |
| **22** | Pale gray | |
| 23 | Pale gray | |
| **24** | Dark gray | |
| **25** | Cream | |
| 26 | Off-white | Remaining paints look more modern |
| **27** | Dark gray | |
| 28 | Gray | |
| **29** | Blue-gray | |
| 30 | White | |
| **31** | Dark gray | |
| **32** | Cream | |
| **33** | Cream | |
| **34** | Cream | |
| **35** | Cream | |
| **36** | Cream | |
| **37** | Cream | |
| **38** | Cream | |
| 39 | Gray | |
| **40** | Olive green | |
| **41** | Dark gray | |
| 42 | White | |
| **43** | Dark gray | |
| **44** | Dark gray | |
| **45** | Dark gray | |
| 46 | Light Gray | |
| **47** | Gray | Current finish |

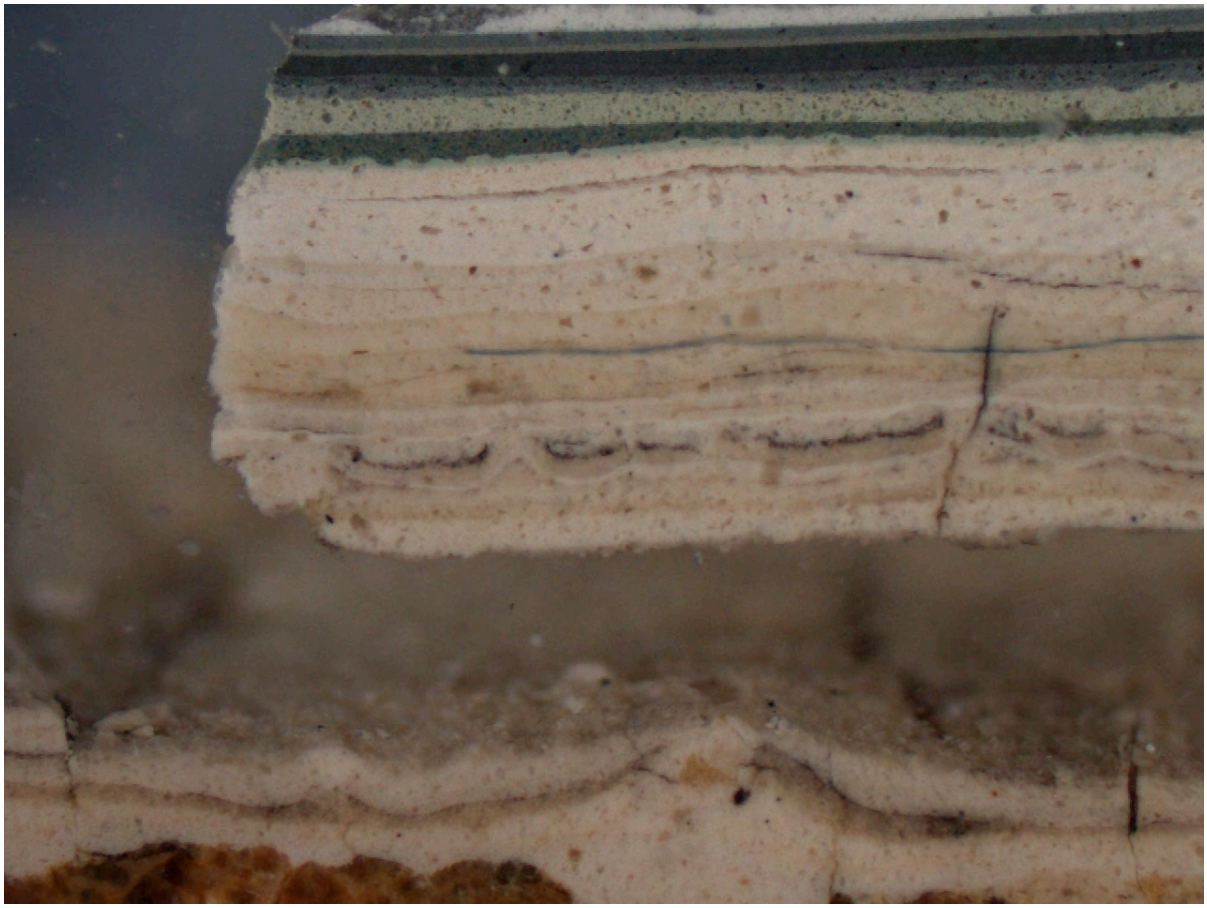
* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.5 (100x, Visible Light) |
| **LOCATION:** | Cistern, west elevation, finishes on brick. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Brick (missing in photo) | No sign of weathering of brick surface, suggests brick was always finished |
| **1** | Off-white | Translucent, white wash |
| **2** | Off-white | Translucent, white wash |
| **3** | Off-white | |
| **4** | Off-white | Modern paint |
| **5** | White | |
| **6** | White | Current finish |

* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.6 (40x, Visible Light) |
| **LOCATION:** | Lighthouse, exterior, north wall now enclosed adjacent to door, finishes on brick. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Brick | Surface looks soiled |
| **1** | Tan | Thin, translucent, lime wash |
| 2 | Cream | |
| **3** | Tan | Translucent |
| 4 | Cream | |
| **5** | Tan | |
| 6 | Cream | |
| **7** | Buff | |
| 8 | Cream | |
| **9** | White | |
| **10** | Cream | |
| **11** | Cream | |
| **12** | Cream | |
| **13** | Cream | |
| **14** | Cream | |
| **15** | Cream | |
| **16** | Cream | |

| | | |
|---|---|---|
| **17** | Cream | |
| **18** | Cream | |
| **19** | Cream | |
| 20 | [fracture] | |
| 21 | White | |
| 22 | Light Green | |
| **23** | Blue | |
| 24 | Light Green | |
| **25** | Blue | |
| **26** | Dark Blue | |
| **27** | Dark Blue | |
| **28** | Gray | |
| **29** | Gray-blue | |
| **30** | White | Current finish |

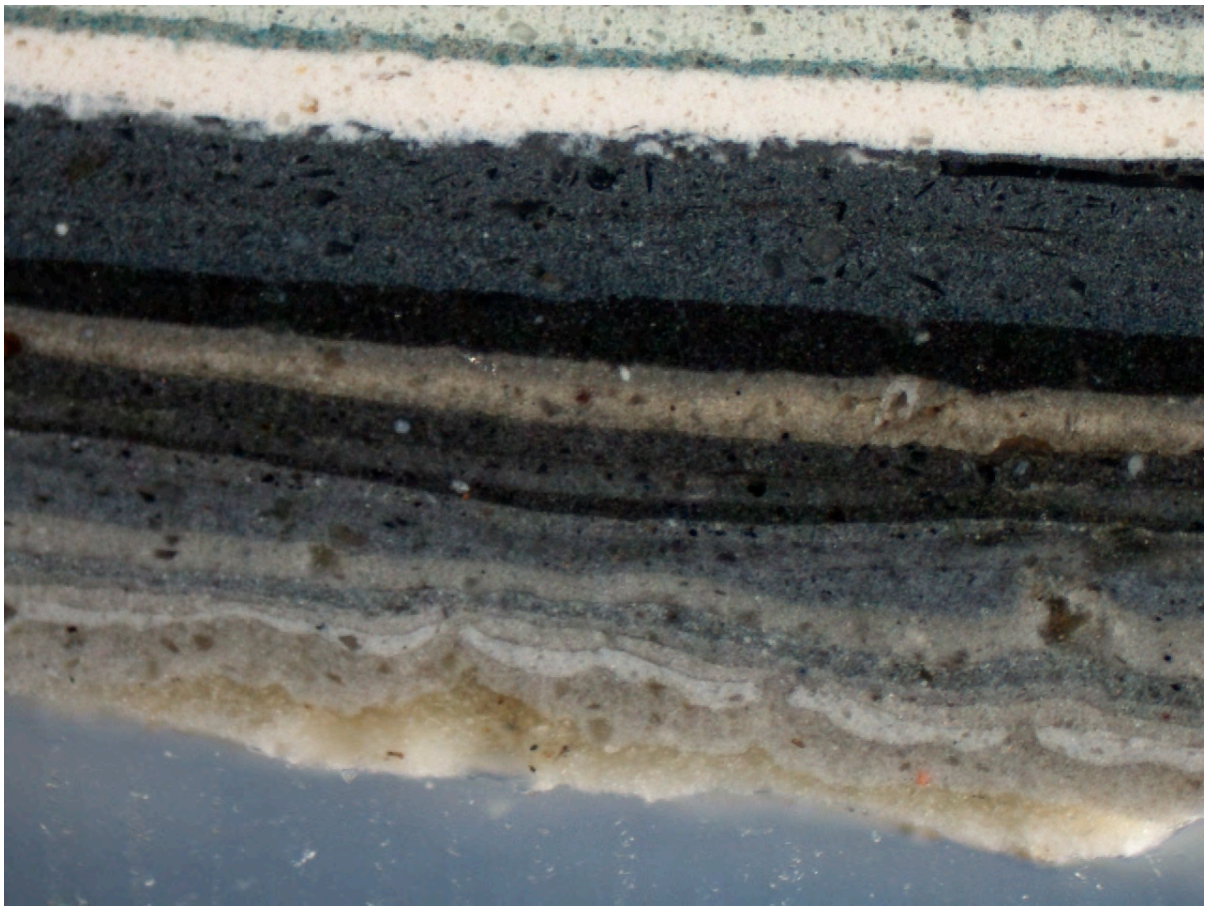


| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.7 (40x, Visible Light) |
| **LOCATION:** | Lighthouse, exterior, west wall now enclosed, door frame, finishes on wood. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Wood | |
| **1** | Cream | |
| 2 | Off-white | |
| **3** | Off-white | |
| **4** | Cream | |
| **5** | Off-white | |
| **6** | Cream | Translucent |
| 7 | Off-white | |
| **8** | Cream | |
| **9** | Off-white | |
| **10** | Dark green-gray | Translucent |
| **11** | Blue-gray | |
| **12** | Dark blue-gray | |
| **13** | Gray | |
| **14** | Blue-gray | |
| **15** | Light blue-gray | |
| **16** | Light blue-gray | |
| 17 | White | |
| **18** | Light blue-gray | |

| | | |
|---|---|---|
| **19** | Light blue-gray | |
| **20** | Blue-gray | |
| **21** | Blue-gray | |
| **22** | Dark blue-gray | |
| **23** | Light blue-gray | |
| 24 | Gray | |
| **25** | Light gray | |
| **26** | Gray | |
| **27** | Blue-gray | |
| **28** | Blue-gray | |
| **29** | Blue-gray | |
| **30** | Blue-gray | |
| **31** | Blue-gray | |
| **32** | Blue-gray | |
| **33** | Blue-gray | |
| **34** | Gray | Thin |
| **35** | Dark blue-gray | |
| **36** | Blue-gray | |
| 37 | White | |
| 38 | White | |
| **39** | Blue-gray | |
| 40 | Light blue-gray | |
| **41** | Gray | Current finish |

* **bold** indicates a finish layer and not a primer

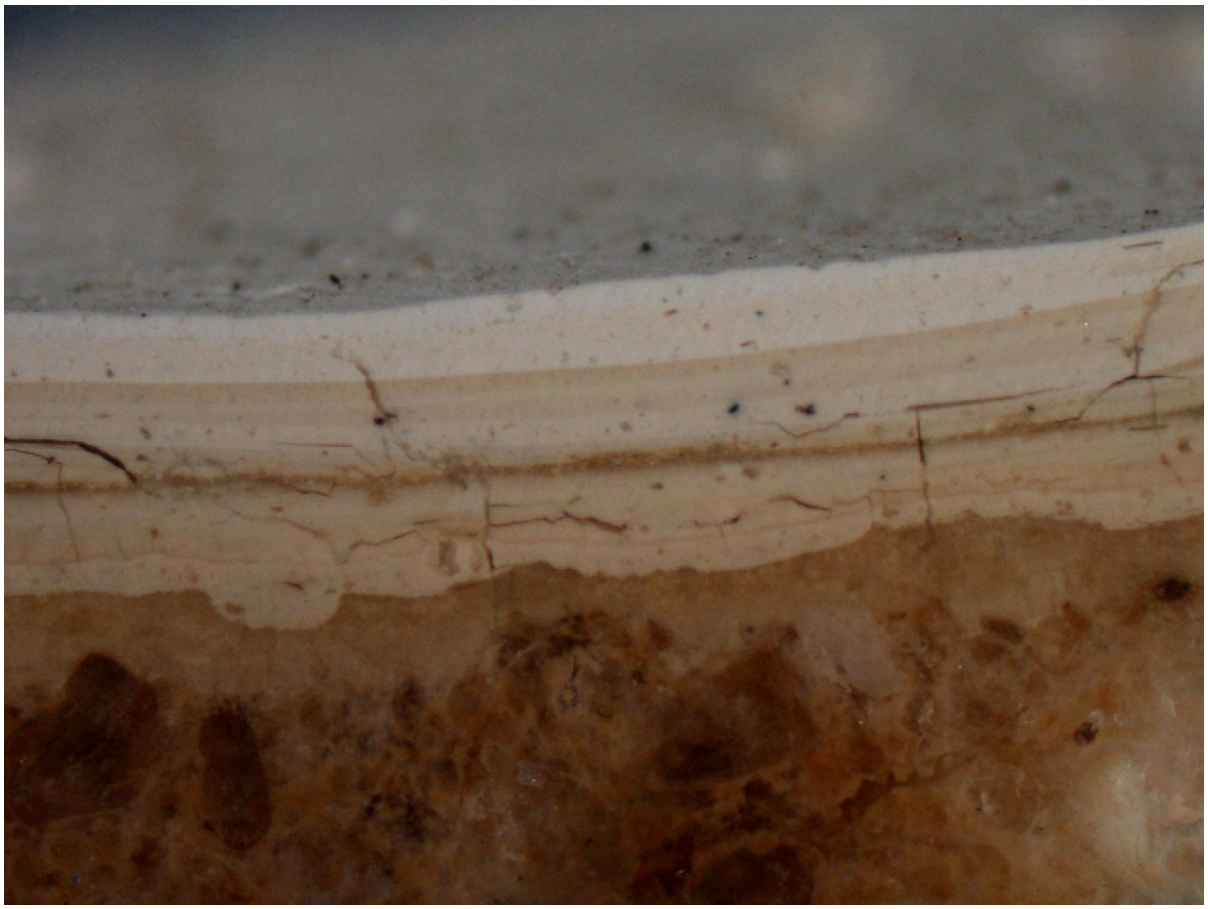


| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.8 (100x, Visible Light, only earliest layers visible in photo) |
| **LOCATION:** | Lighthouse, exterior, west wall now enclosed, door, finishes on wood. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Wood (not visible in photo) | |
| 1 | Cream | |
| **2** | Light gray | |
| **3** | Light gray | |
| **4** | Gray | |
| **5** | Gray | |
| **6** | Blue-gray | |
| 7 | Gray | |
| **8** | Blue-gray | |
| 9 | Blue-gray | |
| **10** | Blue-gray | |
| **11** | Blue-gray | |
| **12** | Light blue-gray | |
| **13** | Light blue-gray | |
| **14** | Dark blue-gray | |
| **15** | Blue-gray | |
| **16** | Blue-gray | |
| 17 | White | |
| **18** | Blue-green | |

| | | |
|---|---|---|
| 19 | Light blue-green | |
| **20** | Blue-green | |
| **21** | Blue-gray | |
| 22 | Blue-gray | |
| **23** | Blue-gray | |
| 24 | Light blue-gray | |
| **25** | Light blue-gray | |
| **26** | Light green | |
| **27** | Dark blue | |
| **28** | Blue-gray | |
| 29 | Light blue-gray | |
| **30** | Gray | Current finish |

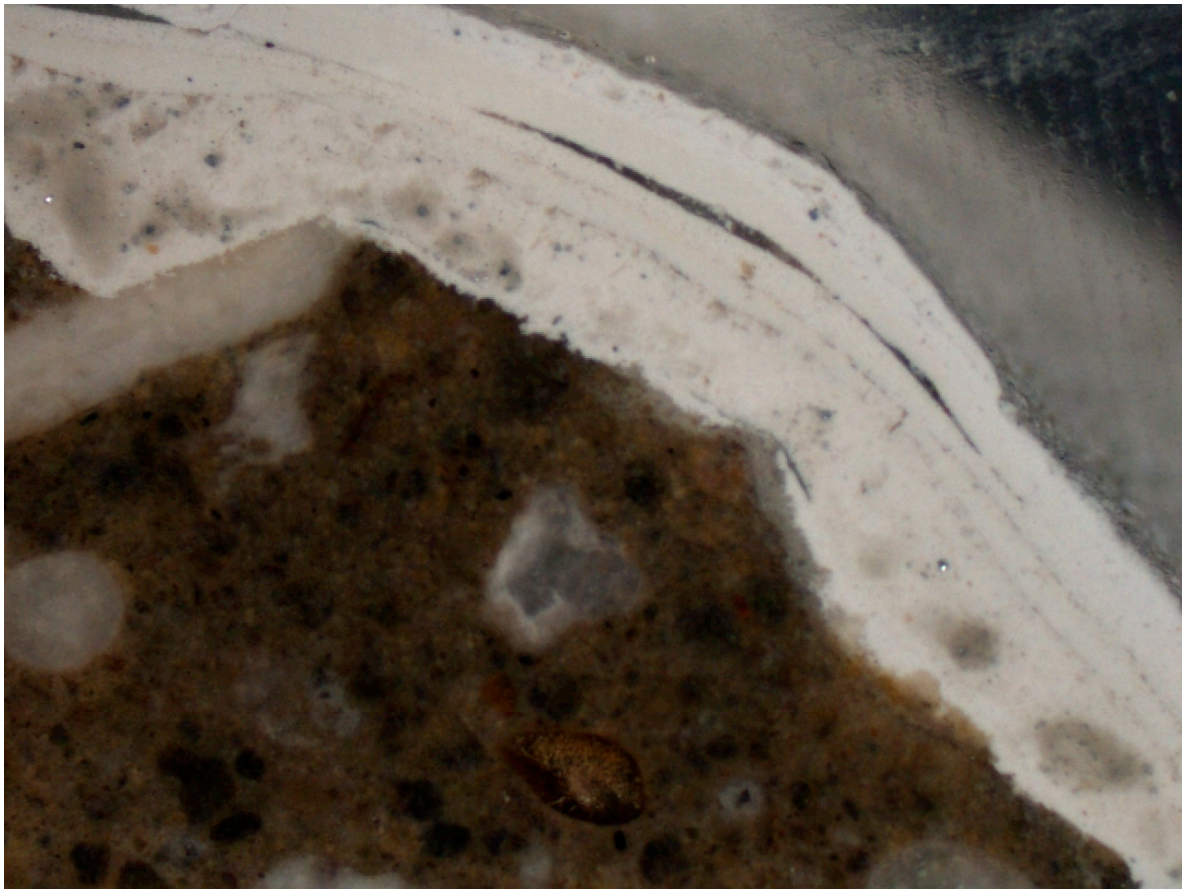
* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.9 (40x, Visible Light) |
| **LOCATION:** | Oil House, exterior, east wall, finishes on brick. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Brick | Surface looks weathered |
| **1** | Cream | Translucent, limewash |
| **2** | Cream | Remaining layers look like paint |
| **3** | Cream | |
| **4** | Cream | Translucent material at surface |
| **5** | Cream | |
| 6 | Off-white | |
| 7 | Cream | |
| 8 | Cream | |
| **9** | Cream | |
| 10 | White | Translucent |
| 11 | Cream | |
| **12** | White | Current Finish |

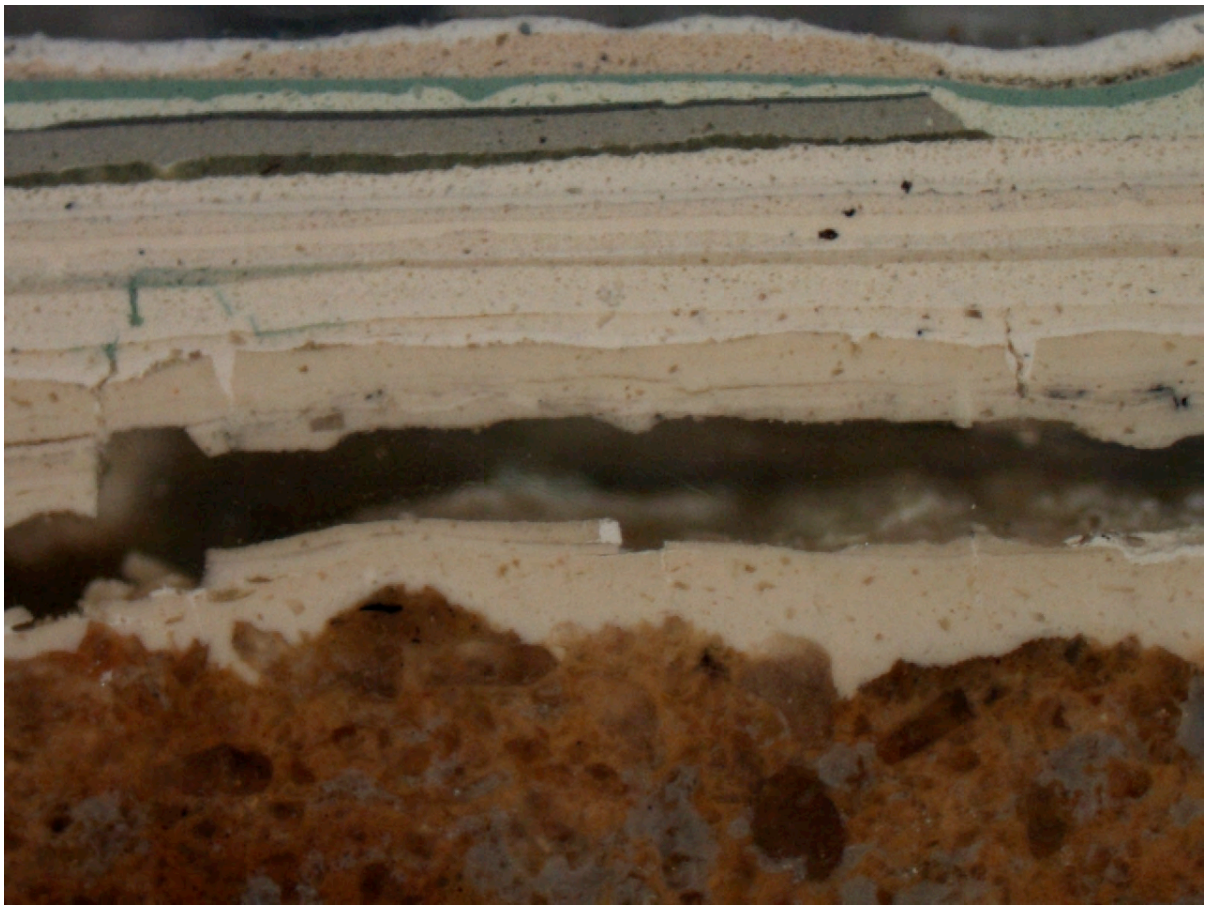
* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.10 (40x, Visible Light) |
| **LOCATION:** | Kitchen Building, exterior, east elevation, finishes on brick. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Brick/Mortar | |
| **1** | White | All layers are modern paint |
| **2** | White | |
| **3** | White | |
| **4** | White | |
| **5** | White | Current Finish |

* **bold** indicates a finish layer and not a primer

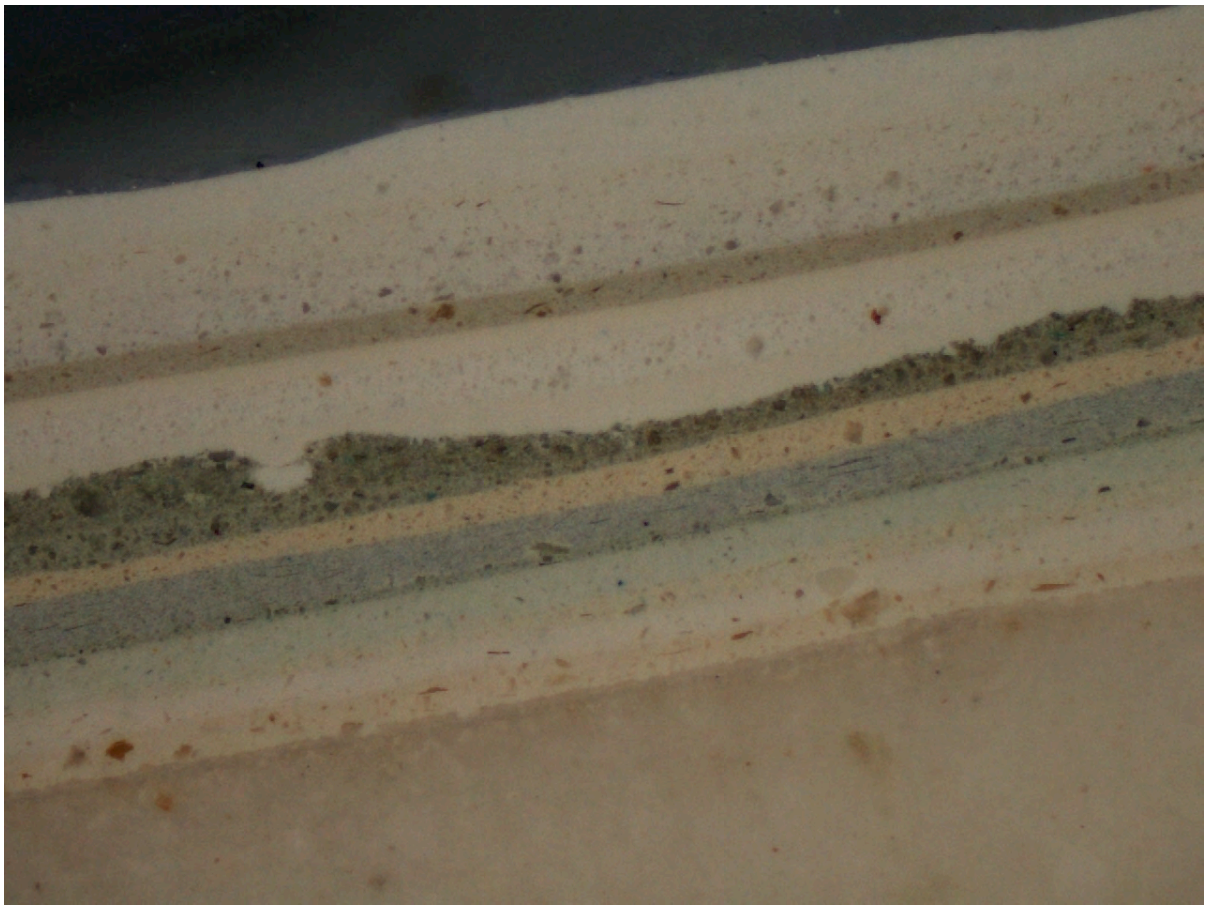


| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.11 (40x, Visible Light) |
| **LOCATION:** | Oil House, exterior, south elevation now enclosed, finishes on brick. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Brick | Surface is weathered, suggests exposure |
| **1** | Cream/tan | Translucent, lime wash (partial layer) |
| 2 | Cream | |
| **3** | Cream | |
| 4 | Cream | |
| **5** | Light cream | |
| **6** | Cream | |
| 7 | Cream | |
| **8** | Cream | |
| 9 | Cream | |
| **10** | Cream | |
| 11 | Cream | |
| **12** | Cream | |
| 13 | White | |
| **14** | Off-white | |
| **15** | White | |
| 16 | Gray | |
| 17 | Light gray | |
| 18 | Light gray/off-white | |

| | | |
|---|---|---|
| 19 | Off-white | |
| **20** | Cream | |
| **21** | Off-white | |
| 22 | Light gray/off-white | |
| **23** | Off-white | |
| 24 | Green | |
| 25 | Gray | |
| **26** | Dark blue-gray | |
| 27 | Light green | |
| **28** | Green | |
| 29 | Peach | |
| **30** | White | Current finish |

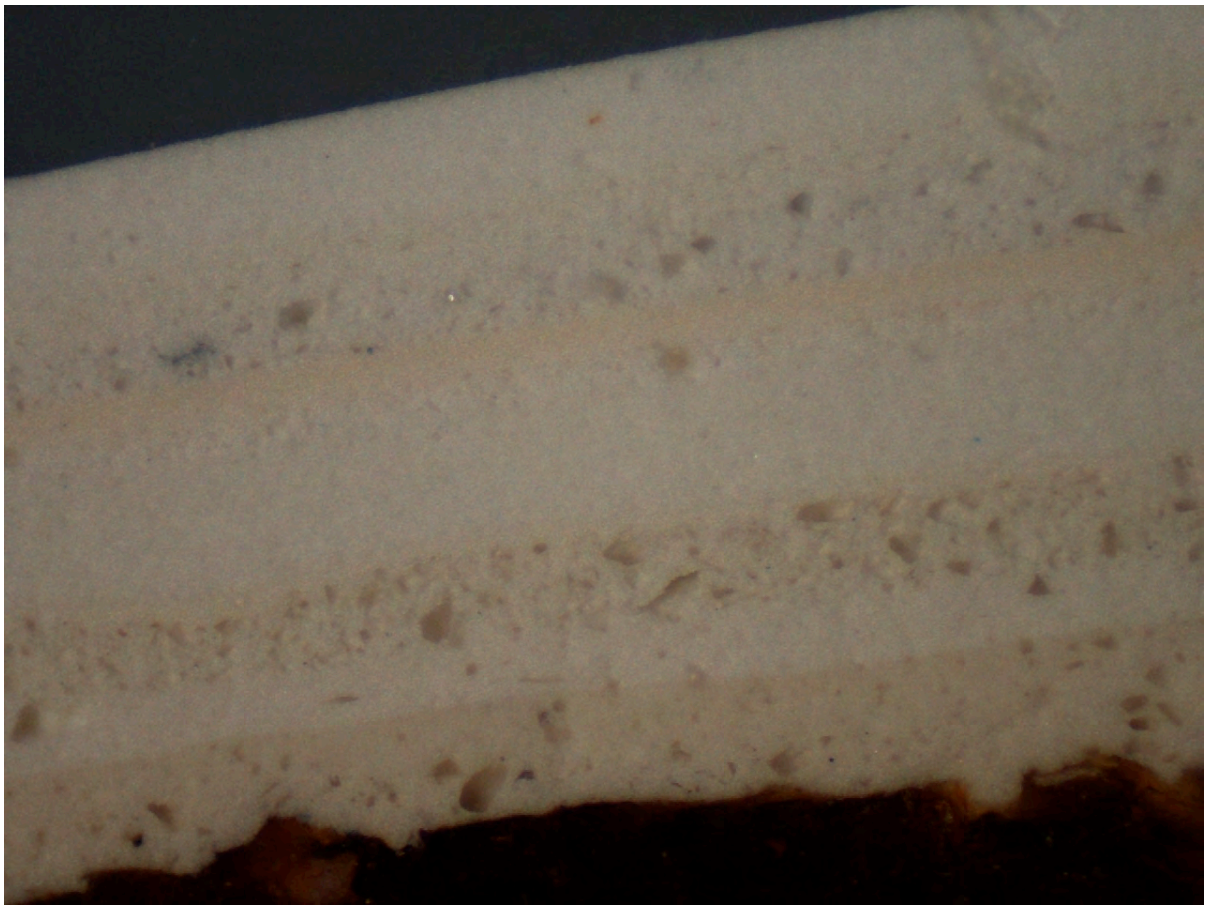
* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.12 (100x, Visible Light) |
| **LOCATION:** | Keeper's Dwelling, interior, hallway outside bathroom, west wall, finishes on plaster. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Plaster | |
| 1 | Cream | |
| 2 | White | |
| 3 | Cream | |
| **4** | Light green | |
| **5** | Light green | |
| 6 | White | |
| **7** | Medium blue | |
| 8 | Warm yellow | |
| **9** | Medium green | |
| 10 | Cream | |
| 11 | White | |
| **12** | Cream | |
| **13** | Light gray/beige | |
| 14 | White | |
| 15 | Cream | |
| **16** | White | Current finish |

* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.13 (200x, Visible Light) |
| **LOCATION:** | Keeper's Dwelling, interior, hallway outside bathroom, cornice, finishes on wood. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Wood | Sealed with clear coat |
| 1 | Cream | |
| **2** | White | |
| **3** | Cream | |
| 4 | White | |
| **5** | Cream | |
| 6 | White | |
| **7** | Cream | Current finish |

* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.14 (100x, Visible Light) |
| **LOCATION:** | Keeper's Dwelling, interior, bathroom, west wall, finishes on plaster. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Plaster | |
| 1 | Cream | |
| 2 | White | |
| **3** | Light Green | |
| 4 | Light Gray | |
| **5** | Gray | |
| **6** | Blue | |
| 7 | Warm cream | |
| 8 | White | |
| **9** | Light blue | |
| 10 | White | |
| **11** | Light blue | Current finish (behind drywall) |

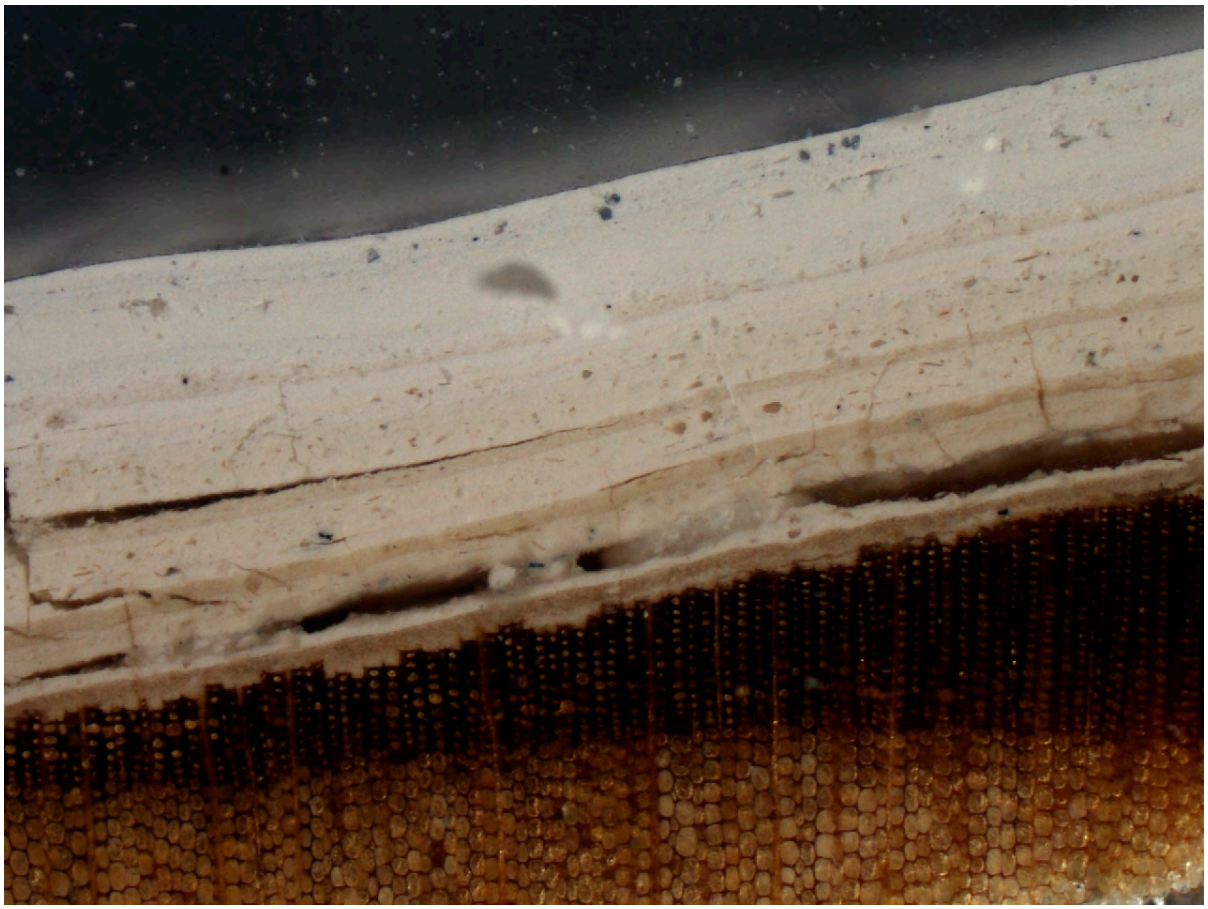
* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.15 (100x, Visible Light) |
| **LOCATION:** | Keeper's Dwelling, exterior, east elevation, front door surround, finishes on wood. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Wood | Surface distressed, looks stripped, missing earliest finish? |
| **1** | Dark green | Soaked into pores of wood at surface |
| **2** | Cream | |
| **3** | White | Thin |
| **4** | Gray-green | |
| 5 | White | |
| **6** | Dark red | Thin |
| 7 | Dark gray | |
| **8** | Dark red | Disrupted, weathered |
| 9 | White | |
| **10** | White | Current finish |

* **bold** indicates a finish layer and not a primer



| | |
|---|---|
| **SAMPLE NO:** | LOKE.F.16 (40x, Visible Light) |
| **LOCATION:** | Keeper's Dwelling, exterior, east elevation, porch soffit (rear face), finishes on wood. |

| ***LAYER**** | ***COLOR*** | ***NOTES*** |
|---|---|---|
| Substrate | Wood | |
| 1 | White | |
| **2** | Cream | Translucent |
| **3** | White | |
| **4** | Cream | |
| **5** | Off-white | |
| **6** | Cream | |
| **7** | Cream | |
| **8** | White | |
| **9** | Cream | |
| 10 | White | |
| **11** | White | Current finish |

* **bold** indicates a finish layer and not a primer

# APPENDIX B.

# MORTAR AND PLASTER ANALYSIS REPORT
# (TESTWELL, INC. 2009)

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## 1. Introduction

On March 27, 2009, Testwell received eleven mortar and plaster samples from Ms. Dorothy Krotzer of Building Conservation Associates, Inc. reported to have been sampled from various structures at the Loggerhead Key Light Station in the Dry Tortugas National Park, FL (Figs. 1 through 4). Samples are identified by the client as follows:

| Sample No. | Building | Description |
|---|---|---|
| LOKE.M.1 | Oil House | Exterior, east elevation mortar. Taken from protected wall now enclosed. Sample from interior of wall (from an area where a hole was cut through wall for a pipe). |
| LOKE.M.2 | Brick Cistern | Exterior, east elevation mortar. |
| LOKE.M.3 | Brick Cistern | Interior, parging. Taken from upper portion of interior wall. |
| LOKE.M.4 | Lighthouse | Exterior, west elevation, mortar. Taken approximately 8-feet from ground. |
| LOKE.M.5 | Lighthouse | Exterior, west elevation, mortar. Taken from former exterior wall now enclosed, adjacent to entrance to lighthouse. |
| LOKE.M.6 | Lighthouse | Interior, mortar. Taken from wall at ground floor level. |
| LOKE.M.7 | Lighthouse | Interior, mortar. Taken from wall below watch level (supposedly rebuilt in 19th century). |
| LOKE.M.8 | Oil House | Interior, south wall, plaster. Taken from behind modern wood paneling and earlier beadboard wall; three-layer plaster system applied over brick. |
| LOKE.M.9 | Kitchen Building | Exterior, north elevation, mortar. Sample from interior of wall. |
| LOKE.M.10 | Keeper's Dwelling | Exterior, west wall, mortar. |
| LOKE.M.11 | Keeper's Dwelling | Interior, bathroom, west wall, plaster. Two-coat plaster system. |

At the client's request, all samples are examined petrographically in order to identify material constituents and assess the degree of microcracking and associated mineral deposition. Aside from some of the plaster coats, all samples are also analyzed chemically in order to provide information regarding original binder chemistries and estimate original component proportions. Water-soluble chloride analysis is also requested for the four lighthouse mortar samples in order to provide information regarding possible salt crystallization or hydration distress. Finally, statistical point-count analysis is performed on three strategically chosen samples in order to provide a cross-check of the material proportion estimates generated from the chemical analyses.

## 2. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within *ASTM C 1324: Standard Test Method for Examination and Analysis of Hardened Masonry Mortar*. Data collection is performed by a degreed geologist who by nature of his/her 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 3 of *ASTM C 856*.

Chemical analysis was conducted via a modification of the procedures outlined in *ASTM C 1324: Standard Test Method for Examination and Analysis of Hardened Masonry Mortar*. Water, carbon dioxide and aggregate weight percentages are determined gravimetrically. Oxide weight percentages are determined by atomic absorption spectroscopy.

Statistical point counting was conducted in general accordance with the procedures outlined in *ASTM C 457: Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete.* Sample sizes do not satisfy the minimum requirements outlined in the method and results are used as an approximate cross-check for other more quantitative methods.

Water-soluble chloride analysis was performed in accordance with *ASTM C 1218: Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.*

## 3. Petrographic Findings

| *SAMPLE ID* | **LOKE.M.1 (Oil House)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, mortar fragments weighing 17.91g. |
| Surfaces | One piece has two parallel sides that may be a joint surface. Approximately 0.5" thick. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is dull. Fresh paste color is light gray (Munsell color designation approximately 2.5Y 7/2). |
| Cracks, Deposits, Etc., | Cracking cannot be assessed due to the fragmental nature of the sample. No mineral deposits are observed. There is a low abundance of coal fragments detected. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve with most material estimated to pass. Peak abundance is estimated between the No. 16 and No. 30 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented though there is a somewhat preferential alignment of more elongate grains parallel or subparallel to the bed. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate to moderately high capillary porosity on average. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Natural cement relicts are found in moderate to moderately high abundance. These are fine to medium grained and generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also commonly found as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 4% - 6% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are rounded and subspherical to irregular in shape on average. |
| Secondary Deposits | No secondary deposits are positively identified. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. No cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | Trace microcracking is found along one edge of the sample in thin section. Otherwise, no significant macroscopic or microscopic cracking is detected. |

| *SAMPLE ID* | **LOKE.M.2 (Brick Cistern)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, mortar fragments weighing 26.79 g. |
| Surfaces | One piece has two parallel sides that may be a joint surface. Approximately 0.5" thick. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is dull with some waxy areas where there are cement streaks. Fresh paste color is light gray (Munsell color designation approximately 2.5Y 7/2). |
| Cracks, Deposits, Etc., | Cracking cannot be assessed due to the fragmental nature of the sample. There is an adherent veneer of a white coating on many pieces. Sand grains are exposed below this wash indicating prior weathering. Low abundance of coal fragments are detected. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve. Peak abundance is estimated between the No. 16 and No. 30 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented. Preferential alignment of more elongate grains are not obvious. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate to moderately high capillary porosity on average. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Natural cement relicts are found in moderate abundance. These are fine to medium grained and generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also commonly found as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 3% - 5% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are rounded and subspherical to irregular in shape on average. |
| Secondary Deposits | No secondary deposits are positively identified. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. Minor abundance of microcracking found around aggregate paste interfaces. No secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | Minor abundance of polygonal microcracking found passing through the paste and around aggregate paste interfaces. Some green-colored organic material is observed within cracks. No other significant macroscopic or microscopic cracking is detected. |

| *SAMPLE ID* | **LOKE.M.3 (Brick Cistern)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, parging mortar fragments weighing 97.83 g. |
| Surfaces | Approximately 0.25” - 0.5” in thickness. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is dull. Fresh paste color is light brownish gray (Munsell color designation approximately 10YR 6/2). |
| Cracks, Deposits, Etc., | No significant cracking is detected in hand sample. Paste is in positive relief over the aggregate at the microscopic scale along the exposed surface. There is a low abundance of coal fragments detected. No mineral deposits are observed. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to N8). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve. Peak abundance is estimated between the No. 16 and No. 30 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented though there is a somewhat preferential alignment of more elongate grains parallel or subparallel to the bed. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate to moderately high capillary porosity on average. The paste has a very slightly clumpy texture. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Natural cement relicts are found in moderate abundance. These are fine to medium grained and generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also commonly found as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 5% - 7% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are subrounded and subspherical to irregular in shape on average. |
| Secondary Deposits | Most voids are free of secondary deposits with only traces of sparry carbonate detected. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are relatively well coated with binder. No variation in binder characteristics are found adjacent to aggregate. Moderate abundance of small discontinuous polygonal cracking found along aggregate paste interfaces. Secondary mineral deposits are found at aggregate interfaces in trace abundance as sparry carbonate. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | Microscopic discontinuous hairline polygonal cracking detected in moderate abundance throughout the thin section. No other significant macroscopic or microscopic cracking is detected. |

| *SAMPLE ID* | **LOKE.M.4 (Lighthouse)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, mortar fragments weighing 24.14 g. |
| Surfaces | One piece has two parallel sides that may be a joint surface. Approximately 0.5" thick. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is dull. Fresh paste color is light gray (Munsell color designation approximately 2.5Y 7/2). |
| Cracks, Deposits, Etc., | Cracking cannot be assessed due to the fragmental nature of the sample. There is an adherent veneer of a white powdery coating on many pieces. There is a low abundance of coal fragments detected. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. One chalcedony grain detected may belong to the cement. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve with most material estimated to pass. Peak abundance is estimated between the No. 16 and No. 30 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented though there is a somewhat preferential alignment of more elongate grains parallel or subparallel to the bed. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate capillary porosity on average. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is mostly carbonated though some areas remain isotropic. |
| Residual Hydraulic Grains | Natural cement relicts are found in varied abundance with some mortar pieces exhibiting a high abundance. These are variously sized grains and are generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also commonly found as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 4% - 6% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are irregular in shape on average. |
| Secondary Deposits | No secondary deposits are positively identified. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. No cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, most portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | No significant macroscopic or microscopic cracking is detected. |
| **MISCELLANEOUS** | |
| Details | Opaque finishes are detected above a discontinuous microscopic veneer of depleted material in some areas of the perimeter. |

| *SAMPLE ID* | **LOKE.M.5 (Lighthouse)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, mortar fragments weighing 28.28 g. |
| Surfaces | All pieces exhibit irregular surfaces. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is dull. Fresh paste color is light gray (Munsell color designation approximately 2.5Y 7/2). |
| Cracks, Deposits, Etc., | Cracking cannot be assessed due to the fragmental nature of the sample. There is an adherent veneer of a white powdery coating on many pieces and a minor amount of adherent brick residue. There is a low abundance of coal fragments detected. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve with most material estimated to pass. Peak abundance is estimated between the No. 16 and No. 50 sieve and moderately low amount of fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented though there is a somewhat preferential alignment of more elongate grains parallel or subparallel to the bed. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate to moderately high capillary porosity on average. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Natural cement relicts are found in moderately low abundance. These are fine to medium grained and generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also commonly found as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 4% - 6% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are irregular in shape on average. |
| Secondary Deposits | Most voids are free of secondary deposits. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. Zones of possible bleed water channels are found around some aggregate paste interfaces. Trace, small discontinuous cracks are found subparallel to the surface and passing around aggregates interfaces. No secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | Traces of very fine grained deposits are found only within one microcrack surface and these have characteristics consistent with either sulfates or chlorites. |
| **CRACKING** | |
| Details | Small discontinuous cracks are found subparallel to the surface and passing around aggregates interfaces. Otherwise no significant macroscopic or microscopic cracking is detected. |
| **MISCELLANEOUS** | |
| Details | A layer of lime wash is detected that is well bonded to the mortar. Lime wash appears to have two distinct layers. There is an opaque finish found above the lime wash. |

| *SAMPLE ID* | **LOKE.M.6 (Lighthouse)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, mortar fragments weighing 59.75 g. |
| Surfaces | One piece has two parallel sides that may be a joint surface. Approximately 0.5" thick. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is dull. Fresh paste color is light gray (Munsell color designation approximately 10YR 7/2). |
| Cracks, Deposits, Etc., | Cracking cannot be assessed due to the fragmental nature of the sample. There is an adherent veneer of a white powdery coating on many pieces and a minor amount of adherent brick residue. There is a low abundance of coal fragments detected. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 8 sieve with all material estimated to pass. Peak abundance is estimated between the No. 16 and No. 30 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented though there is a somewhat preferential alignment of more elongate grains parallel or subparallel to the bed. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate capillary porosity on average. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Natural cement relicts are found in moderate to moderately high abundance. These are variously sized grains and are generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also found as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 6% - 8% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than or equal to 1 mm in dimension. Voids are rounded and subspherical to irregular in shape on average. |
| Secondary Deposits | Most voids are free of secondary deposits. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. No cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | A microscopically thin lining of isotropic, low relief secondary deposits tends to line the exterior surfaces of many of the mortar pieces. Some are also found within voids just adjacent to the surface but never in the interior. |
| **CRACKING** | |
| Details | No significant macroscopic or microscopic cracking is detected. |

| *SAMPLE ID* | **LOKE.M.7 (Lighthouse)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, mortar fragments weighing 42.36 g. |
| Surfaces | All pieces exhibit irregular surfaces. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is dull. Fresh paste color is light gray (Munsell color designation approximately 10YR 7/2). |
| Cracks, Deposits, Etc., | Cracking cannot be assessed due to the fragmental nature of the sample. No mineral deposits are observed. There is a low abundance of coal fragments detected. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve. Peak abundance is estimated between the No. 16 and No. 30 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented. Preferential alignment of more elongate grains is not obvious. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate capillary porosity on average. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Natural cement relicts are found in moderate to moderately high abundance. These are variously sized grains and are generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also commonly found as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 3% - 5% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are rounded and subspherical to irregular in shape on average. |
| Secondary Deposits | No secondary deposits are positively identified. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. No cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | No significant macroscopic or microscopic cracking is detected. |

| *SAMPLE ID* | **LOKE.M.8 (Oil House)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | The sample represents a complete cross section of a three coat plaster system. One large piece and several smaller pieces were received from the interior, south wall weighing 40.17 g. The nominal thickness of the whole sample is 0.75". Three distinct material types are detected. Thicknesses of the three general layers is as follows:<br>Scratch coat: approximately 1/8"<br>Brown coat: approximately 3/8"<br>Finish coat: approximately 1/8" |
| Surfaces | Contact surfaces are more or less planar. The scratch and finish coats are partially adhered to the brown coat. The finish coat disbonds easily along a relatively clean surface. |
| Hardness / Friability | Scratch coat: Moderately soft and moderately non-friable.<br>Brown coat: Hard and non-friable.<br>Finish coat: Moderately soft and moderately friable. |
| Appearance | Scratch coat: Dull luster and nearly white on fresh exposure (Munsell color code approximately 5Y 8/1).<br>Brown coat: Opaque waxy luster and light gray on fresh exposure (Munsell color code approximately 10YR 7/2).<br>Finish coat: Moderately dull luster and bright white on fresh exposure (Munsell color code approximately N9). |
| Cracks, Deposits, Etc., | No significant cracking is visible in the larger sample though incipient disbonds may be present at layer contacts. No mineral deposits are observed. There is a low abundance of coal fragments detected within the brown coat. |

| *SAMPLE ID* | **LOKE.M.8 (Oil House plaster scratch coat)** |
|---|---|
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9). The luster is dull. |
| Size and Gradation | The sand is medium-grained and narrowly graded. The nominal top size is estimated at the No. 8 sieve with all material estimated to pass. A strong peak abundance is estimated between the No. 16 and No. 30 sieves and only a moderately low abundance of material is estimated to pass the No. 30 sieve. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented. Preferential alignment of more elongate grains is not obvious. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Homogeneous mildly hydraulic matrix with high capillary porosity on average and a moderate abundance of discontinuous polygonal microscopic cracks. |
| Residual Hydraulic Grains | Natural cement relicts are found in very low abundance. These are fine to medium grained and generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and trace grains of partially combined quartz silt isolated within the paste matrix. |
| Residual Lime Grains | Low abundance of fine residual lime grains. Grains are fully carbonated with no internal relict rock textures or hydraulic inclusions. However, textures are difficult to assess due to a limited sample size. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 2% - 3% |
| Consolidation / Distribution | The plaster is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are rounded and subspherical in shape on average. |
| Secondary Deposits | No secondary deposits are positively identified. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. Discontinuous polygonal cracking is detected along some of the interfaces. Otherwise, no significant cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are soft when scratched with a steel pick. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | Discontinuous polygonal cracking. Otherwise, no significant macroscopic or microscopic cracking is detected. |

## *SAMPLE ID* LOKE.M.8 (Oil House plaster brown coat)

| | |
|---|---|
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and narrowly graded. The nominal top size is estimated at the No. 8 sieve with all material estimated to pass. A strong peak abundance is estimated between the No. 16 and No. 30 sieves and only a moderately low abundance of material is estimated to pass the No. 30 sieve. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented though there is a somewhat preferential alignment of more elongate grains parallel or subparallel to the bed. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate capillary porosity on average. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Natural cement relicts are found in moderate to moderately high abundance. These are fine to medium grained though fines are much more abundant and are generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also commonly found in high abundance as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 4% - 6% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are rounded and subspherical to irregular in shape on average. |
| Secondary Deposits | No secondary deposits are positively identified. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. No cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | No significant macroscopic or microscopic cracking is detected. |

## *SAMPLE ID* LOKE.M.8 (Oil House plaster finish coat)

| | |
|---|---|
| **AGGREGATE** | |
| Details | No aggregate is present in the finish coat. |
| **BINDER MATRIX** | |
| Hardened Binder | Homogeneous mixed binder matrix with high capillary porosity and no significant microcracking. The matrix consists of a mixture of very fine grained, hydrated gypsum crystallites and fine mostly carbonated lime. |
| Residual Hydraulic Grains | None detected. |
| Residual Lime Grains | Residual lime grains are found in high abundance as fine- to medium grained particles. Most are fully carbonated though fully uncarbonated grains are also observed. Relict rock textures are rare and are difficult to interpret. However, these have the character of partially calcined silicate minerals. No evidence for significant hydraulic inclusions is observed. |
| Residual Gypsiferous Grains | Medium-grained gypsum relicts are relatively rare. Some of rehydrated to gypsum while some still represent unhydrated hemihydrate. Dead-burned anhydrite crystals are extremely rare. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 2% - 3% |
| Consolidation / Distribution | The plaster is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are irregular in shape on average. |
| Secondary Deposits | No significant secondary deposits are observed. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | No significant macroscopic or microscopic cracking is detected. |

| *SAMPLE ID* | **LOKE.M.9 (Kitchen Building)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, mortar fragments weighing 28.75 g. |
| Surfaces | One piece has two parallel sides that may be a joint surface. Approximately 0.5" thick. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is dull. Fresh paste color is light gray (Munsell color designation approximately 2.5Y 7/2). |
| Cracks, Deposits, Etc., | Cracking cannot be assessed due to the fragmental nature of the sample. There is an adherent veneer of a white coating on many pieces. There is a low abundance of coal fragments detected. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. Low abundance of opaques are also detected. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve with most material estimated to pass. Peak abundance is estimated between the No. 16 and No. 30 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented though there is a somewhat preferential alignment of more elongate grains parallel or subparallel to the bed. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with a moderately high to high capillary porosity. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Natural cement relicts are found in moderate abundance. These are medium grained and generally carbonated in cross polarized light. Microtextures are varied but include typical calcined dolomite rhombs with rims of iron-bearing ferrite and distributed grains of partially combined quartz silt. Rimmed quartz silt is also commonly found as isolated grains within the paste matrix. No significant clinkered material is detected but there are traces of inert aluminate clusters. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 4% - 6% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are rounded and subspherical to irregular in shape on average. |
| Secondary Deposits | No secondary deposits are positively identified. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. No cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | No significant macroscopic or microscopic cracking is detected. |

| *SAMPLE ID* | **LOKE.M.10 (Keeper's Dwelling)** |
|---|---|
| **GENERAL APPEARANCE** | |
| Sample Type/Dimensions | Multiple, irregular, mortar fragments weighing 32.83 g. |
| Surfaces | One piece has two parallel sides that may be a joint surface. Approximately 0.5" thick. There are weathered areas with a type of biological growth present in low abundance. |
| Hardness / Friability | Moderately hard and non-friable. |
| Appearance | Luster on freshly exposed surfaces is mostly dull, however the mortar does exhibit streaking and high variation. Fresh paste color is very pale brown (Munsell color designation approximately 10YR 8/2). |
| Cracks, Deposits, Etc., | Cracking cannot be assessed due to the fragmental nature of the sample. No mineral deposits are observed. |
| **AGGREGATE** | |
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. |
| Appearance | Viewed on weathered surfaces the sand is white in some cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve with most material estimated to pass. Peak abundance is estimated between the No. 16 and No. 50 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented. Preferential alignment of more elongate grains is not obvious. |
| Other | No cracking, coatings, or chemical reactions are detected. |
| **BINDER MATRIX** | |
| Hardened Binder | Dense and homogeneous cementitious matrix with moderate to moderately high capillary porosity on average. No significant calcium hydroxide as a cementitious hydrate is detected and the paste is almost completely carbonated. |
| Residual Hydraulic Grains | Residual portland cement is detected in moderate abundance as medium grained belite agglomerates with interstitial ferrite. Virtually all grains are well hydrated and consist only of a ferrite "skeleton". Alite forms are also detected within agglomerates in moderately low abundance. |
| Residual Lime Grains | None detected. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 3% - 5% |
| Consolidation / Distribution | The mortar is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are rounded and subspherical to irregular in shape on average. |
| Secondary Deposits | Some voids are lined with secondary deposits with optical characteristics consistent with gypsum. Otherwise most voids are free of secondary deposits. |
| **AGGREGATE INTERFACES** | |
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. No cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately hard when scratched with a steel pick and do not exhibit any significant friability. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, all portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | No significant macroscopic or microscopic cracking is detected. |

## *SAMPLE ID* LOKE.M.11 (Keeper's Dwelling)

**GENERAL APPEARANCE**

| | |
|---|---|
| Sample Type/Dimensions | The sample represents a complete cross section of a two coat plaster system. Several pieces were received from the interior bathroom, west wall weighing 30.60 g. The nominal thickness of the whole sample is approximately 0.5 including brown coat and finish coat. The brown coat is well bonded to the finish coat. A layer of paint is also detected on the finish coat. Approximate thicknesses of the two coats is as follows:<br>Brown Coat: 3/8"<br>Finish Coat: 1/8" |
| Surfaces | The contact surface is mostly planar and the two coats well bonded. |
| Hardness / Friability | Brown coat: Moderately hard and moderately non-friable.<br>Finish coat: Moderately hard and non-friable. |
| Appearance | Brown coat: Luster on freshly exposed surfaces is dull. Fresh paste color is nearly white with a yellowish cast (Munsell color designation approximately 5Y 8.5/1).<br>Finish coat: Luster on freshly exposed surfaces is dull. Fresh paste color is white (Munsell color designation approximately N9). |
| Cracks, Deposits, Etc., | No significant cracking, efflorescence, or secondary mineral deposits are detected in hand sample. However, cracking is difficult to assess due to the fragmental nature of the sample. A moderately low abundance of light-colored fiber reinforcement is identified in the brown coat. |

## *SAMPLE ID* LOKE.M.11 (Keeper's Dwelling plaster brown coat)

**AGGREGATE**

| | |
|---|---|
| Lithology and Mode | Carbonate natural sand consisting of shell fragments and porous coral fragments. |
| Appearance | The sand is white in most cases and with a pale yellow hue (Munsell color code approximately N9 to 5Y 8/1). The luster is slightly reflective to dull. |
| Size and Gradation | The sand is medium-grained and somewhat narrowly graded. The nominal top size is estimated at the No. 16 sieve with most material estimated to pass. Peak abundance is estimated between the No. 16 and No. 50 sieve and few fines are present below No. 50. |
| Shape | Subrounded in shape on average. Aspect ratios are subequant to subelongate. |
| Distribution | Homogeneous and somewhat randomly oriented though there is a somewhat preferential alignment of more elongate grains parallel or subparallel to the bed. |
| Other | No cracking, coatings, or chemical reactions are detected. |

**BINDER MATRIX**

| | |
|---|---|
| Hardened Binder | Homogeneous gypsiferous matrix with high capillary porosity on average. While the matrix consists of an interlocking network of fine-grained gypsum crystals, the texture is somewhat coarse. |
| Residual Hydraulic Grains | None detected. |
| Residual Lime Grains | None detected. |
| Residual Gypsiferous Grains | A high abundance of medium-grained gypsum residuals are detected and almost all are fully hydrated to coarser grained gypsum. Finer unhydrated hemihydrate crystals are less common. There is moderately low abundance of very fine-grained, dead burned anhydrite. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |

**AIR-VOID SYSTEM**

| | |
|---|---|
| Estimated Air Content | Estimated at 8% - 10% |
| Consolidation / Distribution | The plaster is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than or equal to 1 mm in dimension. Voids are subspherical in shape on average. |
| Secondary Deposits | No significant secondary deposits are detected. |

**AGGREGATE INTERFACES**

| | |
|---|---|
| Details | Sand grains are well coated with binder. No variation in binder characteristics are found adjacent to aggregate. No cracking or secondary mineral deposits are found at aggregate interfaces. In honed section, interfaces are moderately soft when scratched with a steel pick but do not exhibit any significant friability. |

**SECONDARY REACTIONS**

| | |
|---|---|
| Carbonation | No carbonation is detected. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |

**CRACKING**

| | |
|---|---|
| Details | No significant macroscopic or microscopic cracking is detected. |

| *SAMPLE ID* | **LOKE.M.11 (Keeper's Dwelling plaster finish coat)** |
|---|---|
| **AGGREGATE** | |
| Details | No aggregate is present in the finish coat. |
| **BINDER MATRIX** | |
| Hardened Binder | Homogeneous mostly gypsiferous matrix with high capillary porosity on average. The matrix consists of a network of ultrafine gypsum crystallites with a minor carbonated component. |
| Residual Hydraulic Grains | None detected. |
| Residual Lime Grains | Residual lime grains are found in very low abundance as fine-grained mostly carbonated particles. No internal rock textures or hydraulic inclusions are detected within lime grains. |
| Residual Gypsiferous Grains | A low abundance of fine-grained gypsum residuals are detected and almost all are fully hydrated to coarser grained gypsum. Finer unhydrated hemihydrate crystals and dead burned anhydrite are both relatively uncommon. |
| Residual Pozzolans | None detected. |
| Pigments | None detected. |
| **AIR-VOID SYSTEM** | |
| Estimated Air Content | Estimated at 2% - 4% |
| Consolidation / Distribution | The plaster is well consolidated and the air distribution is homogeneous. |
| Size / Shape | Voids are generally less than 1 mm in dimension. Voids are subspherical in shape on average. |
| Secondary Deposits | No significant secondary deposits are detected. |
| **SECONDARY REACTIONS** | |
| Carbonation | In thin section, the lime portions of the sample exhibit virtually full carbonation. |
| Other | No other evidence for chemical reaction is found within the bulk of the material. |
| **CRACKING** | |
| Details | No significant macroscopic or microscopic cracking is detected. |

**4. Point-Count Analyses**

Point-count analysis was performed using methods adapted from ASTM C 457. Honed cross sections of the materials were prepared for the analysis. Sample LOKE.M.3 was chosen as a robust cross-check sample as sufficient material was available for both chemical analysis and point-count analysis. LOKE.M.4 and LOKE.M.7 were chosen for point-count analysis as these represent natural cement mortar samples with extremes in binder to sand ratio estimated via chemical analysis. It should be noted that that surface area of these latter two prepared samples and the number of points counted is smaller than required to produce the accuracy reported by the test method.

**Table 4.1 - Point-Count Data**

| **Sample ID**<br>Location | **LOKE.M.3**<br>Cistern Exterior | **LOKE.M.4**<br>Lighthouse Exterior | **LOKE.M.7**<br>Lighthouse Interior |
|---|---|---|---|
| Approximate surface area ($in.^2$) | 1.9 | 0.9 | 0.4 |
| Sand points | 252 | 72 | 116 |
| Paste points | 342 | 108 | 194 |
| Air-void points | 34 | 12 | 13 |
| **Total points** | **628** | **192** | **323** |

**Table 4.2 - Solid Volume Percentages**

| **Sample ID**<br>Location | **LOKE.M.3**<br>Cistern Exterior | **LOKE.M.4**<br>Lighthouse Exterior | **LOKE.M.7**<br>Lighthouse Interior |
|---|---|---|---|
| Sand | 40.1 | 37.5 | 35.9 |
| Paste | 54.5 | 56.3 | 60.0 |
| Air-voids | 5.4 | 6.2 | 4.0 |
| **Totals** | **100.0** | **100.0** | **99.9** |

**Table 4.3 - Calculated Bulk Ratios**

| **Sample ID**<br>Location | **LOKE.M.3**<br>Cistern Exterior | **LOKE.M.4**<br>Lighthouse Exterior | **LOKE.M.7**<br>Lighthouse Interior |
|---|---|---|---|
| Sand volume percentage | 56 | 53 | 50 |
| Cement volume percentage | 44 | 47 | 50 |
| **Cement : Sand Ratio (by volume)** | **1 : 1.3** | **1 : 1.1** | **1 : 1.0** |

Notes:
1) Solid volume of sand is adjusted by considering the void ratio of the sand in damp, loose condition. Paste volume is adjusted downward to account for the volume increase resulting from hydration of the cement. Counted sand volumes are divided by 0.62 to account for void space and paste volumes divided by 1.05 to account for volume increase upon hydration.
2) Adjusted bulk volumes are normalized to 100% as presented in this table.
3) Cement to sand ratios represent the ratios of these normalized values.

**5. Chemical Analyses**

The chemical preparations used on all samples with the exception of the finish coat plaster represent significant deviations from the standard procedures given in ASTM C 1324. The carbonate sand is exceptionally soluble in any acid capable of dissolving the binder and there is no effective way to separate the binder and sand effectively. Therefore, it was decided to fuse the sample into a glass, dissolve that in concentrated acid and measure the bulk chemistry of the entire sample. A separate acid digestion was performed in order to produce an insoluble residue. Instead of representing the sand, this residue is used to examine the uncalcined inclusions within the natural cement binder. Water-soluble chloride was also measured for the Lighthouse samples and this was done in general accordance with ASTM C 1218.

The analysis for the finish plaster also represents a deviation from ASTM C 1324 in that a hot acid digestion was used to bring all sulfate species into solution as well as all lime. These methods are more consistent with those of ASTM C 114 for the measurement of sulfates in cement.

**Table 5.1a: Chemical Analysis Results**

| ***SAMPLE ID*** | **LOKE.M.4** | **LOKE.M.5** | **LOKE.M.6** | **LOKE.M.7** |
|---|---|---|---|---|
| Location | Lighthouse Exterior | Lighthouse Exterior | Lighthouse Interior | Lighthouse Interior |
| **Component (wgt. %)** | | | | |
| $SiO_2$ | 7.06 | 8.63 | 8.34 | 10.26 |
| CaO | 40.17 | 37.42 | 38.30 | 37.20 |
| MgO | 6.97 | 7.65 | 7.18 | 5.63 |
| $Al_2O_3$ | 1.26 | 1.41 | 1.22 | 1.53 |
| $Fe_2O_3$ | 0.95 | 0.98 | 1.01 | 1.08 |
| $Na_2O$ | 0.98 | 1.30 | 0.69 | 2.28 |
| $K_2O$ | 0.08 | 0.38 | 0.65 | 1.01 |
| Cl | 1.12 | 0.43 | 1.35 | 1.09 |
| Insoluble residue | 1.35 | 3.09 | 2.53 | 5.26 |
| LOI %, to 110°C (Free water) | 4.03 | 4.75 | 4.30 | 4.82 |
| LOI %, 110°C-550°C (Combined water) | 8.48 | 9.75 | 8.32 | 10.04 |
| LOI %, 550°C-950°C (Carbon dioxide) | 28.41 | 25.93 | 28.90 | 24.44 |
| **Measured Totals** | **98.40** | **98.20** | **98.92** | **98.27** |

Notes:
1) The insoluble residue is not included in the totals calculation as it represents an intentional duplicate measurement.
2) Chloride is also not included in the totals calculation nor is an adjustment made for the reduced oxygen that must accompany the alternate anion.

**Table 5.1b: Chemical Analysis Results**

| ***SAMPLE ID*** | **LOKE.M.2** | **LOKE.M.3** | **LOKE.M.9** | **LOKE.M.10** |
|---|---|---|---|---|
| Location | Cistern Exterior | Cistern Exterior | Kitchen Bldg. Exterior | Keeper's Dwelling |
| **Component (wgt. %)** | | | | |
| $SiO_2$ | 8.18 | 8.87 | 7.98 | 5.44 |
| CaO | 42.03 | 40.07 | 40.24 | 45.67 |
| MgO | 5.52 | 5.85 | 6.93 | 1.62 |
| $Al_2O_3$ | 1.71 | 1.58 | 1.40 | 1.27 |
| $Fe_2O_3$ | 1.07 | 1.07 | 1.31 | 0.68 |
| $Na_2O$ | 0.34 | 0.31 | 0.35 | 0.36 |
| $K_2O$ | 0.01 | 0.07 | 0.17 | 0.34 |
| Insoluble residue | 2.33 | 3.09 | 2.90 | 0.72 |
| LOI %, to 110°C (Free water) | 2.77 | 2.49 | 3.33 | 2.37 |
| LOI %, 110°C-550°C (Combined water) | 5.27 | 4.19 | 7.67 | 6.19 |
| LOI %, 550°C-950°C (Carbon dioxide) | 31.88 | 32.80 | 29.95 | 32.34 |
| **Measured Totals** | **98.80** | **97.31** | **99.33** | **96.27** |

Notes:
1) The insoluble residue is not included in the totals calculation as it represents an intentional duplicate measurement.

**Table 5.1c: Chemical Analysis Results**

| ***SAMPLE ID*** | **LOKE.M.1** | **LOKE.M.8** | **LOKE.M.8** |
|---|---|---|---|
| Location | Oil House Exterior | Oil House Plaster Brown Coat | Oil House Plaster Finish Coat |
| **Component (wgt. %)** | | | |
| $SiO_2$ | 8.05 | 6.22 | 0.67 |
| CaO | 40.05 | 41.20 | 45.20 |
| MgO | 5.43 | 6.94 | 3.55 |
| $Al_2O_3$ | 1.83 | 1.33 | 0.15 |
| $Fe_2O_3$ | 1.09 | 1.13 | 0.14 |
| $Na_2O$ | 1.18 | 0.61 | 0.79 |
| $K_2O$ | 0.38 | 0.22 | 0.23 |
| $SO_3$ | n.d. | n.d. | 13.57 |
| Insoluble residue | 2.70 | 4.03 | 0.00 |
| LOI %, to 110°C (Free water) | 3.59 | 2.29 | 1.54 |
| LOI %, 110°C-550°C (Combined water) | 7.60 | 9.01 | 7.70 |
| LOI %, 550°C-950°C (Carbon dioxide) | 28.68 | 29.66 | 27.23 |
| **Measured Totals** | **97.88** | **98.62** | **100.78** |

Notes:
1) The insoluble residue is not included in the totals calculation for the natural cement samples as it represents an intentional duplicate measurement.

**Table 5.2a: Calculated Components**

| ***SAMPLE ID*** | **LOKE.M.4** | **LOKE.M.5** | **LOKE.M.6** | **LOKE.M.7** |
|---|---|---|---|---|
| Location | Lighthouse Exterior | Lighthouse Exterior | Lighthouse Interior | Lighthouse Interior |
| **Component** | | | | |
| Portland cement (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Natural cement (wgt. %) | 32 | 41 | 39 | 47 |
| Lime expressed as dry hydrate (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Hydraulic lime (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Pozzolans (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Mineral pigment (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Sand (wgt. %) | 68 | 59 | 61 | 53 |
| Binder : sand ratio (by volume) | 1 : 2.0 | 1 : 1.4 | 1 : 1.5 | 1 : 1.1 |

**Table 5.2b: Calculated Components**

| ***SAMPLE ID*** | **LOKE.M.2** | **LOKE.M.3** | **LOKE.M.9** | **LOKE.M.10** |
|---|---|---|---|---|
| Location | Cistern Exterior | Cistern Exterior | Kitchen Bldg. Exterior | Keeper's Dwelling |
| **Component** | | | | |
| Portland cement (wgt. %) | Not detected | Not detected | Not detected | 33 |
| Natural cement (wgt. %) | 35 | 39 | 36 | Not detected |
| Lime expressed as dry hydrate (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Hydraulic lime (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Pozzolans (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Mineral pigment (wgt. %) | Not detected | Not detected | Not detected | Not detected |
| Sand (wgt. %) | 65 | 61 | 64 | 67 |
| Binder : sand ratio (by volume) | 1 : 1.7 | 1 : 1.5 | 1 : 1.7 | 1 : 2.4 |

**Table 5.2c: Calculated Components**

| ***SAMPLE ID*** | **LOKE.M.1** | **LOKE.M.8** | **LOKE.M.8** |
|---|---|---|---|
| Location | Oil House Exterior | Oil House Plaster Brown Coat | Oil House Plaster Finish Coat |
| **Component** | | | |
| Portland cement (wgt. %) | Not detected | Not detected | Not detected |
| Natural cement (wgt. %) | 36 | 28 | Not detected |
| Lime expressed as dry hydrate (wgt. %) | Not detected | Not detected | 68 |
| Hydraulic lime (wgt. %) | Not detected | Not detected | Not detected |
| Gypsum as hemihydrate (wgt. %) | Not detected | Not detected | 32 |
| Pozzolans (wgt. %) | Not detected | Not detected | Not detected |
| Mineral pigment (wgt. %) | Not detected | Not detected | Not detected |
| Sand (wgt. %) | 64 | 72 | Not detected |
| Binder : sand ratio (by volume) | 1 : 1.7 | 1 : 2.4 | n/a |
| Gypsum : lime ratio (by volume with lime as a hydrate) | n/a | n/a | 1 : 0.2 |
| Gypsum : lime ratio (by volume with lime as a putty) | n/a | n/a | 1 : 0.3 |

Notes:

1) For the natural cement mortars, parging, and plaster coats, the cement weight is calculated assuming an original cement silica content of 27% and calcium oxide content of 35%. Cement content is calculated assuming all measured silica is attributed to this average natural cement composition. Excess calcium is then attributed to the carbonate sand and the equivalent weight of calcium carbonate is calculated by molecular weight conversion. Both calculated weights are then normalized to 100%. Volumetric ratios are calculated assuming bulk densities for natural cement and damp loose sand of 75 lb./cu. ft. and 80 lb./cu. ft. respectively.
2) For the portland cement mortar (LOKE.M.10), the cement weight is calculated assuming an original cement silica content of 21% and calcium oxide content of 63%. Cement content is calculated assuming all measured silica is attributed to this average cement composition. Excess calcium is then attributed to the carbonate sand and the equivalent weight of calcium carbonate is calculated by molecular weight conversion. Both calculated weights are then normalized to 100%. Volumetric ratios are calculated assuming bulk densities for portland cement and damp loose sand of 94 lb./cu. ft. and 80 lb./cu. ft. respectively.
3) For the Oil House plaster finish coat (LOKE.M.8), the gypsum weight as hemihydrate is calculated by assuming that all measured sulfate is attributed to this component. Sufficient calcium oxide is taken up to account for this calculated gypsum component. The remaining calcium oxide and all magnesium oxide is attributed to the lime component and the mass is calculated by molecular weight conversion for both calcian and magnesian lime species. All calculated weights are then normalized to 100%. Volumetric ratios are calculated assuming bulk densities for dry gypsum plaster and dry lime hydrate of 93.5 lb./cu. ft. and 40 lb./cu. ft. respectively. A separate calculation is presented considering lime as a putty rather than a dry hydrate. This assumes an approximate 40% loss in bulk volume to turn a volume of dry lime hydrate into a stiff putty by addition of water.

## 6. Discussion and Conclusions

### *6.1 Mortar Materials*

All mortar samples are identified as pure cement mortars containing a natural carbonate sand (Figs. 5 through 15). Additionally, the brown coat of the Oil House plaster sample LOKE.M.8 is very similar and is grouped in this discussion for convenience. No lime-type binders, pozzolans, or mineral pigments are identified in any of these samples. Original water to cement ratios are difficult to assess due to the advanced age of the materials. However, variations in the quantity of cement relicts, differences in capillary porosity, and differences in lightness of the cement paste indicate relative differences in water to cement ratios between the samples. For the most part, the lighthouse samples exhibit slightly lower capillary porosities suggestive of a lower original water to cement ratio (Figs. 8 and 9). Sample LOKE.M.10 (Keeper's Dwelling) differs in that the binder is a portland rather than natural cement and this sample will be discussed separately. Therefore, this discussion includes samples LOKE.M.1 through LOKE.M.7 as well as LOKE.M.9 and the brown coat of LOKE.M.8.

The cement in these samples are all identified as American natural cements typical of those manufactured in the more productive cement regions such as Rosendale, NY or Louisville, KY. All unhydrated cement relicts exhibit microstructural properties consistent with the low-temperature calcination of an argillaceous and partly ferruginous dolomitic limestone. Such textures include fine-grained, calcined carbonate rhombs surrounded by a rim of iron-bearing phase as well as partly burned quartz silt and sand grains surrounded by a rim of hydraulic product (Figs. 12 through 15). While some variation is observed across all samples, the general cement characteristics are grossly similar. Furthermore, the chemical analysis of all samples indicates a magnesium component no less than half that of the silica component and usually much more than this. Such chemistries are characteristic of the American natural cements and this clearly distinguishes them from a European product. Minor fine-grained coal fragments are also detected in most samples and these are interpreted to be contaminants from the cement burning.

While difficult to ascertain different placement vintages based on cement characteristics, there are some subtle variations observed both petrographically and chemically that appear to group cements into similar batches or sources. Three of the four lighthouse samples (all but LOKE.M.5) exhibit a greater variation in the grind of the cement. All other samples exhibit a fine to medium grind but these three contain unhydrated cement relicts that are found as large as several hundred microns in dimension (Fig. 12). It is tempting to interpret this coarseness as representative of an earlier vintage but this would be purely speculative. The very slight difference in the sand gradation in LOKE.M.5 (discussed below) in addition to slightly different cement characteristics could suggest that this sample is not contemporaneous with the other lighthouse samples. It is also noted that some variation exists within the fragments of sample LOKE.M.4 (Fig. 9). Some portions of this sample exhibit cement characteristics more similar to those of the Oil House plaster brown coat (LOKE.M.8) rather than those of the other lighthouse samples . The distinctive texture here is a much greater abundance of very fine-grained, partially calcined quartz silt grains dispersed as isolated cement residuals throughout the paste (Fig. 13). The acid-insoluble residues measured chemically for both samples is also the highest in these two samples and this is consistent with the petrographic observation. The cement in these two samples is clearly of a different quality than the others and this has implications in the estimation of sand to binder ratios as discussed below. What is not clear based on examination of the fragments is the reason that LOKE.M.4 appears to contain two different types of cement within one sample.

The sand in all samples is virtually identical with only subtle differences in gradation (Figs. 5 through 11). The sand is identified as a natural carbonate sand containing coral and shell fragments similar to that making up the sediment of the Dry Tortugas. A local source is certainly expected given the isolated nature of the site. No obviously crushed particles or foreign siliceous sands are identified that might suggest some modification to the local source. While it would be impossible to separate the sand from the binder through acid digestion, it is fairly clear through low-powered examination of fresh surfaces that the sand is homogeneous in color ranging from nearly white to pale yellow with no significant variegation. The grains are rounded due to natural weathering processes but tend to be somewhat elongate due to the original shapes of the organisms. All samples exhibit a relatively narrow sand gradation. Generally, all grains are estimated to pass a No. 8 sieve, most passing No. 16, with a minor to a moderately low amount of grains estimated to pass the No. 50 sieve. With some minor exception, the samples exhibit a sharp peak abundance of material between the No. 16 and No. 30 sieves. Such narrow gradations within this size range make geological sense in beach zones subject to regular wave action. While the site sand was not examined for this report, it is fully expected from a geological perspective that the local material would match the observed gradations without further processing.

Several subtle differences are detected in the sand gradations but these are very minor when compared to the general pattern. Some samples contain a slightly higher abundance of material retained on the No. 16 sieve. These include samples

LOKE.M.2, M.3, M.6, M.7, M.8 and (brown coat). In two cases the nominal top size is estimated at the No. 8 rather than No. 16 sieve where it appears that more than 10% of the material is retained on No. 16. and these include samples LOKE.M.6 and M.8. Some minor differences are also found in the fine end of the gradation. In most cases, minor material is estimated to pass the No. 50. A slightly higher abundance of fines is found in sample LOKE.M.5. The brown coat of sample LOKE.M.8 contains only a moderately low abundance of material estimated to pass the No. 30 sieve and is therefore even more narrowly graded.

Generally speaking, all samples discussed in this section exhibit cement and sand components that are well mixed and distributed. Air contents tend to be low and the mortars are well consolidated. Hydration qualities of the cement are adequate with a homogeneous distribution of cementitious product. While some variation in original water to cement ratios are suggested by minor variations in capillary porosity (Figs. 8 through 11), all appear to have been mixed without an excess of water or significant retempering.

Establishing original component proportions is challenging for this particular combination of sand and cement. Typically, a chemical methodology would be utilized whereby insoluble sand would be separated chemically for gravimetric measurement and the elemental chemistry of the dissolved binder component would be reverse engineered based on a fairly robust assumption of original binder chemistry. In this case, the sand is completely soluble and original natural cement chemistries are more variable than those of American portland cements or limes. Two analytical options are available to overcome these complications. The first is a microscopical point-counting of sand and binder components on polished slabs of the mortar. This method is insensitive to variations in the original binder chemistry and only measures paste and sand volume. The second is a complete fusion, or bulk chemical analysis of the mortar. Analysis of this chemistry requires an assumption of the original binder chemistry in order to partition the binder portion. This is followed by a calculation of the sand based on the remaining calcium unaccounted for by the binder partitioning. The former method may be considered more robust but requires a relatively large sample in order to be statistically significant. As such large sized samples were not available, it was agreed in discussions with the client that the chemical analysis that requires a smaller sample would be performed on all samples. The point-count method is then performed on sample LOKE.M.3 as a large sample is available. Comparison of the independent results is then expected to inform how well the chemical analysis may estimate the proportions. Additional point-counts on less than adequate samples are then performed on mortar samples estimated to exhibit extremes of binder to sand ratios based on the chemistry. These are performed on sample LOKE.M.4 and LOKE.M.7. A summary of the estimates are given in the table below based on bulk volume.

| Sample ID | Cement to sand ratio by chemical analysis | Cement to sand ratio by point-count analysis |
|---|---:|---:|
| **LOKE.M.1** | 1 : 1.7 | n.d. |
| **LOKE.M.2** | 1 : 1.7 | n.d. |
| **LOKE.M.3** | 1 : 1.5 | 1 : 1.3 |
| **LOKE.M.4** | 1 : 2.0 | 1 : 1.1 |
| **LOKE.M.5** | 1 : 1.4 | n.d. |
| **LOKE.M.6** | 1 : 1.5 | n.d. |
| **LOKE.M.7** | 1 : 1.1 | 1 : 1.0 |
| **LOKE.M.8 (brown coat)** | 1 : 2.4 | n.d. |
| **LOKE.M.9** | 1 : 1.7 | n.d. |

Some interesting features are revealed particularly in light of the qualitative petrographic observations. First, the independent methods result in good agreement for the binder to sand ratio in sample LOKE.M.3. This suggests that the assumption of original natural cement chemistry is relatively effective at estimating ratios from the bulk chemical analysis. Similar agreement is found in sample LOKE.M.7 even though the point-count sample is smaller than might be desired for statistical significance. Interestingly, the chemical analysis of samples LOKE.M.4 and M.8 result in a higher sand content calculation than the other mortars yet such variation is not evident by qualitative petrographic observations where all sand contents appear more or less similar. These are the two samples where the characteristics of the relict cement grains are distinctly different than the others in the suite with a high abundance of partially burned quartz silt. Point-count analysis of LOKE.M.4 suggests half the sand content as that estimated from the chemical analysis. It is interpreted that the original cement chemistry is different in these samples and the proportions estimated via the chemical analysis may represent an overestimation of sand content for these two.

Based on these analyses, it is interpreted that most binder to sand ratios are approximately 1 : 1.5 by volume. Samples LOKE.M.4 and LOKE.M.7 may be closer to 1 : 1. Such low sandings with narrow and relatively coarse sand gradations are considered typical of historical natural cement mortars. If in-kind replication is a priority, mix designs with these proportions and gradations may be considered viable.

### *6.2 LOKE.M.10 Materials*

The exterior mortar of the Keeper's dwelling (LOKE.M.10) appears identical to the other mortars based on visual characteristics and is also identified as a pure cement mortar (Figs. 6 and 10). However, the binder is identified as a pure portland cement with no lime additions identified. The distinctive low-magnesium, low insoluble residue values measured chemically are consistent with this qualitative identification. Cement relicts are identified petrographically as medium-sized agglomerates of well-hydrated calcium silicates with interstitial ferrite (Fig. 14). The iron-bearing ferrite identifies the binder as an ordinary gray portland cement. The medium grind and homogeneity of calcium silicate size is consistent with cements produced in the early twentieth century and is considered consistent with the early 1920's vintage reported by the client.

The sand in this sample is identical in composition and only slightly different in gradation as that observed in the natural cement mortars discussed above. As with these, the sand is a natural carbonate sand consistent with the local source (Figs. 6 and 10). The appearance of the sand is also homogenous and light-colored ranging from nearly white to pale yellow. The grains are rounded due to natural weathering processes but tend to be somewhat elongate due to the original shapes of the organisms. The gradation is still narrow with a nominal top size estimated at the No. 16 sieve but the peak abundance is estimated to be spread more evenly between the No. 16 and No. 50 sieves as compared to other samples in the suite. Still, there are relatively few fines in the sand estimated to pass the No. 50 sieve size. As with the other samples, this relatively narrow gradation is considered geologically consistent with the local sediment.

LOKE.M.10 exhibits cement and sand components that are well mixed and distributed. Air contents tend to be low and the mortar well consolidated. Hydration qualities of the cement are virtually complete with a homogeneous distribution of cementitious product. The original water to cement ratio is estimated to be moderate based on the observed capillary porosity and the mortar appears to have been mixed without an excess of water or significant retempering (Fig. 10).

Chemical analysis was performed in order to estimate the original binder to sand ratios. In this case, an estimate based on chemical analysis is considered more robust as portland cement has a less variable chemistry than natural cement. Assuming a typical portland cement chemistry and bulk densities of cement and damp, loose sand, the binder to sand ratio is estimated at 1 : 2.4. The sand content is higher than that observed in the other natural cement mortars but this is considered consistent with historic practice.

### *6.3 LOKE.M.8 Materials*

LOKE.M.8 is reported to represent an Oil House plaster sample and consists of a three-coat plaster system (Figs 16 through 20). Substrate is not included with the sample. The sample includes a relatively soft and porous scratch coat identified as a sanded, lime-based plaster gauged with natural cement, a relatively hard and dense brown coat identified as a sanded, pure natural cement plaster, and a fine-textured, unsanded finish coat consisting of lime gauged with gypsum. Generally speaking, these materials are considered consistent with a mid-nineteenth century vintage and certainly are inconsistent with twentieth century practice. The use of gypsum-based plaster as a gauging material is less well understood. While the use of calcined gypsum as a binder has a long history, the author is unaware of any American references to its use in the States prior to approximately 1880.

The sand in the scratch and brown coats is more or less identical (Fig. 7). As discussed earlier for the brown coat, the aggregate is identified as a natural carbonate sand containing coral and shell fragments similar to that making up the sediment of the Dry Tortugas. Visual examination indicates a homogeneous color ranging from nearly white to pale yellow with no significant variegation. Grains are rounded due to natural weathering processes but tend to be somewhat elongate due to the original shapes of the organisms. The gradation is quite narrow with a nominal top size estimated at the No. 8 sieve with all material estimated to pass. A strong peak abundance is estimated between the No. 16 and No. 30 sieves with only a moderately low abundance of material estimated to pass the No. 30 sieve.

The binder matrix in the scratch coat is characterized by a highly porous, carbonated paste, with a moderate abundance of microscopic shrinkage cracks. The paste matrix is typical of a high lime binder (Fig. 16). Larger relict lime grains are observed in low abundance and these exhibit homogeneous internal textures. Given the limited sample available for the scratch coat, it is not possible to speculate on the source of the lime. Furthermore, a chemical analysis could not be performed and no information is available for the lime chemistry. Natural cement grains identical to those of the brown coat are found in very low abundance (Fig. 17). The cement is estimated to represent a minor gauging affording only minimal hydraulic property to the scratch coat. While no quantitative estimate is offered, it is unlikely that the cement represents more than one tenth part of the lime by volume. The sanding is interpreted to be relatively low based on petrographic observations and the binder to sand ratio is probably less than 1 : 2 by volume.

Due to the similarity of the brown coat to the natural cement mortars, more detail for this layer is provided above. The binder matrix is moderately dense and consists of a natural cement binder with no lime addition. The cement is identified as a magnesium natural cement consistent in texture with the more productive American manufactories. However, a higher abundance of calcined silt is observed than in any of the other mortar samples with the exception of portions of sample LOKE.M.4. Chemical analysis was performed on this sample and binder to sand ratio estimated at 1 : 2.4 by volume. However, based on arguments presented earlier, this is likely a significant overestimate due to a distinctly different chemistry for this cement. Petrographic similarity of this sample with those of the other mortar samples suggest that the actual ratio may be closer to 1 : 1.5.

The finish coat matrix is fine-textured and porous (Fig. 19). An abundance of fine residual lime grains indicates the layer is mostly lime based. Chemical analysis was performed on this layer. Even assuming that all magnesium is contained in the lime, a CaO/MgO weight ratio of 10 (an order of magnitude higher than an ideal dolomitic ratio of 1.4) suggests a high calcium rather than dolomitic lime. Traces of calcined silicate contaminants suggest a rock lime source but not enough material is observed petrographically to offer a definitive statement. Gypsum plaster is identified as a gauging material (Fig. 20). Very few unhydrated gypsum relicts are identified. The rare abundance of coarser hemihydrate or finer dead-burned anhydrite suggests that the plaster was not a cement plaster or Keene's cement but rather a fine finishing plaster such as Plaster-of-Paris.

Chemical analysis was performed on the finish coat in order to estimate the lime to plaster proportions. Assuming the lime was added as a dry hydrate, the lime to plaster ratio is estimated at 1 : 0.2. It is unlikely that the lime was a prepackaged hydrate. However, a given volume of dry hydrate has a more constant weight ratio of constituent elements than a given volume of putty and the estimate may be considered more robust. Assuming a similar mass of hydrate loses approximately 40% of its volume when mixed with water to the consistency of a stiff putty, the ratio is recalculated at 1 : 0.3 by volume.

### *6.4 LOKE.M.11 Materials*

LOKE.M.11 is reported to represent an Keeper's Dwelling plaster sample and consists of a two-coat plaster system (Figs. 21 through 24). Substrate is not included with the sample. The sample includes a relatively hard but porous brown coat identified as a sanded, gypsum-based plaster and a relatively hard but porous, unsanded finish coat consisting of a fine-textured gypsum gauged with lime. The use of gypsum materials rather than lime for interior plastering is considered consistent with the 1920's vintage reported by the client.

The brown coat contains a relatively coarse-textured and porous binder matrix composed of a network of fine-grained gypsum hydrate (Fig. 21). Coarser hydrated residuals are relatively common and unhydrated hemihydrate and fine-grained, dead-burned anhydrite are also present though in lower abundance (Fig. 22). A chemical analysis was not requested for this sample and further information regarding the plaster provenance cannot be provided. However, the microtexture of the coat clearly discounts a refined finishing plaster and the presence of the dead-burned gypsum (anhydrite) suggests that the plaster may have been a Keene's cement. It should be noted that the term "cement" here does not refer to hydraulic calcium silicates and Keene's cement represents a relatively pure calcium sulfate product.

The sand in the brown coat is identical to that of the other samples in the suite and is most similar to the other Keeper's Dwelling sample (LOKE.M.10) in gradation (Figs. 7 and 21). The aggregate is identified as a natural carbonate sand containing coral and shell fragments similar to that making up the local sediment. Visual examination indicates a homogeneous color ranging from nearly white to pale yellow with no significant variegation. Grains are rounded due to natural weathering processes but tend to be somewhat elongate due to the original shapes of the organisms. The gradation is

somewhat narrow with a nominal top size estimated at the No. 16 sieve. The peak abundance is estimated between the No. 16 and No. 50 sieves with only a minor abundance of material estimated to pass the No. 50 sieve.

The finish coat matrix is fine-textured and moderately porous. The paste matrix is dominated by a network of very-fine grained hydrated gypsum crystallites (Fig. 23). Very few unhydrated gypsum relicts are identified. The rare abundance of coarser hemihydrate or finer dead-burned anhydrite suggests that the plaster was not a cement plaster or Keene's cement but rather a fine finishing plaster such as Plaster-of-Paris (Fig. 24). A very low abundance of carbonated lime grains are dispersed throughout the largely gypsum-based matrix. While a chemical analysis was not performed for this sample, the lime is interpreted to represent a minor gauging rather than a major component of the finish plaster.

***6.5 Cracking Distress and Salt Crystallization***

The client requested some discussion regarding the possible role of salts as a deleterious agent in the examined suite of samples. A combination of petrographic and chemical techniques are utilized in order to address this concern.

First, it is noted that while some samples are provided in fragmental condition, very little internal microcracking is detected in the majority of the samples (Fig. 25). Most exhibit good microstructural integrity. Some minor to moderate microcracking is detected in the cistern samples (LOKE.M.2 and M.3) and some minor microcracking is found in the Lighthouse sample LOKE.M.5. It should be stated that while minor salt deposits are detected within some of these cracks and other samples have chemistries suggestive of some soluble salt content, there is no evidence suggesting that any sample in the suite has undergone any deterioration related to either salt crystallization or salt hydration distress (Fig. 26). Minor sulfate deposits are observed petrographically in sample LOKE.M.5 as well as fine deposits likely to represent chloride salts based on their optical character. Similar salts consistent with chlorides are found as minor thin surface linings in sample LOKE.M.6. The greatest amount of secondary sulfate as gypsum is found within air-voids of sample LOKE.M.10. This is not surprising as this is the only sample containing a portland cement binder with hydrates more susceptible to secondary gypsum recrystallization. Even here however, the deposits are not related to any significant cracking distress.

The alkali elements sodium and potassium were measured quantitatively for all samples analyzed chemically. These are somewhat elevated for most samples. Additionally, water-soluble chloride was measured for the four Lighthouse samples and these may also be considered slightly elevated in content. However, it is likely that the local carbonate sand was unwashed prior to mixing and was rich in soluble alkali salts (particularly chlorides). It is also noted that no natural freshwater sources are present in the Dry Tortugas and all freshwater would have to have been collected by cistern systems. Given the scarcity of freshwater, it is also likely that the mortars were mixed with saltwater. A greater proportion of the alkali content is more likely to be related to the original mix constituents rather than later contamination. It is interesting to note that the cistern samples (LOKE.M.2 and M.3) exhibit the lowest alkali contents. Given the application, these mortars and pargings likely had a greater exposure to freshwater through drinking water storage and the reduced alkali content may be related to leaching and dilution of original chloride salts.



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Senior Petrographer/ Geologist

*Samples will be discarded 30 days after the final report date unless otherwise instructed. This report is the confidential property of the client and any unauthorized reproduction is strictly prohibited. The interpretations and conclusions presented in this report are based on the samples provided.*

## Appendix I: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic reflected light microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The overlays presented in the photomicrographs (e.g., text, scale bars, and arrows) are prepared as layers in Adobe Photoshop and converted to the jpeg format. Digital processing is limited to those functions normally performed during standard print photography processing. Photographs intended to be visually compared are taken under the same exposure conditions whenever possible.

The following abbreviations may be found in the figure captions and overlays and these are defined as follows:

| | | | |
|---|---|---|---|
| cm | centimeters | PPL | Plane polarized light |
| mm | millimeters | XPL | Crossed polarized light |
| μm | microns (1 micron = 1/1000 millimeter) | | |
| mil | 1/1000 inch | | |

Microscopical images are often non-intuitive to those not accustomed to the techniques employed. The following is offered as a brief explanation of the various views encountered in order that the reader may gain a better appreciation of what is being described.

**Reflected light images**: These are simply magnified images of the surface as would be observed by the human eye. A variety of surface preparations may be employed including polished and fractured surfaces. The reader should note the included scale bars as minor deficiencies may seem much more significant when magnified.

**Plane polarized light images (PPL)**: This imaging technique is most often employed in order to discern textural relationships and microstructure. To employ this technique, samples are milled (anywhere from 20 to 30 microns depending on the purpose) so as to allow light to be transmitted through the material. In many cases, Testwell also employs a technique whereby the material is impregnated with a low viscosity, blue-dyed epoxy. Anything appearing blue therefore represents some type of void space (e.g.; air voids, capillary pores, open cracks, etc.) Hydrated cement paste typically appears a light shade of brown in this view (with a blue hue when impregnated with the epoxy). With some exceptions, most aggregate materials are very light colored if not altogether white. Some particles will appear to stand out in higher relief than others. This is a function of the refractive power of different materials with respect to the mounting epoxy.

**Crossed polarized light images (XPL)**: This imaging technique is most often employed to distinguish components or highlight textural relationships between certain components not easily distinguished in plane polarized light. Using the same thin sections, this technique places the sample between two pieces of polarizing film in order to determine the crystal structure of the materials under consideration. Isotropic materials (e.g.; hydrated cement paste, pozzolans and other glasses, many oxides, etc.) will not transmit light under crossed polars and therefore appear black. Non-isotropic crystals (e.g.; residual cement, calcium hydroxide, calcium carbonate, and most aggregate minerals) will appear colored. The colors are a function of the thickness, crystal structure, and orientation of the mineral. Many minerals will exhibit a range of colors due to their orientation in the section. For example, quartz sand will appear black to white and every shade of gray in between. Color differences do not necessarily indicate material differences. When no other prompt is given in the figure caption, the reader should appeal to general shapes and morphological characteristics when considering the components being illustrated.

**Chemical treatments:** Many chemical techniques (etches and stains typically) are used to isolate and enhance a variety of materials and structures. These techniques will often produce strongly colored images that distinguish components or chemical conditions.




**Figure 1:** Photographs of the four Lighthouse mortar samples as received by Testwell for examination.




**Figure 2:** Photographs of mortar samples from the cistern, Kitchen Building and Keeper's Dwelling as received by Testwell for examination.

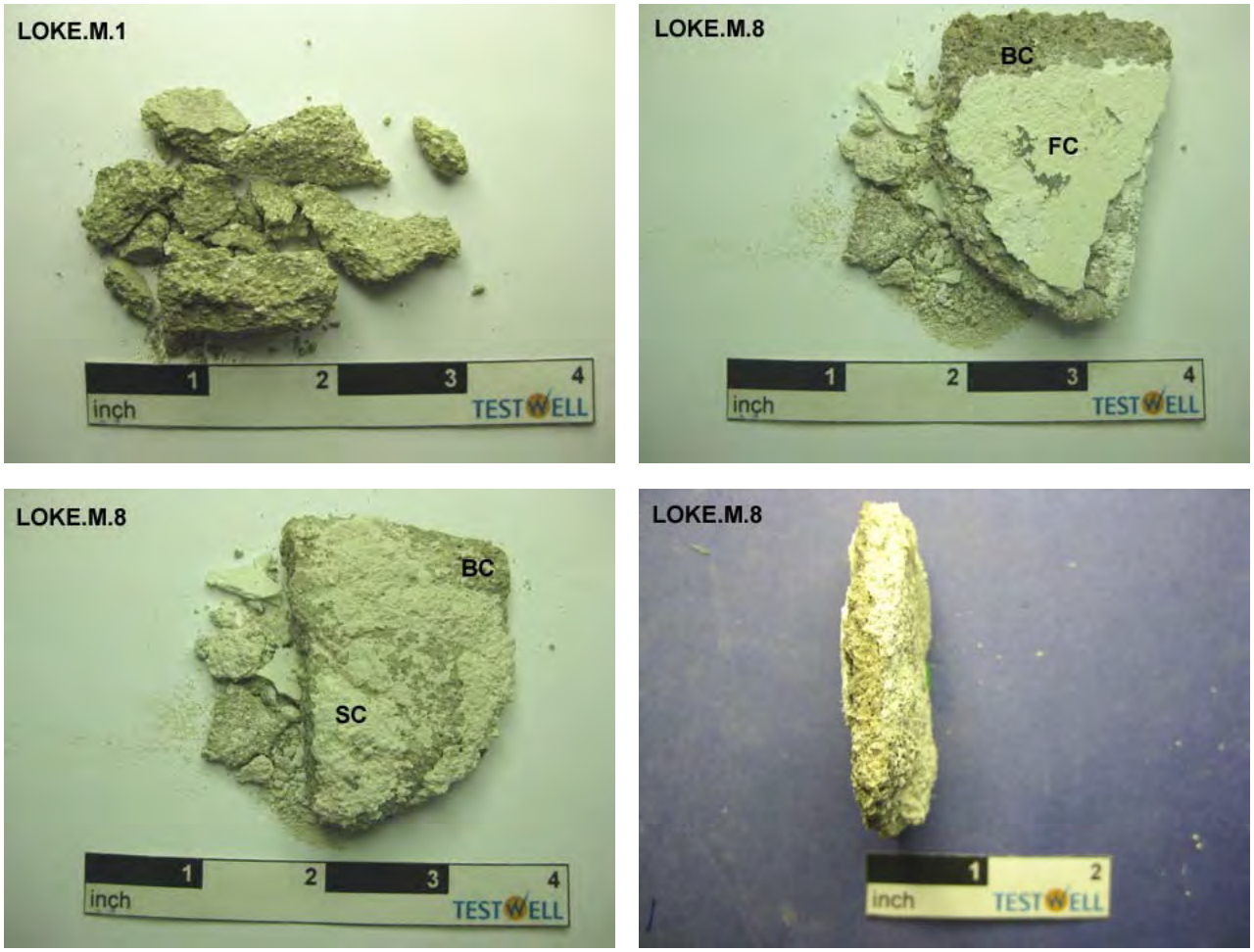



**Figure 3:** Photographs of the samples from the Oil House as received by Testwell for examination. Sample LOKE.M.8 is a plaster sample. A top view (top right) and rear view (bottom left) show the scratch coat (SC), brown coat (BC), and finish coat (FC) in this three-coat plaster. The last photograph presents a side view.

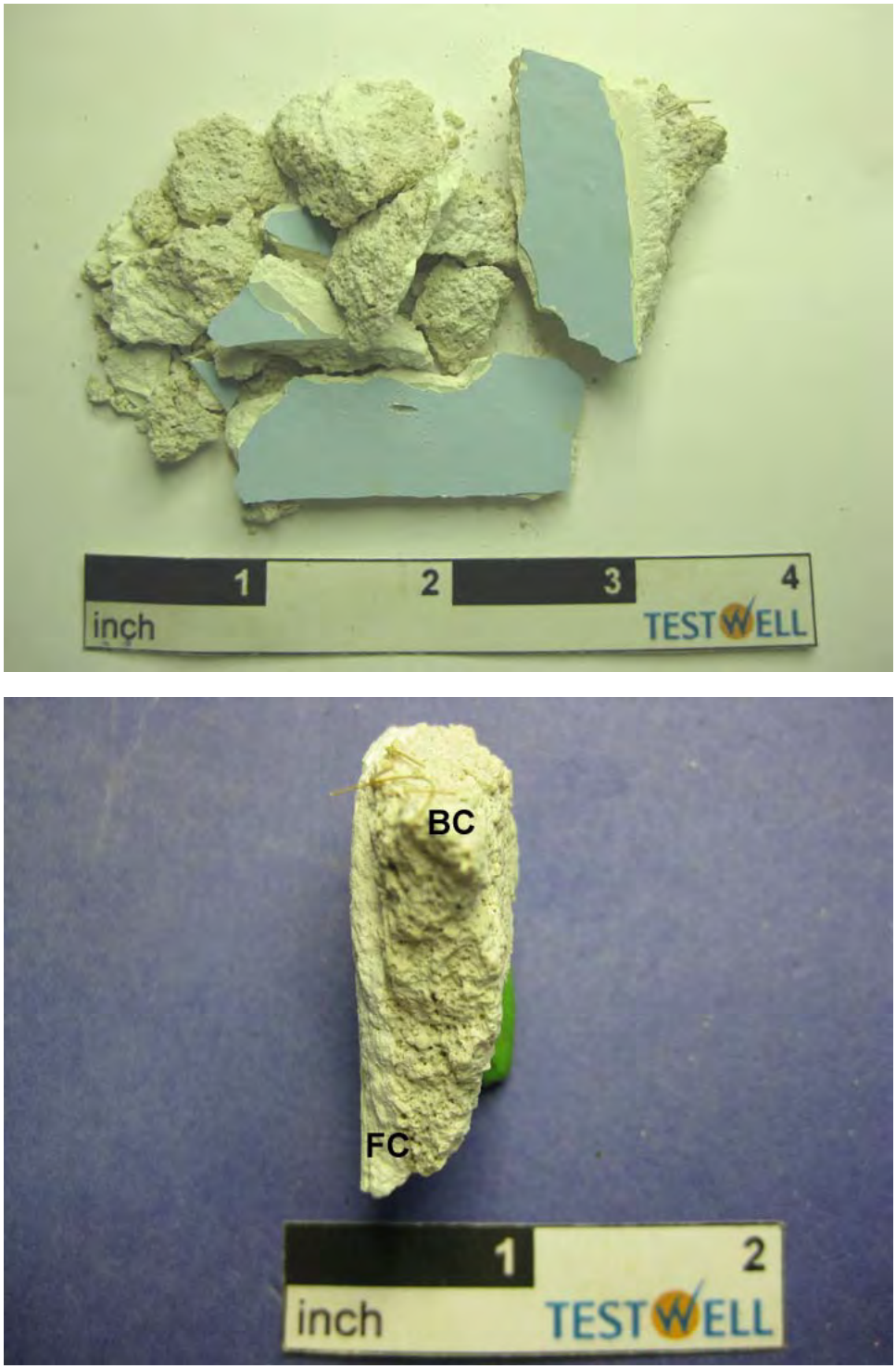



**Figure 4:** Photographs of the plaster sample from the Keeper's Dwelling as received by Testwell for examination. The bottom photograph presents a side view of the two-coat plaster with brown coat (BC) and finish coat (FC) visible.

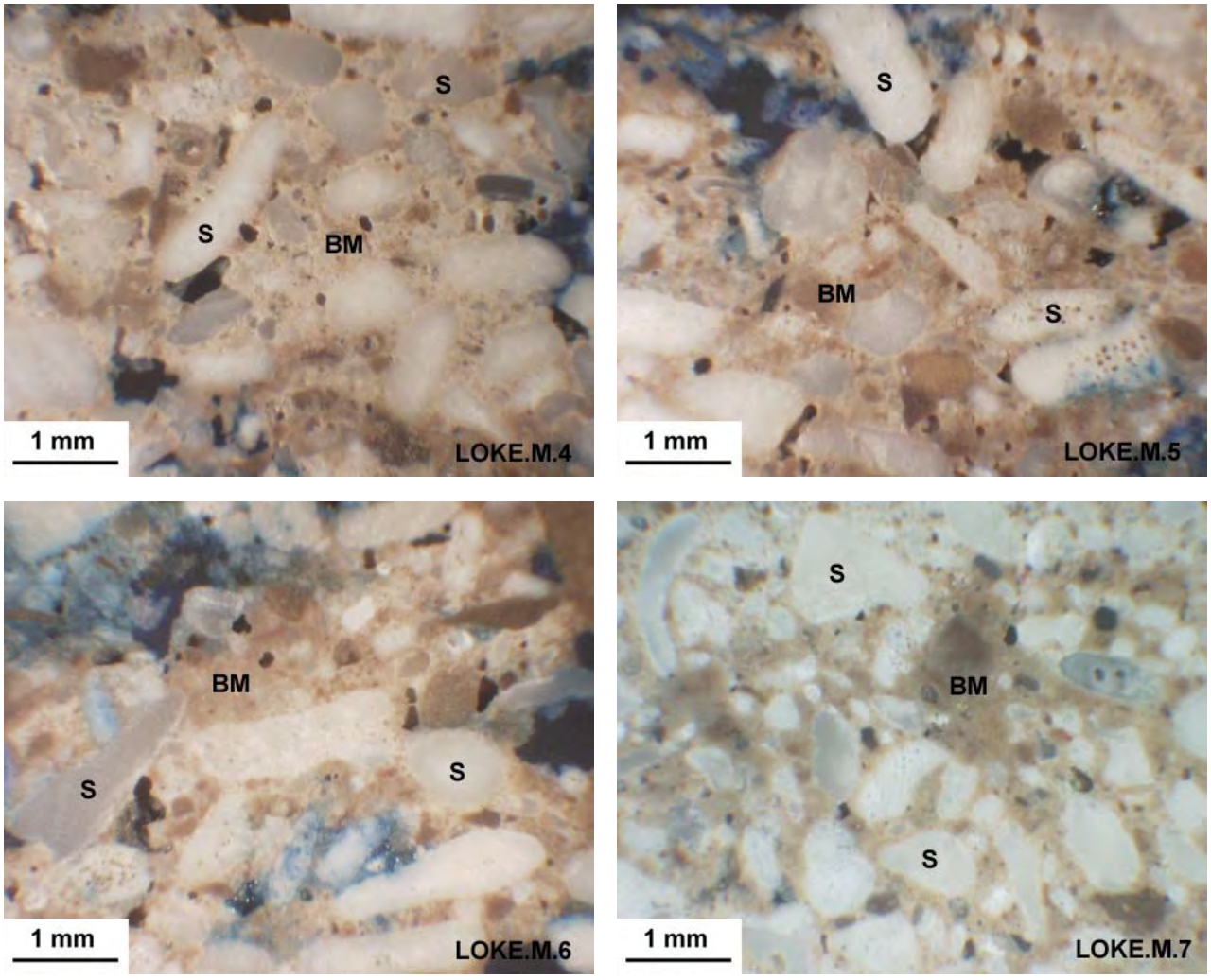



**Figure 5:** Reflected light photomicrographs of honed cross sections of the Lighthouse mortar samples. Binder matrix is well compacted and consolidated around sand grains (S). The sand is light-colored and homogeneous and the same type of sand component is found in all samples. Gradations tend to be relatively narrow with all material estimated to pass a No. 8 sieve and little material found below the No. 50 sieve. Blue coloration in some of the samples is due to the impregnation of a low-viscosity blue dyed epoxy. Several of the honed sections were prepared directly from residual thin section billets where total sample size is small.

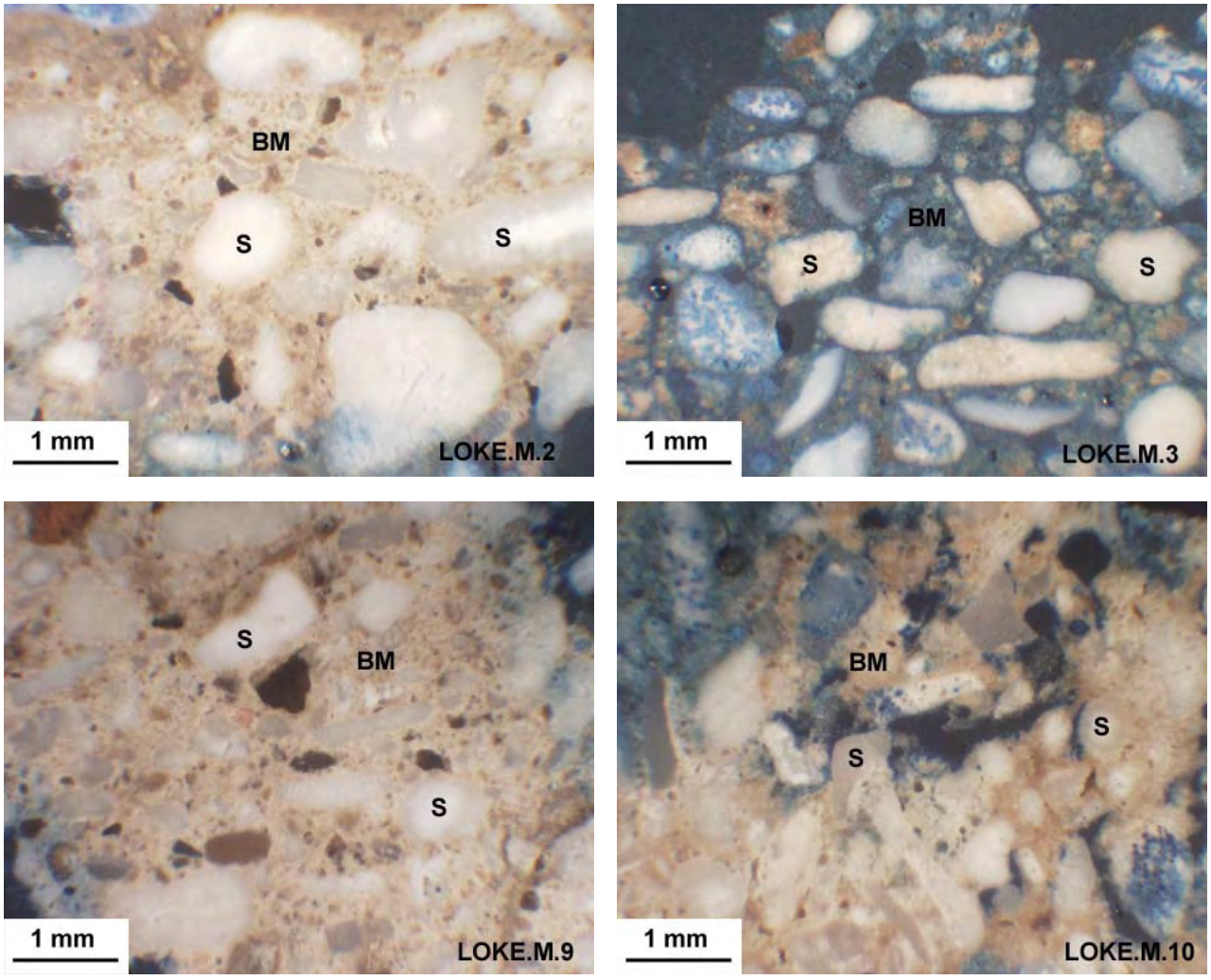



**Figure 6:** Reflected light photomicrographs of honed cross sections of mortar samples from the cistern, Kitchen Building and Keeper's Dwelling. Binder matrix is well compacted and consolidated around sand grains (S). The sand is light-colored and homogeneous and the same type of sand component is found in all samples. Gradations tend to be relatively narrow with all material estimated to pass a No. 8 sieve and little material found below the No. 50 sieve. Blue coloration in some of the samples is due to the impregnation of a low-viscosity blue dyed epoxy. Several of the honed sections were prepared directly from residual thin section billets where total sample size is small.

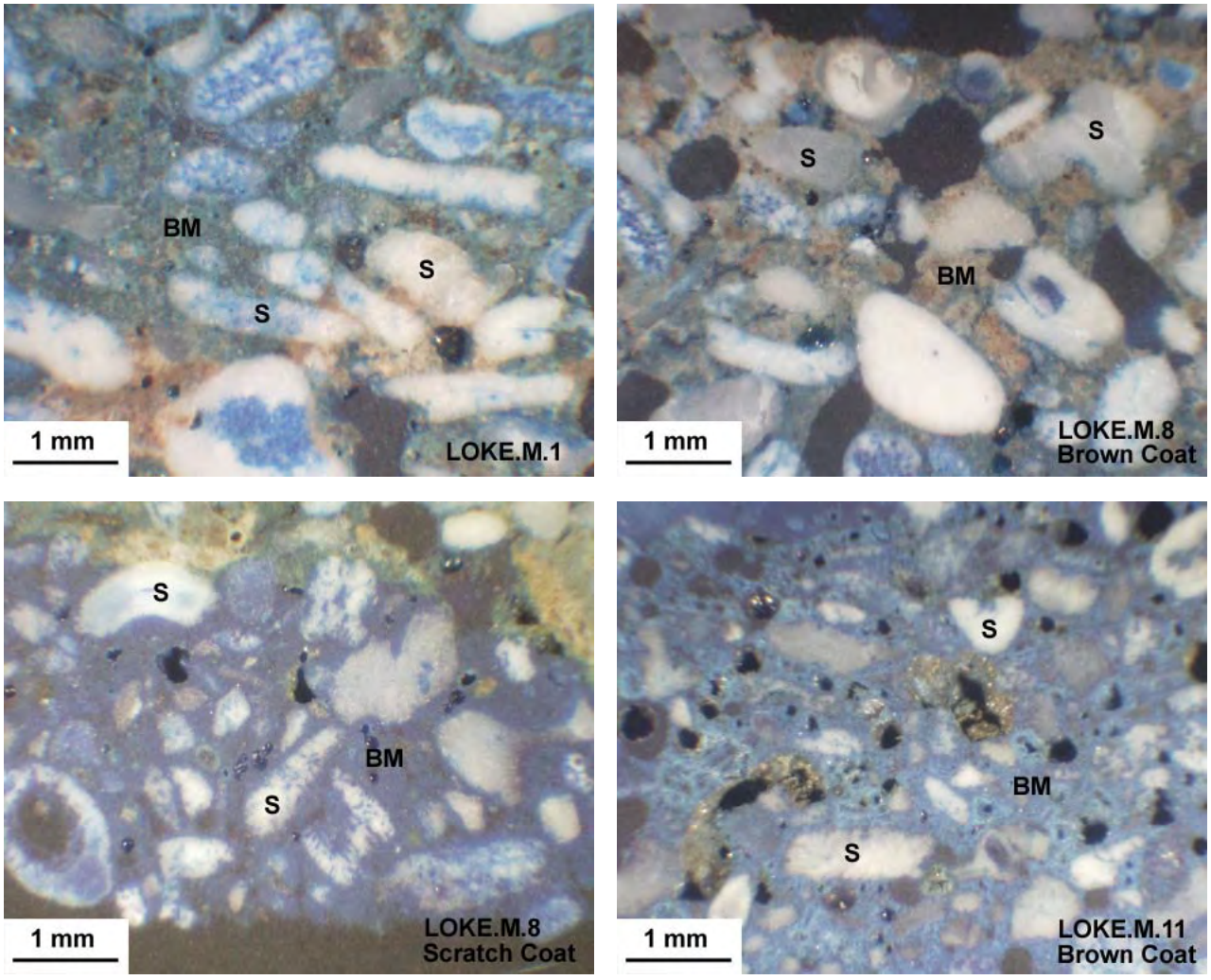



**Figure 7:** Reflected light photomicrographs of honed cross sections of samples from the Oil House and sanded plaster coats. Binder matrix is well compacted and consolidated around sand grains (S). The sand is light-colored and homogeneous and the same type of sand component is found in all samples. Gradations tend to be relatively narrow with all material estimated to pass a No. 8 sieve and little material found below the No. 50 sieve. Blue coloration in some of the samples is due to the impregnation of a low-viscosity blue dyed epoxy. Several of the honed sections were prepared directly from residual thin section billets where total sample size is small.

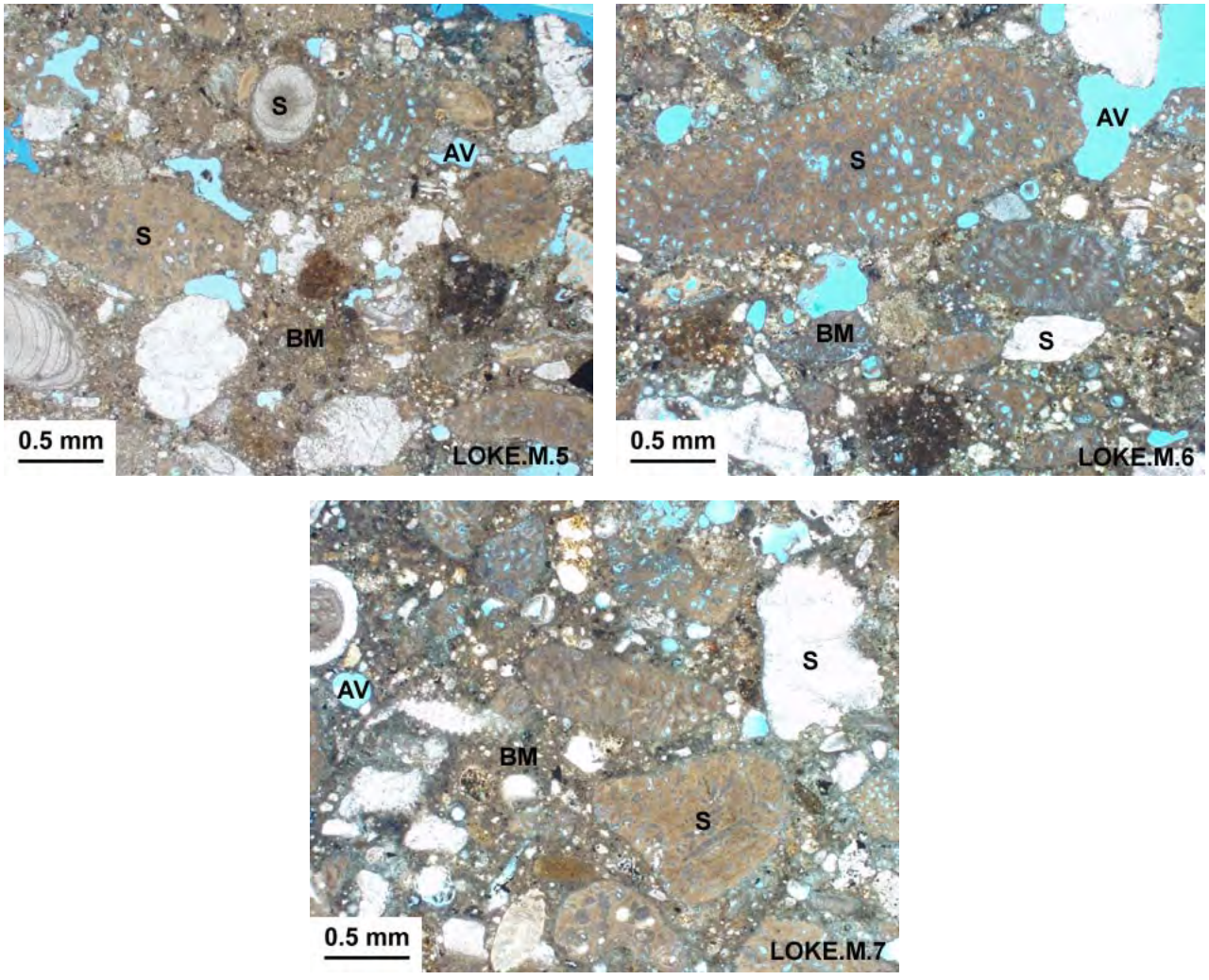



**Figure 8:** PPL photomicrographs illustrating the overall microstructure of the Lighthouse mortar samples. Sample LOKE.M.4 is not shown here and is presented in the next figure. The hydraulic binder matrix (BM) is well developed. Porosities tend to be moderate for the Lighthouse samples and this is demonstrated by the relatively low absorption of blue-dyed epoxy used in the sample preparation. The sand (S) is well coated with binder and is identified as a soft, natural carbonate sand composed of a variety of coral and shell fragments. Air-voids (AV) are not abundant.

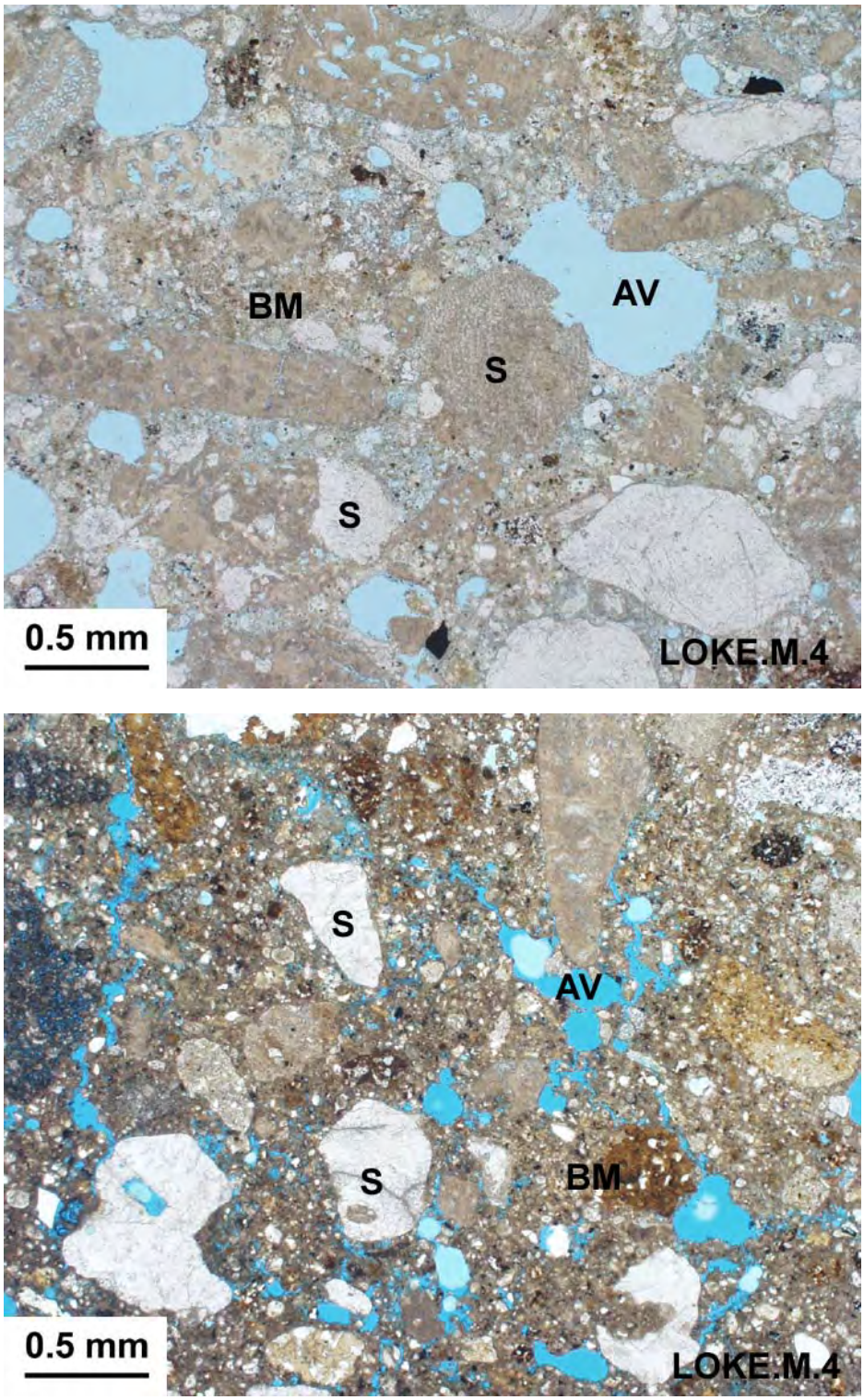



**Figure 9:** PPL photomicrographs illustrating the overall microstructure of Sample LOKE.M.4. Sample LOKE.M.4 is unusual in that two different microtextures are found within the same sample. The top image shows a binder matrix (BM) that has a higher porosity than the one in the image below. This is shown by the difference in absorption of blue-dyed epoxy used in the sample preparation. The binder matrix in the lower image also has a "grittier" character. This is interpreted to be due to a difference in the cement for this portion of the sample. The feature is shown in greater detail in Figure 13 below. The sand (S) has the same characteristics as that of the other Lighthouse samples. Air-voids (AV) are not abundant.

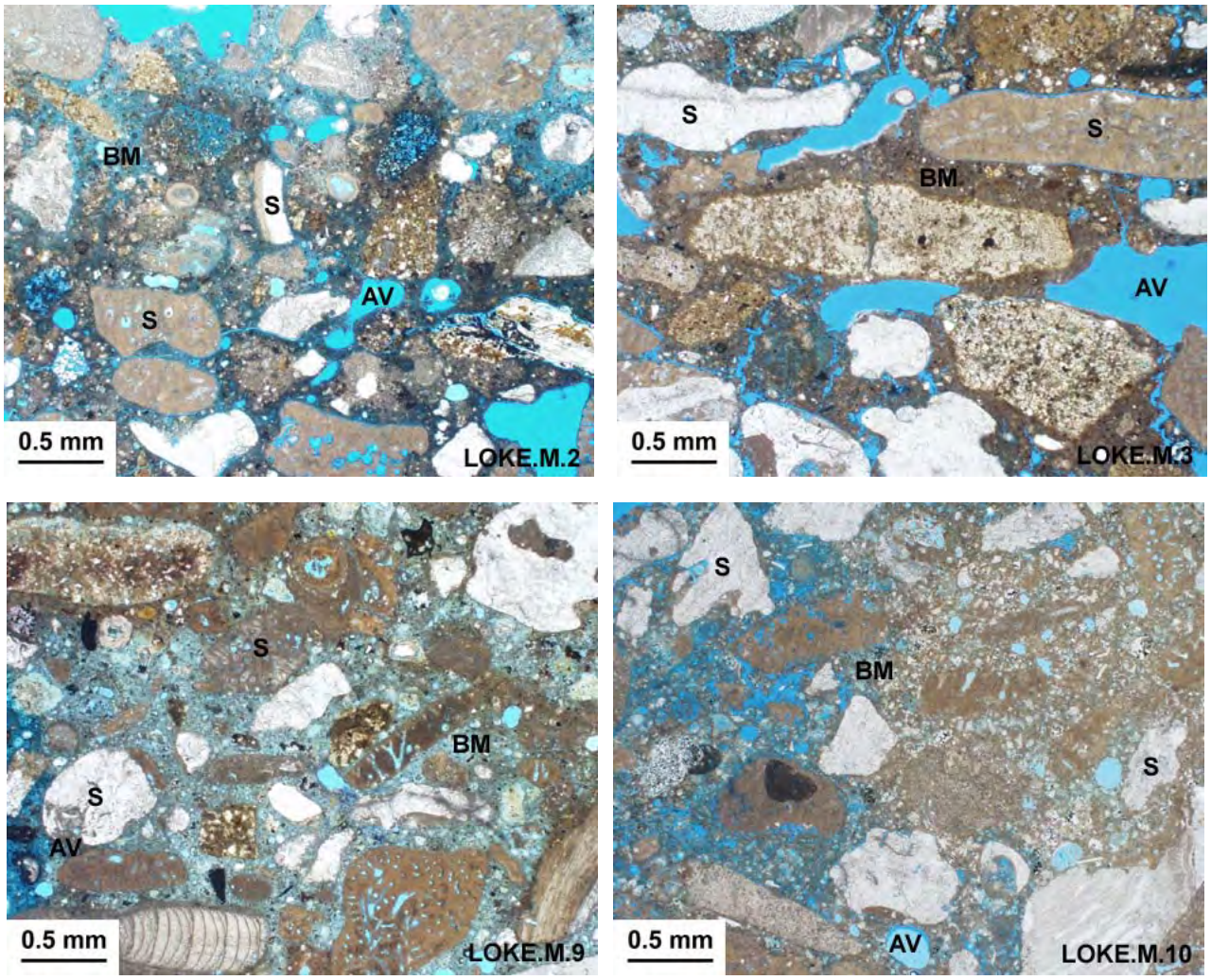



**Figure 10:** PPL photomicrographs illustrating the overall microstructure of mortar samples from the cistern, Kitchen Building and Keeper's Dwelling. The hydraulic binder matrix (BM) is well developed. Porosities tend to be moderate to moderately high for these samples and this is demonstrated by the moderate absorption of blue-dyed epoxy used in the sample preparation. Sample LOKE.M.9 has a high porosity in some areas of the sample. The sand (S) is well coated with binder and is identified as a soft, natural carbonate sand composed of a variety of coral and shell fragments. Air-voids (AV) are not abundant.

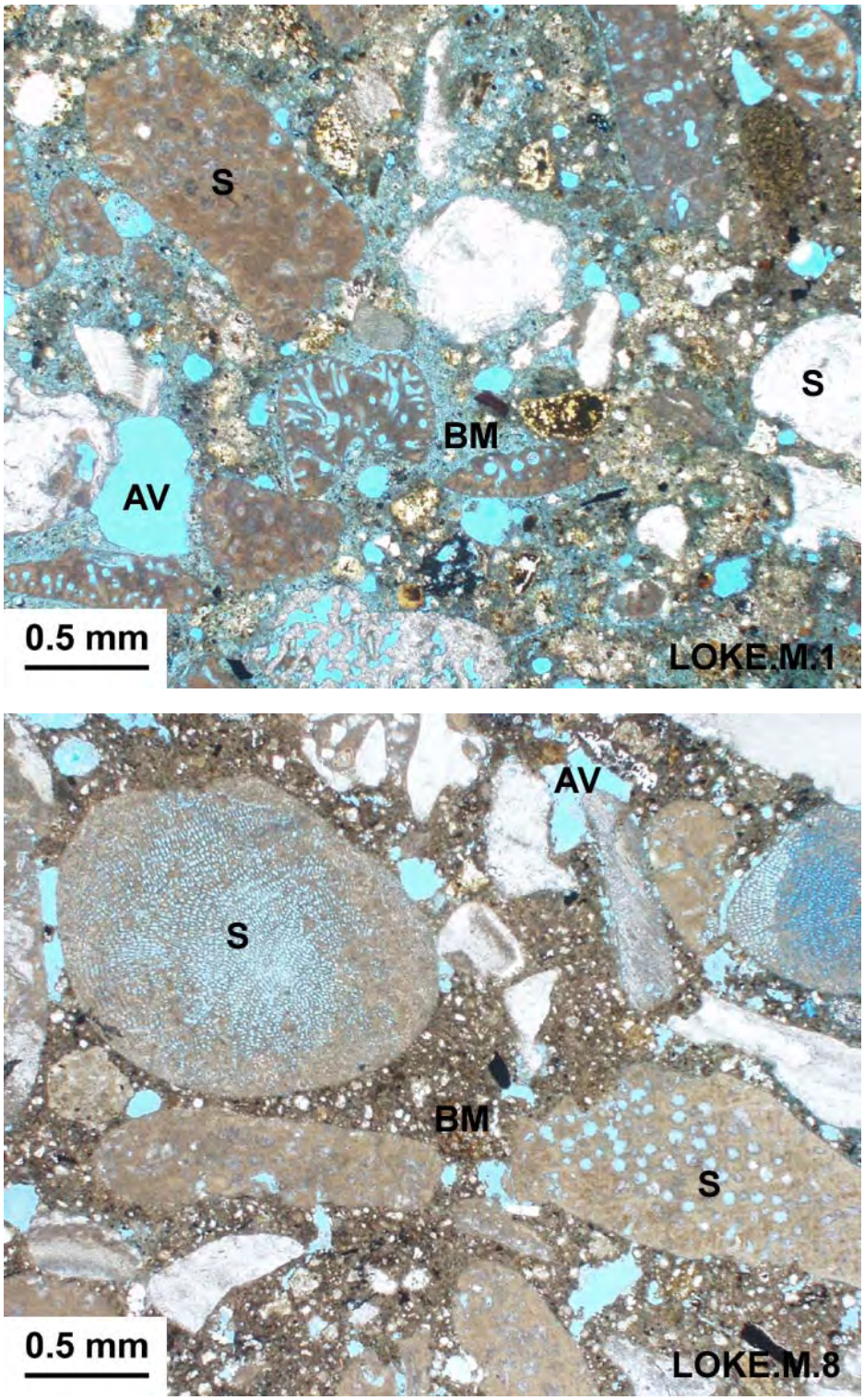



**Figure 11:** PPL photomicrographs illustrating the overall microstructure of the Oil House samples. The brown coat is shown for LOKE.M.8 as this material is more or less identical to that of the masonry mortar samples. The hydraulic binder matrix (BM) is well developed. Porosities tend to be moderately high for LOKE.M.1 and moderate for the brown coat of LOKE.M.8 samples and this is demonstrated by variations in the absorption of blue-dyed epoxy used in the sample preparation. The sand (S) is well coated with binder and is identified as a soft, natural carbonate sand composed of a variety of coral and shell fragments. The brown coat contains the coarsest sand of all examined samples and this is evident in this photomicrograph. Air-voids (AV) are not abundant in either sample.

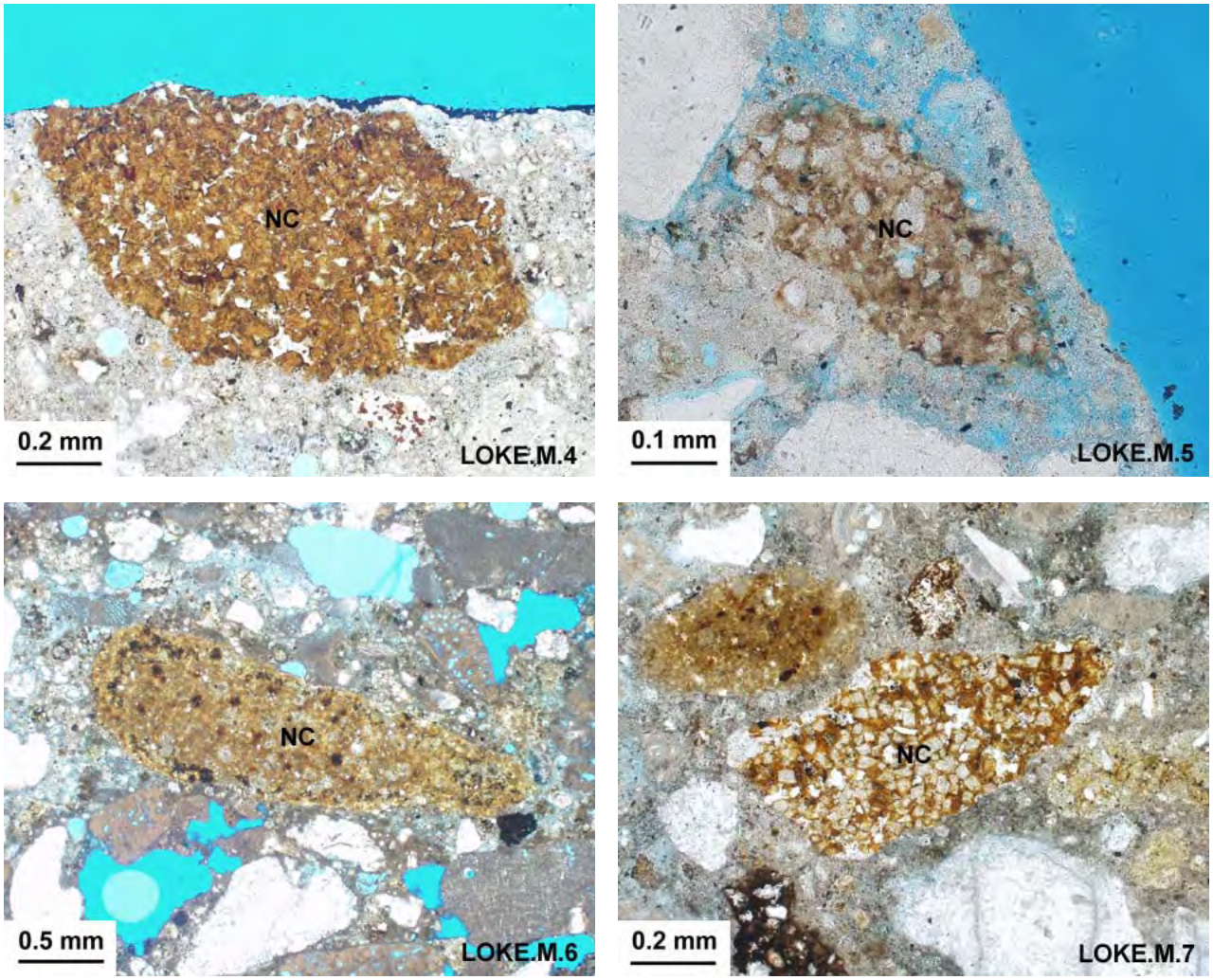



**Figure 12:** PPL photomicrographs illustrating binder residuals in the Lighthouse mortar samples. All are identified as natural cement relicts (NC). Typical textures within these grains include calcined dolomite rhombs surrounded by an iron-rich hydraulic product and partially burned quartz silt grains evenly dispersed throughout the particles. These textures are characteristic of magnesium-rich American cements of the nineteenth century. With the exception of sample LOKE.M.5, the Lighthouse samples tend to have more variably-sized cement relicts with coarse grains not uncommon. This is different than other samples in the suite and may suggest a different cement batch or source for these three mortars.

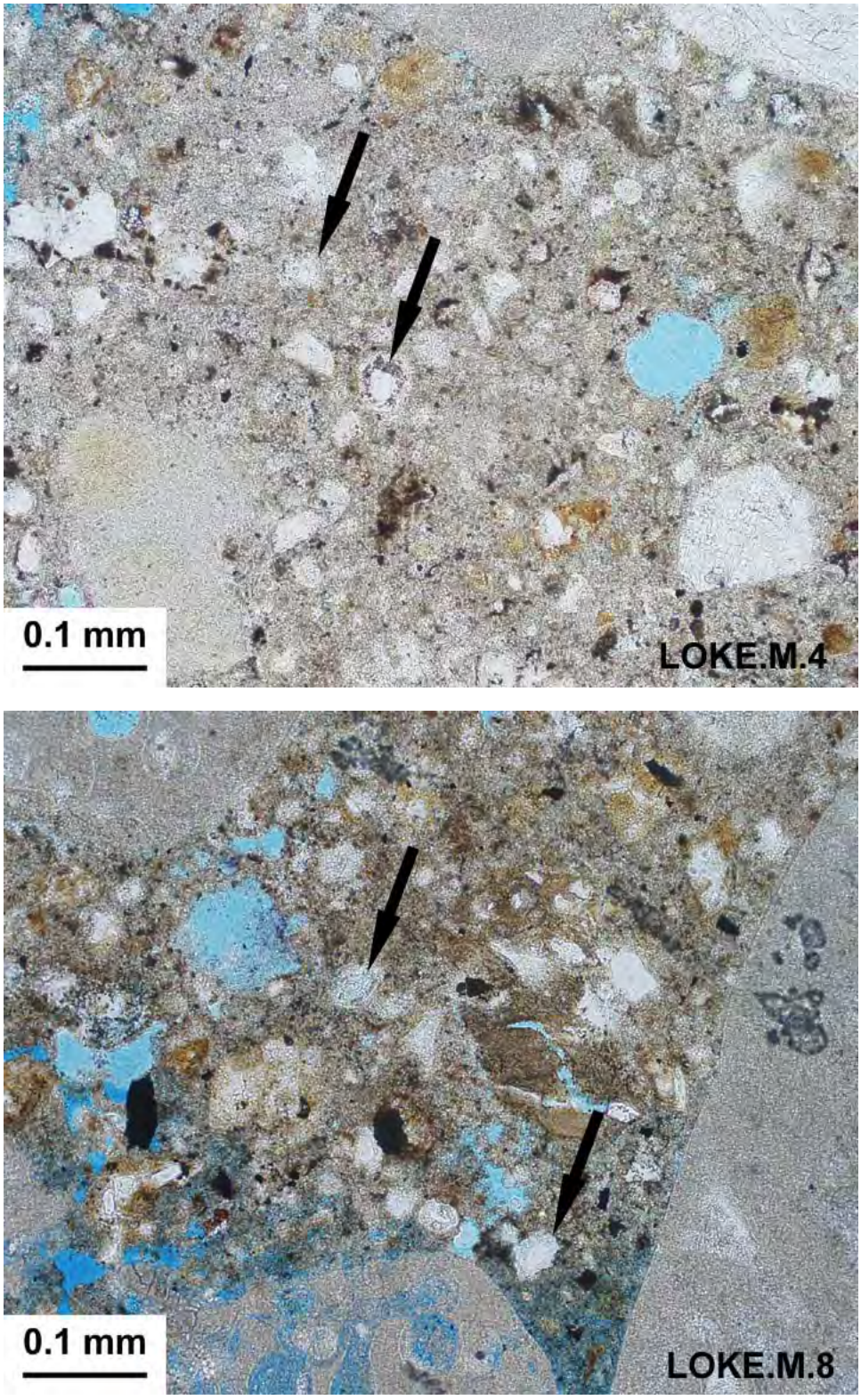



**Figure 13:** PPL photomicrographs illustrating distinctive cement microtextures in portions of LOKE.M.4 and all of the brown coat in LOKE.M.8. The arrows exhibit isolated fine silt grains dispersed throughout the paste matrix. These are not a component of the sand as closer inspection reveals fine calcination rims around these grains. Such calcined quartz silt is a common component of natural cements and in fact, these are found in all the natural cement mortars examined for this report. However, the abundance is distinctively high in these two samples suggesting a different cement batch or source.

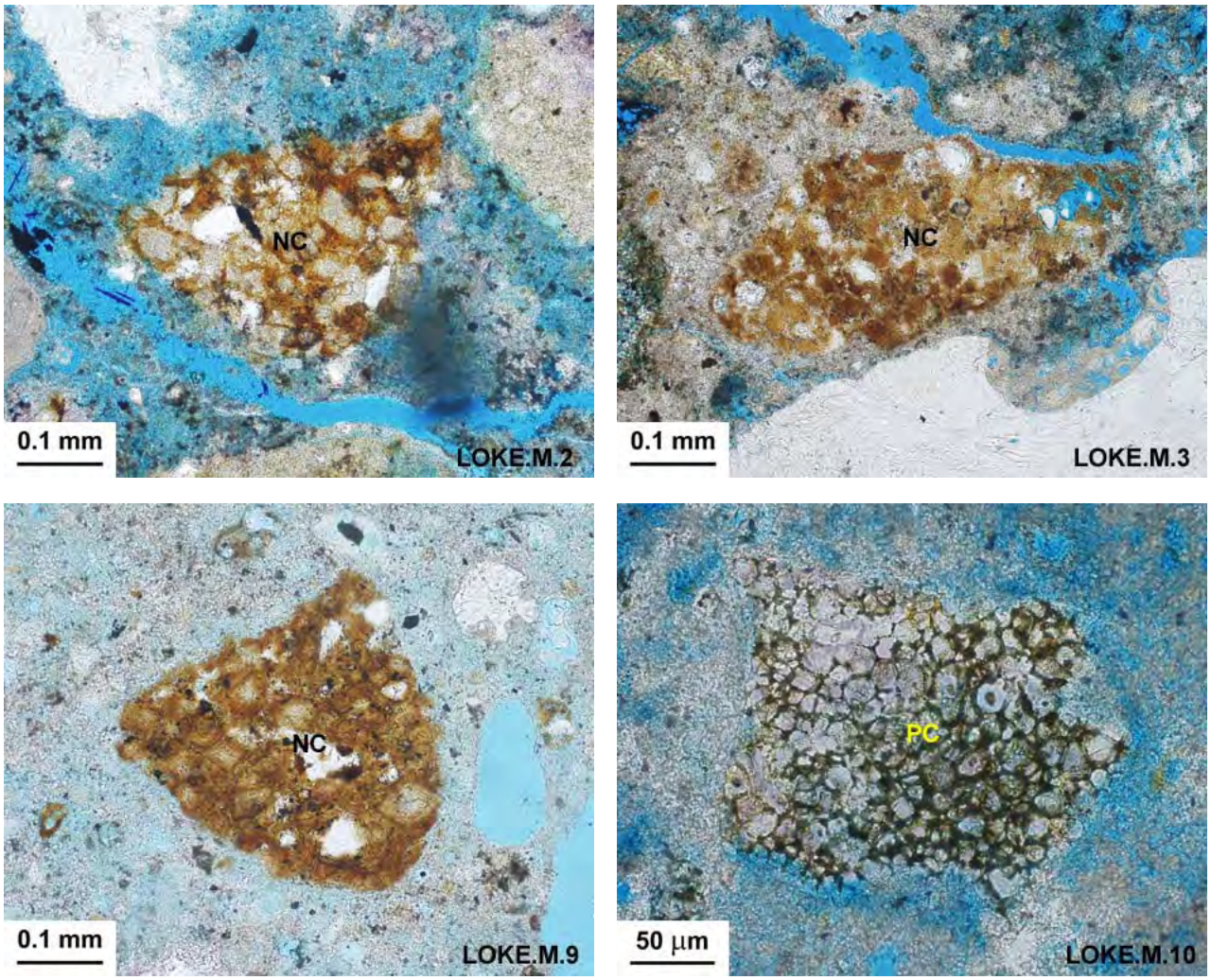



**Figure 14:** PPL photomicrographs illustrating binder residuals in mortar samples from the cistern, Kitchen Building and Keeper's Dwelling. All but those in LOKE.M.10 (Keeper's Dwelling) are identified as natural cement relicts (NC). Typical textures within these grains include calcined dolomite rhombs surrounded by an iron-rich hydraulic product and partially burned quartz silt grains evenly dispersed throughout the particles. These textures are characteristic of magnesium-rich American cements of the nineteenth century. Residual cement tends to fine- to medium-grained. The residual binder in LOKE.M.10 is identified as an ordinary gray portland cement (PC). The grain shown here contains rounded "ghosts" of fully hydrated calcium silicate with interstitial iron-bearing cement phases. The grind and consistency of the cement is characteristic of early twentieth century portlands.

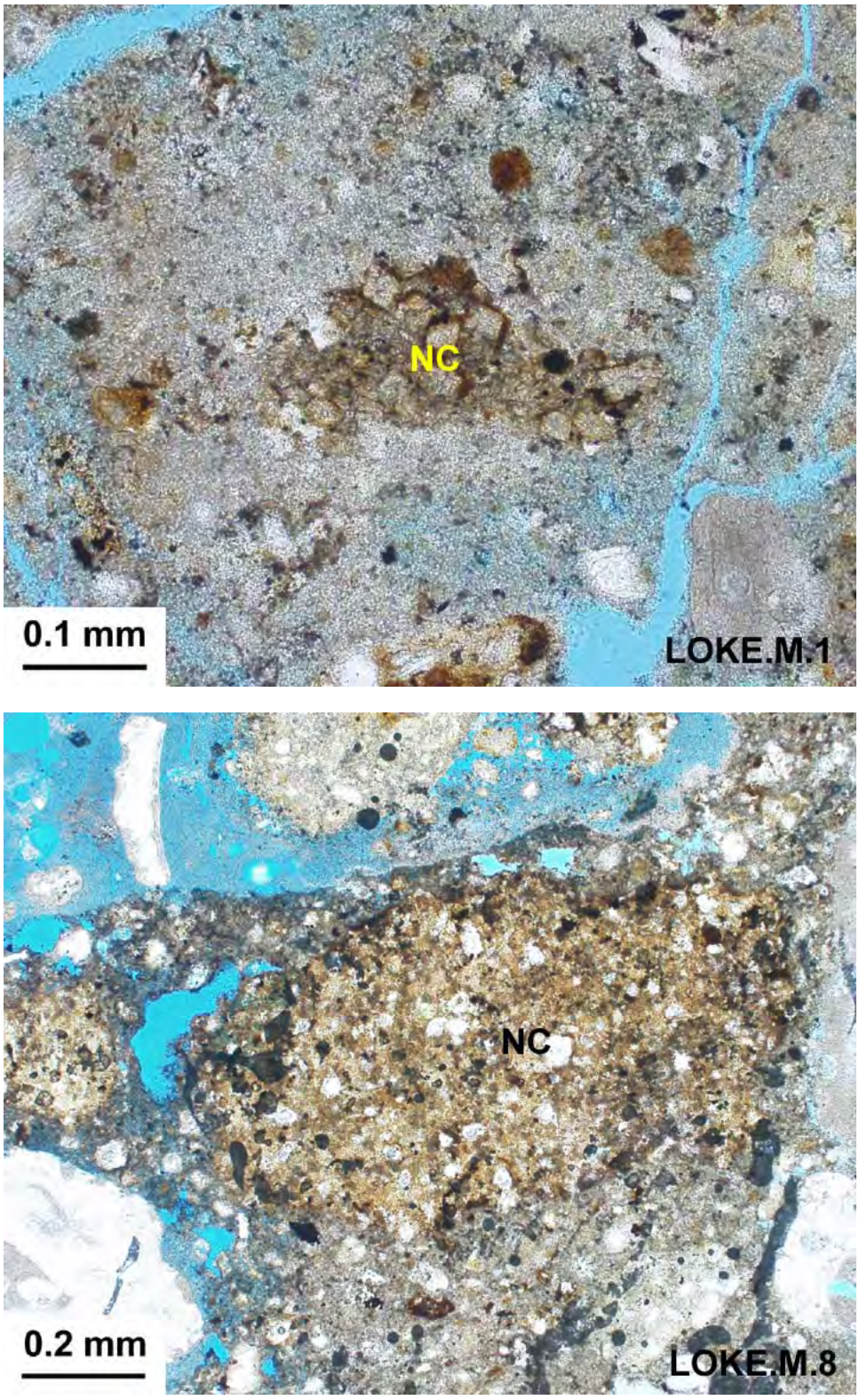



**Figure 15:** PPL photomicrographs illustrating binder residuals in some of the Oil House samples. The brown coat is shown for LOKE.M.8 as this material is more or less identical to that of the masonry mortar samples. All are identified as natural cement relicts (NC). Typical textures within these grains include calcined dolomite rhombs surrounded by an iron-rich hydraulic product and partially burned quartz silt grains evenly dispersed throughout the particles. These textures are characteristic of magnesium-rich American cements of the nineteenth century. Residual cement tends to fine- to medium-grained.

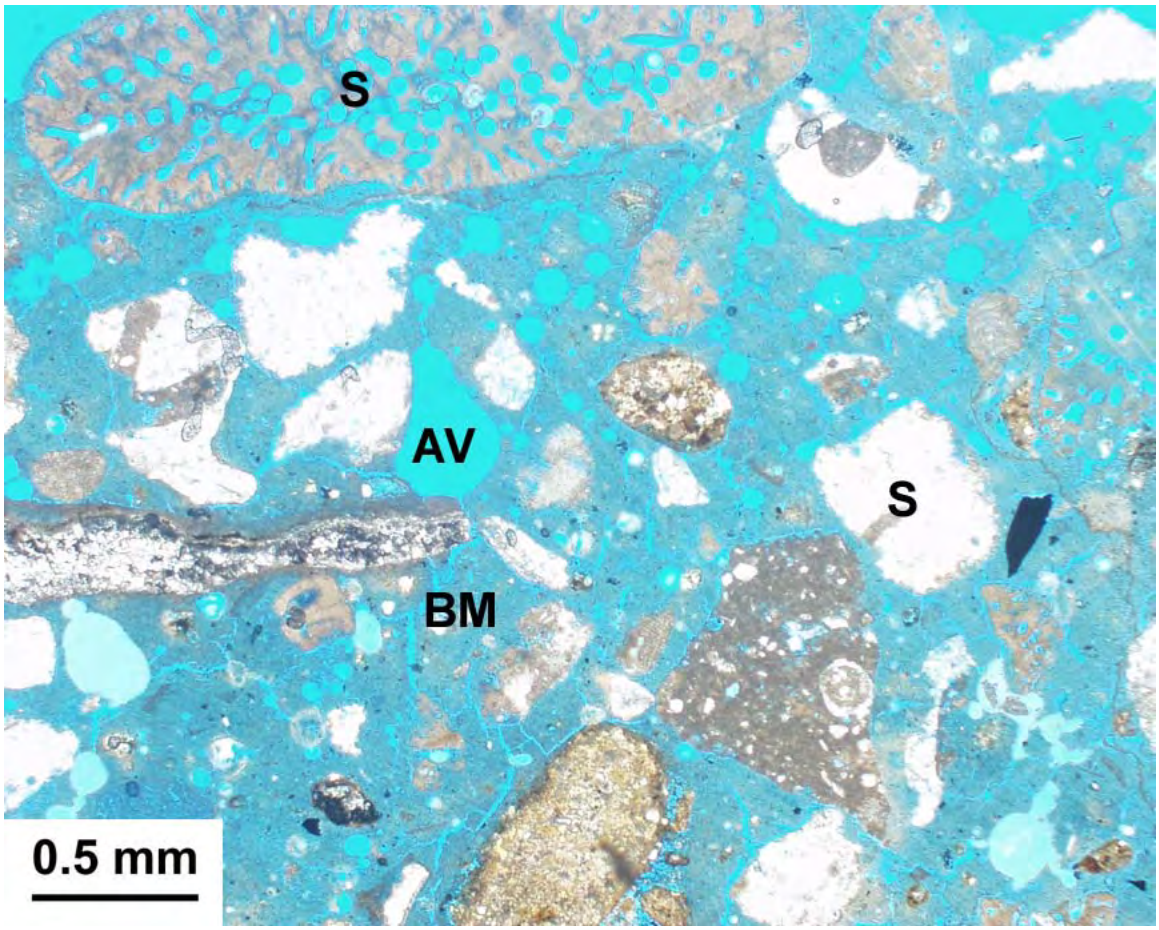



**Figure 16:** PPL photomicrograph illustrating the overall microstructure of the scratch coat in sample LOKE.M.8. The binder matrix (BM) has a high capillary porosity as indicated by the high absorption of blue-dyed epoxy used in the sample preparation. Fine shrinkage cracks are also detected within the matrix and these two features are characteristics of high-lime binder matrices. The sand (S) is the same soft, natural carbonate sand found in the mortar samples. Air-voids (AV) are moderately abundant.

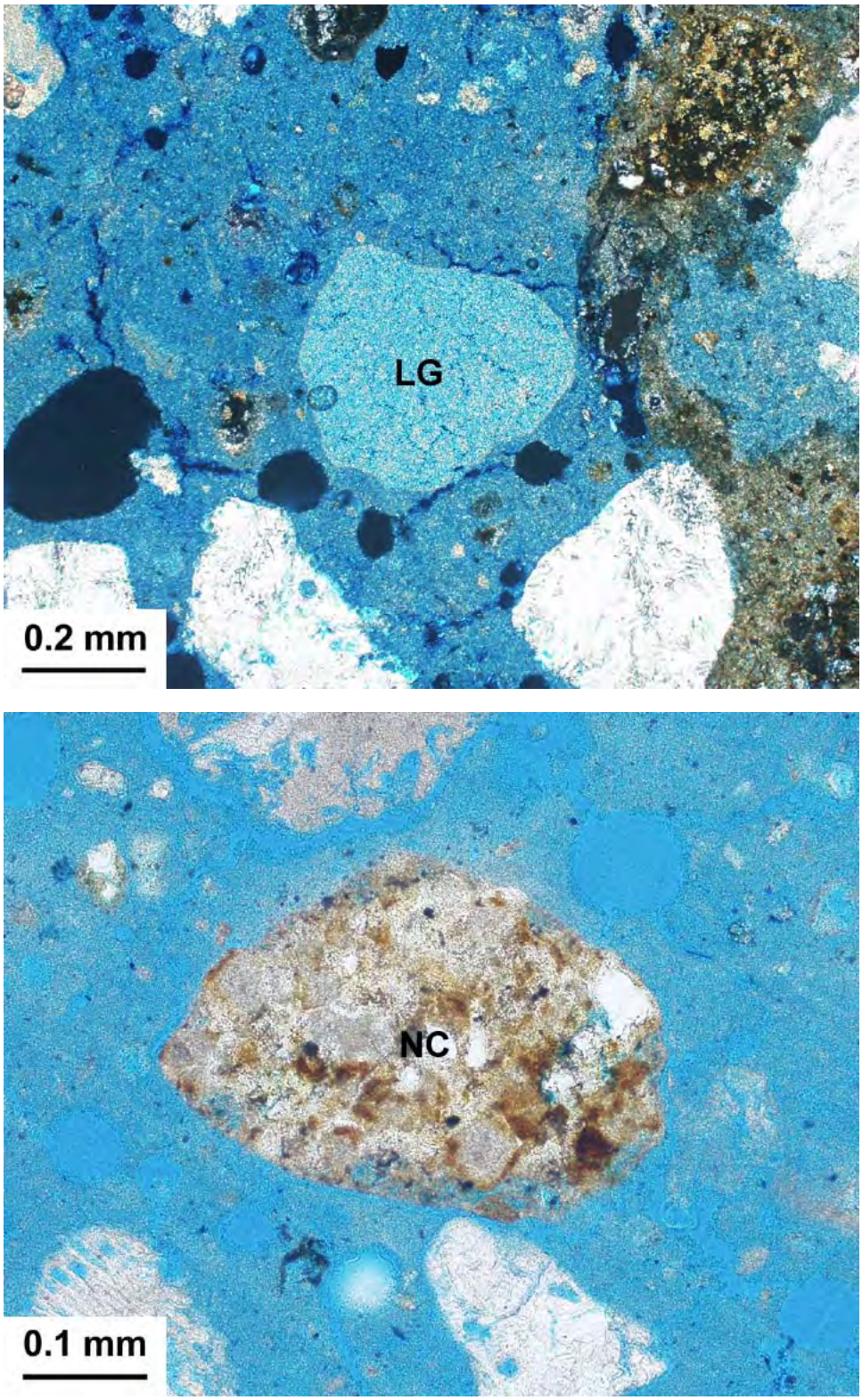



**Figure 17:** Photomicrographs illustrating binder residuals in the scratch coat in sample LOKE.M.8. (Top) XPL image. A lime grain (LG) is shown. The internal texture of the lime is homogeneous and little evidence is provided that might suggest the provenance of the lime. (Bottom) PPL image. A natural cement relict is shown (NC). These have the same characteristics as other cements in the sample suite. The cement is present in low abundance and is estimated to represent a minor gauging of an otherwise non-hydraulic lime plaster.

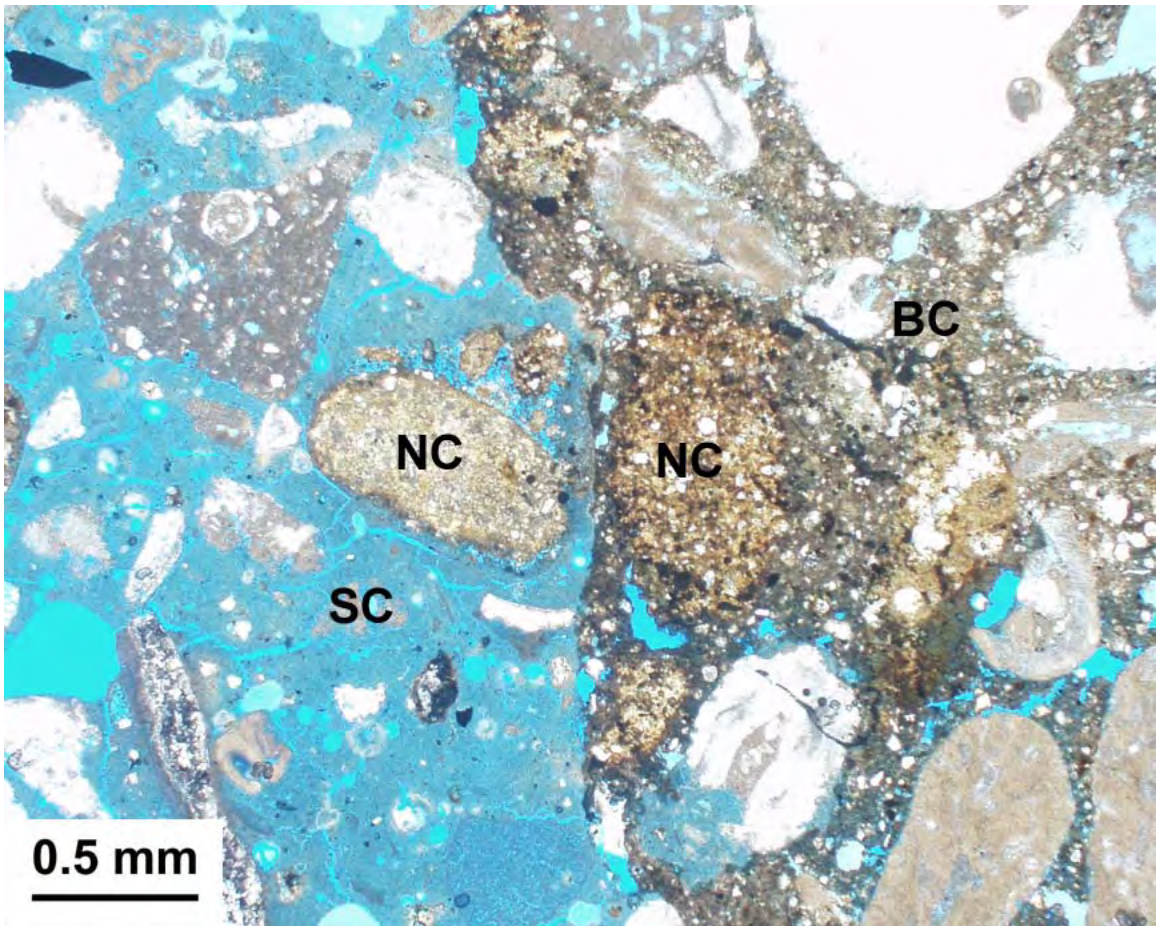



**Figure 18:** PPL photomicrograph illustrating the contact between the scratch coat (SC) and brown coat (BC) in LOKE.M.8. While natural cement (NC) is present in both, the difference in binder texture between a lime plaster gauged with cement (left) and a pure cement plaster (right) is quite apparent and difficult to mistake. Other details of the brown coat are presented above and are not repeated here.

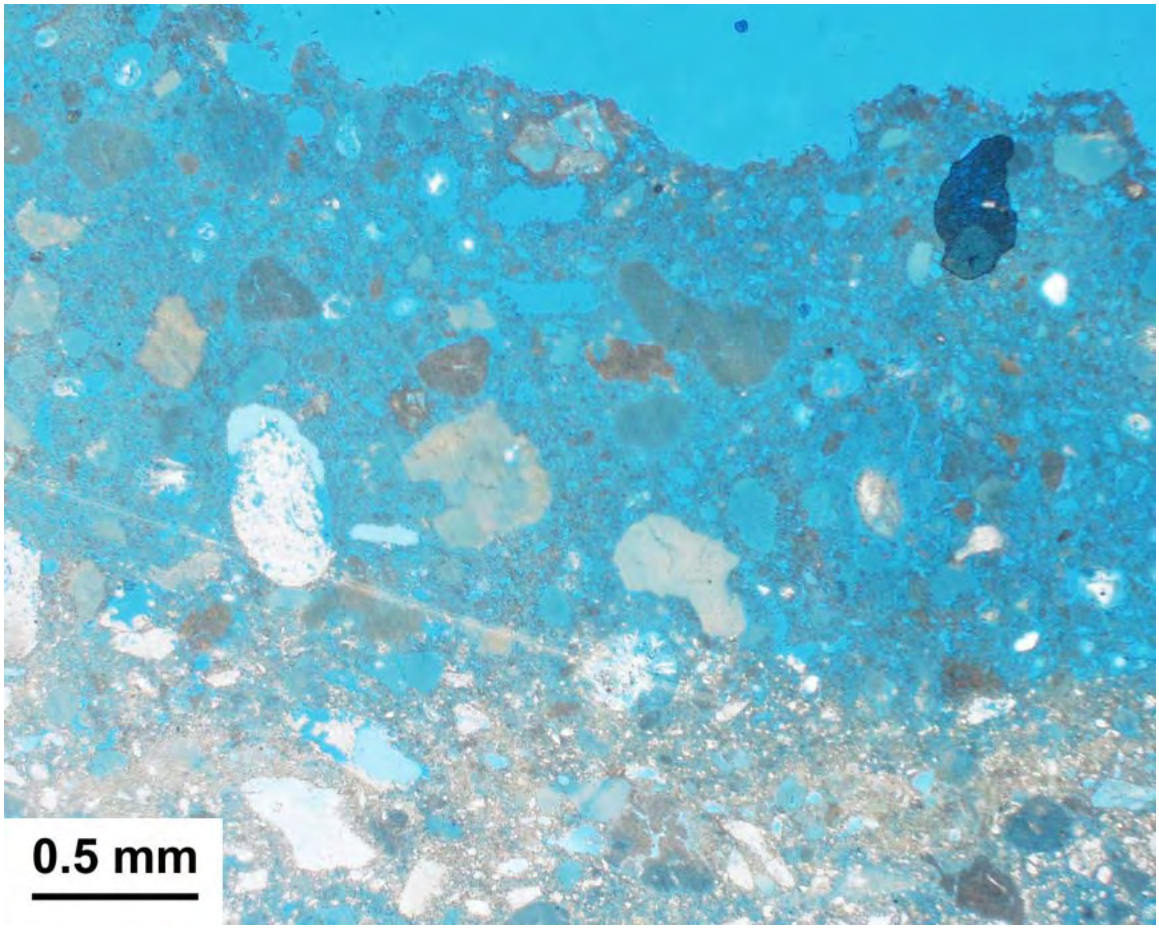



**Figure 19:** PPL photomicrograph illustrating the overall microstructure of the finish coat in sample LOKE.M.8. The binder matrix (BM) has a high capillary porosity as indicated by the high absorption of blue-dyed epoxy used in the sample preparation. The layer is unsanded and all grains observed here are part of the binder.

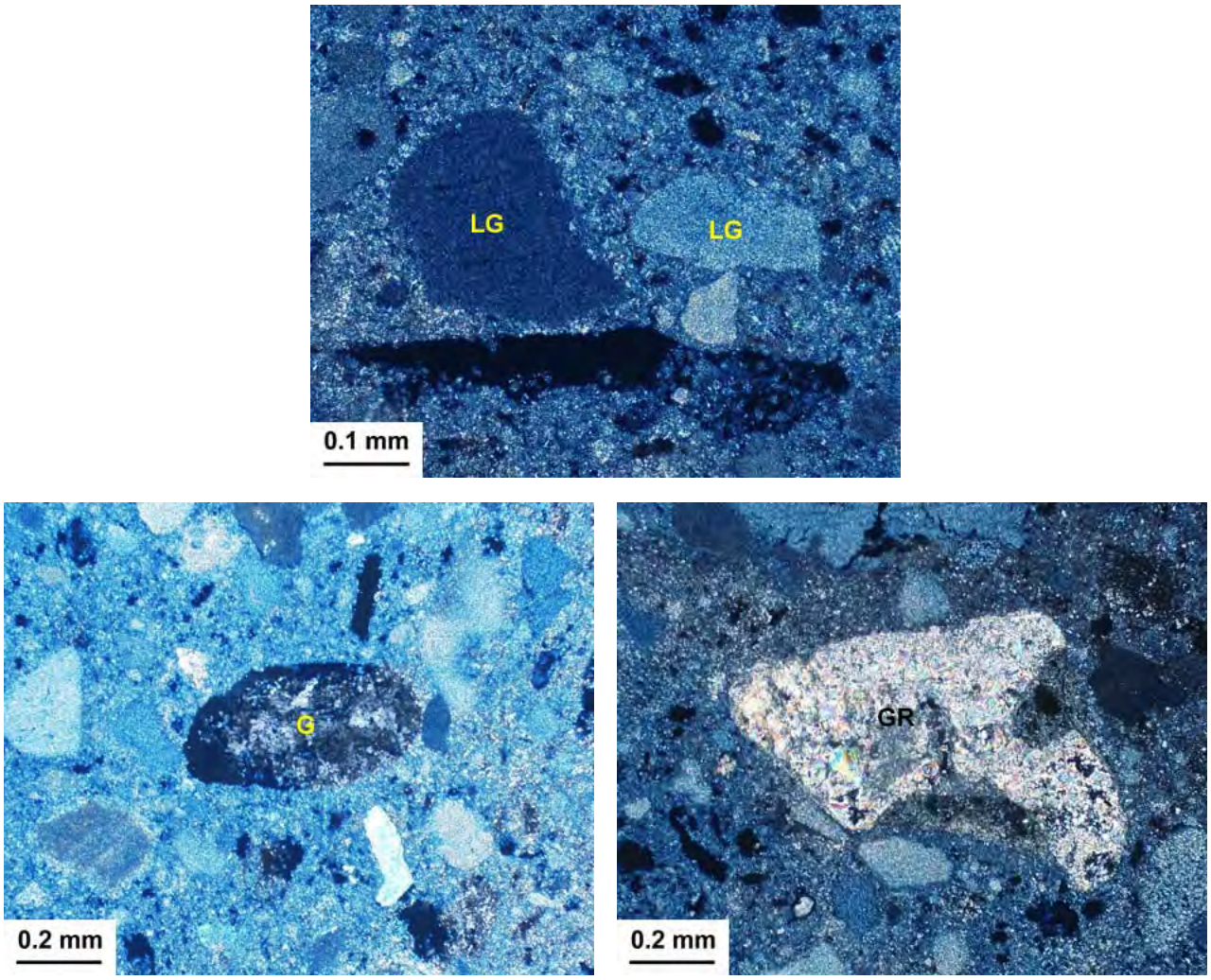



**Figure 20:** Photomicrographs illustrating binder residuals in the finish coat in sample LOKE.M.8. (Top) XPL image. Lime grains (LG) are found in high abundance. Chemical analysis indicates that the finish is principally a lime plaster with a moderate gypsum gauging. The darker appearance of the grain at left indicates that it has not carbonated. The brighter grain at right is carbonated as are most observed residuals. (Bottom left) A gypsum residual (G) represents a grain of originally unhydrated hemihydrate that has hydrated to coarser grained gypsum. (Bottom right) This gypsum residual (GR) contains residual unhydrated hemihydrate. Both types of residual are relatively rare in this fine-textured plaster coat.

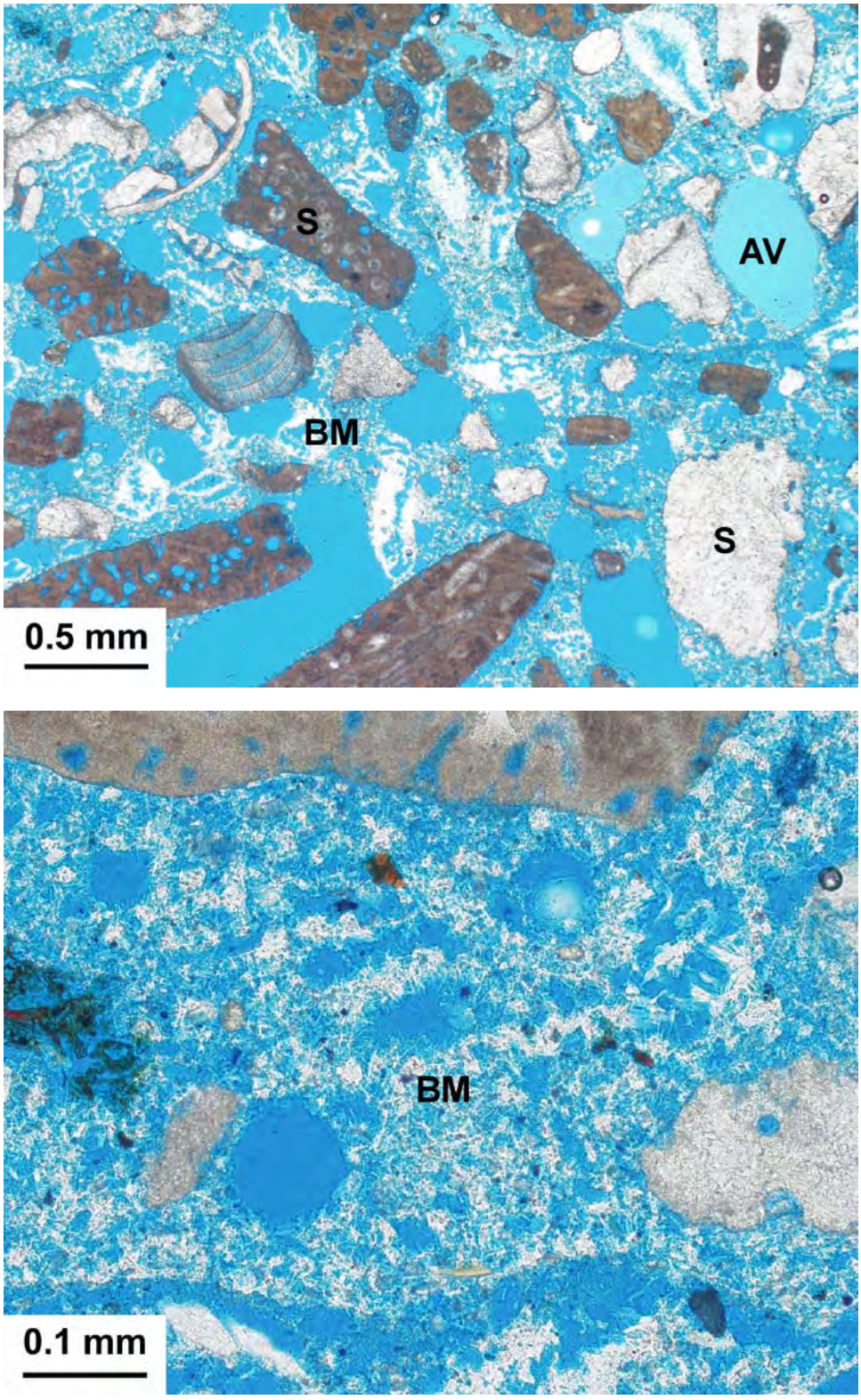



**Figure 21:** PPL photomicrographs illustrating the overall microstructure of the brown coat in sample LOKE.M.11. (Top) The binder matrix (BM) has a high capillary porosity as indicated by the high absorption of blue-dyed epoxy used in the sample preparation. The sand (S) is the same soft, natural carbonate sand found in the mortar samples. Air-voids (AV) are moderately abundant. (Bottom) The matrix is defined by a network of fine hydrated gypsum crystals. Still, the texture is somewhat coarse when compared to the finish coat (Fig. 23 below) and the plaster in this coat may have been a Keene's cement.

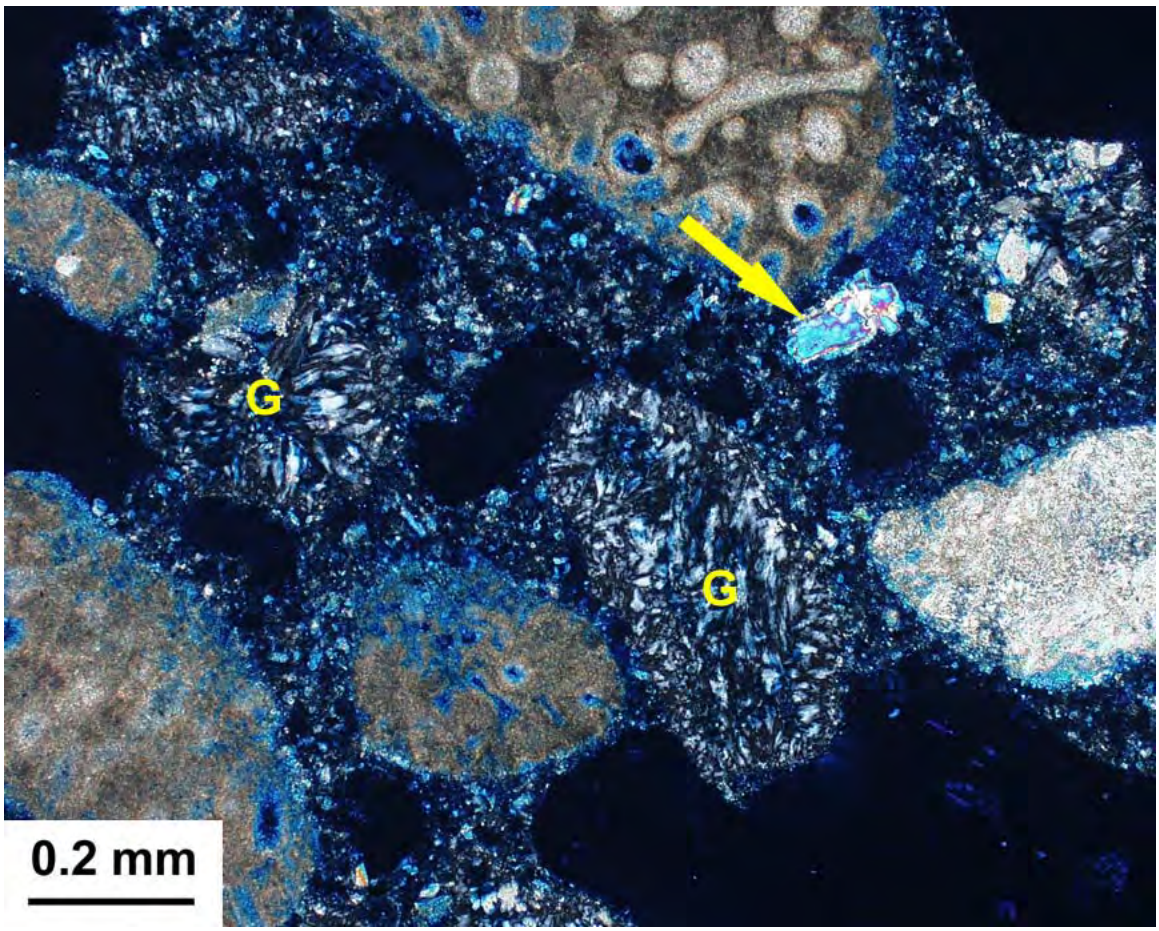



**Figure 22:** XPL photomicrographs illustrating binder residuals in the brown coat of sample LOKE.M.11. Gypsum residuals (G) represent grains of originally unhydrated hemihydrate that has hydrated to coarser grained gypsum. The arrow indicates a fine crystal of dead-burned anhydrite. This type of inclusion is typical of Keene's cement and would not be abundant in a Plaster-of-Paris.

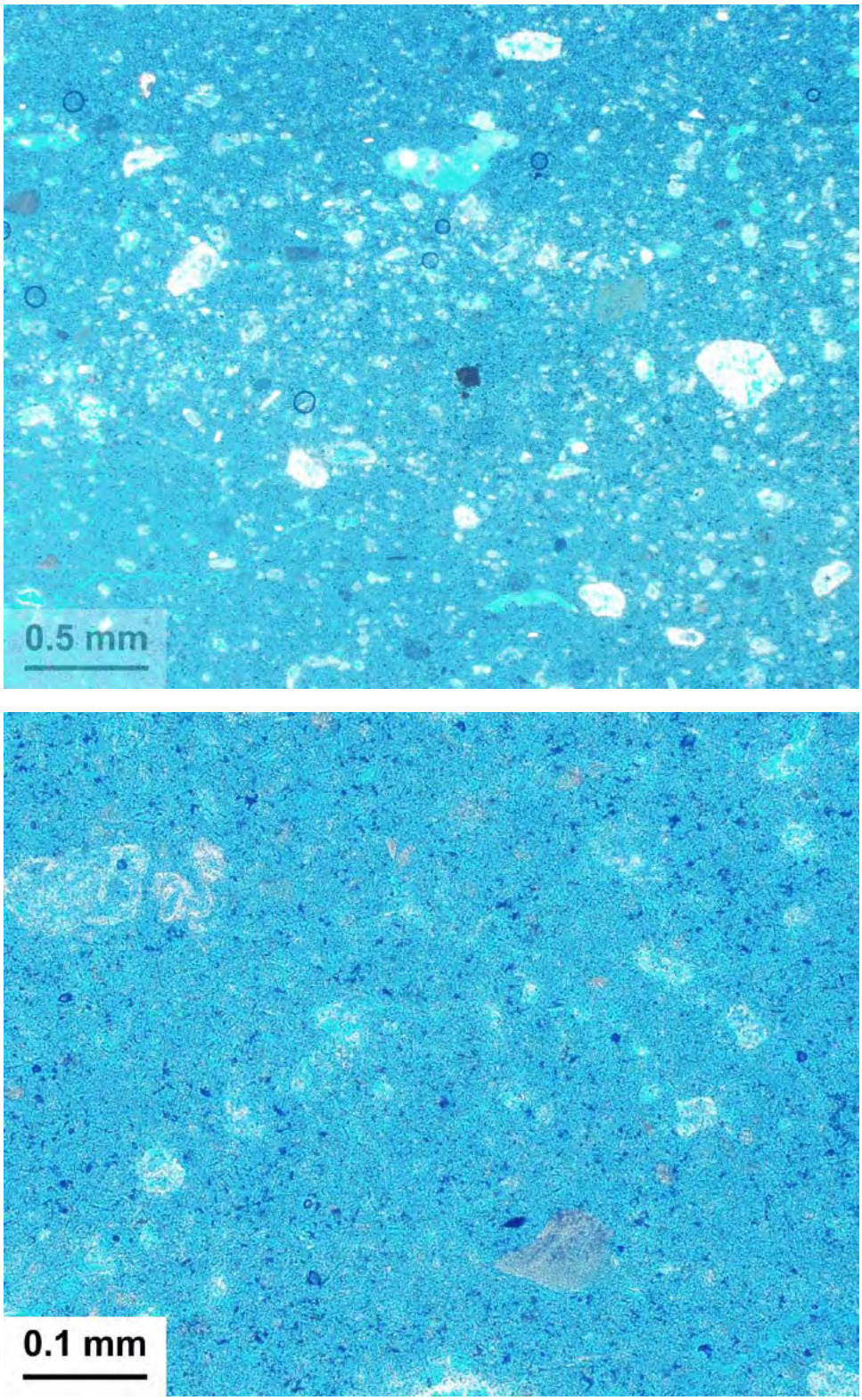



**Figure 23:** PPL photomicrographs illustrating the overall microstructure of the finish coat in sample LOKE.M.11. (Top) The binder matrix (BM) has a high capillary porosity as indicated by the high absorption of blue-dyed epoxy used in the sample preparation. The layer is unsanded and all grains observed here are part of the binder. (Bottom) The matrix is defined by a network of fine hydrated gypsum crystals. Even in this higher magnification image, the texture is difficult to see and the finish coat plaster is much finer textured.

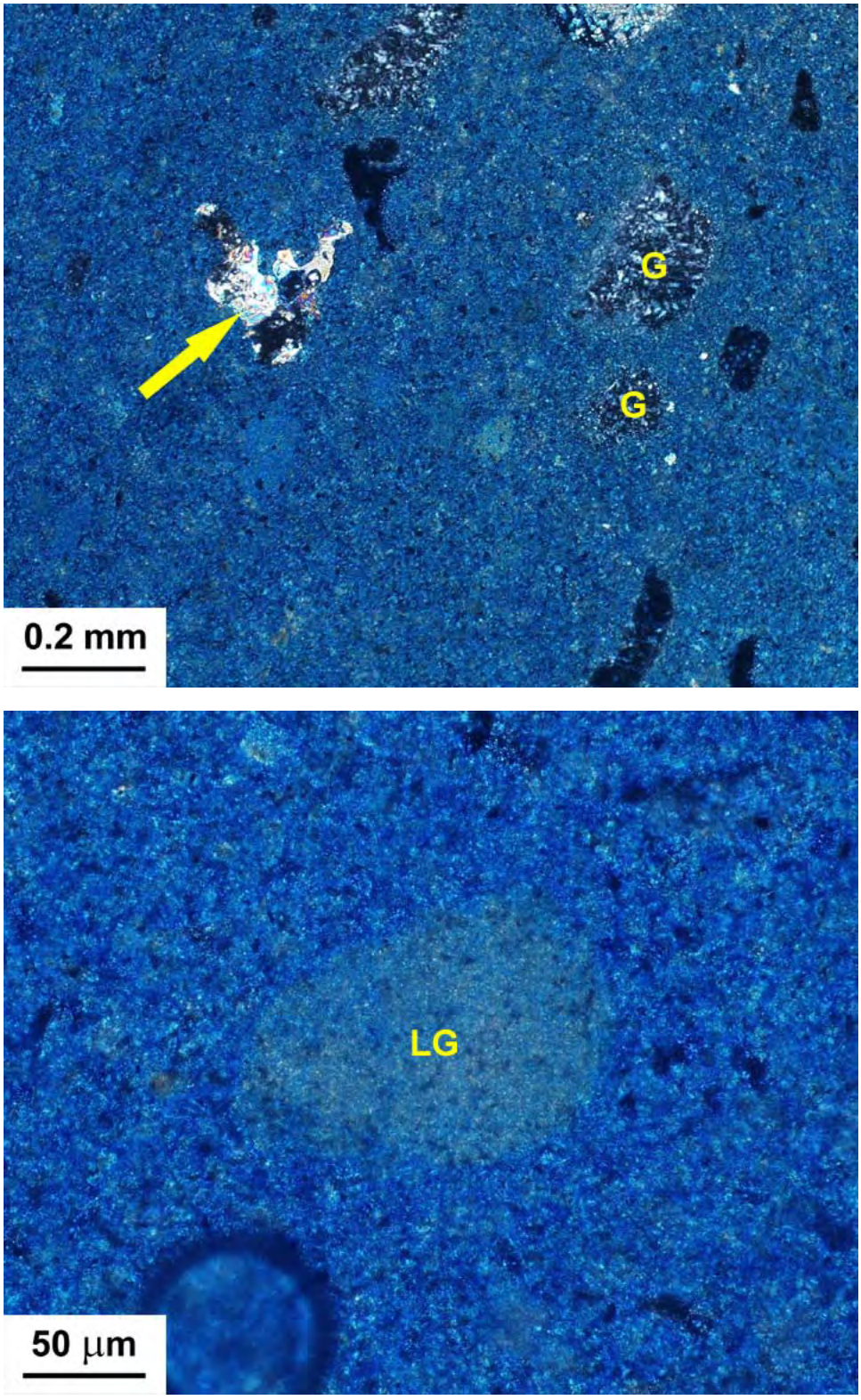



**Figure 24:** Photomicrographs illustrating binder residuals in the finish coat in sample LOKE.M.11. (Top) XPL image. Gypsum residuals (G) represent grains of originally unhydrated hemihydrate that have hydrated to coarser grained gypsum. The arrow indicates an unhydrated hemihydrate residual. Both types of residual are relatively rare in this fine-textured plaster coat. (Bottom) A carbonated lime grain is shown (LG). While chemical analysis was not performed on this sample, the lime is interpreted to represent a very minor gauging based on its observed abundance.

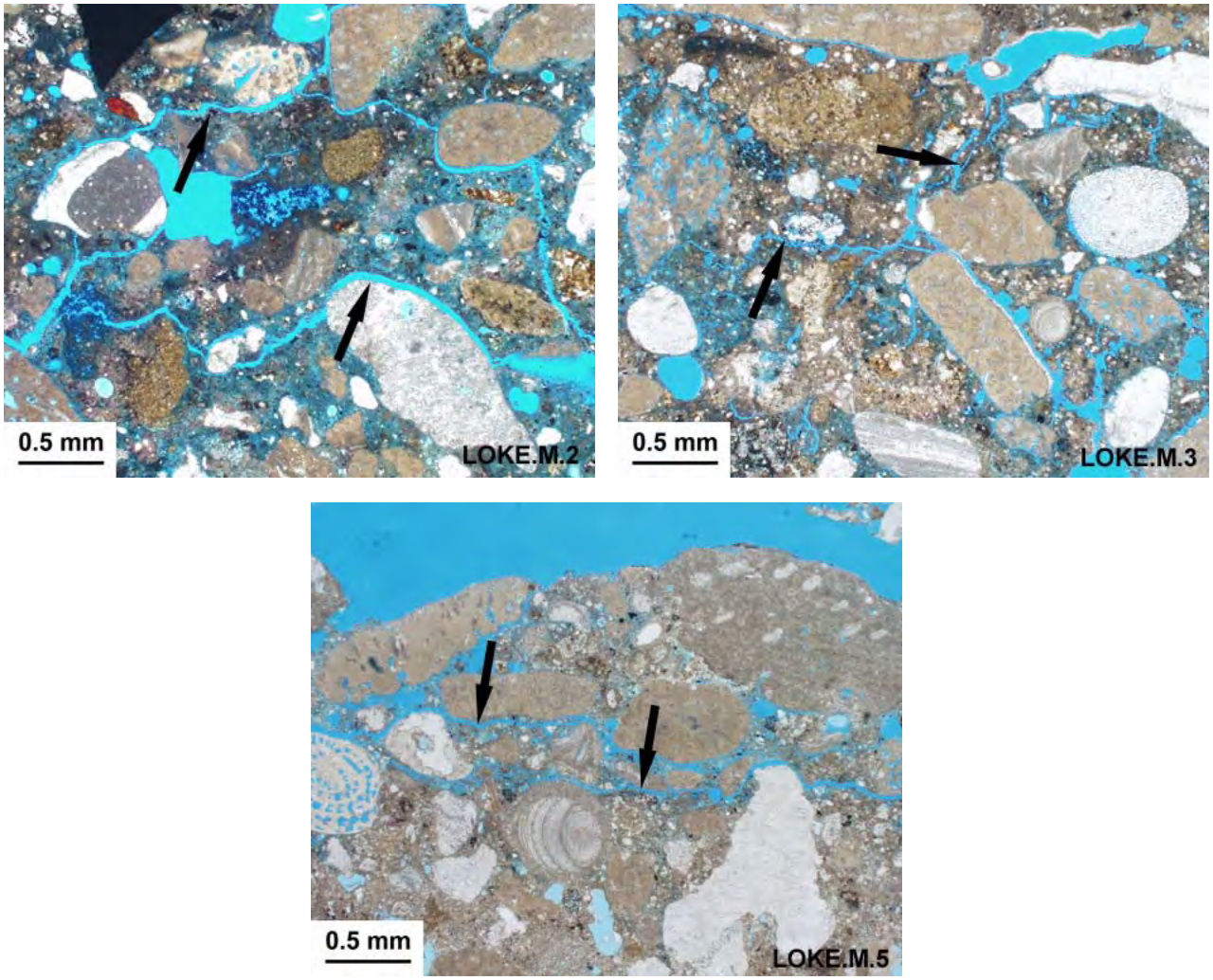



**Figure 25:** PPL photomicrographs illustrating microcracks in the cistern samples and one of the Lighthouse samples (arrows). These are minor and no sample in the examined suite exhibits any significant cracking distress.

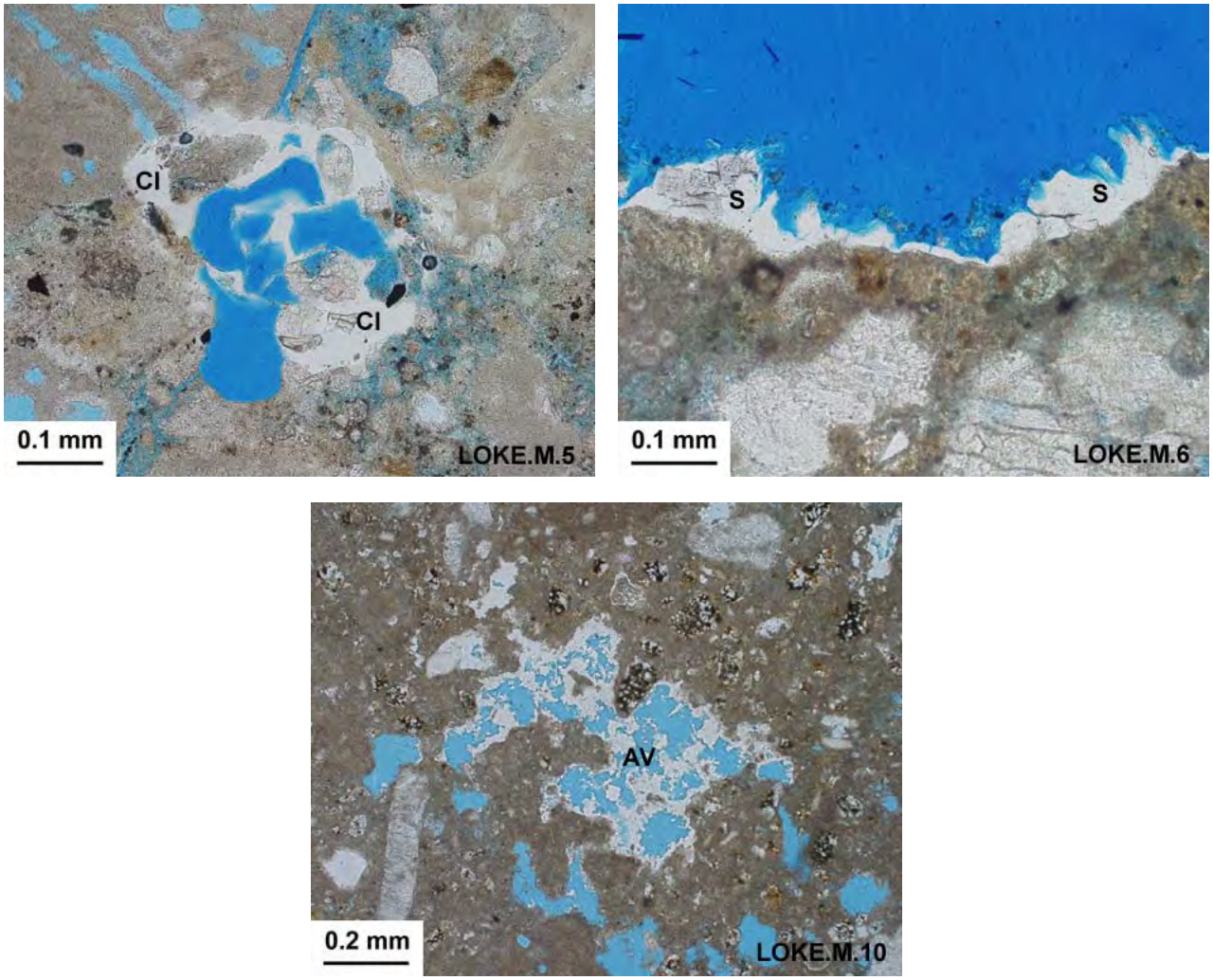



**Figure 26:** PPL photomicrographs illustrating the few secondary chemical deposits detected petrographically in the examined sample suite. No visible distress is associated with any of these deposits. (Top left) Isotropic mineral deposits consistent with chlorides (Cl) are found in low abundance in samples LOKE.M.5 and LOKE.M.6. (Top right) Fine secondary deposits consistent with sulfates (S) are quite rare. (Bottom) Some air-voids in the portland cement mortar of sample LOKE.M.10 contain linings of secondary gypsum but again, no associated distress is noted.

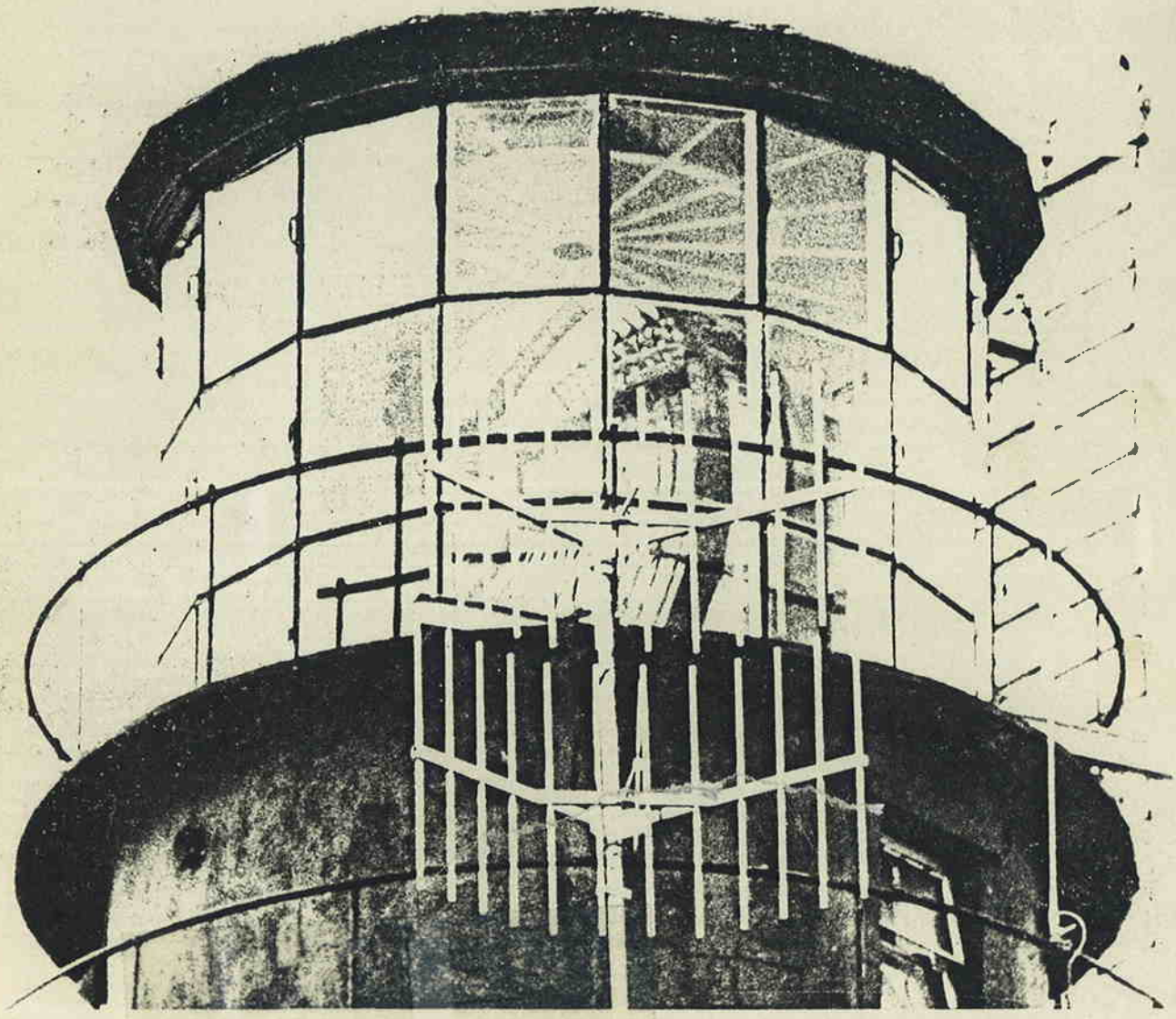
# APPENDIX C.

# REHABILITATION REPORT AND NATIONAL REGISTER NOMINATION FOR THE UNITED STATED COAST GUARD LIGHT STATION DRY TORTUGAS LIGHTHOUSE, LOGGERHEAD KEY, FLORIDA (1984)

# REHABILITATION REPORT
# and
# NATIONAL REGISTER NOMINATION

**for the**

**UNITED STATES COAST GUARD LIGHT STATION**
**DRY TORTUGAS LIGHTHOUSE**
**LOGGERHEAD KEY, FLORIDA**



## ACKNOWLEDGEMENTS

THE DOCUMENT DETAILED HEREIN WAS PREPARED BY THE STAFF OF THE DEPARTMENT OF INTERIOR, NATIONAL PARK SERVICE, NATIONAL REGISTER PROGRAMS DIVISION, PRESERVATION SERVICES BRANCH FOR THE DEPARTMENT OF TRANSPORTATION, UNITED STATES COAST GUARD, SEVENTH COAST GUARD DISTRICT. THE REHABILITATION REPORT WAS PREPARED BY RICHARD RAMSDEN, HISTORICAL ARCHITECT. THE NATIONAL REGISTER NOMINATION WAS PREPARED BY STUART JOHNSON, HISTORIAN. THE DOCUMENT WAS COMPLETED AND SUBMITTED TO THE DEPARTMENT OF TRANSPORTATION, ON OCTOBER 31, 1984.

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## National Register Nomination

SEE ATTACHED

# REHABILITATION REPORT/INTRODUCTION

THIS REHABILITATION REPORT IS MEANT TO BE USED AS A GUIDE IN THE PREPARATION OF CONTRACT DOCUMENTS. THE FOLLOWING RECOMMENDATIONS FOR REHABILITATION ARE NOT EXPECTED TO COVER THE TOTAL SCOPE OF THE LIGHTHOUSE AUTOMATION AND MODERNIZATION PROJECT, BUT WILL ADDRESS SPECIFIC ISSUES PERTAINING TO THE RECONDITIONING OF HISTORIC FABRIC.

# REHABILITATION REPORT/LIGHTHOUSE

## MASONRY TOWER - EXISTING CONDITIONS

THE EXISTING SURFACE CONDITIONS WHICH REQUIRE REHABILITATION OF THE INTERIOR AND EXTERIOR OF THE MASONRY TOWER ARE AS FOLLOWS:

1.) RANDOM BREAKDOWN OF MORTAR JOINTS IS OCCURRING AT THE WALL'S SURFACE ON BOTH THE INTERIOR AND EXTERIOR OF THE TOWER. APPROXIMATELY 20% OF THE TOWERS GROSS SURFACE AREA DEMONSTRATES THIS CONDITION. THE MORTAR JOINT DEPTH OF DETERIORATION VARIES FROM 1/8" DEEP TO 3/4" DEEP (SEE ILLUSTRATIONS I-3 & I-7). THE BREAKDOWN OF MORTAR STOPS AT 3/4" AND THE CONSISTENCY OF THE MORTAR FROM THAT DEPTH ON BECOMES STABLE. THEREFORE, UPON INSPECTION AND ANALYSIS OF THE MASONRY TOWER AND MORTAR SAMPLES, IT CAN BE CONCLUDED THAT THE BREAKDOWN IS CONFINED TO THE AREA AT THE FACE OF THE WALL ON BOTH INTERIOR AND EXTERIOR SURFACES.

2.) THE PAINT HAS LOST ITS ABILITY TO ADHERE AT THE AREAS WHERE THE MORTAR IS BREAKING DOWN ON BOTH THE INTERIOR AND EXTERIOR SURFACES.

## RECOMMENDATIONS FOR RECONDITIONING

THE RECOMMENDATIONS FOR RECONDITIONING OF INTERIOR AND EXTERIOR WALL SURFACES ON THE MASONRY TOWER ARE AS FOLLOWS:

1.) THE MORTAR JOINTS DEMONSTRATING FAILURE SHOULD BE REPOINTED. THE REMOVAL OF DETERIORATED MORTAR SHOULD BE CARRIED OUT BY TRAINED CRAFTS-MEN FAMILIAR WITH REPOINTING TECHNIQUES FOR

HISTORIC BUILDINGS. DETERIORATED MORTAR SHOULD BE RESTORED BY MANUAL MEANS ONLY; I.E. HAND RAKING OR STIFF BRISTLE BRUSHES SHOULD BE USED. THE DEPTH OF MORTAR REMOVAL SHOULD BE APPROXIMATELY 1 INCH THUS ALLOWING SUFFICIENT DEPTH FOR BEDDING. JOINTS DEMONSTRATING 1/8" OR LESS BREAKDOWN WITH STABLE MORTAR BACK UP SHOULD NOT BE REPOINTED BUT BRUSHED CLEAN. MECHANICAL DEVICES I.E. POWER GRINDERS, SAWS, ETC., SHOULD NOT BE USED IN ATTAINING SUFFICIENT BEDDING DEPTH. (SEE ENCLOSED PRESERVATION BRIEF # 2 FOR FURTHER DISCUSSION ON PROPER TECHNIQUES AND PRECAUTIONS). THE NEW MORTAR APPLICATION SHOULD DUPLICATE THE EXISTING INTACT STABLE JOINT PROFILE. THE COMPOUND/MIX USED IN REPOINTING SHOULD BE THAT RECOMMENDED IN THE MORTAR ANALYSIS FURNISHED BY LAW ENGINEERING TESTING COMPANY. (LETC PP 11 THRU 16)

2.) UPON PROPER PREPARATION OF WALL SURFACES, BOTH EXTERIOR AND INTERIOR, A NEW APPLICATION OF PAINT SHOULD BE APPLIED. THE PAINT USED SHOULD CONFORM TO RECOMMENDATIONS AND SPECIFICATIONS BY LETC (ENCLOSED).

PAINT ANALYSIS OF THE EXISTING FACE OF THE MASONRY TOWER CONCLUDES THAT THERE ARE TWO EXISTING LAYERS OF PAINT. THIS CONDITION COUPLED WITH THE 20% EXISTING DETERIORATION CAUSED BY THE MORTAR BREAKDOWN POINT TO THE REMOVAL AND APPLICATION OF NEW PAINT AS THE RECOMMENDED ACTION. THE EXISTING LAYERS OF PAINT SHOULD BE REMOVED BEFORE A NEW APPLICATION OF AN ALKALI RESISTANT PAINT IS APPLIED. REMOVAL OF PAINT LAYERS SHOULD BE PERFORMED BY THE GENTLEST MEANS POSSIBLE. (SEE ENCLOSED PRESERVATION BRIEF #6 FOR FURTHER DISCUSSION ON PROPER TECHNIQUES

AND PRECAUTIONS). A LARGE NUMBER OF RESTORATION CLEANERS EXIST ON TODAY'S MARKET SUCH AS PRO SO CO "SURE-KLEAN RESTORATION CLEANER", AND DIEDRICH 606 MULTI LAYER PAINT REMOVER "DIEDRICH CHEMICAL". CHEMICAL CLEANING WITH CHEMICALS SUCH AS HYDROCHLORIC (MURIATIC) ACID AND MECHANICAL CLEANING WITH GRINDERS AND SANDING DISCS SHOULD BE AVOIDED AT ALL TIMES. THE RESTORATION CLEANER USED SHOULD BE PATCH TESTED PRIOR TO GENERAL APPLICATION. MOST RESTORATION CLEANERS REQUIRE PRESSURE WASH RINSES OF APPLIED SOLVENTS. BUT BY NO MEANS SHOULD THE WATER RINSE BE ALLOWED TO EXCEED 600 PSI/6 GALLONS PER MINUTE. FURTHER DISCUSSION CONCERNING THIS SUBJECT CAN BE FOUND IN PRESERVATION BRIEF #1 ENCLOSED.

THIS CONCLUDES THE RECOMMENDATIONS FOR RECONDITIONING OF THE MASONRY TOWER.

**GALLERY/WATCH ROOM** - EXISTING CONDITIONS (ILLUSTRATIONS 2,9,& 10)

THE EXISTING STRUCTURAL AND SURFACE CONDITIONS WHICH REQUIRE REHABILITATION OF THE INTERIOR AND EXTERIOR OF THE MASONRY GALLERY ARE AS FOLLOWS:

1.) THE INTERIOR AND EXTERIOR STUCCOED SURFACES OF THE WATCHROOM ARE IN STRUCTURAL DISREPAIR. VISUAL EXAMINATION DEMONSTRATES VERTICAL AND HORIZONTAL CRACKS AT THE SURFACE. STUCCO AT THE UPPER PART OF THE ARCHED DOOR IS CRACKING AND FALLING OFF. THE SURFACE CRACKS ARE NUMEROUS ON BOTH THE INTERIOR AND EXTERIOR WALL SURFACES. THESE CRACKS ARE FOLLOWING A MASONRY VERTICAL/ HORIZONTAL COURSE PATTERN.

2.) THE EXTERIOR RAIL AND PICKET ASSEMBLY ON THIS LEVEL SHOWS SEVERE CORROSIVE DETERIORATION, SPECIFICALLY, AT CONNECTIONS.

RECOMMENDATIONS FOR RECONDITIONING.

THE RECOMMENDATIONS FOR RECONDITIONING THE WATCH ROOM ARE AS FOLLOWS:

1.) BOTH INTERIOR AND EXTERIOR STUCCO SURFACES SHOULD BE REMOVED FOR STRUCTURAL MASONRY EXAMINATION AND PROBABLE REPAIR. A REFERENCE FROM THE UNITED STATES COAST GUARD CLIPPING FILE DATED 1875 DESCRIBES ALTERATIONS UNDERTAKEN THEN. BE WATCHFUL FOR THOSE MODIFICATIONS AS DESCRIBED HEREIN BELOW:

"IN ORDER TO CONTINUE THE LIGHT, REPAIRS TO THE OLD TOWER WERE ESSENTIAL, AS THE UPPER PORTION WAS CONSIDERED UNSAFE IN HIGH WINDS. THE OLD PART, FOR A DISTANCE OF 8 OR 9 FEET BELOW THE LANTERN, INCLUDING WATCH-ROOM WALLS, HAS BEEN ENTIRELY REBUILT, AND THE ANCHORS OF THE LANTERN EXTENDED DOWNWARD THROUGH THE ENTIRE DISTANCE, WITHOUT IN ANY WAY INTERFERING WITH THE REGULAR EXHIBITION OF THE LIGHT. WHEN IT IS REMEMBERED THAT THE TOWER IS ABOUT 150 FEET HIGH, THE DIFFICULTY IN MAKING THESE REPAIRS WILL BE BETTER APPRECIATED. THEY WERE ACCOMPLISHED BY CUTTING OUT THE OLD MASONRY IN NARROW VERTICAL SECTIONS, REPLACING EACH SECTION ENTIRE BEFORE REMOVING THE NEXT."

IF THE LANTERN ASSEMBLY TIE RODS ARE IN FACT EMBEDDED IN THE MASONRY OR STUCCO THEY SHOULD, UPON DISCOVERY, BE INSPECTED FOR STRUCTURAL SOUNDNESS. IF SURFACE CORROSION IS PRESENT, THE TIE RODS SHOULD BE PREPPED AND TREATED WITH AN ANTI-CORROSIVE COATING. THE MASONRY WALL UNITS AND MORTAR JOINTS SHOULD BE INSPECTED FOR STRUCTURAL SOUNDNESS AND CONSEQUENT REPAIRABILITY. STRUCTURAL REPAIRS TO THE WATCH ROOM

WALL AT THIS POINT MAY CONSIST OF MINOR REPOINTING RANGING TO REMOVAL AND REPLACEMENT OF ISOLATED WHOLE SECTIONS AS REQUIRED IN THE 1875 REHABILITATION.

AFTER STRUCTURAL REPAIRS ARE MADE TO THE TIE RODS, MASONRY UNITS AND MORTAR JOINTS; THE WATCH ROOM PERIMETER WALL SHOULD BE RESTUCCOED ON THE EXTERIOR WITH A WATER RESISTANT MIX. TWO VERTICAL CONTROL JOINTS AT MID POINTS SHOULD BE INCORPORATED TO ALLOW MOVEMENT OF SURFACE FABRIC.

2.) EXTERIOR RAIL AND PICKET ASSEMBLY SHOULD BE BLAST-CLEANED TO REMOVE EXISTING PAINT AND CORROSIVE SCALING AND PITTING. AFTER SURFACE IS CLEANED, CONNECTIONS SHOULD BE INSPECTED FOR STRUCTURAL SOUNDNESS. BOLT AND THREADED PICKETS WHICH NEED REPLACING SHOULD BE REPLACED WITH A COMPATIBLE SUBSTITUTE. UPON COMPLETION OF SURFACE PREPARATION AND REPLACEMENT OF DETERIORATED MEMBERS, ALL RAIL AND PICKET SURFACES SHOULD BE TREATED WITH A SELF-CURING COATING WHICH IS HARD, ABRASION RESISTANT AND PROVIDES CATHODIC PROTECTION SIMILAR TO GALVANIZING.

NOTE: A VISUAL INSPECTION OF THE CAT WALK AT THE WATCH ROOM LEVEL SHOWS NO STRUCTURAL OR SURFACE DETERIORATION. AS A MAINTENANCE PRECAUTION, THE STAINLESS STEEL TENSION COLLAR SHOULD BE INSPECTED FOR TORQUE RESISTENCE ONLY.

THIS CONCLUDES THE RECOMMENDATIONS FOR RECONDITIONING THE GALLERY/WATCH ROOM.

**METAL LANTERN ROOM** - EXISTING CONDITIONS (ILLUSTRATIONS 2,3,8 & 9)

THE EXISTING SURFACE CONDITIONS WHICH REQUIRE REHABILITATION ON THE EXTERIOR OF THE LANTERN ROOM ARE AS FOLLOWS:

1.) THE RAIL AND PICKET ASSEMBLY HAVE DETERIORATED TO THE SAME CONDITION AS THAT OF THE ASSEMBLY ON THE WATCH ROOM LEVEL. THE METAL CAT WALK SURFACE IS IN FAIR CONDITION BUT THE CONNECTIONS ARE SHOWING SEVERE SIGNS OF CORROSIVE DETERIORATION.

IN ADDITION IT HAS BECOME DESIRABLE TO EFFECT THE FOLLOWING ALTERATIONS:

A.) BULLET PROOF GLAZING IS REQUIRED IN ORDER TO CURB VANDALISM OF THE LIGHT.

B.) THE FRENCH LENS ASSEMBLY HAS TO BE REMOVED TO FACILIATE AUTOMATION.

NOTE: THE STRUCTURAL INTEGRITY OF THE METAL LANTERN ROOM IS EXCELLENT.

RECOMMENDATIONS FOR RECONDITIONING AND AUTOMATION

THE FOLLOWING ARE RECOMMENDATIONS ADDRESSING THE REHABILITATION ISSUES OF THE METAL LANTERN ROOM:

1.) THE RAIL AND PICKET ASSEMBLY SHOULD BE RE-HABILITATED IN A MANNER SIMILAR TO THAT RECOMMENDED FOR THE GALLERY/WATCH ROOM ASSEMBLY WHICH WAS DISCUSSED EARLIER. (REFER TO GALLERY/WATCHROOM, ITEM #2 PAGE 6).

THE CANTILEVERED METAL CAT WALK SHOULD BE BLASTED CLEAN WITH SAND. THE NUT AND BOLT CONNECTIONS ON THE UNDER SIDE SHOULD BE REPLACED IN-KIND WITH A COMPATIBLE METAL. THE EXISTING SURFACE SHOULD THEN BE TREATED WITH AN ANTI-CORROSIVE PAINT.

2.) THE EXISTING WIRE SAFETY GLASS AND CAULKING BED WILL NEED TO BE REMOVED. UPON REMOVAL OF THE GLAZING, THE STEEL FRAMES SHOULD THEN BE PREPPED FOR PAINTING BY LIGHT BLAST CLEANING WITH SAND (80-100PSI). NEXT, AN ANTI-CORROSIVE PRIMER SHOULD BE APPLIED TO ALL METAL SURFACES. INDIVIDUAL BULLET PROOF PANES SHOULD THEN BE INSTALLED IN THE EXISTING GRID CONFIGURATION. NEW METAL STOPS/GLAZING ANGLES WHICH ARE NOW SECURED TO THE STRUCTURAL GRID WILL NEED TO BE FABRICATED TO COMPENSATE FOR THE ADDED THICKNESS IN GLAZING. AT PRESENT, THE EXISTING FACE GLAZING ANGLES ARE SECURED TO THE GRID WITH SCREWS. THIS DETAIL IS CAUSING MOISTURE PROBLEMS. THE PROBLEM CAN BE ALLEVIATED BY USE OF A PROPER SEALANT MATERIAL AND GLAZING ANGLES WITH A STIFFER DESIGNED SECTION MODULAS. THE FACE SEALANT TYPE USED IN RETROFIT SHOULD BE POLYURETHANE OR VINYL ACRYLIC. FURTHER DISCUSSION CONCERNING THIS SUBJECT CAN BE FOUND IN PRESERVATION BRIEF #13, ENCLOSED.

3.) THE FRENCH LENS ASSEMBLY SHOULD BE REMOVED FROM THE LANTERN ROOM PRIOR TO REHABILITATION. ON SITE STORAGE OR STORAGE AT OTHER COAST GUARD FACILITIES IS ADEQUATE BUT NOT PREFERABLE. A COMPETENT MUSEUM THAT SPECIALIZES IN NAVAL AND/OR LIGHTHOUSE ARTIFACTS SHOULD BE CONTACTED AND ARRANGEMENTS MADE FOR DISPOSITION OF THE ASSEMBLY TO THAT FACILITY.

THIS CONCLUDES THE RECOMMENDATIONS FOR RECONDITIONING AND AUTOMATION OF THE METAL LANTERN ROOM.

**COPPER DOME AND FINIAL** - EXISTING CONDITIONS (ILLUSTRATIONS 2,5,&6)

THE EXISTING SURFACE CONDITIONS ARE AS FOLLOWS:

1.) THE COPPER DOME HAS HAD SEVERAL LAYERS OF TAR APPLIED TO ITS ENTIRE EXTERIOR SURFACE.

2.) THE FINIAL IS IN GOOD CONDITION WITH TAR ALSO APPLIED TO ITS SURFACE.

RECOMMENDATIONS FOR RECONDITIONING.

THE RECOMMENDATIONS FOR RECONDITIONING THE COPPER DOME AND FINIAL ARE AS FOLLOWS:

1.) AT PRESENT, IT IS INDECERNABLE WHETHER OR NOT THE COPPER SHEATHING CAN BE REPAIRED. USING STRIPPERS, THE TAR MUST BE REMOVED TO PROPERLY ASSESS THE AMOUNT OF DAMAGE TO THE HISTORIC FABRIC. THIS INVESTIGATION IS RECOMMENDED FIRST OVER TOTAL IMMEDIATE REPLACEMENT AS A MEASURE WHICH MIGHT SAVE THE EXISTING HISTORIC FABRIC, IN ADDITION TO MODERATING COSTS. IF IT IS FINALLY DETERMINED THAT REPAIR TO THE DOME IS NOT POSSIBLE, THEN REPLACEMENT IN-KIND IS RECOMMENDED.

IN EITHER CASE, THE EXISTING FINIAL SHOULD BE CLEANED AND RETAINED.

THIS CONCLUDES THE RECOMMENDATIONS FOR RECONDITIONING OF THE DOME AND FINIAL AND ALSO CONCLUDES THE INVESTIGATION OF THE DRY TORTUGAS LIGHTHOUSE, PROPER.

# REHABILITATION REPORT/SUPPORT STRUCTURES

**Bosun's Work Shop, Radio Room, Guest House, Crews Quarters and Masonry Cisterns** - EXISTING CONDITIONS (ILLUSTRATION I-1)

THE EXTERIOR AND INTERIOR OF THE SUPPORT STRUCTURES LISTED ABOVE ARE IN STABLE CONDITION.

RECOMMENDATIONS

IF THE INTERIOR SURFACES ARE TO BE REHABILITATED, CONSIDERATION SHOULD BE GIVEN TO THE REMOVAL OF APPLIED NON-HISTORIC FABRIC I.E., SIMULATED WOOD PANELING AND THE RETENTION OF HISTORIC ROOM CONFIGURATIONS.

THIS CONCLUDES THE OBSERVATION CONCERNING THE SUPPORT STRUCTURES.

**LAW ENGINEERING TESTING COMPANY**
geotechnical, environmental & construction materials consultants
396 PLASTERS AVENUE, N.E.
P.O. BOX 13260 • ATLANTA, GEORGIA 30324
(404) 873-4761

August 2, 1984

National Park Service
Southeast Regional Office
75 Spring Street S.W.
Suite 1140
Atlanta, Georgia 30303

Attention: Mr. Richard Ramsden

Subject: Engineering Evaluation
of Paint and Mortar Samples
United States Coast Guard
Dry Tortugas Lighthouse
Key West, Florida
LETCO Job Number G-10170

Dear Mr. Ramsden:

As authorized by your purchase order PX 5000-4-0666, an engineering evaluation was performed on paint and mortar samples taken from the Dry Tortugas Lighthouse in Key West, Florida and delivered to Law Engineering Testing Company. The purpose of the work was to determine the possible causes of mortar breakdown and the composition of the paint of the lighthouse.

## BACKGROUND

Background information was furnished by Mr. Richard Ramsden of National Park Service.

The Dry Tortugas Lighthouse has been a landmark in southern Florida for approximately 100 years. Recent collapses of the mortar and bricks brought the need to renovate the structure. Testing of the mortar and paint was requested to restore the lighthouse to its original condition with the same type materials.

## INVESTIGATIVE PROCEDURES

The as-received samples of mortar and paint were submitted for chemical analysis to determine the composition of each. This data was then utilized to determine the cause of mortar breakdown, paint type and possible recommendations to prevent further deterioration.

## MORTAR ANALYSIS

The chemical analysis of the mortar samples submitted was performed in accordance with the general procedures outlined in ASTM C 85, "Cement Content of Hardened Portland Cement Concrete". The results of the chemical analysis are presented in the attached Table I.

Pieces of the mortar were examined under the stereo microscope to evaluate the aggregates and to assist in the analysis of the mortar. The fine aggregate in the mortar is a combination of fine silica sand and broken shells. The paste appeared to be a dull tan color.

The shell aggregates are calcium carbonate and appear in the chemical analysis as soluble calcium oxide, the same as lime. Because of this it is not possible to determine the exact proportions of the mortar. There appears to be a small percentage of portland cement in the mortar and possibly some gypsum. The majority of the cementitious binder is lime. The aggregate is silica sand and shells (calcium carbonate).

The proportions of the mortar appear to be high in lime. A mortar mixture which would probably be similar to the material in place would be:

| | |
|---|---|
| Cement | 1 part |
| Lime | 3 parts |
| Sand | 12 parts |

This mortar proportion may not be as weather resistant as a mortar which contained a higher proportion of cement. Mortars with high lime proportions harden by carbonation of the lime. These mortars can be attacked by the elements and with time become chalky and crumble. Old age has probably caused the breakdown of the existing mortar. If the mortar will be covered with paint, a mortar with a much higher cement content may be appropriate for use in repairing the lighthouse. The proportions and guidelines for selection of masonry mortars are outlined in ASTM C 270, "Specification for Mortar for Unit Masonry".

## PAINT ANALYSIS

Microscopic examination of the paint flakes showed that they consisted of two layers. Infrared analysis of each layer proved to be of similar composition. A composite analysis of the non-volatile portion is also shown in Table II. The results summarized in Table II show that the paint was primarily a lead-zinc based acrylic-polyvinyl acetate mixture and would be considered alkali resistant. This type of paint would be considered appropriate for a marine environment such as a lighthouse.

## CONCLUSIONS

Based on the engineering evaluation of the paint and mortar samples the following conclusions are relevant to the purpose of the work:

1) The paint flakes were determined to be composed of two paint coats of similar chemical composition. The paint was determined to be a lead and zinc based acrylic-polyvinyl acetate mixture which would be highly suitable for a marine environment and would be considered alkali resistant.

2) The mortar proportions can not be determined due to broken shells in the aggregate fraction. The shell fragments contain soluble calcium oxide which masks the lime content of the mortar. Based on the microscopic examination the mortar appears to contain a high proportion of lime. A mortar proportion which would probably be similar to the in place material would be:

| | |
|---|---|
| Cement | 1 part |
| Lime | 3 parts |
| Sand | 12 parts |

Please let us know if we may assist you further in this matter. Thank you for calling on LETCO.

Very truly yours,

LAW ENGINEERING TESTING COMPANY

Richard H Norris

Richard H. Norris
Staff Materials Engineer

Robert S. Jenkins, P.E.
Senior Materials Engineer

RHN:RSJ/ljh

## TABLE I

## CHEMICAL ANALYSIS OF MORTAR
## DRY TORTUGAS LIGHTHOUSE
## KEY WEST, FLORIDA
## LETCO JOB NUMBER G-10170

| | |
|---|---|
| Loss on Ignition | 39.4% |
| Total Acid Insoluble | 10.0% |
| Soluble Silica ($SiO_2$) | 1.47% |
| Calcium Oxide (CaO) | 35.4% |
| Sulfates ($SO_3$) | 1.16% |



LAW ENGINEERING TESTING COMPANY

## TABLE II

## CHEMICAL ANALYSIS OF PAINT FLAKES
## DRY TORTUGAS LIGHTHOUSE
## KEY WEST, FLORIDA
## LETCO JOB NUMBER G-10170

Binder 30.6%

Infrared spectrographic analysis of the binder showed it to be an acrylic-polyvinyl acetate mixture

Pigment 69.4%

Semiquantitative spectrographic analysis of the pigment(%):

| | |
|---|---|
| Silicon (Si) | 0.1 - 1.0 |
| Iron (Fe) | 0.1 - 1.0 |
| Aluminum (Al) | 0.1 - 1.0 |
| Calcium (Ca) | 1.0 - 10.0 |
| Magnesium (Mg) | 1.0 - 10.0 |
| Sodium (Na) | 1.0 - 10.0 |
| Potassium (K) | 0.1 - 1.0 |
| Phosphorus (P) | 0.01 - 0.1 |
| Barium (Ba) | 0.1 - 1.0 |
| Lead (Pb) | Major |
| Zinc (Zn) | Major |

Quantitative Analysis: % of Pigment

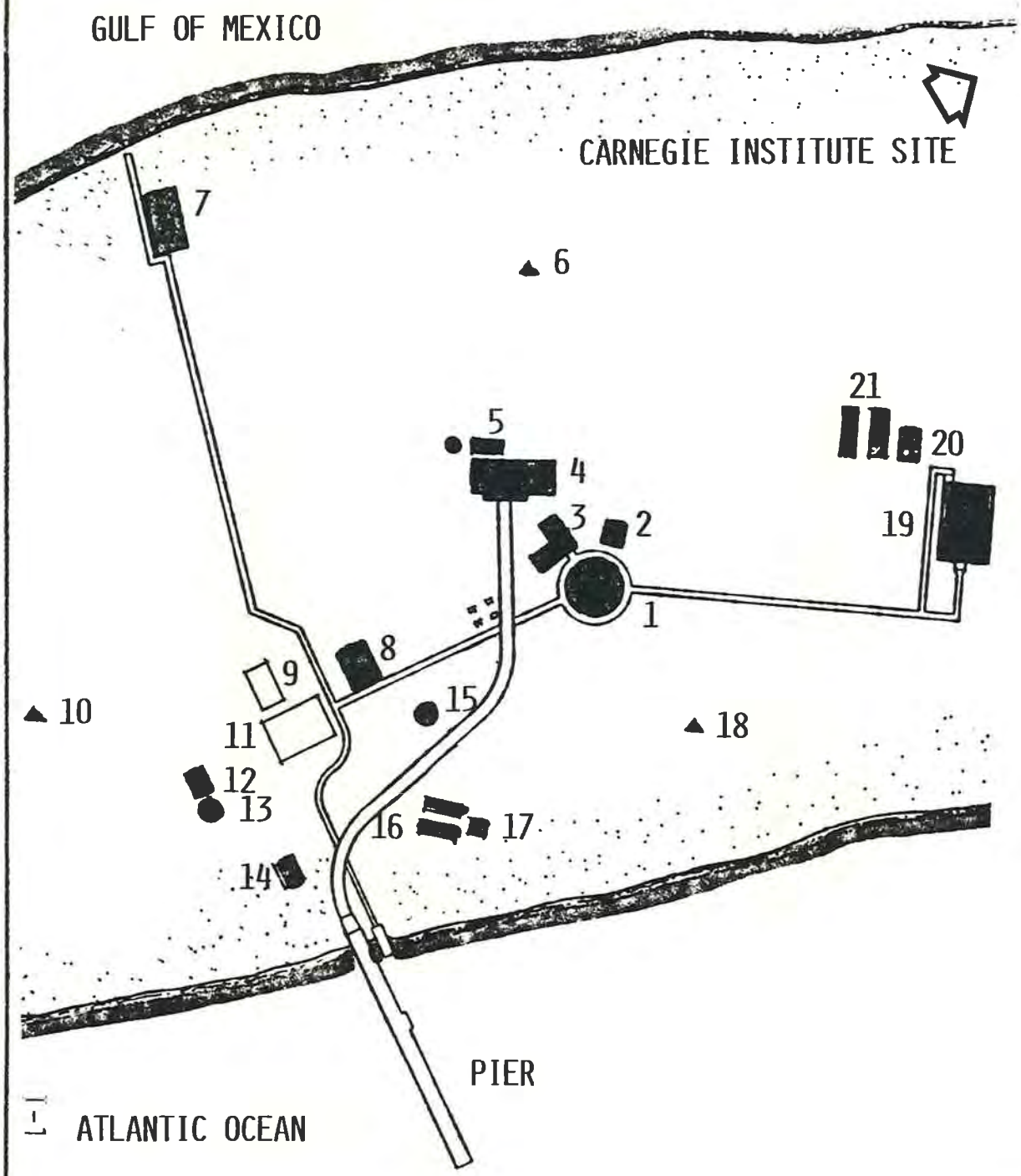
| | |
|---|---|
| Calcium Carbonate ($CaCO_3$) | 9.6 |
| Magnesium Carbonate ($MgCO_3$) | 4.5 |
| Sodium Oxide ($Na_2O$) | 3.5 |
| Lead Oxide (PbO) | 41.6 |
| Zinc Oxide (ZnO) | 28.7 |

LAW ENGINEERING TESTING COMPANY

## REHABILITATION REPORT/CONCLUSION

IF ALTERATIONS WHICH WILL IMPACT HISTORIC FABRIC, I.E., WINDOW REPLACEMENT, NEW PARTITION DESIGNS, ETC. ARE PLANNED FOR ANY OF THE BUILDINGS LISTED ON THE NATIONAL REGISTER NOMINATION, DOCUMENTATION SHOULD BE SUBMITTED TO THE NATIONAL PARK SERVICE DESCRIBING THOSE ALTERATIONS SO THAT THEY CAN BE REVIEWED FOR COMPLIANCE WITH THE SECRETARY OF THE INTERIOR'S STANDARDS FOR REHABILITATION.

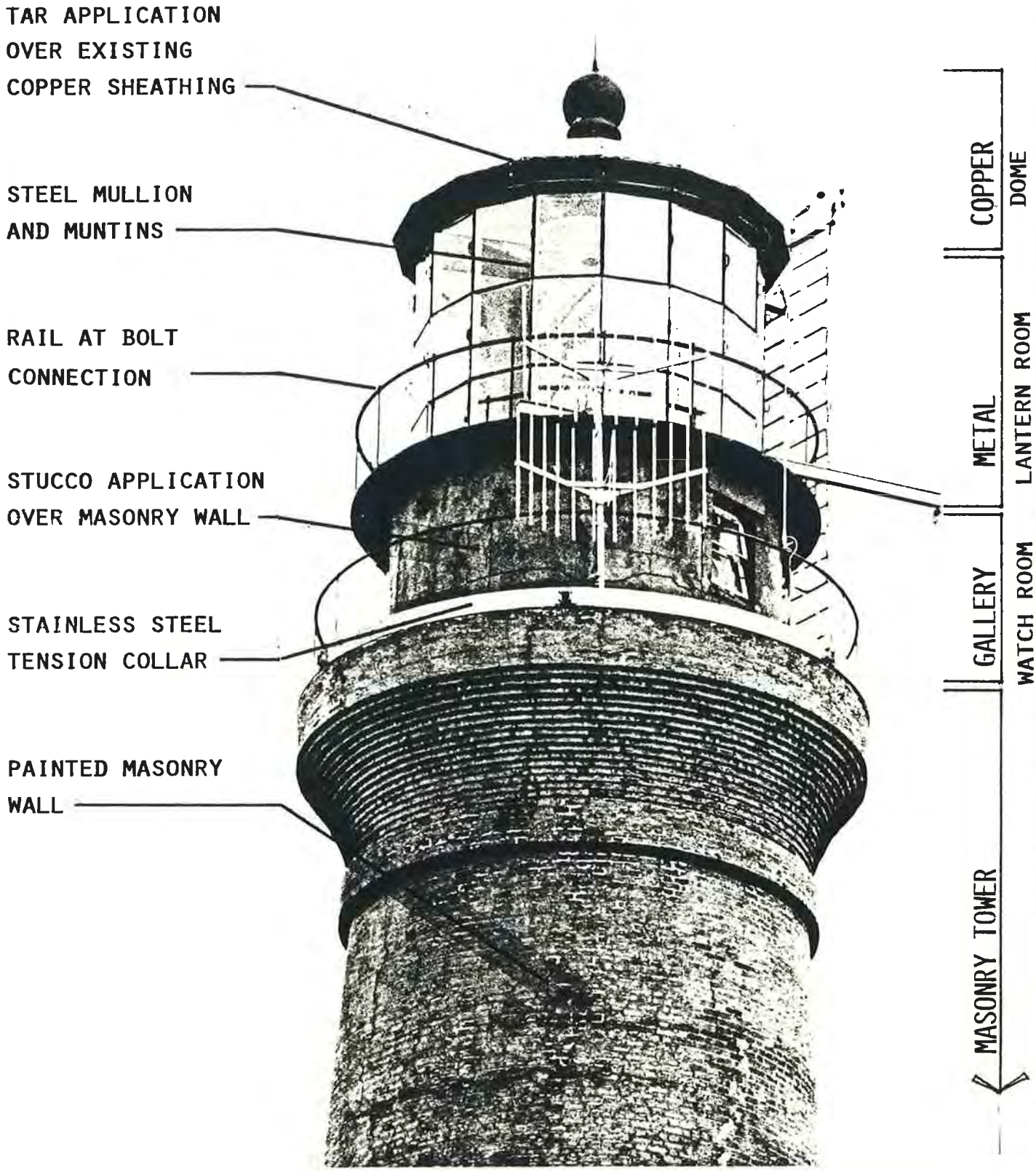
ALL AREAS OF REHABILITATION ON THIS PROJECT WHICH REQUIRE SKILLED LABOR, SHOULD BE CONTRACTED TO PROFESSIONALS AND CRAFTSMEN WHO ARE KNOWLEDGEABLE OF RESTORATION SKILLS AND TECHNIQUES.




| NO. | STRUCTURE/USE | REMARKS/MATERIAL |
|---|---|---|
| 1. | Dry Tortugas Lighthouse | Brick |
| 2. | Bosun's Work Shop (Former Oil Storage Building) | Concrete |
| 3. | Radio Room (Former Oil Storage Building) | Brick |
| 4. | Generator Building | Metal |
| 5. | Day Tanks (2-280 Gallon) Salt Water Well | N/A |
| 6. | Instrument Tower | N/A |
| 7. | Boat House | Concrete |
| 8. | Guest House (Former Kitchen Building) | Brick |
| 9. | Former Kitchen & Dining Building | Demolished |
| 10. | Radio Beacon Antenna | N/A |
| 11. | Former Assistant Keepers Apartments | Demolished |
| 12. | Cistern (10,000 Gallon) | Concrete |
| 13. | Cistern (6,400 Gallon) | Brick |
| 14. | Paint Locker | Metal |
| 15. | Cistern (8,600 Gallon) | Brick |
| 16. | Storage Tanks (2-5000 Gallon) | N/A |
| 17. | Pump House | N/A |
| 18. | Antenna | N/A |
| 19. | Crews Quarters (Former Keepers Quarters) | Brick |
| 20. | Cistern (12,000 Gallon) | Concrete |
| 21. | 2-Water Tanks | Fiberglass |

# SITE PLAN

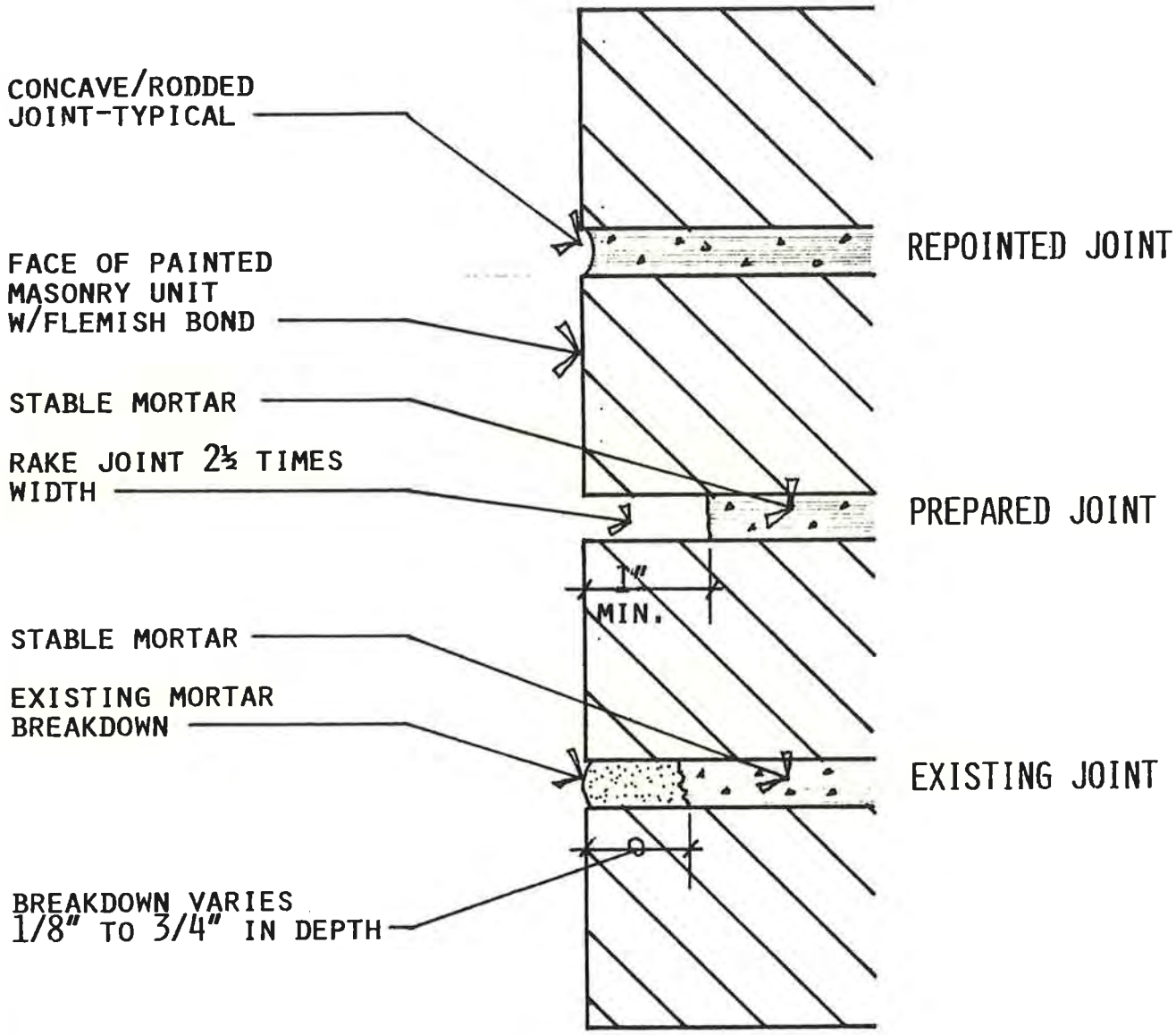
UNITED STATES COAST GUARD LIGHT STATION
DRY TORTUGAS LIGHTHOUSE
LOGGERHEAD KEY, FLORIDA




# LIGHTHOUSE ELEVATION

UNITED STATES COAST GUARD LIGHT STATION
DRY TORTUGAS LIGHTHOUSE
LOGGERHEAD KEY, FLORIDA

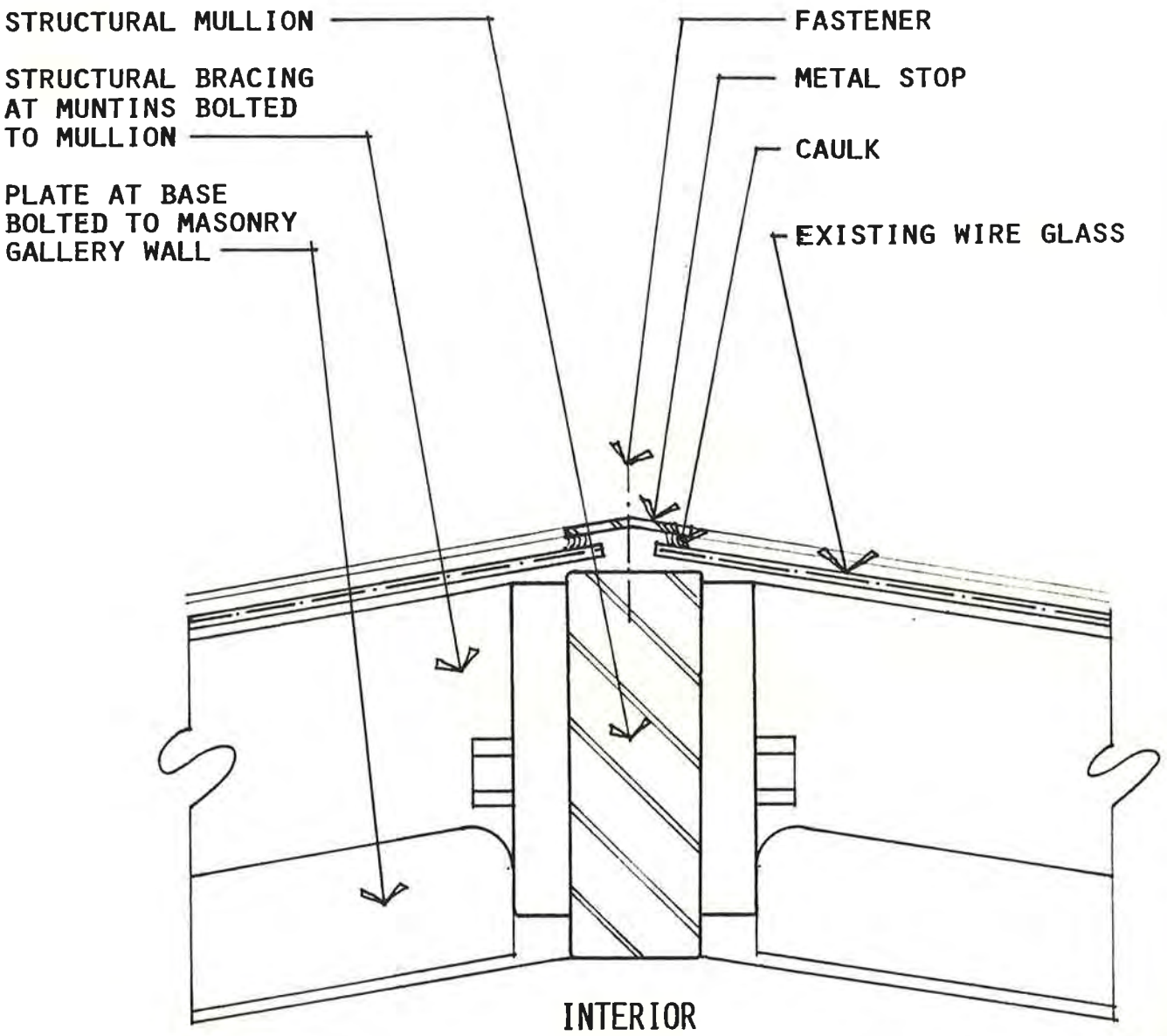
EXTERIOR/INTERIOR




# SECTION at MASONRY WALL

UNITED STATES COAST GUARD LIGHT STATION
DRY TORTUGAS LIGHTHOUSE
LOGGERHEAD KEY, FLORIDA

EXTERIOR



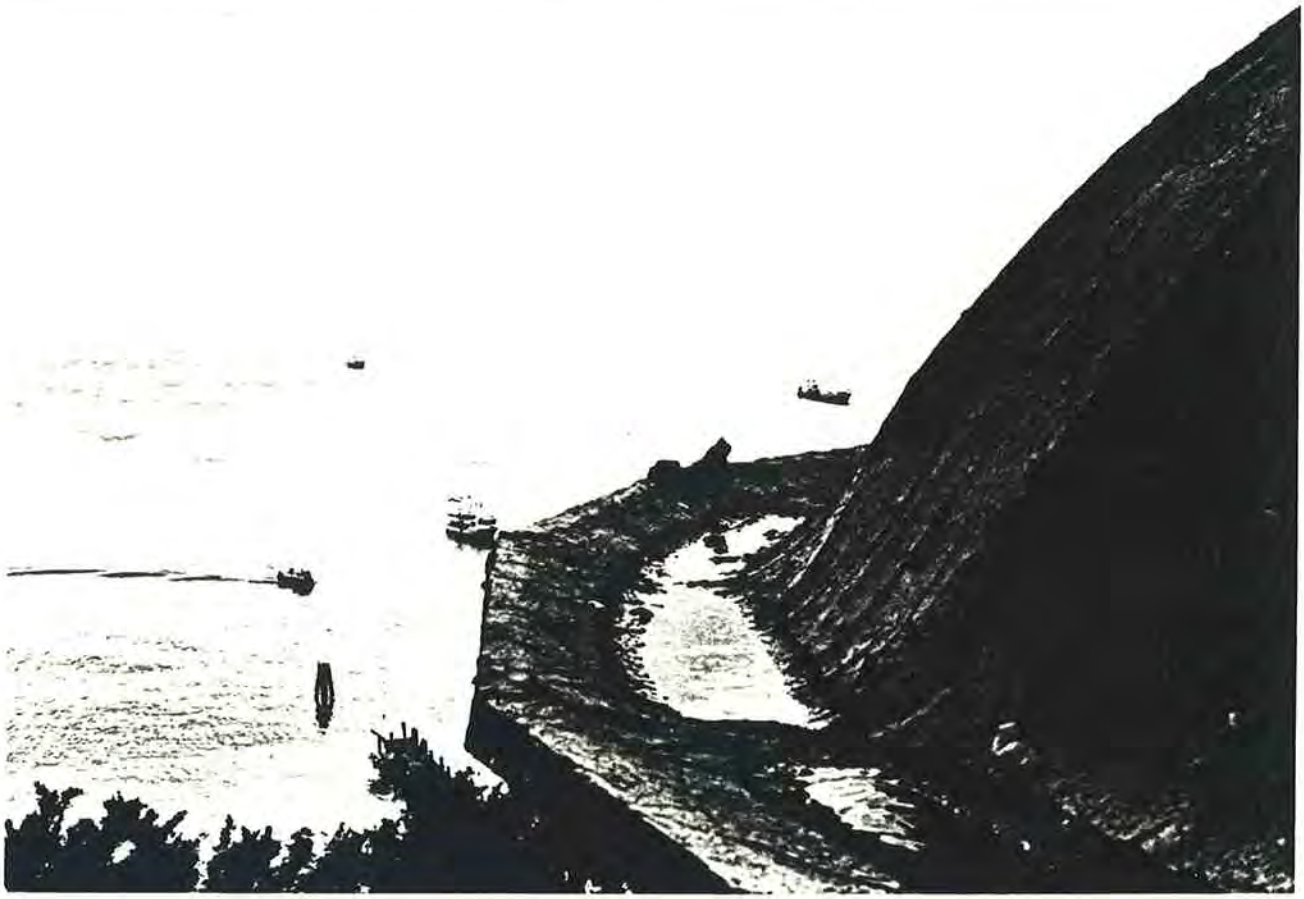

INTERIOR

# SECTION at LANTERN ROOM MULLION

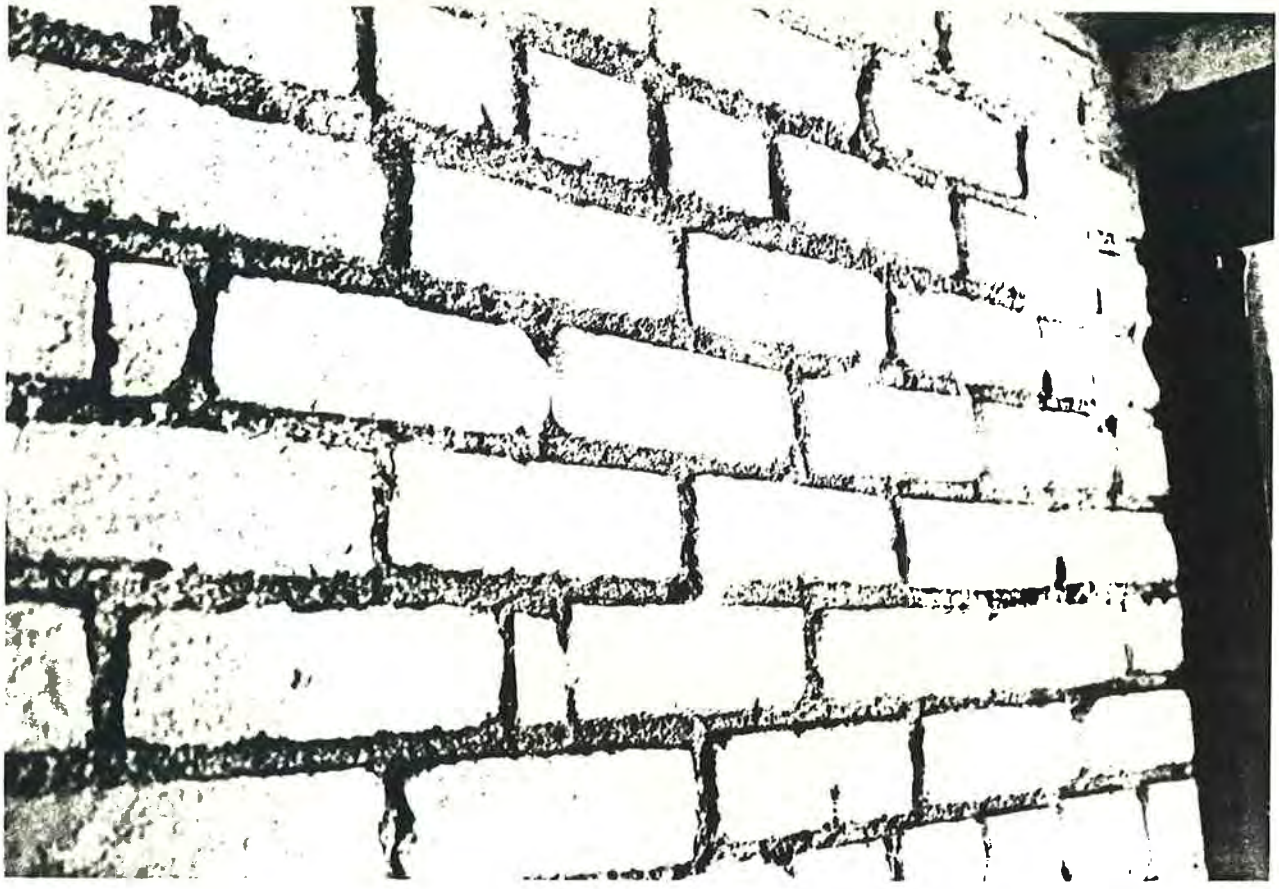
UNITED STATES COAST GUARD LIGHT STATION
DRY TORTUGAS LIGHTHOUSE
LOGGERHEAD KEY, FLORIDA



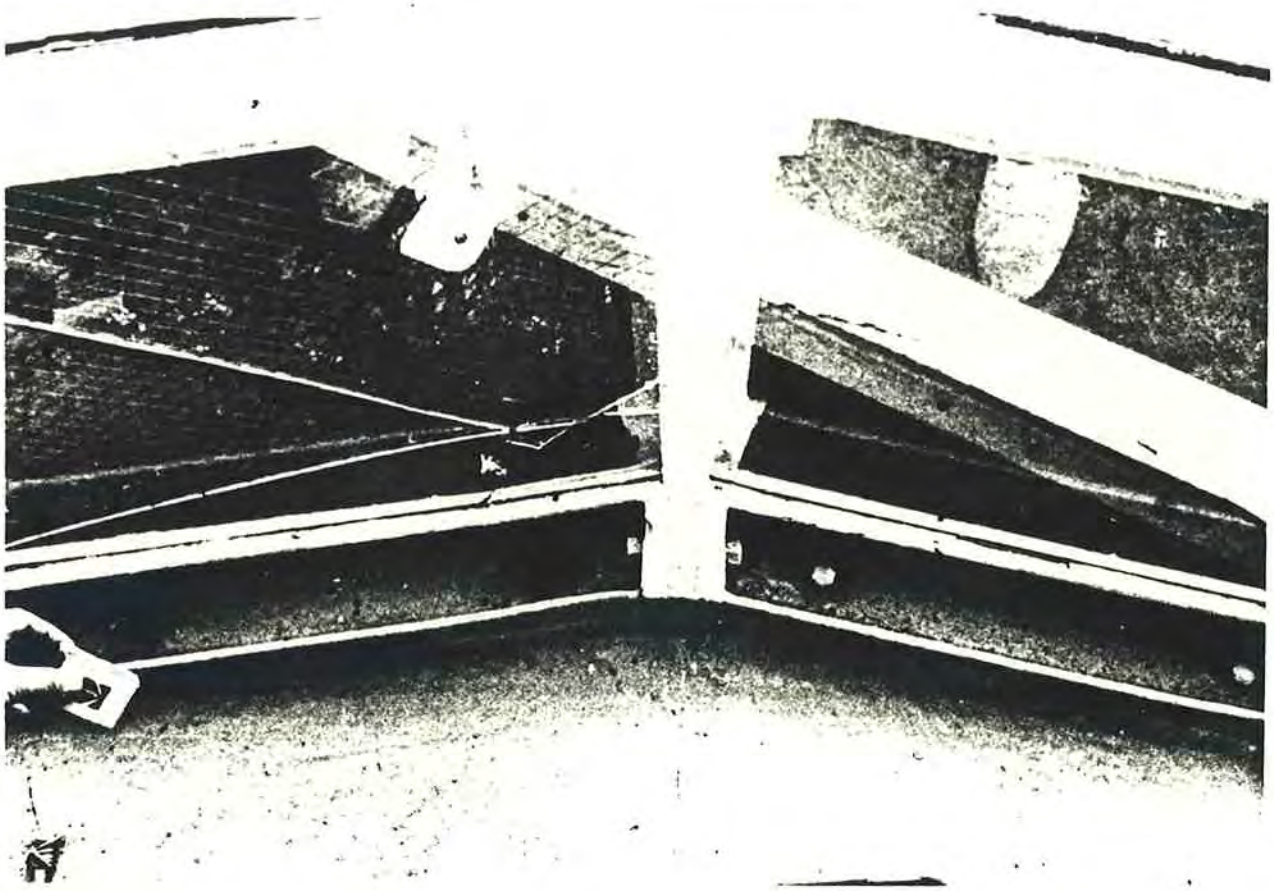
EXISTING CONDITION OF FINIAL AT DOME



EXISTING CONDITION OF GUTTER AT DOME
I-6



EXISTING CONDITION OF INTERIOR MASONRY WALL (TYPICAL)
I-7



EXISTING CONDITION OF INTERIOR MULLION AT METAL LANTERN ROOM
I-8



EXISTING CONDITION OF EXTERIOR RAIL AND PICKET
AT METAL LANTERN ROOM AND GALLERY I-9



EXISTING CONDITION OF EXTERIOR STUCCO WALL AT GALLERY ROOM
I-10

## APPENDIX C

# Various Specifications, Descriptions and Materials List for Keeper’s Residence

REPRODUCED AT THE NATIONAL ARCHIVES

A T-MC
408

408 A

Dry Tortugas Lt.Sta.,Fla. January 14,1920.

Superintendent of Lighthouses, Key West, Fla.

1. Referring to Bureau letter of July 31,1919, allotting $6,500 for keeper's dwelling at Dry Tortugas,Florida.

2. The drafting force at the Bureau is in a position to undertake the preparation of plans and specifications for this project. Should you desire such assistance, advise this office at an early date, submitting data as to size number of rooms, materials, general arrangements, and such other instructions as may be necessary.

REPRODUCED AT THE NATIONAL ARCHIVES

ATIONS TO
SUPERINTENDENT OF LIGHTHOUSES
KEY WES FLA.

JAN 26 1920 10 12 AM

DEPARTMENT OF COMMERCE
LIGHTHOUSE SERVICE

408 A

LIGHT JAN 26 1920 HOUSES

HBH-LHP.

Inclosure Received

OFFICE OF SUPERINTENDENT, 7TH DISTRICT
KEY WEST, FLA.

Dry Tortugas Lightstation, Fla.

January 23, 1920.

6/23/20 Wrote 7th Supt.

QWS
Pls take up with Bp in case
HHM
Jan 27/20

Commissioner of Lighthouses, Washington, D. C.

1. There are forwarded herewith specifications for Keeper's dwelling for Dry Tortugas Lightstation, Fla., which should have been forwarded with endorsement of January 22, 1920, on Bureau letter No. 408 of January 14, 1920.

Wm. H. Emerson

Superintendent of Lighthouses.

AHB

REPRODUCED AT THE NATIONAL ARCHIVES

HBH-VAA

406 A

Jan. 20, 1920

DRY TORTUGAS L.S., FLA.
KEEPERS' DWELLING
Preliminary Description of Dwelling, Materials, etc.

---

GENERAL DESCRIPTION

All walls, foundations, columns, steps, cheek blocks and porch floors to be of concrete, without reinforcing, or with as little reinforcing as is absolutely necessary to use. (On account of salty, damp atmosphere iron corrodes readily and cracks the concrete.)

Concrete walls, inside and outside, and all concrete work to be rubbed smooth (not plaster coated); outside work to be painted with water-proof concrete paint; inside walls to be tinted. (This method is believed to be better than plastering for this climate.)

Structure should be designed for hurricane of 125 miles per hour.

Foundation on which building will set is white sand and shell. Ceiling to be T. & G. cypress, smooth finished and painted. Ceiling joists to be of cypress, or best quality long leaf, Georgia pine. (Plastering overhead dangerous during hurricanes.)

Inside Flooring: Floor joists to be of best quality unbled long leaf Georgia pine, painted with two coats of wood preservative. Double floors with heavy building paper between the subfloor and finished floor; subfloor to be of cypress; finished floor to be of select quarter sawed oak.

Roof: Rafters to be of cypress, if practicable, or best grade unbled long leaf Georgia pine; rafters to be left exposed (that is, without ceiling) except where necessary.

Roof sheathing to be T. & G. cypress.

Roof to be a hip-roof of 30° pitch (Flat concrete roofs are not satisfactory in this climate.) Roof to be covered with hexagonal method 12" x 12" x 1/8" asbestos shingles, with slater's asbestos felt and copper storm nails.

Gutters to be 6" half round galv. eave troughs, with 4" conductor pipes and cast iron leads to cistern.

Shelving and dressers to be of cypress.

Window frames, venetian blinds and doors, of cypress.

Large doors and windows, and transoms over doors where practicable, desirable for this climate. Venetian blinds for all outside doors and blinds desirable on account of glare and heat of sun in this climate, and to protect glasses from being broken during hurricanes.

REPRODUCED AT THE NATIONAL ARCHIVES



(Dry Tortugas, Keepers Dwelling).

No chimneys required as Keeper will use oil cooking stove and oil heater. Temperature seldom falls below 50° F. during winter, and that for only a few days at a time. Average temperature for the winter about 66° F. No snow and no frost.

Window sashes should be 1-3/8" thick, 12-light, double thick glass as small panes are stronger, and easier to renew at this isolated station when broken.

Glazing in bath room window to be hammered glass.

No ventilators have been placed on roof as they permit thedwelling to be flooded during a hurricane. If ventilators are considered necessary, they should be designed to keep out water from a horizontal direction.

All fittings should be solid brass, where available; otherwise of galvanized iron.

Concrete walks to be installed, as noted, on sketch.

All wood work to be painted regulation colors.

Wire screens are not considered necessary at this station as there are seldom any mosquitoes at this place, and the dwelling will be cooler without them.

Local beach sand and 1" Ojus' rock (coral formation) could be used for the foundations, porch columns, fence posts and sidewalks, where it is not essential to have them moisture proof. The concrete for walls proper of the dwelling and the cistern to be made of silica sand and trap rock. Best quality of Portland cement to be used for all concrete and mortar.

The relative positions of the new dwelling etc. and of the other dwellings, tower, and outhouses are shown on the map herewith.

Dry Tortugas Lightstation is situated on Loggerhead Key about 64 miles west of Key West, Fla.

PLUMBING

All soil and waste pipes to be of cast iron.

Water supply: Concrete tower about 20 feet high, with 2 500-gal. water tanks, (double tank), to be erected in rear of dwelling. Lower part of tower to be used as a wash house and pump house. Fresh water to be supplied to bath tub, wash basin, kitchen sink and laundry tubs; surface water to be supplied to all of these and to the water closet.

Closet: Plain vitreous china syphon jet water closet with vitreous china low tank ivory white, with side top lever elevated ball cock and flush valve,

REPRODUCED AT THE NATIONAL ARCHIVES



TOUBES

(Dry Tortugas, Keepers' Dwelling).

with all connections and fittings.

Bathtub: Cast iron enameled 5'-6" bath of ordinary pattern, with all fittings.

Lavatory: Enameled lavatory, with slab, oval basin with center outlet, overflow, and back in one piece. Slab 18" x 24", with all fittings.

Kitchen sink: 1 sanitary one-piece enameled kitchen sink, left hand drain board and left hand end piece; size of sink 20" x 28", length over all 52 inches; fitted with concealed cast-iron brackets and two adjustable bronzed iron legs; supplied with two 3/4" brass compression cocks, trap and fittings.

Laundry trays: One set of two granite laundry trays, 21" x 48" to be installed in washhouse in lower part of water tower. Trays to be fitted with strong substantial frame and attachments for a wringer. Supply two 3/4" brass compression cocks for each tray (4 in all.)

OK

All water supply pipes to be brass or galvanized iron, as surface water is more or less brackish and will corrode unprotected iron. Also damp, salty atmosphere corrodes unprotected iron very rapidly in this climate.

Supply pump to be 1 horsepower gasoline motor with belt connected force pump, with all necessary pipes and fittings for pumping both fresh and surface water to proper tanks. Cylinder of pump should be brass.

Cistern to be of concrete of dimensions shown on sketch.

Well 4" diameter about 16-feet deep to be dug and cased with 4" galvanized gas pipe.

NOK

REPRODUCED AT THE NATIONAL ARCHIVES

# SPECIFICATIONS
for
A SINGLE DWELLING FOR KEEPER
at
DRY TORTUGAS LIGHTSTATION, FLORIDA

1. Location. Dry Tortugas Lightstation is located on Loggerhead Key, about 64 miles west of the city of Key West, Fla. The exact position of the dwelling will be given by the Superintendent of Lighthouses.

2. Work to be done. The work to be done consists in building a keeper's dwelling in accordance with the attached plans and the following specifications, and in furnishing all labor, material, equipment, subsistence, etc., necessary therefore.

3. Transportation. - Free transportation of materials and men from Key West, Fla., to Loggerhead Key, Fla. (Dry Tortugas L.S.), and from Loggerhead Key to Key West will be furnished as follows: The heavy and bulky materials and equipment may be transported by the large tender of this district, but all such materials and equipment must be ready at some accessible point at one time. One of the smaller tenders may be had for a trip about every two weeks, at such times as such trip can conveniently be made, weather permitting. On these trips (either on large or small tenders) subsistence can be obtained by the personnel of the contractor's force, while en route, at the regular government rate of allowance per man per day, which amount must be paid by the contractor to the proper officer at the close of each month; the contractor will be held responsible for all subsistence thus furnished, and for the conduct of the men transported. The government will not be responsible for any of the materials or equipment thus transported, and the loading and unloading of such materials or equipment must be done by the contractor's force, excepting such as the Superintendent of Lighthouses, 7th Dist., may permit to be done by the crew of the vessel, which latter must be considered as a concession and not as a part of the contract.

(a) Other vessels make trips to Tortugas Harbor (Garden Key), more or less regularly, about once a week, on which transportation of a limited number of persons and quantity of supplies may be obtained by making request to the proper authorities. From Garden Key to Loggerhead Key, a distance of about 3 miles, the trip may be made in the lightstation motor boat, which will be at the disposal of the contractor for such purpose, to such extent as may be authorized by the Superintendent.

4. Laying out the work. The Superintendent will indicate the proper location of the dwelling, but the contractor must lay out the work and be responsible for the accuracy of dimensions and grades.

5. Excavation. All necessary excavations shall be made for the foundations as indicated on the drawings. The bottoms of pits shall be made level, and covered with building paper or other equally effective material to prevent escape of water and cement from first layer of foundation walls, etc.

6. Foundations. All concrete, unless otherwise specified shall consist of one part cement, two parts sand and four parts broken stone. Foundation walls

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to level of water table, piers, porch floor and steps shall be of concrete. Suitable grout tight forms, sufficiently rigid to prevent distortion when filled with concrete shall be provided for all concrete work. The space between the foundation of house walls and porch foundation walls, and also the space beneath the steps, shall be filled with well compacted sand, upon which the porch floor and step slabs shall be laid. The porch floor shall be divided into separate panels by through joints as indicated on plans. Provide a 20 x 24 inch hatch in rear basement wall, with 1-1/2 inch frame, 7/8 inch hinged batten door with brass bolt.

7. Water table. The six inch belt course or water table shall be of precast concrete blocks of convenient lengths, composed of one part cement, one and one-half parts of best quality, well graded concrete sand and not more than three parts of fine (¼ to ⅜ inch) hard gravel or broken stone. Exposed surfaces shall be straight and smooth. The top of the foundation wall shall be brought to a true level surface with cement mortar for receiving the belt course and ends of floor joists. After the floor joists are set, the space behind the water table to the inside line of foundation wall, between the joists, is to be filled with concrete.

8. Hollow Concrete Block Walls. The walls of the dwelling, from the water table to plate, approximately 8 feet three inches, shall be built up of hollow concrete blocks, 8 x 8 x 16 inches, and of the general type as shown on the drawings. Special blocks shall be provided for window and door openings as may be required. Porch columns shall be of hollow blocks and provided at top with concrete cap as per specifications for water table. Cap shall have openings corresponding to holes in concrete blocks to permit setting of rods in grout for securing porch girders to top of columns, and for reinforcing the columns, as noted on drawings. Each column shall be provided with two of these rods, 5/8 inch in diameter, set in opposite corners, and extending the entire length of column. The surrounding space shall be completely filled with cement grout.

(a) The walls of the dwelling shall be similarly reinforced by one 5/8 inch rod at each corner and between each opening, where practicable, upper ends of rods to terminate two inches below top of upper concrete block and be completely imbedded in cement grout. Bolts for securing the 2 x 8 inch plate will be grouted into the two upper courses of concrete blocks as noted on plans.

(b) Concrete blocks shall be composed of one part cement, one and one-half parts sand and three parts fine gravel or crushed rock, not less than ¼ nor more than ⅜ inch in size. The natural beach sand at Dry Tortugas, and crushed Ojus or coquina rock may be used. Blocks must be well corrugated on both exposed sides, to form a key for the exterior stucco and interior plaster. The faces must be rectangular, the bedding surfaces free from detrimental projections, and blocks must be seasoned at least seven days in a moist condition before being placed in walls or subjected to any distorting force.

(c) The blocks must be laid in tempered cement mortar, true to line, with joints completely filled with mortar. No imperfect or broken blocks shall be used.

9. Concrete Materials. The cement must be first quality Portland cement conforming to the requirements of the Bureau of Standards Specifications,

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Bulletin No. 33, 3rd. Edition. Contractor must furnish satisfactory evidence that the cement furnished, meets these requirements.

(a) Sand:-The local sand at Dry Tortugas or a similar sand may be used for foundation walls and cement blocks. For all other concrete and mortar, only a good quality of course, or well graded concrete sand free from salt shall be used. All sand must be free from organic matter or other harmful substances.

(b) Coarse Aggregate:- For foundation walls and concrete blocks, crushed Ojus or coquina rock, screened to remove all particles less than ¼ inch, will be satisfactory. For the concrete blocks, the size shall not exceed ½ inch, and for foundation walls, size shall not exceed 1-1/2 inches. For all other concrete, only clean, hard crushed stone or gravel, not less than ¼ not more than 1 inch in size, shall be used.

10. Mixing and placing. Concrete for foundation walls and blocks shall be mixed as dry as practicable and shall be well tamped into forms. All concrete shall be mixed, whether by hand or machine, until the entire mass is of a uniform consistency and color, and must be placed at once, before any signs of initial set appear. Forms shall remain in place for at least 48 hours, and all concrete must be kept moist by any convenience means suitable to the Superintendent for not less than 7 days. The porch floor and concrete steps shall have a wearing surface of at least one inch of 1 to 2 mortar, laid while the concrete underneath is still green, and troweled to a smooth, plane surface.

11. Mortar. Mortar for laying hollow concrete blocks shall be composed of 1 part cement and 2½ parts sand. Hydrated lime not to exceed 10% by volume of the cement shall be used for tempering.

12. Stucco on Concrete Blocks. Exterior surfaces of concrete block walls and exterior foundation walls from water table to 2 inches below grade shall be covered with not less than 3/4-inch thickness of stucco applied in the following manner: The first coat composed of one part cement, two parts sand and one-tenth part hydrated lime, shall be applied with force so as to key behind the scoring of concrete block, also to prevent air bubbles and holes, and shall be thoroughly scratched to insure proper bond with the next coat. The second coat composed of 1 part cement, 2½ parts sand and one-tenth part hydrated lime, should be applied as soon as the first coat has sufficiently set to allow working on same and should be made straight, level and in true plane by darby and straight edge, then floated with cork or wooden float to prevent waves showing in finished wall. Should it be impossible to apply the second and last coats as soon as the former has become thoroughly set, wet down already the coat applied before applying the others. The third, or finish, coat composed of one part cement, 3 parts sand, with water to which Trus-Con Waterproofing Paste manufactured by the Trus-Con Laboratories, or its equal, has been added in the proportion of 1 part of the paste to 18 parts of water. It should be applied as far as possible to the entire area of one side of the structure to the corners at one operation. Finish coat shall be floated free from any porous imperfections. If stucco work is to be done in dry weather, the surfaces of the concrete and block walls are to be thoroughly wetted before applying

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the first coat and surface to be kept clean. The stucco shall be kept thoroughly wetted down until the cement has set.

13. Plastering. Interior plastering must be completed before finished floor is laid. All interior walls will be two-coat work. The first coat will be composed of 1 part cement, 2 parts sand and 1/10th part hydrated lime, applied with force to cause good keying behind scoring of concrete block. This coat of plaster will be brought out even with face of grounds which must be set plumb and even. After this coat is two-thirds dry the finish coat, composed of a cement plaster equal to the U.S.Gypsum Co's. "Adamant", properly mixed in accordance with manufacturer's directions, will be applied, trowelled and brushed to a hard uniform surface. All finished surfaces must be plumb, straight and true planes meeting at true angles, clean, free from blisters, cracks, discolorations and other defects. All walls shall be thoroughly wetted down before plaster is applied. Only such plaster as can be applied in one hour by the force employed will be mixed at one time and under no circumstances shall any plaster be used that has commenced to set.

14. Framing. All framing lumber shall be long leaf yellow pine, prime grade, Gulf Coast Classifications, of sizes and spacing as shown on plans. Double the framing around openings, and stay the floor joists with 1-1/4 x 2-1/2 inch bridging accurately fitted and securely nailed. The 2 x 6 inch wall plates will be halved at corners and secured to top of concrete block wall with bolts grouted in wall as indicated on plans.

15. Floors. The floors shall be double; the subfloor shall be 7/8 x 6 inch, dressed on one side to uniform thickness, laid diagonally and securely nailed to each joist. The finish floor shall be 7/8 x 3-1/4 inch prime grade, edge grain, long leaf yellow pine, closely driven up, and blind nailed. One layer of heavy water proof building paper shall be placed between sub floor and finished floor.

16. Ceilings, etc. Interior ceilings shall be prime grade, 3/8 x 3-1/4 inch T.&G and V yellow pine ceiling, closely driven up and blind nailed. Under side of eaves shall be finished with 7/8 x 3-1/4 inch prime grade flooring. The ceiling of porch shall be finished with 7/8 x 4 inch prime grade boards, S 4 S, with 1/4 inch open joints, secured to joists by finishing nails, well set, and nail holes puttied. A 3 x 3 foot hatch shall be provided in porch ceiling where shown. The hatch shall be suitably framed and provided with flush door, conforming in appearance with porch ceiling; door to be hinged to swing downward and provided with substantial mal. iron buttons for securing in closed position.

17. Interior finish. All interior trim, including base board, mouldings, window and door trim shall be of cypress, grade "selects". Window and door trim and base board shall be of plane section with rounded edge or edges. Moulding at intersection of ceiling and side walls shall consist of a plain strip, 3/4 x 3 inches with lower edge rounded, and a 1 inch quarter round moulding. Door and window casings and apron shall be approximately 7/8 x 4½ inches; Baseboard 7/8 x 7½ inches. Joint at base and floor to be finished with 1 inch quarter round moulding.

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18. Exterior trim. All exterior trim shall be prime grade yellow pine, of the shapes and dimensions shown on plans.

19. Grounds. Suitable grounds or nailing pieces shall be set in the concrete block walls and against the framing as may be required for proper securing of all exterior and interior finish.

20. Lathing. Interior partitions and sidewalks from top of concrete blocks to ceiling line shall be lathed with the Clinton Co's. 18 gage, woven wire lath, galvanized after weaving, or other woven wire lath of equal weight, galvanized after weaving. The wire lath shall be secured to the studding by 3/4 inch No. 14 galvanized round head staples at intervals of not less than 6 inches; it shall be lapped at least 4 inches over concrete blocks and properly secured by staples driven into joints. All lath must be stretched tightly by proper tools, and must finish true to required lines without bulge or sag. Joints shall lap at least one inch.

21. Plastering on metal lath. In addition to the two coats of interior plaster as specified in Paragraph 13, all metal lath shall receive a primary scratch coat of plaster composed of 1 part cement, two parts sand and 1/10 part hydrated lime. This scratch coat shall be not less than 1/4 inch thick, shall be well keyed into the lath and shall be applied with sufficient force to produce a perfect clinch. While still wet, this coat shall be thoroughly scored with diagonal lines nearly through its thickness.

22. Shelving, etc. A tier of four shelves shall be constructed, extending the entire length of pantry wall opposite door. Shelves to be 7/8 x 10 inch dressed prime grade yellow pine, 12 inches apart, supported on substantial bronze finish pressed steel brackets, secured to shelves and to flush grounds with screws. Lower shelf shall be approximately 3 feet from floor. At end of pantry opposite window construct a cupboard or "kitchen cabinet" approximately 3 feet 10 inches wide by 7 feet high. Lower section to be 18 inches deep by 3 feet high; to be divided into a cupboard about 2 feet 10 inches wide, provided with two shelves 14 inches wide and double panel doors with cabinet latch. Remaining portion of lower section to be provided with three substantial drawers, the upper two to be be about 6 inches deep; lower drawer to be lined with heavy tin and further provided with sliding, tinned metal cover. The upper section of cabinet shall be 12 inches deep; shall contain 3 ten inch shelves, and shall be provided with double, glass paneled doors with cabinet latch. The entire cabinet shall be complete with bottom, sides, top and back, of neat design and free from cracks or open joints that will permit entrance of vermin. A commercial article, conforming in general to the above specifications will be acceptable.

(a) Each clothes closet shall be provided with a 14 inch shelf at the back, supported on 3 inch dressed pine strips extending around three sides of closet; strips to be securely nailed to flush grounds and provided with bronzed steel clothes hooks about 8 inches apart.

(b) A 7/8 x 6 inch dressed cypress strip, provided with brass screw hooks about six inches apart, secured to flush grounds, at about 5 feet from floor, shall extend around the corner of kitchen (above the sink) from kitchen window casing to pantry door casing.

23. China Closet. The china closet shall be set into kitchen wall as shown

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and shall consist of a lower tier of three drawers, each approximately 8 inches high, bottom of lower drawer to be on line with top of base board. Above the tier of drawers and separated therefrom by a counter shelf, there shall be three 12 inch shelves, at about 11 inch intervals, supported on 7/8 x 1 inch battens. Top of cabinet shall be 6 feet 8 inches above the floor line. Provide double, glass paneled doors of neat and simple design, with cabinet latch for upper section. Inside of upper section shall be ceiled with same material as room ceilings, set vertically and secured to cross pieces framed between studdings. Close top of cabinet with 7/8 inch matched flooring. Trim around china closet shall conform to window and door trim.

24. Windows. Check rail windows with 12 lights, 10 x 14 inches, 1-3/8 inch sash, glazed with double strength clear glass will be used for all window openings, except bath room window, which shall be glazed with "hammered" glass. Window frames may be of stock pattern, for double hung sash, suitable for concrete block construction, and similar in design to details shown on plans. Sash shall be hung with best quality braided sash cord and balanced with proper sized weights. Pulleys and lavels shall be of non corrosive metal. Sash shall be provided with brass finished fasteners at meeting rails. Window frames shall be made to accomodate double blinds.

25. Blinds. Each window shall be provided with standard double blinds with half stationary and half rolling slats, copper staples, blinds to be hung on heavy brass offset hinges, which will permit blinds to open flat against outside walls, and be provided with substantial catches for holding in closed position and suitable blind adjusters for holding blinds positively in open position.

26. Doors. All doors shall be No. 1 quality clear cypress or white pine, of stock patterns conforming as closely as practicable with details shown on plans. Outside doors shall be 1-3/4 inches thick and interior doors 1-3/8 inches thick. Exterior doors shall be glazed with double strength clear glass. Sizes of doors shall be as follows, (see numbering on plan):-

NO'S. 1, 2 and 10...1-3/4 in. by 2 feet 8 inches by 6 ft. 8 inches.
NO'S. 3,5,6,7,9 and 11... 1-3/8 in. by 2ft. 8in. by 6 ft. 8 inches.
NO'S. 4 and 8..... 1-3/8 in. by 2 ft. 4 in. by 6ft. 8 inches.

Door frames shall be of cypress grade "selects" or equal. Outside door frames shall be provided with stops for slatted doors and fixed glased transoms. Inside door frames shall also be of cypress as above specified; frames for doors no's. 3,5,6,7,9 and 11 shall be provided with louver transoms as shown; doors no's. 4 and 8 will be without transoms. Outside doors shall be fitted with double ventilated doors, 1-3/8 inch thick, with fixed shutters, hung on 4 inch brass, loose pin butts, and provided with flush bolts and knob latches.

(a) Doors shall be provided with plain mortise locks with brass strike, bolt and non-corrosive metal knobs and escutcheons and two keys each, and shall be hung on 4inch x 4inch cast brass butts with loose pins. Closet doors shall be provided with japanned iron rim knob latches with knobs and escutcheons corresponding to other interior doors. Wood stops with rubber bumpers shall be set in baseboard for all doors.

27. Roofing. Two separate bids are desired, one for dwelling with roof as per alternate specification "A" and one for dwelling with roof as per alternate specification "B".

(a) Alternate Specification "A". The rafters shall be sheathed with 7/8 inch

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by 4 inch tongue and grooved prime grade yellow pine, dressed two sides to an even thickness driven tight and securely nailed. Boards to be laid with close horizontal joints, ends of boards to be well supported and nailed and neatly jointed at hips.

(b) The roof boards shall be covered with one thickness of roofing felt, similar to 14-lb. impregnated "Ajax" felt, laid horizontally with 4 inch lap. Install a cant strip 1/2 by 1-1/2 inches parallel to and flush with the eaves.

(c) The roofing material shall be gray asbestos shingles, similar to H. W. Johns-Manville Hexagonal method asbestos shingles. Lay the eave course starters so that they overhang the eaves 1/2 inch. The main body shingles shall be 12 by 12 inch fastened with double galvanized roofing nails and the lower ends of shingles secured by copper storm nails. A yellow pine false shall be provided and the ridge and hips covered with asbestos hip and ridge rolls, fastened with copper ridge fasteners. The shingles abutting the ridge, hips and eaves shall be laid in elastic roof putty.

(d) Alternate Specification "B". Rafters shall be sheathed as specified in alternate specification "A". Roof boards shall be covered with roofing felt as above specified.

(e) The roofing material shall be heaviest grade of asphalt impregnated paper shingles in strips of not less than four shingles per strip; surfaced with grey-green crushed mineral. Shingles shall be carefully laid, in strict accordance with manufacturers specifications, not less than 3-1/2 inches to the weather, in straight lines parallel to eaves and secured with large flat head nails, carefully driven at right angles to roof. Nails shall be "double-galvanized" and not fewer than five to each four shingle strip. Hips shall be covered with 4 inch strips cut from the shingle, laid 3 inches to the weather and firmly nailed about 1 inch from edges. Ridge shall be provided with heavily galvanized "Armco" (or other) pure iron ridge roll with plain ends.

28. Gutters and leaders. Gutters and leaders shall be No. 26 gage "Armco" iron or equal, heavily galvanized. Gutters shall be properly pitched to leader openings, joints lapped and well soldered, and secured by galvanized nails not less than 4 inch centers. Leaders shall be 4 inches in diameter, joints riveted and well soldered. Leaders shall be well supported and secured to dwelling with substantial galvanized iron fittings. Leaders shall terminate at about height of water table of dwelling with "Kouhn" type rain water cutoff, with leader for waste water extending to ground and terminating with a conductor shoe.

29. Painting. Outside wood work shall be primed as soon as practicable and all knots shellaced. Window and door frames adjoining concrete surfaces shall receive a priming coat before placing. Priming coat shall be pure white lead, boiled linseed oil and japan drier. Two additional coats of white paint shall be applied after building has been completed. A standard brand of ready mixed exterior paint of best quality will be acceptable. The blinds shall be painted green. Interior woodwork and trim shall be neatly sanded and knots shellaced and shall receive a priming coat of white lead and linseed oil, and two additional coats of standard ready mixed interior paint. All interior woodwork including the ceilings shall be white; plastered wall will not be painted.

(a) All nail holes shall be neatly puttied before final coat is applied. Painting shall be done only in dry weather, and no paint shall be applied until

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the previous coat is thoroughly hard and dry.

30. Wood Preservative. Before erecting, all first floor joists and girder members shall be given two coats of creosote or other standard wood preserver, well brushed in so that all surfaces shall be completely covered.

31. Plumbing. Rough in all necessary connections for kitchen sink, bath tub, lavatory and water closet. Two separate lines of 3/4 inch galvanized wrought iron pipe shall extend from sink, bath tub and lavatory, connecting into two common runs of 1 inch galvanized wrought iron pipe which shall extend beyond the foundations of dwelling not more than six feet as shall be directed by the Superintendent.

(a) A 3 inch cast iron pipe, with proper connections for waste pipes from sink, lavatory, bath tub and water closet, shall be suspended securely from the bottom of floor joists and extend through foundation wall and terminate with Y-branch and cleanout plug. The cast iron pipe shall have a fall of not less than 1/2 inch per foot and shall be located as directed by the Superintendent.

(b) Plumbing fixtures. Bidders are requested to submit a separate bid on plumbing fixtures, completely installed and connected to waste and supply pipes as follows:

(c) One cast iron roll rim kitchen sink, 36 by 20 inches, integral back with hollow space for pipe connections. Sink to be enameled inside and on roll rim and back. Outside exposed surfaces to be ground smooth and given two coats of white enamel paint after erection. Sink to be secured to wall with concealed hangers secured to wall with 1/4 x 3 inch brass expansion bolts. Waste to be 1-1/2 inch lead pipe with S trap, unvented, with nickel plated strainer in sink.

(d) One rectangular pattern, 20 by 18 inch, enameled iron, integral back roll rim lavatory, with oval bowl, apron, and open integral overflow, Lavatory to be supported on concealed hangers secured to partition with heavy wood screws. Waste to be 1-1/2 inch nickel plated brass pipe and unverted S-trap. Rubber stropper and chain are to be supplied. Supply pipes to be 1/2 inch nickel plated brass.

(e) One 5 foot, enameled, cast iron, roll rim bath tub supported on cast-iron ball feet. Out side surfaces to be given one coat of white lead paint and two coats of white enamel after erection. Supply pipes to be 1/2 inch and waste and overflow pipes 1-1/2 inch nickel plated brass. Trap to be of concealed type, placed below floor, and provided with cleanout cap.

(f) One vitreous ware, flushing rim, syphon jet water closet, with pedestal base and moulded in trap, provided with substantial, well finished seat and cover and low-down, vitreous ware flushing tank, complete with necessary brass discharging mechanism, and connected to closet with proper size nickel plated brass pipe. Tank to be securely fastened to wall with large brass wood screws and nickel plated angle brackets.

(g) Faucets. All faucets are to be standard grade, well finished nickel plated faucets of Fuller type. Kitchen faucets to be 3/4 inch with adjustable flange and plain nozzles. Lavatory faucets to be side stem pattern with metal handle, and provided with ground joint union for connection to brass supply pipes. Bath tub faucet to be of single outlet, combination pattern, with metal handles and ground joint union connections. All faucets shall be connected

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so that right hand faucets connect with the same main supply pipe, and all left hand faucets with the other supply pipe.

(h) All plumbing fixtures shall be installed in accordance with the best modern practice, in a neat manner. All pipes passing through floors shall be fitted with suitable floor flanges.

32. Payments. Payments will be made as follows: first, One third of contract price when concrete walls (including porch floor) have been completed, except stucco and interior plastering, to full height, i.e., to top of concrete block wall; Second, One third contract price when all framing and roofing is completed; and final, balance due when all work covered by contract is completed and accepted by the Superintendent; Provided However, that should the contractor, through no fault or negligence on his part, be unable to complete the contract in every detail, according to the terms thereof, within a reasonable time after the second partial payment, an additional partial payment may be made before the final payment equal to the unpaid balance of the contract price less an amount extimated by the Superintendent and approved by the Commissioner, to be fully sufficient to complete the contract and to cover any deductions to be made from the contract price in accordance with the liquidated damage, clause or otherwise.

33. Damage to unfinished work. Special attention to paragraph 24, page 14 of printed contract form, covering responsibility of contractor for all work until final acceptance.

NOTE: The Lighthouse Service is limited by law to an expenditure of $6500 for this project, and no bids in excess of this amount can be accepted. Consideration will be given to bids, not in excess of this amount, covering a modified structure of similar character, provided such bids shall be accompanied by complete plans and specifications.

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CONTRACT FOR CONSTRUCTION WORK

# DEPARTMENT OF COMMERCE

LIGHTHOUSE SERVICE

OFFICE OF THE SUPERINTENDENT OF LIGHTHOUSES, 7th DISTRICT

# ADVERTISEMENT

Key West, Fla., Aug. 10, 1920.

Sealed proposals will be received at the Office of the Superintendent of Lighthouses, Key West, Fla., until 2 o'clock p. m., September 30, 1920, and then opened, for furnishing all material for and constructing a Keeper's dwelling at Dry Tortugas L.S. Loggerhead Key, Fla., about 64 miles west of Key West, Fla.

Blank proposals and particulars may be obtained by addressing the Superintendent of Lighthouses.

Formal contract with bond[1] will be required; for amount of bond see Schedule.

If guaranty is not executed, attach to this sheet, over the advertisement, **CERTIFIED CHECK** for the total amount required in the schedule or schedules bid upon.

# PROPOSAL

**(Bidders please read conditions and conform to Instructions accompanying this Form.)**

....., ....., 19....
(Post-office address of bidder.)

To SUPERINTENDENT OF LIGHTHOUSES,

.....

In accordance with the above advertisement, the undersigned bidder hereby agrees to furnish all the materials and labor necessary to perform all the work as specified in the schedule or schedules incorporated herein and forming a part of this proposal, for the amount and within the time stated in the schedule or schedules, in strict accordance with the requirements of the plans, specifications, instructions, and conditions attached hereto and made a part hereof.

The bidder further agrees, if this proposal is accepted, in whole or in part, to enter into formal contract and furnish bond to the satisfaction of the Secretary of Commerce within 15 days after the formal contract and bond have been forwarded for execution, in case a formal contract with bond is required by the schedule.[2]

Mark envelope inclosing proposal—

[4] Proposal No. 3344. ..... [SEAL.][3]
(Signature of bidder.)

[4] To be opened Sept. 30, 1920. By .....

[4] From ..... Title .....

(Postage must be paid on proposal.)

# ACCEPTANCE[5]

To .....
*Bidder.*

.....

Deliver to .....

.....

Under above advertisement and proposal, your bid is accepted.

Please perform this contract, subject to the schedule, plans, specifications, instructions, and conditions herein, at the prices and within the time named in your proposal.

Place and date, .....

[1] Superintendent to insert "will" or "will not," as the case may be.

[2] Bidders should carefully read Instructions on page 2 and Conditions on page 10, since they all constitute a part of the proposal and contract, and should also read the provisions of the contract.

[3] If bidder is a corporation affix corporate seal.

[4] Superintendent to insert number, date, and name of prospective bidder to whom issued.

[5] **This form of acceptance will be used when formal contract with bond is not required by the schedule.** If proposal is accepted in part only, a letter should accompany the acceptance showing the item or items accepted and a signed copy of such letter should be attached hereto.

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Brick Dwelling 408 A

# ESTIMATE OF COST OF PROPOSED WORKS

## DEPARTMENT OF COMMERCE
LIGHTHOUSE SERVICE

NAME OF AID: Dry Tortugas Lightstation, Fla. OFFICE OF LIGHTHOUSE INSPECTOR, 7th DIST.

PROPOSED WORK: Construct brick dwelling for keeper. Key West, Fla., December 12, 1921

| ITEMS, QUANTITIES, AND UNIT PRICES | | AMOUNT |
|---|---|---|
| Face brick | 18 M. at $45.00 | $810.00 |
| Common brick | 20 M. at $25.00 | 500.00 |
| Lumber | 13,600 F.B.M. at $60.00 | 816.00 |
| Windows and doors | | 500.00 |
| Roofing materials, Hex.Asbestos Shingles, 14 squares at $19.00 | | 266.00 |
| Hardware and fittings | | 200.00 |
| Mortar and cement | | 58.00 |
| Labor:- | | |
| 1 Foreman 2 months at $170.00 M. | $340.00 | |
| 2 Masons 2 " at $150.00 M. | 600.00 | |
| 2 Carpenters 2 months at $150.00 M. | 600.00 | |
| 5 Laborers 2 months at $55.00 M. | 940.00 | |
| 1 Cook 2 months at $90.00 M. | 180.00 | |
| Subsistence for above | 486.00 | $3,046.00 |
| Incidentals | | 304.00 |
| | | $6,500.00 |

Estimate prepared by
E.T.H.

11—940







As the nation'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 U.S. administration.

NPS 364/105055 August 2010