TECHNICAL REPORT

Proposed Changes to Arecibo Observatory Operations: Historic Properties Assessment of Effects

Prepared for

National Science Foundation

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Acronyms and Abbreviations

ACHP	Advisory Council on Historic Preservation
APE	Area of Potential Effects
AST	Astronomical Sciences
C.F.R.	*Code of Federal Regulations*
MOA	Memorandum of Agreement
NAIC	National Astronomy and Ionosphere Center
NRHP	National Register of Historic Places
NSF	National Science Foundation
SHPO	State Historic Preservation Officer
TCP	traditional cultural property
USGS	U.S. Geological Survey

SECTION 1

Introduction

The National Science Foundation (NSF) Directorate for Mathematical and Physical Sciences, Division of Astronomical Sciences (AST) has identified the need to divest several facilities from its portfolio to retain the balance of capabilities needed to deliver the best performance on the key science of the present decade and beyond. The Arecibo Observatory in Puerto Rico is one of the facilities identified for potential divestment. This technical report identifies historic properties located within the Arecibo Observatory and provides an assessment of effects on those historic properties associated with the proposed Alternatives.

1.1 Definition of Proposed Undertaking

The decision regarding the potential changes to the Arecibo Observatory operations is considered a federal undertaking and triggers compliance with Section 106 of the National Historic Preservation Act. NSF initiated Section 106 consultation with the Puerto Rico State Historic Preservation Officer (SHPO) on July 5, 2016. Consultation with the SHPO is ongoing.

1.2 Proposed Alternatives Background

The Arecibo Observatory, which includes the world's largest single-dish radio telescope (the 305-meter radio telescope), is a national center for research in radio astronomy, planetary radar, and aeronomy (including optical facilities). The Observatory is located in west-central Puerto Rico on federal land and occupies 118 acres. Construction of the Arecibo Observatory was funded in the early 1960s by the Department of Defense Advanced Research Projects Agency to perform radar back-scatter studies of the ionosphere. In 1969, the facility was transferred from the Department of Defense to NSF and was made a national research center, with operations led by Cornell University. In 1971, the facility became known as the National Astronomy and Ionosphere Center (NAIC).

A key component of the Arecibo Observatory research facility is a 305-meter-diameter, fixed, spherical reflector. Arecibo Observatory infrastructure includes instrumentation for radio and radar astronomy and ionosphere physics, office and laboratory buildings, a heavily used visitor and education facility, and lodging facilities for visiting scientists.

In 2008, the Arecibo Observatory was listed in the National Register of Historic Places (NRHP) as the NAIC historic district. It was determined to be significant under NRHP Criteria A (associated with events that have made a significant contribution to the broad patterns of our history) and C (embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master).[1]

In September 2011, Cornell University's cooperative agreement with NSF expired, and following competition, a new cooperative agreement was awarded by NSF to SRI International, with sub-awards to Universities Space Research Association and the Universidad Metropolitana. That 5-year cooperative agreement was recently extended, and it now expires on March 31, 2018.

[1] In 2015, after discovering that the Arecibo Observatory was inaccurately listed in the NRHP as owned by Cornell University, NSF contacted the National Park Service and requested that the Arecibo Observatory be de-listed and then re-listed with NSF as the owner. That request was granted and the Arecibo Observatory was removed and then re-listed in the NRHP on December 22, 2015, reflecting the corrected ownership information.

1.3 Proposed Alternatives Description

NSF's AST is the federal steward for ground-based astronomy in the United States, funding research with awards to individual investigators and small research groups, and via cooperative agreements for operation of large telescope facilities. These national and international telescope facilities provide world-leading, one-of-a-kind observational capabilities on a competitive basis to thousands of astronomers per year. These facilities also enable scientific advances by making archived data products available to researchers. Along with funding telescope facilities and research awards, AST supports the development of advanced technologies and instrumentation, and manages the allocation and assignment of specific frequencies in the radio spectrum for scientific use by the entire NSF community.

The need for NSF to reduce its participation in the Arecibo Observatory has been established through a number of reviews and surveys conducted by the science community. At present, the Arecibo Observatory serves a variety of scientific user communities in astronomy, aeronomy, and planetary science, and is funded for all three activities as well as an active education and public outreach program. However, the science community evaluations indicated that the science capability of the Arecibo Observatory is a lower priority than other science capabilities that NSF funds. In a funding-constrained environment, NSF must maintain a balanced research portfolio with the largest science return for the taxpayer dollar; therefore, the purpose of the Proposed Action is for NSF to evaluate changes in operations and to substantially reduce its contribution to the funding of the Arecibo Observatory. The proposed action Alternatives are designed to address this purpose and need.

The five proposed action Alternatives and the No-Action Alternative are described below:

- **Alternative 1 – Collaboration with Interested Parties for Continued Science-focused Operations (Agency-preferred Alternative):** Alternative 1 would include continued science-focused operations by a collaboration of interested parties. Existing buildings that would no longer be of use would be deconstructed.
- **Alternative 2 – Collaboration with Interested Parties for Transition to Education-focused Operations:** Alternative 2 would transition the site to education-focused operations. The visitor center, learning center, and 12-meter-diameter radio telescope would remain operational. The 305-meter radio telescope would be made inoperable, but retained for visual/historical interest. It would be secured and regularly maintained to prevent structural degradation. Existing buildings that would no longer be of use would be deconstructed.
- **Alternative 3 – Mothballing of Facilities:** This proposed Alternative would involve mothballing (preservation) of essential buildings, radio telescopes, and other equipment with periodic maintenance to keep them in working order. This would allow the facility to be reopened at a future date. Structures and facilities that would no longer be of use would be deconstructed. Gates and fencing would be evaluated to determine if upgrades are needed to provide appropriate security/access around portions of the site that would require protection.
- **Alternative 4 – Partial Deconstruction and Site Restoration:** Alternative 4 involves the partial deconstruction of the Observatory, including deconstruction of all abovegrade structures, except the large concrete structures (i.e., towers, anchors, and rim wall). Belowgrade foundations would be stabilized, filled, and abandoned in place.
- **Alternative 5 – Complete Deconstruction and Site Restoration:** Alternative 5 involves the deconstruction of all abovegrade structures, including the large concrete structures (i.e., towers, anchors, and rim wall). All belowgrade foundations would be stabilized, filled, and abandoned in place.

- **No-Action Alternative – Continued NSF Investment for Science-focused Operations:** Under the No-Action Alternative, NSF would continue operations of the Arecibo Observatory. Operations would be contingent on funding appropriations.

1.4 Area of Potential Effects

The Area of Potential Effects (APE) for the proposed undertaking is defined as the property boundary of the Arecibo Observatory, which includes 118 acres of land and is located on U.S. Geological Survey (USGS) Topographic Quadrangle maps Bayaney NE (2013) and Utuado NW (2013) (Figure 1). The boundaries of the Observatory property were determined by NSF as the APE to encompass all areas where the proposed Alternatives could occur, as well as all of the Arecibo Observatory NRHP-listed historic district. Figure 2 shows the historic district boundaries and contributing resources.

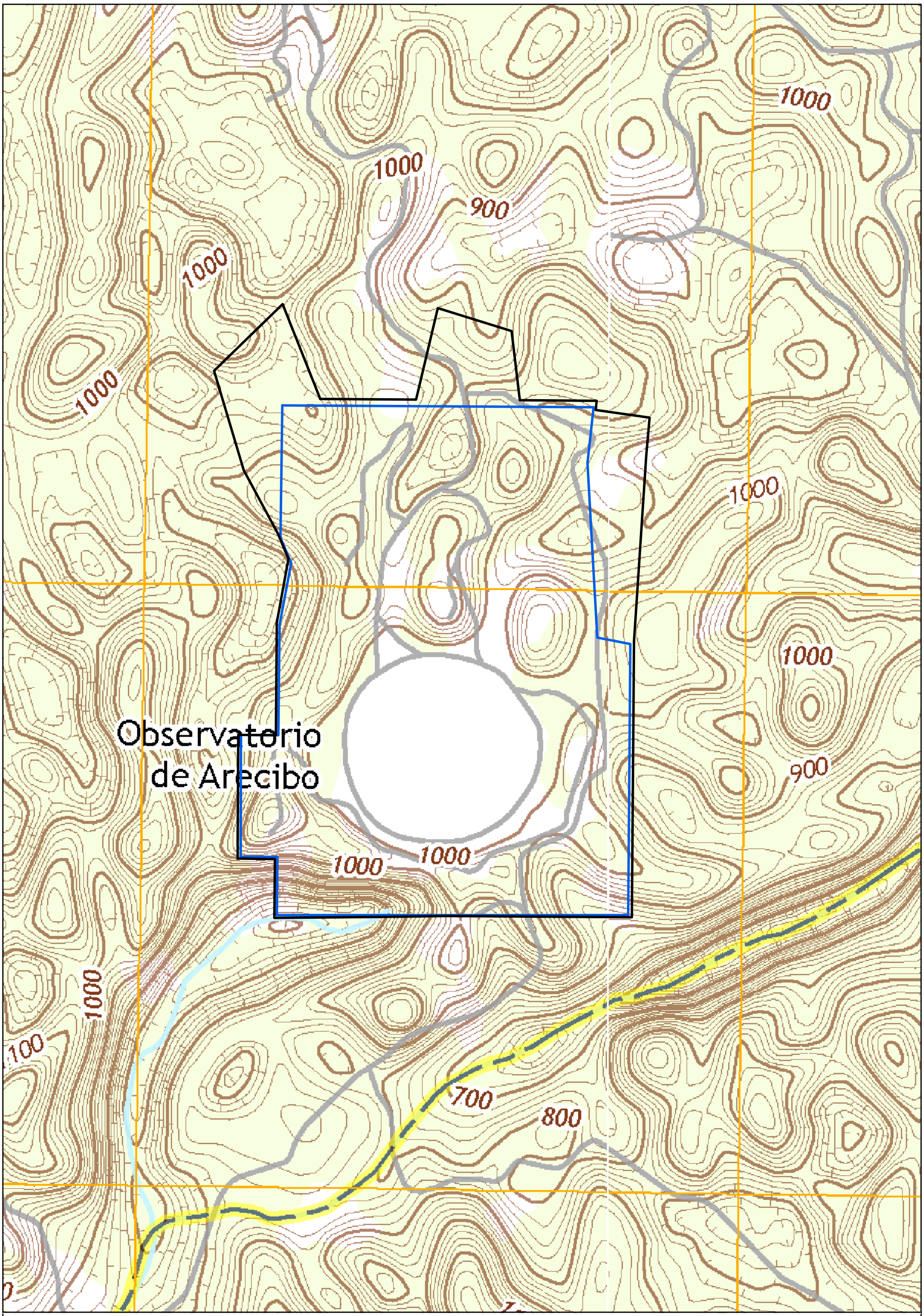
1.5 Methodology

The federal historic properties database known as the National Register Information System was reviewed to identify existing historic properties within the APE. The search showed that the Arecibo Observatory was listed in the NRHP as the NAIC historic district in 2008. A total of 14 buildings and structures are included in the 2008 NRHP nomination. Through correspondence with the Puerto Rico SHPO, eight buildings and one structure were identified as contributing to the NRHP-listed district (see Section 2.2). No other buildings or structures on the 118-acre property are listed in or considered eligible for listing in the NRHP. Because the Arecibo Observatory has been listed in the NRHP, NFS, in consultation with the SHPO, determined that no further inventory or evaluation of historic properties was necessary.

Following several initial meetings with the Puerto Rico SHPO, NSF formally initiated Section 106 consultation on July 5, 2016. As stipulated in 36 *Code of Federal Regulations* (C.F.R.) §800.1(a), the goal of consultation is to identify historic properties potentially affected by the undertaking, assess effects to them, and seek ways to avoid, minimize, or mitigate any adverse effects on historic properties. After historic properties within the APE are identified, the Criteria of Adverse Effect are applied to each Alternative. These criteria are used to make a determination of whether the proposed undertaking could change the characteristics that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Section 106 of the NHPA allows three findings for effects on historic properties:

- No Historic Properties Affected
- No Adverse Effect
- Adverse Effect

When an undertaking is found to have an adverse effect, Section 106 requires notification to the Advisory Council on Historic Preservation (ACHP) and consultation with SHPO and other interested parties regarding appropriate avoidance or mitigation measures. Examples of mitigation measures include such things as redesigning aspects of a project, or relocating or documenting buildings and/or structures. For a finding of adverse effect, the product of consultation is usually a Memorandum of Agreement (MOA) per 36 C.F.R. §800.6(c) among the SHPO, federal agency, ACHP if it chooses to participate, and other consulting parties. This agreement contains stipulations specifying measures to be implemented that would avoid, minimize, and/or mitigate the adverse effects. For this proposed undertaking, an MOA would be drafted to resolve any potential adverse effects from the proposed Alternatives.



Property Boundary and Area of Potential Effects (APE)

Historic District Boundary

N
W E
S

1 inch = 500 feet

0 250 500

Feet

Figure 1
Cultural Resources Area of Potential Effects
Arecibo Observatory
Puerto Rico

USGS Topographic Quads Bayaney NE (2013) and Utuado NW (2013)

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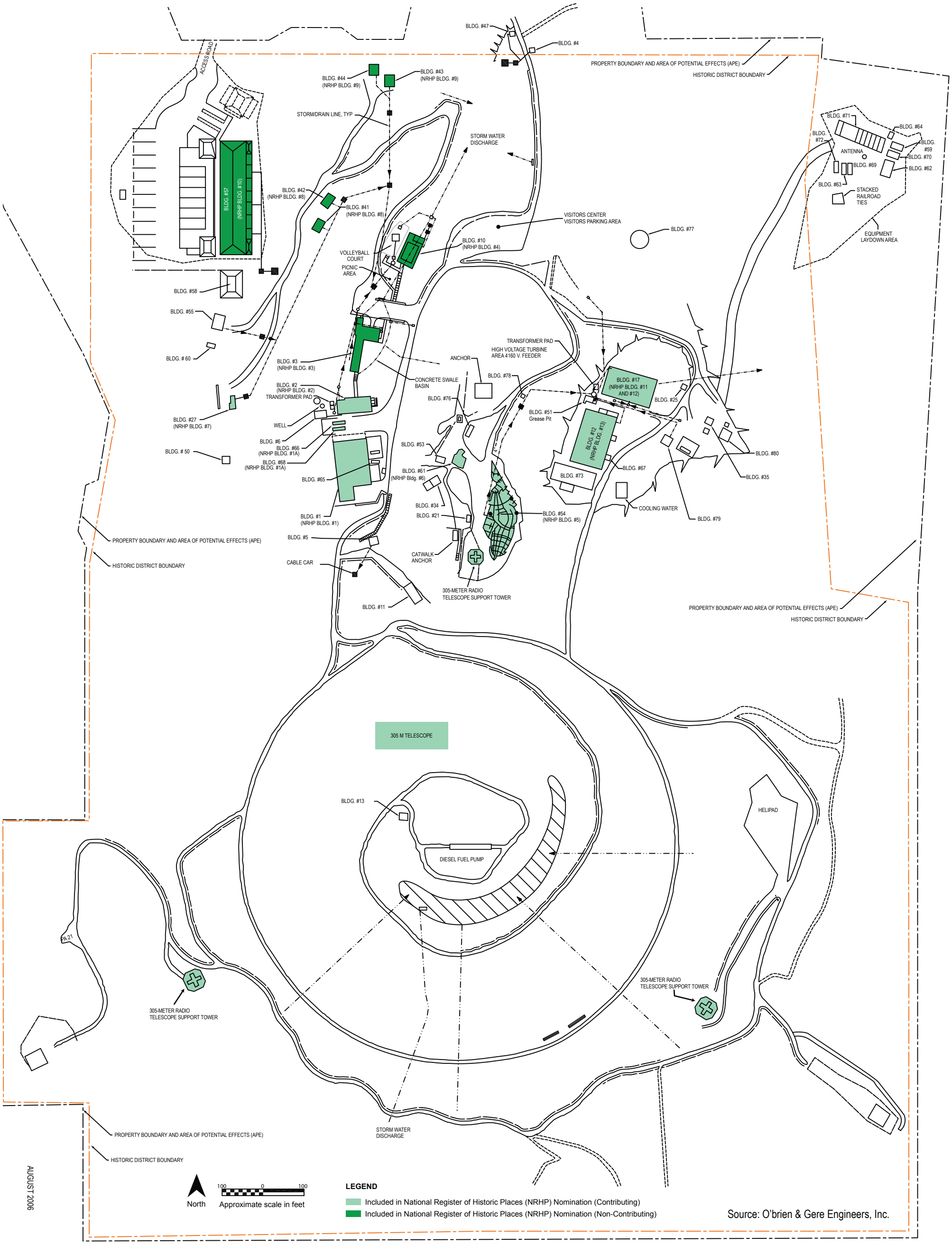

BUILDING NO. DESCRIPTION

1. OPERATIONS BUILDING (1963)
2. ADMINISTRATION BUILDING (1963)
3. VISITING SCIENTIST QUARTERS AND CAFETERIA (1963)
4. ENTRANCE GUARD HOUSE (1963)
5. CABLE CAR HOUSE (1963)
6. PUMP HOUSE/WATER TREATMENT BLDG. (1963)
10. SWIMMING POOL/RESTROOMS (Mid 1960's)
11. LEWIS BUILDING–RIGGING LOFT (Mid 1960's)
12. MAINTENANCE SHOPS (1967)
13. BOWL SHACK (1963)
17. WAREHOUSE (1967)
21. ANTENNA TESTING RANGE
25. PAINT STORAGE BUILDING (Circa 2010)
27. OPTICAL LABS (1985/1997)
34. HIGH VOLTAGE POWER SUPPLY BLDG. (1973)
35. CUMMINGS GENERATOR CONTROL BLDG. (2010)
41. WEST HILL V.S.Q. BACHELOR UNIT NO. 1 (1990's)
42. WEST HILL V.S.Q. BACHELOR UNIT NO. 2 (1990's)
43. WEST HILL V.S.Q. FAMILY UNIT NO. 1 (1990's)
44. WEST HILL V.S.Q. FAMILY UNIT NO. 2 (1990's)
47. MAIN GATE RESTROOM (1963)
50. INTERFERENCE MONITORING SHACK
51. GREASE PIT
53. EMERGENCY GENERATOR BLDG.
54. VISITOR CENTER BLDG. (1997)
55. LIDAR LABORATORY BLDG. (1996)
57. NORTH V.S.Q. BLDG. (2002)
58. NORTH V.S.Q. UTILITY BLDG. (2002)
59. VISITOR CENTER TRAILER
60. ANT. RECE. TESTING BLDG. (Late 1990's)
61. LEARNING CENTER (2001)
62. HFF STORAGE TRAILER
63. IONOSONDE TRAILER
64. ELECTRONIC TRAILER
65. SHIELDED TRAILER (1983)
66. ATMOSPHERIC SCIENCE TRAILER
67. CRYOGENICS LAB TRAILER (1967)
68. SCIENTIFIC OFFICES TRAILER
69. ELECTRONIC TRAILER (WAVEGUIDE)
70. COMPUTER TRAILER
71. ELECTRONICS CABLE TRAILER
72. ELECTRONIC TRAILER (CRYOGENICS)
73. HF TRANSMITTER BUILDING (2000's)
76. INSPIRATION FOR SCIENCE TRAILER (2000's)
77. PHASE REFERENCE ANTENNA (12M) (2010)
78. COFFEE HUT (2000's)
79. ENGINEERING OFFICE BUILDING (2000's)
80. CUMMINGS DIESEL GENERATOR BUILDING (2010)

Figure 2
Architectural Resources and Historic Properties within the APE
Arecibo Observatory
Puerto Rico

A Secretary of the Interior-qualified architectural historian conducted a reconnaissance architectural survey at the Arecibo Observatory on July 19 and 20, 2016. The purpose of the survey was to verify the current conditions of existing known historic properties located at the Arecibo Observatory. The survey included a general site assessment and informal interviews with NSF staff and partners to obtain information regarding alterations to those buildings and structures that contribute to the historic district. Field investigations focused on the nine known resources that contribute to the NRHP-listed historic district to verify that no significant alterations had occurred to the buildings and structures since the district was originally listed in 2008.

There are no known archaeological resources at the Arecibo Observatory, and no archaeological survey work was conducted there as part of the Section 106 process. In addition, no traditional cultural properties (TCPs) have been identified at the Arecibo Observatory; therefore, TCPs are not analyzed in this technical report.

Identified Historic Properties

2.1 Historical Context

The sensitive nature of radio telescopes limits the number of potential locations to establish an observatory. Man-made radio noise from earth can interfere with signals from space, making it difficult to distinguish between various types of data collected. Additionally, severe weather can interfere with the functionality of radio telescopes. Geographic barriers help isolate radio signals from space. Geographic, environmental, and geologic requirements had to be considered when deciding on a location for the 305-meter radio telescope:

> …it had to be near the equator, since there the radar (capable of studying the ionosphere) could also be used to study nearby planets. Furthermore, a site with moderate temperature changes and low winds was desirable for the stability of the instrument – to minimize the expansion and contraction of the structure and to reduce swaying of the suspended feed. The geological formation of the future site was also a very important factor… [necessitating] an appropriate 'hole in the ground' (Santos, 2007).

The Arecibo Observatory site was chosen because it had "a natural depression (to minimize excavation for the projected reflector dish), located away from populous areas and air lanes, in order to reduce radio interference" (Santos, 2007).

Construction at the Arecibo Observatory started in 1960 and construction of the 305-meter radio telescope was completed in August of 1963 at a cost of $9 million (Santos, 2007). A feat of engineering, the "capabilities of the instrument derive from its unique design, which includes a large reflector, movable line feeds that correct for spherical aberration, and high-performance transmitters, receivers, and computers for taking data and analyzing them" (Santos, 2007).

The 305-meter reflector dish has undergone two major upgrades: in 1974, the reflector dish was resurfaced and a high frequency planetary radar transmitter was installed; and in 1997, major new equipment installations included new ground screen shields that block ground radiation, a Gregorian dome with sub-reflectors and new electronics, and a new radar transmitter (Santos, 2007). These improvements greatly increased the capability of the telescope. The 305-meter radio telescope and its supporting facilities have been used over the past to make "numerous and significant contributions" to astronomy:

> After almost fifty years of operations, the Arecibo Radio Telescope [305-meter radio telescope] has become a popular icon, it is recognized as an engineering landmark, and scientists from all over the world compete to use the facility (Santos, 2007).

In addition, the Arecibo Observatory is notable for sharing high-level results of complicated scientific investigations with the public since the construction of the Fundación Angel Ramos Visitor and Educational Facility (Building 54, NRHP Building 5) in 1997. This facility has more than 100,000 visitors each year (Santos, 2007).

2.2 The National Astronomy Ionosphere Center Historic District

In 2008, the Arecibo Observatory was listed in the NRHP as the NAIC historic district. At the time of listing, the site was not yet 50 years old and was therefore evaluated under Criteria Consideration G, for

having achieved an exceptional level of significance within the last 50 years. The associated NRHP nomination form states:

> The National Astronomy and Ionosphere Center (Arecibo Observatory) has nationwide significance under Criterion A, because of its contribution to the history of the sciences of ionosphere studies and the development of radio and radar astronomy in the United States. The property is also eligible under Criterion C, because it represents a significant work of engineering (Santos, 2007).

Eight buildings and one structure contribute to the NRHP-listed historic district. These contributing resources are listed in Table 1 and their locations are shown on Figure 2. The NRHP Registration Form, which was completed in 2007, provides building numbers that do not always correspond to the current facility number designations. For this reason, the current building number is provided in Table 1 along with the corresponding NRHP Registration Form building number. Two trailers associated with Building 1 are identified in the NRHP Registration Form together as Building 1A; however, these two trailers currently have individual designations as Buildings 66 and 68. In addition, the NRHP Registration Form identifies Buildings 11 and 12, which are currently designated as a single building, Building 17.

Table 1. Contributing Resources to the NRHP-Listed Historic District

Structure/Building Number	Building Name	Year of Construction
N/A	305-meter Radio Telescope and Support Towers	1963
Building 1 (and Trailers 66 and 68) [NRHP Buildings 1 and 1A]	Operations Building (with Atmospheric Science Trailer and Visiting Science Trailer)	1963 (addition in 1983) Year of construction for trailers unknown
Building 2 [NRHP Building 2]	Administration Building	1997
Building 54 [NRHP Building 5]	Visitor Center (Fundación Angel Ramos Visitor and Educational Facility)	2001 (addition 2015)
Building 61 [NRHP Building 6]	Learning Center	2001
Building 27 [NRHP Building 7]	Photometry Shack and Optical Laboratory	1985/1997
Building 17 [NRHP Buildings 11 and 12]	Warehouse and Business/Purchasing	1967
Building 12 [Building 13]	Maintenance Building	1967

The results of the reconnaissance architectural survey are presented in a technical memorandum entitled *Proposed Changes to Arecibo Observatory Operations: Cultural Resources Reconnaissance Architectural Survey Summary*, which is included as Appendix A (CH2M, 2016). The technical memorandum includes current photographs of the buildings and structures that contribute to the NRHP-listed historic district as well as a discussion of the historic district's overall integrity.

Assessment of Effects

The sections below describe potential effects to historic properties as a result of the five proposed action Alternatives and the No-Action Alternative. The following descriptions of potential effects are divided into two phases of the Proposed Action: deconstruction and operations.

3.1 Alternative 1 – Collaboration with Interested Parties for Continued Science-focused Operations (Agency-preferred Alternative)

3.1.1 Deconstruction

Alternative 1 involves the deconstruction of several facilities at the Arecibo Observatory that contribute to the NRHP-listed historic district; therefore, Alternative 1 would result in adverse effects under Section 106. Table 2 identifies what would occur to each historic property as a result of the Proposed Action under Alternative 1.

Table 2. Alternative 1 – Description of Proposed Activities

Proposed Activity	Alternative 1
Historic Properties to be Deconstructed	• Building 2 (Administration Building) • Building 17 (Warehouse and Business/Purchasing Building) • Buildings 66 and 68 (the Atmospheric Science Trailer and Visiting Scientist Trailer, both associated with Building 1, Operations Building)
Historic Properties to Remain	• 305-meter radio telescope and its associated structures (reflector dish, foundation, rim wall, support towers, and anchors) • Building 1 (Operations Building) • Building 12 (Maintenance Building) • Building 27 (Photometry Shack/Optical Laboratory) • Building 54 (Visitor Center) • Building 61 (Learning Center)

The deconstruction of contributing resources to an NRHP-listed historic district would result in a finding of Adverse Effect. Although mitigation would be implemented, deconstruction of a historic building is considered adverse because it is a permanent removal of historic fabric. NSF will continue to consult with the Puerto Rico SHPO and other consulting parties to determine the appropriate ways in which to avoid, minimize, and/or mitigate this effect. It is anticipated that any measures that result from these consultations would be documented in an MOA. Although several contributing buildings would be deconstructed, Alternative 1 would avoid complete deconstruction of the historic district. The Observatory would retain most of the historic properties within the historic district, including the site's primary instrument, the 305-meter radio telescope. As a result, the Observatory would still retain sufficient integrity to convey its significance as an NRHP-listed historic district. Deconstruction under Alternative 1 would result in adverse effects to more historic properties than Alternative 3, and to fewer historic properties than Alternatives 2, 4, and 5.

3.1.2 Operations

Operations of the Arecibo Observatory would continue under Alternative 1 through collaboration with interested parties for continued science-focused operations. After deconstruction, six of the contributing resources to the original NRHP-listed historic district would remain extant for operation under Alternative 1. However, the 305-meter telescope, which stands as the focal point of the historic district, and the educational facilities, Building 54 (Visitor Center) and Building 61 (Learning Center), would be retained under Alternative 1, along with three additional historic buildings. The preservation of the 305-meter telescope and several other support facilities, namely the educational facilities, would allow the small collection of historic properties to retain sufficient integrity to qualify as a historic district. As such, historic properties would remain present and could be affected by future operations. However, there are currently no physical alterations proposed for historic properties during operations. Therefore, operations under Alternative 1 would result in No Historic Properties Affected.

3.1.3 Summary

Alternative 1 involves the deconstruction of several historic properties that contribute to the NRHP-listed historic district. As a result, the overall finding of effect for the proposed Alternative is an Adverse Effect to historic properties.

3.2 Alternative 2 – Collaboration with Interested Parties for Transition to Education-focused Operations

3.2.1 Deconstruction

Alternative 2 involves the deconstruction of several facilities at the Arecibo Observatory that contribute to the NRHP-listed historic district and would result in adverse effects. Table 3 lists the contributing resources to the historic district and identifies the proposed activity for each under Alternative 2.

Table 3. Alternative 2 – Description of Proposed Activities

Historic Properties to be Deconstructed	• Building 1 (Operations Building) • Building 2 (Administration Building) • Building 17 (Warehouse and Business/Purchasing Building) • Buildings 66 and 68 (the Atmospheric Science Trailer and Visiting Scientist Trailer, both associated with Building 1, Operations Building)
Historic Properties to Remain	• Building 12 (Maintenance Building) • Building 27 (Photometry Shack/Optical Lab) • Building 54 (Visitor Center) • Building 61 (Learning Center)
Historic Properties to be Safe-abandoned	• 305-meter radio telescope and its associated structures (reflector dish, foundation, rim wall, support towers, and anchors)

Deconstruction activities for Alternative 2 would be similar to Alternative 1, in that both involve the deconstruction of certain contributing resources to an NRHP-listed historic district, but would also avoid complete deconstruction of the historic district. Deconstruction under Alternative 2 would result in adverse effects to more historic properties than Alternatives 1 and 3, and to fewer historic properties than Alternatives 4 and 5.

Alternative 2 would result in additional impacts to the 305-meter telescope than would result from Alternative 1. The 305-meter radio telescope would not be deconstructed under Alternative 2, and

instead would be retained onsite for visual and historic interest. While Alternative 1 would retain the 305-meter radio telescope and supporting facilities for research, Alternative 2 would involve the safe abandonment of the 305-meter radio telescope, which is the focal point of the NRHP-listed historic district. Preparing the structure for safe abandonment would involve securing the structure from environmental damage caused by wind, rain, humidity, and extreme temperatures. The structure would be isolated from public access through the installation of fencing or other means to reduce fall and tripping hazards and preclude vandalism. Although physical changes to the 305-meter reflector dish would be negligible, securing the overall structure would involve physical alterations to it, including the removal of the large support cables for the towers and the removal of the Gregorian dome that is suspended above the 305-meter reflector dish, diminishing the structure's integrity of materials and design. These alterations would be noticeable, but would not substantially diminish the primary characteristics of the 305-meter radio telescope that qualify it for listing in the NRHP. Specific measures to mitigate impacts, agreed upon in consultation with the Puerto Rico SHPO, could help to minimize effects to the historic structure and historic district. The impacts from preparing the structure for safe abandonment would result in a finding of No Adverse Effects to the contributing 305-meter radio telescope.

3.2.2 Operations

Operations of the Arecibo Observatory would continue under Alternative 2 through collaboration with interested parties for continued education-focused operations. Operation activities for Alternative 2 would be similar to those under Alternative 1 and both would retain sufficient integrity to qualify as a historic district. However, under Alternative 2, the 305-meter radio telescope would experience additional effects during operations than it would under Alternative 1. The safe abandonment of the 305-meter radio telescope under Alternative 2 would involve the removal of the radio telescope from service, isolating the structure from public access, and resulting in a change of use. Since the 305-meter radio telescope is a scientific instrument, its use is a primary component of its significance. Although the structure would remain extant, a change of use would diminish its integrity of feeling and association. In addition, because of the lack of maintenance and use, the safe abandonment of the 305-meter radio telescope under proposed Alternative 2 would result in a gradual depletion of the structure's physical integrity, including its integrity of materials, workmanship, and design. Overall, the loss of the 305-meter radio telescope as an active instrument would diminish the NRHP-listed historic district's integrity of materials, feeling, setting, design, workmanship, and association. The decline in the structure's integrity could ultimately result in an Adverse Effect.

3.2.3 Summary

Alternative 2 involves the deconstruction of several historic properties that contribute to the NRHP-listed historic district, and a change of use in the significant 305-meter radio telescope. As a result, the overall finding of effect for the proposed Alternative is an Adverse Effect to historic properties.

3.3 Alternative 3 Mothballing of Facilities

3.3.1 Deconstruction

Under Alternative 3, all buildings and structures that contribute to the NRHP-listed historic district would be mothballed and no historic properties would be deconstructed.

Avoiding deconstruction of historic properties means that they would be preserved for potential future use. In this way, Alternative 3 would retain the collection of contributing resources as a unique historic district that captures a significant period in the field of ionosphere studies and radar and radio astronomy, and architecturally embodies the distinctive characteristics of a type, period, and method of construction. Preparing historic properties for mothballing could involve securing buildings, structures,

and their associated components, turning off utilities, weatherizing, and providing adequate ventilation. These steps could involve some physical treatments but would result in a finding of No Adverse Effects to historic properties. Any modifications required during mothballing would be compatible with the historic resource's style and materials, and would be executed in accordance with the National Park Service's Preservation Brief 31, "Mothballing Historic Buildings" (Park, 2013). If historic properties were returned to use at a future date, any alterations performed as part of the mothballing process could be reversed without physical harm to the historic fabric. Of the five proposed Alternatives, Alternative 3 would result in the least significant effects to historic properties.

3.3.2 Operations

Under Alternative 3, the NRHP-historic district and all its contributing resources would be mothballed, which would include the removal of each facility from daily use, while maintaining the general condition of historic properties for a defined period. Mothballing the 305-meter radio telescope and the other contributing facilities at the Arecibo Observatory would alter the use and setting of the site. The Arecibo Observatory is listed in the NRHP under Criterion A for its association with important events relating to the sciences of ionosphere studies, and the development of radio and radar astronomy that has made a significant contribution to history. The site is also listed under Criterion C for embodying the distinctive characteristics of a type, period, or method of construction and as an example of an important achievement in engineering. Historic properties at the Arecibo Observatory are mostly utilitarian buildings or scientific instruments and their use is a primary component of their significance. Some buildings on the site have achieved significance through their function supporting the scientific mission of the site. The 305-meter radio telescope has achieved its significance through its use as a tool for furthering the field of ionosphere studies, and radar and radio astronomy. For these reasons, if the Observatory were mothballed, the historic district and its contributing historic resources would suffer a loss of association and feeling.

Despite an impact to the historic property's integrity of association and feeling, specific measures could ensure that the effects are minimized. These measures could include such things as photographic documentation of the historic properties at the Arecibo Observatory, a conditions assessment of the contributing resources, compliance with certain security and maintenance standards, and regular monitoring of the buildings and structures that contribute to the NRHP-listed historic district. Such measures would help to ensure the future survival of the historic district and its associated historic properties. Mothballing would be planned and completed in accordance with the National Park Service's Preservation Brief 31, "Mothballing Historic Buildings" (Park, 2013). Following the procedures outlined by the National Park Service, Alternative 3 would result in a finding of No Adverse Effects.

3.3.3 Summary

Alternative 3 involves mothballing historic properties that contribute to the NRHP-listed historic district. As a result, the overall finding of effect for the proposed Alternative is No Adverse Effects to historic properties.

3.4 Alternative 4 – Partial Deconstruction and Site Restoration

3.4.1 Deconstruction

Alternative 4 would involve the deconstruction of historic properties that contribute to the NRHP-listed historic district, resulting in adverse effects to historic properties. Alternative 4 would involve the safe abandonment of some elements of the 305-meter radio telescope, including the foundation and rim wall, support towers, and anchors, as shown in Table 4.

Table 4. Alternative 4 – Description of Proposed Activities

Proposed Activities	Alternative 4
Historic Properties to be Deconstructed	• 305-meter radio telescope and reflector dish • Building 1 (Operations Building) • Building 2 (Administration Building) • Building 12 (Maintenance Building) • Building 17 (Warehouse and Business/Purchasing Building) • Building 27 (Photometry Shack/Optical Laboratory) • Building 54 (Visitor Center) • Building 61 (Learning Center) • Buildings 66 and 68 (the Atmospheric Science Trailer and Visiting Scientist Trailer, both associated with Building 1, Operations Building)
Historic Properties to be Safe-abandoned	• 305-meter radio telescope's associated structures (foundation, rim wall, support towers, and anchors)

Under Alternative 4, the foundation and rim wall, support towers, and anchors of the 305-meter radio telescope would be safe abandoned and would remain extant. However, removal of the telescope mechanism and reflector dish would diminish the historic structure's integrity of materials, design, workmanship, feeling, and association. In addition, deconstructing all the other resources that contribute to the NRHP-listed historic district would diminish what remained of the 305-meter radio telescope's integrity of setting. Once only the foundation and rim wall, support towers, and anchors of the 305-meter radio telescope remain, it is unlikely that they would retain eligibility for the NRHP. The deconstruction of nearly all contributing resources to the NRHP-listed historic district would result in a finding of Adverse Effect.

When an undertaking is found to have an adverse effect, Section 106 requires consultation with SHPO and other consulting parties regarding appropriate avoidance, minimization, and/or mitigation measures. The product of consultation would be a document such as an MOA, per 36 C.F.R. §800.6(c), between SHPO, NSF, and other consulting parties, that would contain stipulations specifying the measures to be implemented. Under this proposed Alternative, NSF would continue to consult with the Puerto Rico SHPO to determine the appropriate mitigation measures to resolve any adverse effects.

3.4.2 Operations

Operations would completely cease under Alternative 4. No historic properties on the site would retain sufficient integrity to remain eligible for the NRHP; therefore, operations of Alternative 4 would result in a finding of No Historic Properties Affected.

3.4.3 Summary

Alternative 4 involves the deconstruction of historic properties that contribute to a NRHP-listed historic district. As a result, the overall finding of effect for the proposed Alternative is Adverse Effect to historic properties.

3.5 Alternative 5 – Complete Deconstruction and Site Restoration

3.5.1 Deconstruction

Alternative 5 would result in the deconstruction of the entire NRHP-listed district and all contributing resources; no historic properties would remain extant. Therefore, of the five proposed action Alternatives, Alternative 5 would incur the greatest impacts to historic properties. The deconstruction of all contributing resources to the NRHP-listed historic district would result in a finding of Adverse Effect.

As described for Alternative 4, when an undertaking is found to have an adverse effect, Section 106 requires consultation with SHPO and other consulting parties regarding appropriate avoidance, minimization, and/or mitigation measures. The product of consultation would be a document such as an MOA, per 36 C.F.R. §800.6(c), between SHPO, NSF, and other consulting parties, that would contain stipulations specifying the measures to be implemented. Under this Alternative, NSF would continue to consult with the Puerto Rico SHPO to determine the appropriate mitigation measures to resolve any adverse effects.

3.5.2 Operations

Operations would completely cease under Alternative 5; therefore, operations of Alternative 5 would result in a finding of No Historic Properties Affected.

3.5.3 Summary

Alternative 5 involves the deconstruction of all historic properties that contribute to a NRHP-listed historic district. As a result, the overall finding of effect for the proposed Alternative is Adverse Effect to historic properties.

3.6 No-Action Alternative

The No-Action Alternative is the continuation of the current use of the Arecibo Observatory. Under the No-Action Alternative, current activities would continue at the site, and no deconstruction would be expected to occur. Current activities at the Observatory include regular maintenance of buildings and structures, and alterations to resources that contribute to the NRHP-listed historic district in order to adapt to changes in science and technology. Maintaining the current conditions of the Observatory could involve minor alterations to historic properties to retain their utility; however, a review of any proposed alterations would occur prior to any action being taken to determine the effects on NRHP-listed properties. No proposed alterations are currently pending, resulting in a finding of No Historic Properties Affected.

SECTION 4

Conclusion

The Arecibo Observatory is listed in the NRHP as the NAIC historic district with nine contributing resources. Under proposed Alternatives 1, 2, 4, and 5, historic properties that contribute to the NRHP-listed historic district would be deconstructed, resulting in a finding of Adverse Effect under Section 106. Alternative 3 would retain historic properties for future use, resulting in a finding of No Adverse Effect to historic properties. Under the No-Action Alternative, there would be no change from the existing conditions and No Historic Properties Affected. The finding of effect for each Alternative is summarized in Table 5.

Table 5. Summary of Effects on Historic Properties

Proposed Alternative	**Finding of Effect** [a]
Alternative 1	Adverse Effect
Alternative 2	Adverse Effect
Alternative 3	No Adverse Effect
Alternative 4	Adverse Effect
Alternative 5	Adverse Effect
No-Action Alternative	No Historic Properties Affected

[a] *Pending concurrence from SHPO.*

SECTION 5

References

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Appendix A
Technical Memorandum: Proposed Changes to Arecibo Observatory Operations, Cultural Resources Reconnaissance Architectural Survey Summary

Proposed Changes to Arecibo Observatory Operations: Cultural Resources Reconnaissance Architectural Survey Summary

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Introduction

Arecibo Observatory was listed in the National Register of Historic Places (NRHP) as the National Astronomy and Ionosphere Center historic district in 2008. A total of 14 buildings and structures are included in the 2008 NRHP nomination. Through correspondence with the Puerto Rico State Historic Preservation Office (SHPO), five of those buildings were identified as non-contributing resources, leaving eight buildings and one structure identified as contributing to the NRHP-listed district. The contributing resources are listed in Table 1. The NRHP Registration Form, which was completed in 2007, provides building numbers that do not always correspond to the current facility number designations. For this reason, the current building number is provided in Table 1 along with the corresponding NRHP Registration Form building number. Two trailers associated with Building #1 are identified together in the NRHP Registration Form as Building #1A. However, these two trailers currently have individual designations as Buildings #66 and #68. In addition, the NRHP Registration Form identifies Buildings #11 and #12, which are currently designated as a single building, Building #17.

No other buildings or structures on the 118-acre property are listed in or considered eligible for the NRHP. Because the Arecibo Observatory has been listed in the NRHP, no further inventory or evaluation of historic properties was determined to be necessary, in consultation with the SHPO.

Table 1. Contributing Resources to the NRHP-Listed Historic District

Structure/Building Number	Building Name	Year of Construction
N/A	305-meter Radio Telescope and Support Towers	1963
Building #1 (and Trailers #66 and #68) [NRHP Buildings #1 and #1A]	Operations Building (and Atmospheric Science Trailer and Visiting Science Trailer)	1963 (addition in 1983)
Building #2 [NRHP Building #2]	Administration Building	1997
Building #54 [NRHP Building #5]	Visitor Center (Fundación Angel Ramos Visitor and Educational Facility)	2001 (addition 2015)

Building #61 [NRHP Building #6]	Learning Center	2001
Building #27 [NRHP Building #7]	Photometry Shack and Optical Lab	1985/1997
Building #17 [NRHP Buildings #11 and #12]	Warehouse and Business/Purchasing	1967
Building #12 [Building #13]	Maintenance Building	1967

Area of Potential Effects

The area of potential effects (APE) for the survey was defined as the property boundary of Arecibo Observatory, which includes 118 acres of land. The boundaries of the Observatory were determined as the APE to encompass all of the Arecibo Observatory NRHP-listed historic district.

Methodology

A Secretary of the Interior-qualified architectural historian conducted a reconnaissance architectural survey at Arecibo Observatory on July 19-20, 2016. The purpose of the survey was to verify the current conditions of existing known historic properties located at Arecibo Observatory. The survey included a general site assessment and informal interviews with the NSF staff and partners to obtain information regarding alterations to those buildings and structures that contribute to the historic district. Field investigations focused on the nine known resources that contribute to the NRHP-listed historic district to verify that no significant alterations had occurred to the buildings and structures since the district was listed in 2008.

Results

During the reconnaissance field survey in July 2016, each contributing resource was photographed and examined to determine if changes or alterations had occurred after the district was listed in 2008 that may have affected the property's overall integrity.

Building #54, the Fundación Angel Ramos Visitor and Educational Facility (visitor center), was renovated in 2015. The renovation included new restrooms, a new entrance, and a new observation deck that extends from the rear (south) elevation of the building. The visitor center is a modern building that was originally constructed in 1997. The building is considered significant within the NRHP-listed historic district for the role it plays in making important scientific investigations available to the public. The recent renovation has not significantly altered the overall integrity of the building; rather, the expansion provided further amenities for visitors, enhancing the overall utility of the building. The renovation had minor effects on the building's integrity of design, but did not diminish the building's integrity of association, feeling, location, setting, workmanship, or materials.

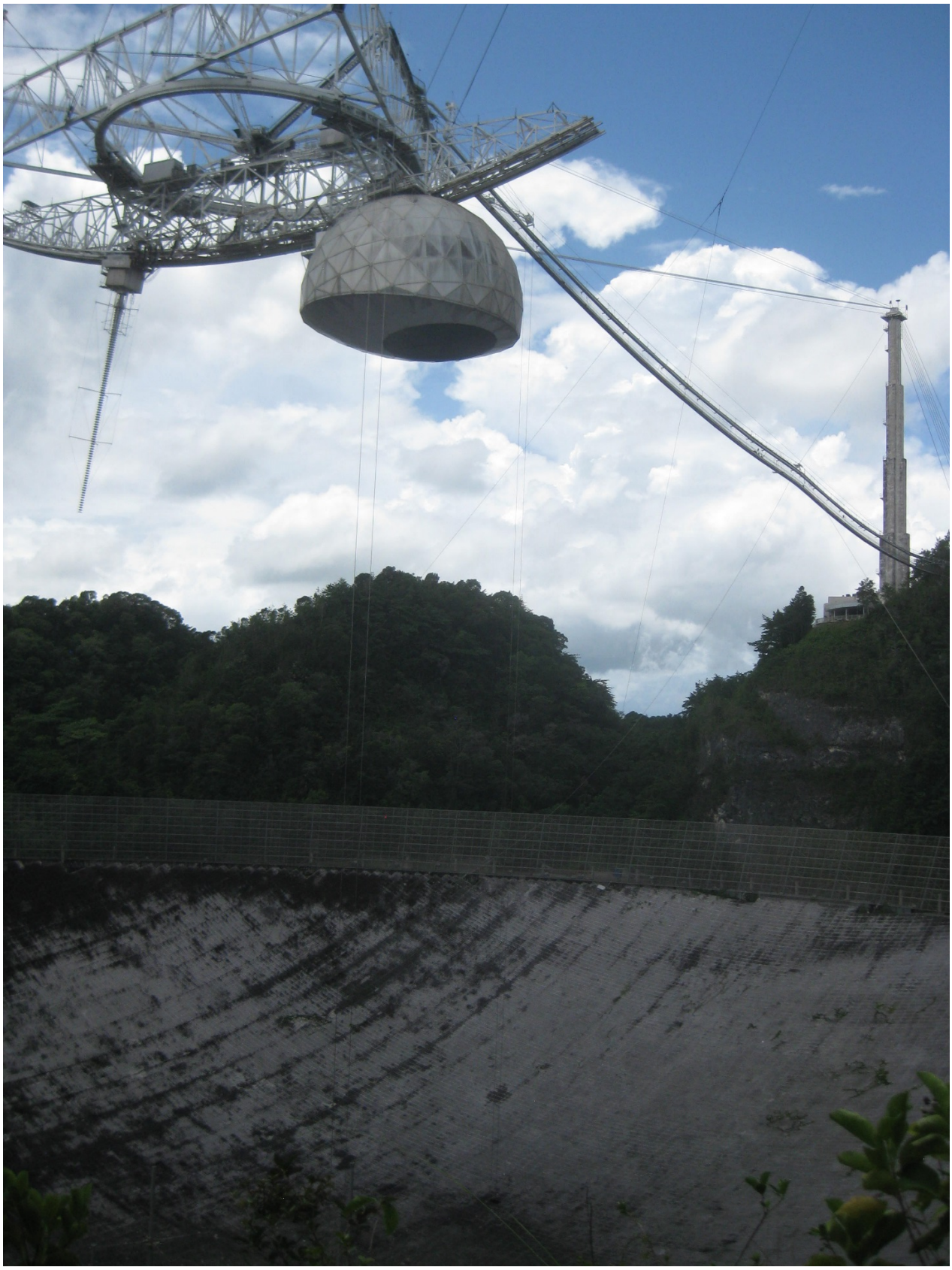
The Observatory buildings are routinely maintained; however, no significant visible changes had occurred to the 305-meter telescope, Building #1, Building #2, Building #61, Building #27, Building #17, or Building #12. Building #2, a masonry building, was painted white in 2008, but has since been repainted with blue accents. A small, non-contributing accessory building, Building #25, the Paint and Flammable Materials Storage, was constructed circa 2010 adjacent to the east elevation of Building #17. Construction of Building #25 has resulted in a minor alteration to the setting of Building #17, which contributes to the historic district; however, Building #25 is a small, utilitarian structure that has not diminished Building #17's integrity of feeling, association, materials, design, location, or workmanship. Several other facilities, including the 12-meter radio antenna, were constructed throughout the district

after 2008, slightly altering the district's integrity of setting. However, the construction of new facilities, most of which are small to medium-sized utilitarian structures, has not diminished the overall integrity of the historic district; rather, additional construction has allowed the Observatory to adapt to changes in the field of astronomy and remain in operation as a critical research center.

Photographs 1 to 10 illustrate the current conditions of the buildings and structures that contribute to the NRHP-listed historic district.

Conclusion

In 2008, Arecibo Observatory was listed in the NRHP as the National Astronomy and Ionosphere Center. There are eight buildings and one structure that contribute to the NRHP-listed district. Field investigations confirmed that no significant alterations have occurred to the contributing resources. While minor alterations have occurred to the setting of the district, the property overall retains integrity of materials, design, workmanship, feeling, association, and location.



Photograph 1. 305-Meter Radio Telescope
Platform, Gregorian Dome, and Supporting Tower visible; view northwest.

Photograph 2. Building #1 (NRHP Building #1), Operations Building
Northeast corner, view southwest

Photograph 3. Buildings # 66 and #68 (NRHP Building #1A), Atmospheric Science Trailer and Visiting Scientist Trailer
East elevations, view west.

Photograph 4. Building #2, Administration Building
Southeast corner, view northwest.

Photograph 5. Building #54 (NRHP Buildings #5), Visitor Center
North elevation, view to the south.

Photograph 6. Building #54 (NRHP Building #5), Visitor Center
2015 rear (south) addition, view to the north.

Photograph 7. Building #61 (NRHP Building #6), Learning Center
South elevation, view to the north.

Photograph 8. Building #27 (NRHP Building #7), Photometry Shack/Optical Lab
Northwest corner, view to the southeast.

Photograph 9. Building #17 (NRHP Buildings #11 and #12), Warehouse and Business/Purchasing
Southeast corner, view to the northwest.

Photograph 10. Building #12 (NRHP Building #13), Maintenance Building
Northeast corner, view to the southwest.