CENTER FOR HERITAGE CONSERVATION

TEXAS A&M UNIVERSITY College of Architecture

Documentation and Conditions Assessment of High Knoll Fort, St. Helena (CHC-2020-01-01)

Report prepared for the British Napoleonic Bicentenary Trust and St. Helena Government

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Introduction

Architectural documentation and preliminary conditions assessments were undertaken by Principal Investigator Brent R. Fortenberry, Associate Director of the Center for Heritage Conservation at Texas A&M University. Post-documentation conditions assessments were completed by Ashburn. Fortenberry spent four of the seven days of the field research period at High Knoll Fort. It is the only major inland fort on the island, owing to its redoubt status, but is also one of the most accessible for heritage tourists and stakeholders. The project was completed over seven days between 18–25 January 2020.

Objectives

1. Undertake comprehensive digital documentation of High Knoll Fort as a part of ongoing heritage conservation management.

2. Complete a preliminary conservation conditions assessment of High Knoll Fort in preparation for conservation costing from an architectural conservator and historic building structural engineer.

Assessment Methodology

High Knoll Fort was visited four days during the research trip. A combination of documentation and assessment methodology was undertaken.

Terrestrial Laser Scanning

A Faro s350 Laser Scanner was used to document the site using phase-based laser capture. 103 scans were collected in the interior of the fort, including the interior of the northern bastions. The laser scan data was processed using Faro's proprietary Scene Software, where registration and point cloud cleaning took place. The point cloud dataset was exported as an e57 file format, that was exported to Capturing Reality software to combine the point cloud dataset with photogrammetric data.

Photogrammetry

In addition to the laser scan data, the exterior of the fort was captured using 350 aerial photographs from a DJI Mavic Air Drone. These photographs were processed in Capturing Reality software to create 3D textured mesh models that were then combined with laser scan files to create the completed model.

Photography

Fortenberry also captured ground photos using a Sony a7 camera for detailed conditions photography.

Conditions assessments and recommendations were made by in-person visual inspect as well as a digital inspection of the 3D models.

Full Dataset Access

A full copy of the dataset can be view and downloaded using this Google Drive Link. Note that for the 3D and photogrammetric models, one needs a program specialized software. Static images and site report components, however, are easily viewed.

https://drive.google.com/drive/folders/1TJbK1afSbKJJfMLBBq2aopUBDoXEzrWk?usp=sharing

High Knoll Fort History

High Knoll Fort is a redoubt fortification with the earliest elements dating to 1790 and appears on Cock's Map of 1804 and Barnes Map of 1811 This original fort was occupied during the Napoleonic period by the 20th Regiment (Denholm 2006: 83–85) and appears dramatically on Whathen's 1821 painting. After Napoleon's death in 1821, British forces withdrew from the island until the site was redeveloped in the early 1860s. Denholm suggests that the northern portion of the existing fort dates from this first period and was subsequently integrated into the larger complex during this second period of construction. Evidence for this is unclear in the surviving fabric, but in principle, the interpretation does seem plausible. The central and southern portions are clearly late 19th century in origin and the entry gate the keystone has a date of 1874. The Royal Engineers finally completed phase two of construction until 1894 (Denholm 2006: 85).

Denholm notes that a large section of the west perimeter wall fell to the north of the guard house in 1994 during a storm event. This would seem to be the section of the wall that was reconstructed in 2001 (see below). This event was independent of the wall collapse further to the south on the west wall, near the south barracks. Today the fort is a heritage site without staff, has basic heritage signage, and is owned by the St. Helena Government, and managed by the St. Helena National Trust.

Reference:
Denholm, Ken. 2006. "South Atlantic Fortress". Jamestown: St. Helena National Trust

Figure 1 (Right): "High Knoll Fort" by James Whathen, 1821.

Figure 2 (Below): H.M.S. Director 1784, at St Helena with a view of Jamestown. National Maritime Museum, London.

Location

High Knoll Fort sits at a height of 1,916 feet and commands a rocky peak and is approximately one mile to the south and east of Jamestown.

Figure 3: Google Earth imagery of High Knoll Fort, highlighted lower right, and Jamestown, highlighted upper right (Image: Google Earth).

Figure 4: Google Earth imagery of High Knoll Fort (Image: Google Earth).

Figure 5: Oblique 3D Google Earth Imagery of High Knoll Fort (Image: Google Earth)

Digital Documentation

The following images represent the combined laser scan point cloud data as well as the aerial- and ground-based photogrammetric data. Combined, the 3D model comprised over 250 million triangular mesh components, textured using the embedded photographic data, with an accuracy of 4 mm.

Raw digital data and completed digital models in various formats are available through the Google Drive link above. This combined model can also be programmed as a part of physical and digital exhibitions of the fort and other heritage sites. Digital models themselves can additionally be annotated with heritage building information and history.

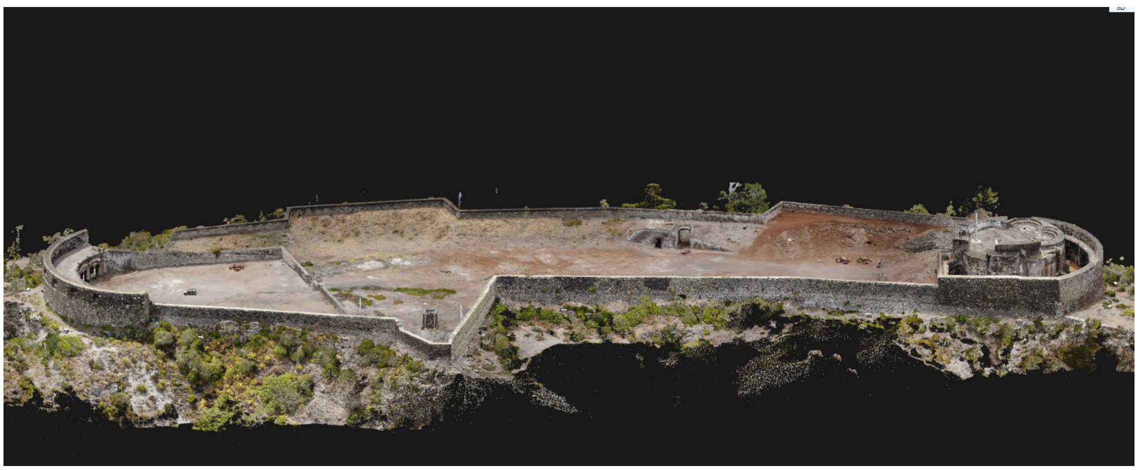

Figure 6:
Photogrammetric model, eastern wall oblique view (Model: B. Fortenberry)

Figure 7:
Photogrammetric model, north wall oblique view (Model: B. Fortenberry).

Digital Documentation

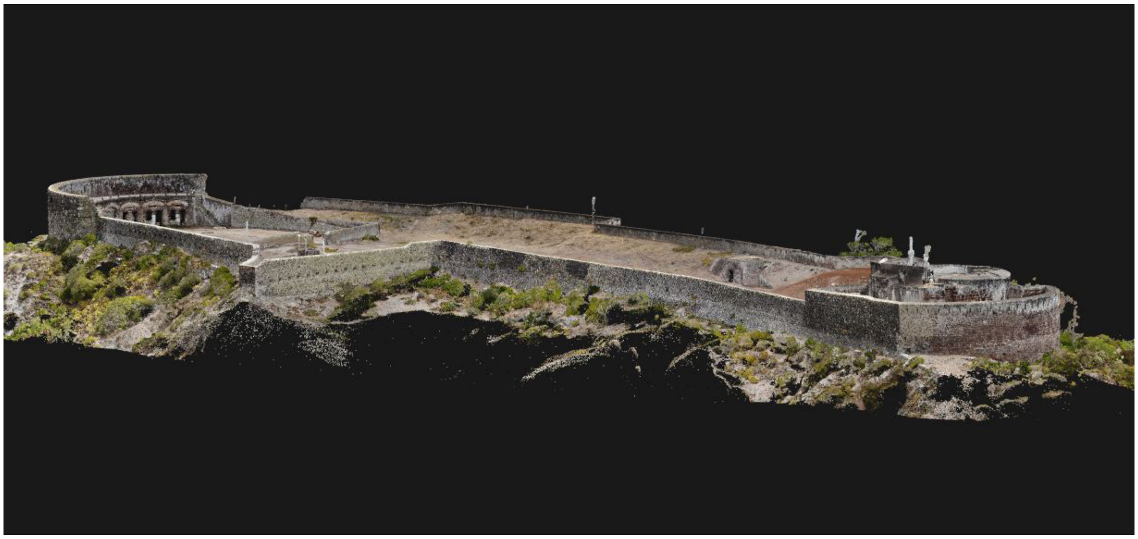

Figure 8: Photogrammetric model, northeast corner oblique view (Model: B. Fortenberry).

Figure 9: Photogrammetric model, southeast corner oblique view (Model: B. Fortenberry).

Figure 10: Photogrammetric model, south wall oblique view (Model: B. Fortenberry).

Digital Documentation

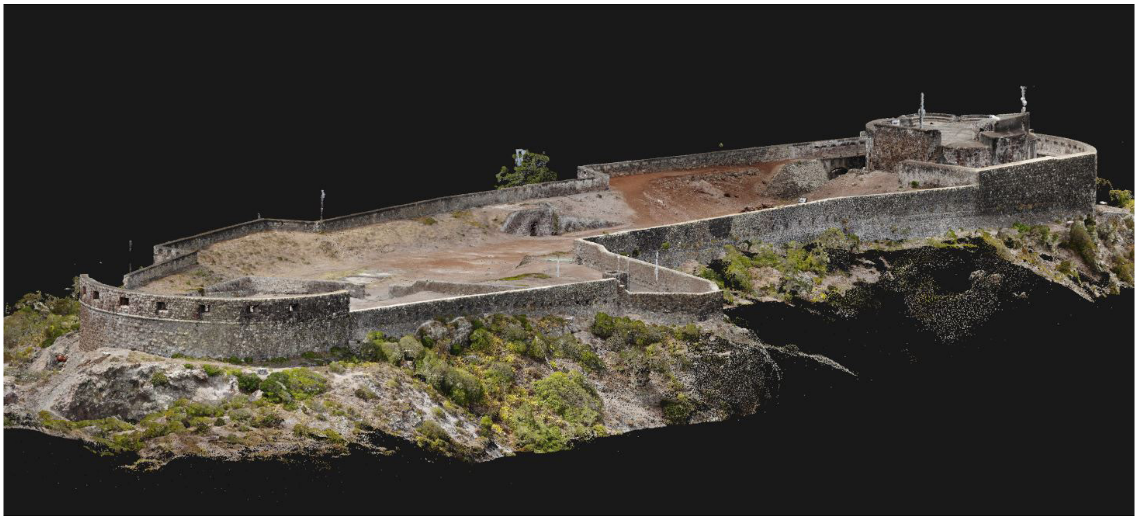

Figure 11:
Photogrammetric model, southeast wall oblique view (Model: B. Fortenberry).

Figure 12:
Photogrammetric model, southwest wall oblique view (Model: B. Fortenberry).

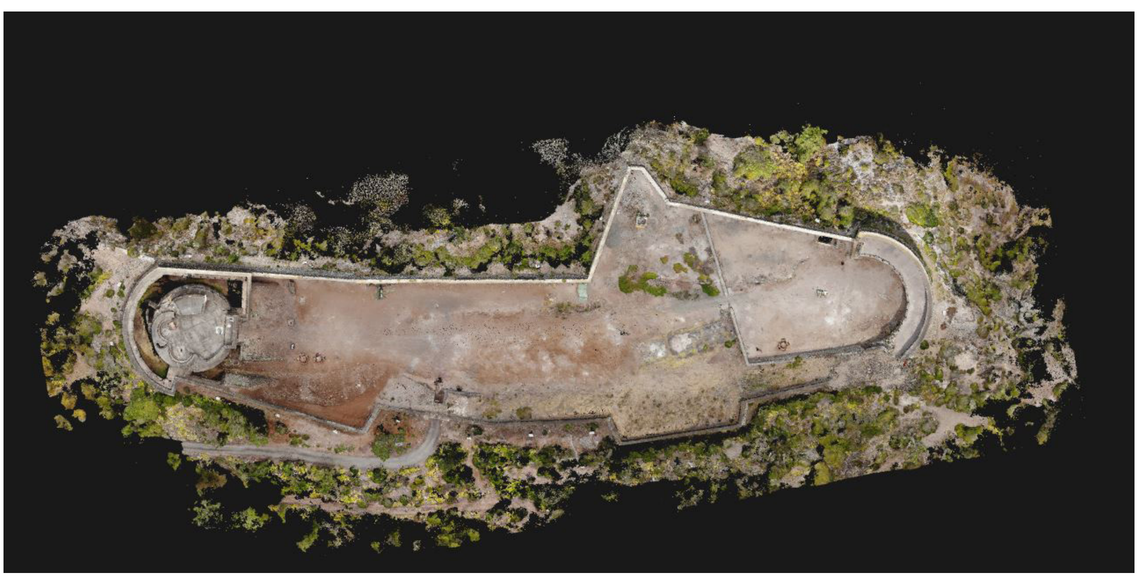

Figure 13:
Photogrammetric model, nadir view (Model: B. Fortenberry).

Introduction to Conditions

The following reporting is divided into structural and non-structural conditions. These conditions were observed through on-site visual inspection and digital model analysis by Fortenberry and Ashburn. There are several instances in the following recommendations where additional expertise is required; several experts have been recommended to the charity.

Where possible, it is recommended that local experts be consulted. While all recommendations are important, at the end of the report is a triaged list of conservation conditions provided. The triaged list are structural in nature and critical to ensuring the integrity of the site.

Figure 14: Oblique aerial view of southeast corner of fort (Image: B. Fortenberry).

Structural–Wall Collapse

A roughly 40-foot section of the western wall collapsed near to its junction with the southern barracks and firing platform. The cause of this collapse was likely a combination of hill erosion to the west and south as well as related deferred maintenance on the wall, for example, if large amounts of bio growth were left unchecked that could have led to the stone destabilization.

For the overall integrity of the south and west wall, this collapse, if not repaired, will cause further detriment to the standing historic fabric. Particularly along the south portion of the collapse where sections of the firing platform are now hanging in the air without support. It is only a matter of time before further wall collapse takes place.

Figure 15: Oblique aerial view of wall collapse from southwest corner of fort (Image: B. Fortenberry).

Structural–Wall Collapse

Figure 16: Photogrammetric detail of wall collapse (Model: B. Fortenberry).

Figure 17: Oblique aerial view of wall collapse from southwest corner of fort with adjoining western wall in view (Image: B. Fortenberry).

Structural–Wall Collapse

Figure 18: Aerial view of wall collapse from southwest corner of fort looking south (Image: B. Fortenberry).

Figure 19: Oblique Aerial view of wall collapse from southwest corner of fort looking southeast (Image: B. Fortenberry).

Structural–Wall Collapse

Figure 20: Oblique Aerial view of wall collapse from southwest corner of fort looking east (Image: B. Fortenberry).

Figure 21: Nadir aerial view of wall collapse from southwest corner with base of collapse in detail (Image: B. Fortenberry).

Structural–Wall Collapse

Figure 22: Nadir aerial view of wall collapse from southwest corner with base of collapse in detail (Image: B. Fortenberry).

Figure 23: Nadir aerial view of wall collapse from southwest corner with top of collapse in detail (Image: B. Fortenberry).

Structural–Wall Collapse

Figure 24: Aerial view of wall collapse from southwest corner with wall section in detail (Image: B. Fortenberry).

Figure 25: Aerial view of wall collapse from southwest corner with wall section and firing platform in detail (Image: B. Fortenberry).

Structural–Wall Collapse

Figure 26: Aerial view of wall collapse from southwest corner with wall section in detail (Image: B. Fortenberry).

Figure 27: Aerial view of wall collapse from southwest corner with wall section elevation in detail (Image: B. Fortenberry).

Structural–Wall Collapse

Figure 28: Aerial view of wall collapse in southwest corner looking north, western failed wall section in detail (Image: B. Fortenberry).

Figure 29: Aerial view of wall collapse in southwest corner looking southwest, interior walls and fence in detail (Image: B. Fortenberry).

Structural–Wall Collapse

Figure 30: Aerial view of wall collapse in southwest corner from the southern exterior of the fort (Image: B. Fortenberry).

Figure 31: Aerial view of wall collapse from the northern edge of the fort complex, image looks south (Image: B. Fortenberry).

Structural–Wall Collapse Recommendations

1. The wall collapse is the most pressing condition that needs to be addressed at High Knoll Fort, and a structural engineer specializing in historic buildings should be consulted prior to any conservation work taking place. The engineer should examine the photographs, drone images, 3D models, and drawings to make preliminary determinations of the scope of rehabilitation and repair. An on-site visit is preferable for detailed inspection.

2. Concurrent with the engineer's inspection, all surviving wall fragments from the collapse should be recorded and documented in situ, and recovered from being used a part of the reconstruction of the wall.

3. While the structural engineer will address the historic fabric, a geologist or environmental engineer should also be consulted to discuss how current erosion conditions contributed to the collapse and how they might be mitigated as a part of site rehabilitation. For example, could additional vegetation in the area be used to reduce soil erosion?

4. Immediate action should be taken to segregate this area from the public areas of the site. A chain-link fence is draped over the small hill to the east of the collapse that does not adequately isolate this dangerous area from visitors, still too, on the exterior of the fort complex, there is no barrier, permitting individuals potential access to hazardous areas in and around the collapse. The area needs to be marked using health and safety guidelines.

Structural–Interior Erosion

To the north of the guard house along the western wall the interior soil which forms a ramp to the top of the western wall, is eroding. This is likely a product of inappropriate infilling after the wall collapse in 1994 and subsequent repair in 2001 (see history section above). When repairs took place, the soil was not adequately compacted to hold the hillside; additionally, the heterogeneous rock infill coupled with water intrusion has caused the hill to erode. If this continues unabated, the structural integrity of this wall section will be undermined, perhaps causing further collapse. This area of recent fill can be identified from its red-brown color.

Figure 32: Aerial view of northern terminus of fort interior, erosion in detail in the right portion of image (Image: B. Fortenberry).

Structural–Interior Erosion

Figure 33: Aerial view of western interior wall section with erosion of 21st century infill in detail (Image: B. Fortenberry).

Figure 34: Aerial view of western interior wall section with southern extreme of erosion of 21st century infill, in detail (Image: B. Fortenberry).

Structural–Interior Wall Erosion Recommendations

1. Consult an environmental engineer to discuss appropriate mitigation measures. These might include a replacement of the heterogeneous infill with homogeneous fill that is compacted, a retaining wall at the base of the hill to add further integrity, or vegetation to abate erosion.

Mortars and Stucco

Mortar is present as a bonding medium throughout the stone structure. Inappropriate replacement mortars (incompatible with historic mortar composition) are used throughout the fort stone walls. At least seven different mortars were identified with varied compositions ranging from those with high levels of modern concrete to those without aggregate and Portland cement. Additionally, several of the mortar mixes were not properly composed and contained organic inclusions allowing bio growth to take root. Several areas of dry-laid stone were also identified.

Failing stucco is also present in a small section of the northern tower complex.

Figure 35: Aerial view of stucco from northern tower complex, stucco campaigns in detail (Image: B. Fortenberry).

Mortars and Stucco

Figure 36: Detail of Portland based mortar with date plate from 2001 (Image: B. Fortenberry).

Figure 37: Detail of Portland based mortar in detail (Image: B. Fortenberry).

Mortars and Stucco

Figure 38: Detail of dry-laid stone wall with bio-growth present (Image: B. Fortenberry).

Figure 39: Detail of Portland based mortar without aggregates in detail (Image: B. Fortenberry).

Mortars and Stucco

Figure 40: Detail of Portland based mortar without aggregates and bio-growth present in detail (Image: B. Fortenberry).

Figure 41: Detail of Portland based mortar with raised joints in detail (Image: B. Fortenberry).

Mortars and Stucco

Figure 42: Detail of Portland based mortar and dry-laid stone in detail, bio-growth also present (Image: B. Fortenberry).

Figure 43: Detail of Portland based mortar with raised joints and haphazard application in detail (Image: B. Fortenberry).

Mortars and Stucco

Figure 44: Aerial image of stucco present on the north tower complex (Image: B. Fortenberry).

Figure 45: Aerial image of stucco present on the north tower complex (Image: B. Fortenberry).

Mortars and Stucco Recommendations

1. Identify and test in-context, identified historic mortars. Samples should be taken from the south and north exterior walls and tested through aggregate analysis and acid digestion to identify appropriate historic composition. This should be done by an architectural conservator.

2. In consultation with an architectural conservator, the dry-laid sections of the wall on the fort's interior should be monitored to ensure their long-term integrity, consultation with a conservator and historic building contractor should a dry-laid wall collapse is recommended. Consider isolating these walls from the public areas of the site with appropriate health and safety barriers and signage.

3. Do not remove inappropriate mortars without oversight from an architectural conservator. Monitor these areas for mortar failure and repair with historically appropriate mortar composition derived from mortar analysis (Recommendation 1). Mortar replacement should be completed in consultation with an architectural conservator.

4. Care should be taken to preserve the surviving stucco on the site.

Bio-growth and Soiling

Bio-growth occurs intermittently on several areas of High Knoll Fort, particularly in areas where water pools. In the southern barracks, uneven floors allow water to pool after rain events. Still too, non-structural wall cracking allows water infiltration from the walls and through the ceiling above. In the northern armory and magazine rooms, non-structural cracking has similarly allowed for water intrusion and invading bio-growth. Large amounts of bio-growth are also present in the dry-laid stone walls on the fort's interior (see Recommendation 2). Due to the size of the plants growing from the wall, the roots of the bio-growth likely penetrate deeply into the substrate. Bio-growth is also present on the flat surfaces such as the concrete caps on the walls.

Soiling has occurred from constant wind activity depositing on the standing walls and platforms.

Figure 46: Aerial image of bio-growth on the top surface of the southern firing platform (Image: B. Fortenberry).

Bio-growth and Soiling

Figure 47: Aerial image of bio-growth on the exterior western wall (Image: B. Fortenberry).

Figure 48: Aerial image of bio-growth on the southern bastion (Image: B. Fortenberry).

Bio-growth and Soiling

Figure 49: Aerial image of bio-growth on the eastern wall (Image: B. Fortenberry).

Figure 50: Aerial image of bio-growth on the southern bastion (Image: B. Fortenberry).

Bio-growth and Soiling

Figure 51: Aerial image of bio-growth on the eastern wall (Image: B. Fortenberry).

Figure 52: Aerial image of bio-growth on the northeastern wall (Image: B. Fortenberry).

Bio-growth and Soiling

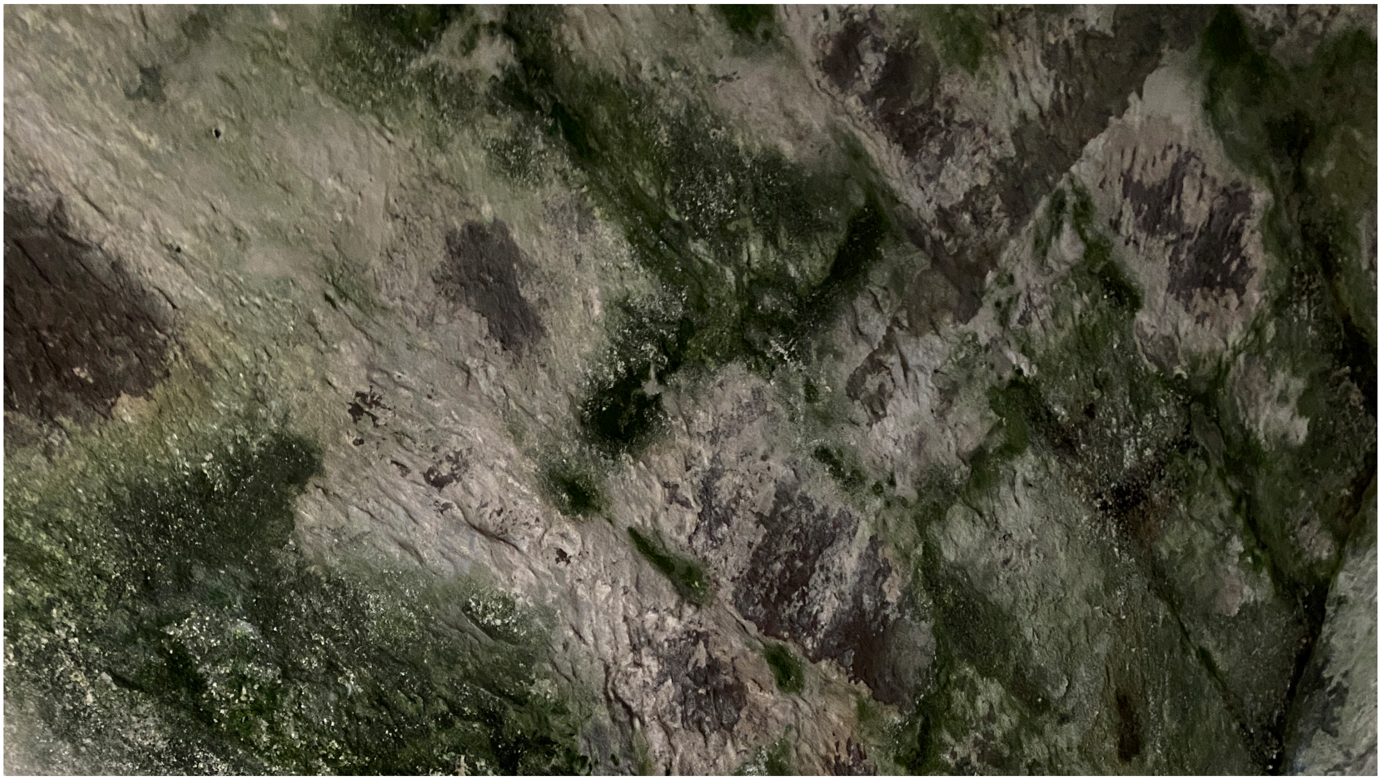

Figure 53: Detail of bio-growth in the armory in the northern tower (Image: B. Fortenberry).

Figure 54: Detail of bio-growth in the magazine in the northern tower (Image: B. Fortenberry).

Bio-growth and Soiling

Figure 55: Detail of bio-growth in the barracks in the southern complex (Image: B. Fortenberry).

Figure 56: Detail of bio-growth on the interior fort wall (Image: B. Fortenberry).

Bio-growth and Soiling

Figure 56: Soiling on the interior wall of the southern complex (Image: B. Fortenberry).

Figure 57: Aerial image of soiling on the interior wall of the southern complex (Image: B. Fortenberry).

Bio-growth and Soiling Recommendations

1. Physically remove bio-growth using non-mechanical means (e.g., soft plastic or hair bristle brushes, wooden tongue depressors).

2. Use a conservation-approved bio-cide such as D2 to aid in the removal and prevent the additional growth of the bio-growth. Care should be taken in the removal of bio-growth from dry-laid stone walls as roots will extend into the wall fabric. Their removal could dislodge smaller stones.

3. In cases of non-structural cracking that is allowing the invasion of bio-growth, consult a conservator for use of restoration mortar to fill cracks.

4. To remove soiling and bird waste from the substrate, standing walls using a low-pressure water wash. Under no circumstances should a pressure washer.

Efflorescence

Salt build-up (efflorescence) due to the proximity to the ocean, this site is located in a marine environment. It will be impossible to prevent the build-up of salt on this site. It is primarily located on the southern firing platform. While not necessarily detrimental to the substrate, efflorescence can be unattractive.

Figure 58: Efflorescence detail on the firing platform of the southern complex (Image: B. Fortenberry).

Efflorescence

Figure 59: Efflorescence on the southern face of the northern tower complex (Image: B. Fortenberry).

Figure 60: Efflorescence on the northern face of the southern firing platform (Image: B. Fortenberry).

Efflorescence Recommendations

1. If build-up becomes excessive, use a plastic bristle brush to gently remove salt from the substrate. Efflorescence is a natural process that allows the salt to escape the substrate. Under no circumstances should a water-proofing coating be applied to the substrate.

Conditions of Metal Elements

Cast iron guard rails on the southern firing platform are placed within a cast concrete footing. The guard rails consist of piers connected by two thin metal rails. Some of the rails are bent. Due to the combination of metal, concrete, and marine environment, the metal is experiencing heavy corrosion. This corrosion is causing several issues, a) causing the coating to de-laminate from the metal substrate, and b) causing rust jacking in the concrete footing.

Figure 61: Cast iron pier and guard rail failure in northern complex (Image: B. Fortenberry).

Conditions of Metal Elements

Figure 62: Cast iron pier failure and rust jacking in concrete footing on southern firing platform (Image: B. Fortenberry).

Figure 63: Cast iron pier and guard rail failure on southern firing platform (Image: B. Fortenberry).

Conditions of Metal Elements Recommendations

1. Remove any loose metal elements from the guard rail. Use a rust converter to consolidate areas of corrosion, and re-coat with a marine environment approved appropriate coating. This coating should match the existing colors. If the original color is unknown, finish analysis by an architectural paint conservator is recommended.

2. Remove any loose fragments of concrete, and reattach them using appropriate restoration mortar. Using restoration mortars seal the bases of each loose pier.

3. Consult with historic cast-iron metals expert who can restore original form to bent piers and replace missing elements. New elements should be replaced in similar historic form and color.

4. The placement of these metal elements ensures the health and safety of visitors on the firing platform. If additional guard rails are installed, care should be taken that they match the historic examples.

Signage and Visitor Experience

There was evidence of visitor impact, particularly in the northern complex of rooms, including the magazine and armory. Beer bottles, food wrapper waste, and other miscellaneous items suggest that individuals and groups come to the site after hours for social gatherings. While there was no evidence of negative impact on the historic fabric, their presence after dark creates liability for the site.

Health and safety signage must be updated.

Figure 64: Interior view of guard house entrance to High Knoll Fort (Image: B. Fortenberry).

Signage and Visitor Experience

Figure 65: Danger sign and failing fencing near southwestern wall collapse (Image: B. Fortenberry).

Figure 66: Picnic area on the upper surface of tower complex (Image: B. Fortenberry).

Signage and Visitor Experience Recommendations

1. Additional lights might deter after-hours visitors to the site.

2. An after-hours gate could also impede after-hours visitations.

3. Additional signage should be installed to indicate that visitors should not climb on any stone elements, or approach the collapsed wall section.

4. Additional guard rails should be installed on the western portion of the southern firing platforms to prevent visitors from injury from falling from high stone platforms.

5. The temporary "Danger Sign" should be replaced with more obvious signage.

6. The southwestern stair of the firing platform should be cordoned off.

7. Some interpretive panels appear to be missing and need to be replaced along the eastern wall.

Triage Recommendations

1. IMMEDIATE: Install signage and barriers that conform to UK Health and Safety Guidelines. Areas of concern are detailed in the Wall Collapse and Signage and Visitor Experience sections.

2. SHORT TERM: Address the wall collapse on the southwest corner of the exterior fort wall. This item is a priority both in terms of the continued structural integrity of the fort and the health and safety of visitors.

Figure 67: Ground image looking north towards tower complex on Fort interior (Image: B. Fortenberry).