Detail view of Overview Landscape Model

Rosedown Plantation
3-D Scan and Digital Model

Final Report | March 28th, 2022

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INTRODUCTION

This project was conducted under the National Park Service Historic Preservation Grant program and in response to the Louisiana Division of Historic Preservation's call for projects that digitize historic resources. In wake of a mandatory lockdown during early stages of the COVID-19 pandemic, many public agencies focused on how to make resources available to citizens that were not able to travel or access sites in-person. This was the opportunity to laser-scan one of Louisiana's largest historical resources and create a digital model that citizens could access through any common web portal.

The Rosedown State Historic Site located just outside St. Francisville, Louisiana, was formerly a cotton plantation built by Daniel and Martha Turnbull. The original land holdings included seven tracts totaling 3,455 acres (today 371 acres) tended to by roughly 250 enslaved people.[1] The main house is a Jacksonian-period Greek Revival structure built over the span of six months in 1834 at a cost of $13,109.20.[2]

The Turnbull's sole surviving daughter Sarah married James Bowman from the neighboring Oakley Plantation in the 1850s. The Bowmans lived at Rosedown with Martha after Daniel passed in the 1860s and together they raised ten children.[3] The Bowmans continued producing cotton under the tenant farming system following the Civil War and eventually included Rosedown in the tourist circuit in 1930s as travelers discovered plantation tours between New Orleans and Natchez. The four unmarried Bowman daughters inherited Rosedown when Sarah passed in 1914, living in the main house until the last sister died in 1955.

Milton and Catherine Underwood of Houston, Texas purchased Rosedown in 1956. The Underwoods had the main house restored under direction of New Orleans architect

[1] Rosedown presently comprises 371 acres.
[2] This brief historic background is comprised by information from the official Rosedown visitor's brochure and the National Register of Historic Places nomination packet.
[3] Oakley Plantation is also currently owned by the State of Louisiana.

George Leake and restored the gardens under Houston landscape architect Ralph Ellis Gunn.[4] Following the renovation, the Underwoods opened Rosedown to the public and maintained the site as a tourist destination until it was sold to a Gene Raymond Silvka in 1994. The State of Louisiana purchased Rosedown in 2000.

Main extant features of Rosedown include the main house, 660-foot live oak allée, 18-acre ornamental garden which retains high historical integrity, and dependencies. Rosedown maintains high historical integrity partly because it survived in original family until mid-twentieth century with roughly 2,500 acres intact. The gardens are particularly important because they are well preserved and documented in Martha Turnbull's surviving Garden Diary. Rosewdown is listed on the National Register of Historic Places and included in the Historic American Building Survey, however it is only documented with photographs and does not include drawings.

[4] Catherine Underwood was president of River Oaks Garden Club in Houston. Gunn previously worked for E.A. McIlhenny at Jungle Gardens Nursery at Avery Island.

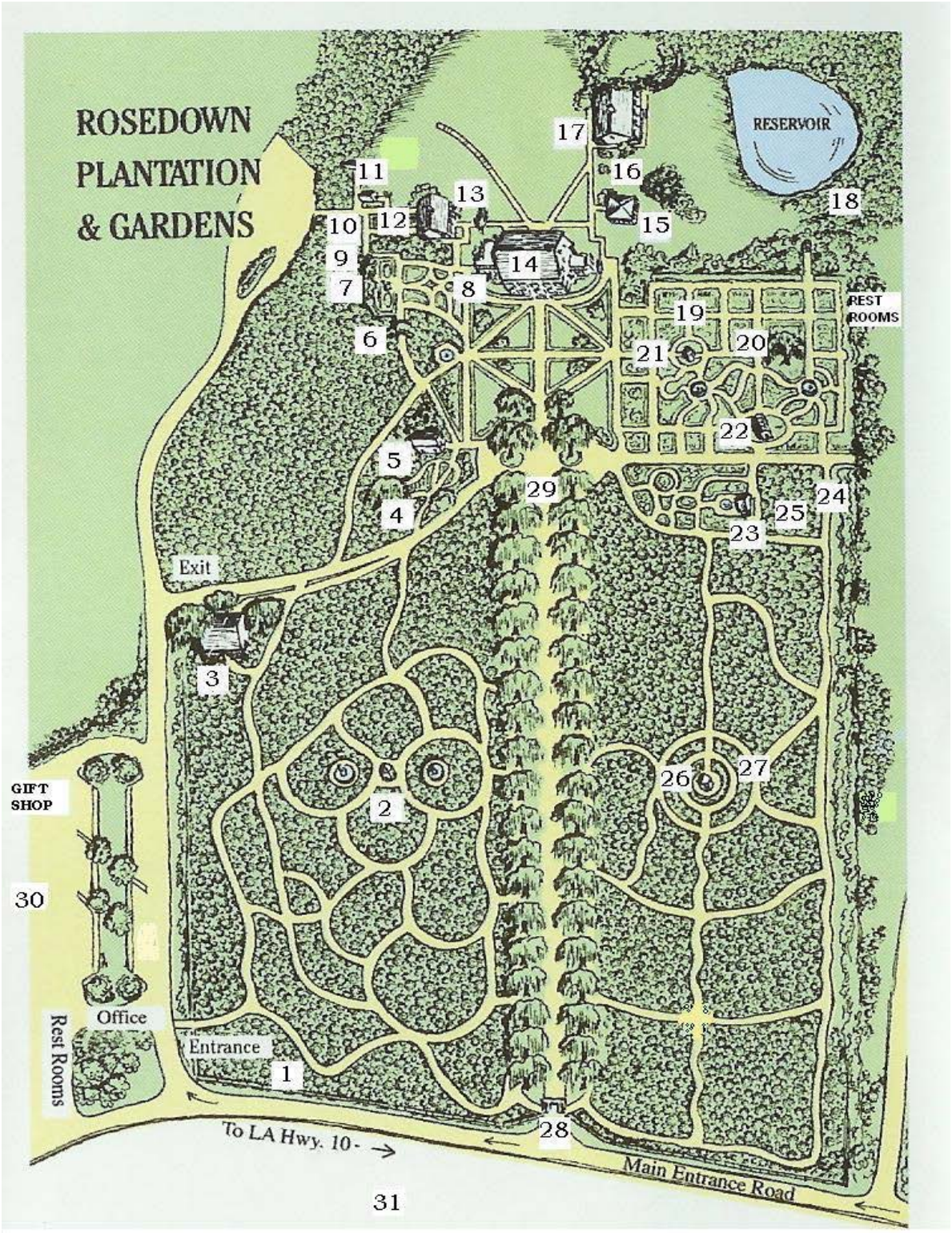

Figure 1: The above image inside a Microsoft Word file for the Rosedown brochure was the only known drawing of the site when this project began.

METHODS

Data for three-dimensional models of the Rosedown house and gardens were collected by laser scanning and photogrammetry and processed to create point-cloud models. These models are currently hosted on a Louisiana State University server and accessed through Potree, an open-source WebGL based point cloud renderer developed at the Vienna University of Technology.[5]

Point clouds are multi-dimensional sets of x, y, and z coordinates that can have other variables such as red, green, and blue color values. Buildings, landscapes, and objects can be recorded in precise detail as clouds of millions or even billions of points using either laser scanning or photogrammetry. In laser scanning, the three-dimensional position of points hit by laser pulses are calculated based on the orientation of the scanner and its distance from the target points. The distance from the scanner to the point is derived from the time of flight or phase difference of the laser pulse.[6] Points clouds can also be generated from photographic surveys using photogrammetric techniques such as structure from motion, which reconstructs three-dimensional form from overlapping images taken from different views.[7] Often a combination of approaches is necessary.

Point clouds generated from laser scanning and photogrammetry have been used in preservation practice to limited extent over the past decade. These technologies are more common in the civil engineering and construction industries. Traditional barriers for use in preservation include initial cost of equipment and complex data, however equipment costs have been falling over the last several years and the methods are being

[5] https://github.com/potree/potree

[6] Morsdorf, F. Kükenbrink, D. Schneider, F. D. Abegg, M. & Schaepman, M. E., "Close-Range Laser Scanning in Forests: Towards Physically Based Semantics across Scales." *Interface Focus* 8, no.2 (2018) https://doi.org/10.1098/rsfs.2017.0046.5.

[7] Ullman, S., "The Interpretation of Structure from Motion." *Proceedings of the Royal Society of London, Series B, Biological Sciences* 203 no.1153, (1979): 405–426. https://doi.org/10.1098/rspb.1979.0006; Westoby, M. J., Brasington, J., Glasser, N. F., Hambrey, M. J., & Reynolds, J. M., "'Structure-from-Motion' Photogrammetry: A Low-Cost, Effective Tool for Geoscience Applications." *Geomorphology* 179 (2012): 300–314. https://doi.org/10.1016/j.geomorph.2012.08.021.

adopted by more professionals. Several resources are listed in the bibliography for those seeking further information.

For this project the terrestrial laser scanner used for most scans was the Faro Focus 3D X330 HDR mounted on a Manfrotto 055 Aluminum 3-section tripod. The house façade and Live Oak allée scans used a Seco 5321-17-ORG Extra-Tall Fiberglass Elevator Tripod to get data from a greater range of heights. Laser scanned data was processed using Faro Scene software and Agisoft Metashape Professional 1.7.1.

Unmanned aerial vehicle (UAV) or drone photogrammetry mainly used a DJI Matrice 600 Pro hexacopter with a Zenmuse X5 camera and a DJI Phantom 4 Pro quadcopter and camera (FC550) with a 15 mm lens. Object photogrammetry used a Nikon D5600 digital SLR camera with an 18mm lens. Photogrammetric data were processed using Agisoft Metashape Professional 1.7.1.

The scans are assembled into several digital models for ease of access. Combining all scans into a single model is possible but would result in an extremely complex file that would trouble the average computer. We have also included data downloads for the overall landscape model, the rockery model, and the dining room model.

Figure 2: The research team used a DJI Matrice 600 Pro hexacopter to collect imagery for photogrammetry. Several missions were flown over four separate site visits. Image from site visit on March 20th, 2021.

Figure 3: The team used a Faro Focus 3D to collect point cloud data. Here Brendan Harmon is scanning the outside of an original summerhouses in the south formal garden. Image from site visit on March 7th, 2021.

Figure 4: Scanning the façade using the Faro Focus 3D mounted to a Seco giant elevating tripod. Normally drone photogrammetry would be used to document higher portions of an exterior façade, however large oak trees in close proximity prevented the use of drone in this instance.

MODELS

Model	Link
Overall Database	https://xyz.cct.lsu.edu
Landscape Model	https://xyz.cct.lsu.edu/data/rosedown/landscape.html
Landscape Data	https://xyz.cct.lsu.edu/data/rosedown/landscape.laz
House Interior	https://xyz.cct.lsu.edu/data/rosedown/interior.html
House Façade	https://xyz.cct.lsu.edu/data/rosedown/house.html
Rockery	https://xyz.cct.lsu.edu/data/rosedown/rockery.html
Rockery Data	https://xyz.cct.lsu.edu/data/rosedown/rockery.laz
Dining Room	https://xyz.cct.lsu.edu/data/rosedown/dining-room.html
Dining Room Data	https://xyz.cct.lsu.edu/data/rosedown/dining-room.laz
Oak Allée	https://xyz.cct.lsu.edu/data/rosedown/allee.html
Formal Garden	https://xyz.cct.lsu.edu/data/rosedown/formal-garden.html
Martha's Screen	https://xyz.cct.lsu.edu/data/rosedown/marthas-screen.html

Table 3: Models listed with online links. Links ending in ".html" lead to an online version of the model where users can interact with the data through Potree. Performance of the online interface will depend on the graphics card and internet access speed of the local machine. Links ending with ".laz" download the raw data for hosting on a private machine and are for advanced users.

Model	# Scans	Resolution	Points	Instrument
Landscape	1	2cm	360,445,708	Matrice
Interior	94	1/16	771,951,841	Faro Focus
Dining Room	7	¼	268,464,534	Faro Focus
Façade	27	1/8	55,847,608	Faro Focus
Rockery	26	1/8	47,414,057	Faro Focus
Milk House	12	1/8	58,657,059	Faro Focus
Gazebo	7	1/8	41,176,644	Matrice + Faro
Allée	131	1/8	> 1 billion	Matrice + Faro

Table 1: Models listed with associated data structures.

Rosedown Laser Scan Settings			
Location	Scans	Resolution	Quality
Interior (total)	94	1/16	4x
Dining Room	7	1/4	4x
Downstairs	48	1/16	4x
Upstairs	27	1/16	4x
Slave Staircase	19	1/16	4x
Facade	27	1/8	4x
Milk House	12	1/8	4x
Rockery	26	1/8	4x
Live Oak Allee	130	1/8	4x

Table 2: Rosedown Scan Settings

Overall Landscape Model

We first attempted to complete an overview scan with a FireFLY 6 Pro unmanned aerial vehicle (UAV) and a Micasense RedEdge-M multispectral sensor. This flight was not successful because the UAV lost radio signal with the basestation. We then used DJI Matrice 600 Pro hexacopter with a Zenmuse X5 camera on a mission flown on May 31st, 2021, which proved successful.[8] For this flight we used a cross grid flight plan to capture 257 images over 0.0825 square kilometers at 99.2 meters above ground level with a Zenmuse X5 camera set at a 60-degree angle capturing data at 2.12 centimeters per pixel. This resulted in an overall model with 360,442,316 cloud points. Ten ground control points placed strategically throughout the property were included and geolocated using an Emlid Reach RS+ Real Time Kinematic GNSS rover with NTRIP corrections through the LSU Center for Geoinformatics (C4G) network. Ideally ground control points would be spread evenly throughout the scan area, however the reality of surveying landscapes with mature trees necessitates taking advantages of open areas that prioritize clean line of sight for the UAV. Ground Control point error ranged from 0.86 cm to 16.55 cm. We used Agisoft Metashape Professional 1.7.1 to process data by aligning and optimizing photos based on GCPs, building an ultra-high quality dense cloud, and then manually cleaning the cloud before exporting it.

[8] Several missions were flow over 4 separate site visits, but this mission comprised the majority of data for the eventual landscape overview model.

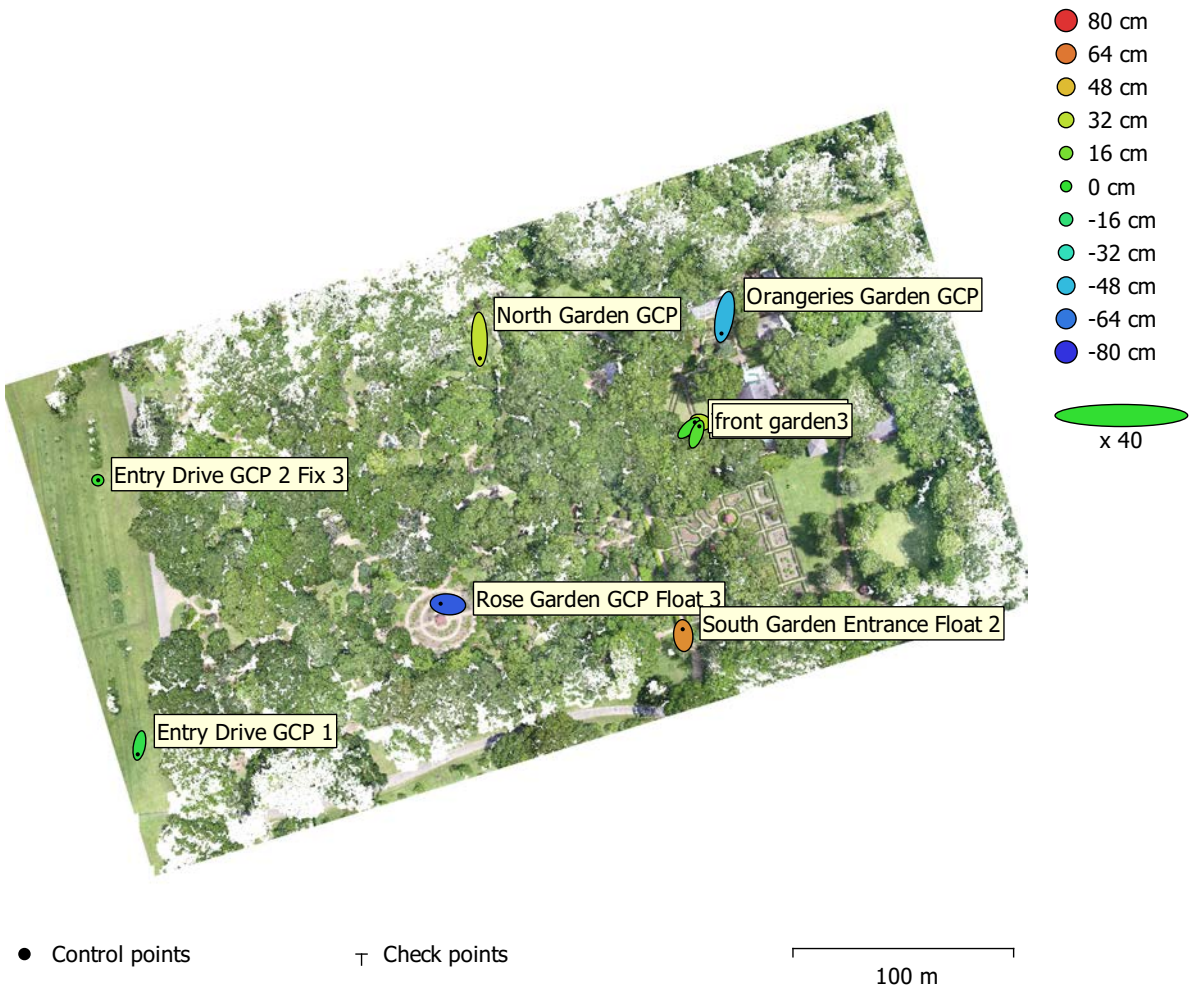

Figure 5: Ten ground control points were surveyed using an Emlid Reach RS+ Real Time Kinematic GNSS rover with NTRIP corrections through the LSU Center for Geoinformatics (C4G) network.

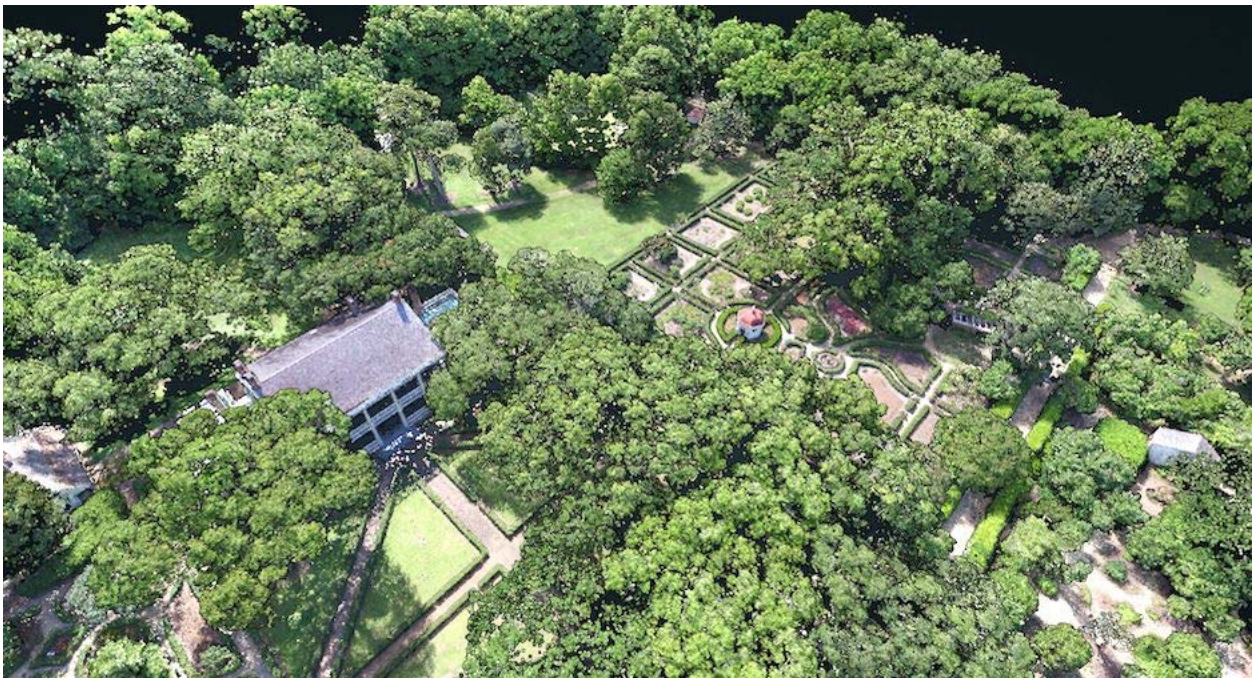

Figure 6: Detail of overview landscape model.

Figure 7: Overview Landscape model

Main House Interior and Façade

The interior and exterior of the house were scanned and assembled into separate models, mainly because the interior was such a large dataset. The Faro Focus was used to collect all data for both models, mounted to a regular Manfrotto 055 Aluminum 3-section tripod for the interior scans and to a Seco 5321-17-ORG Extra-Tall Fiberglass Elevator Tripod for the façade scans. Ideally drone photogrammetry would also be used to get roof details for the exterior façade model, however the proximity of several mature live oaks prevented using drones close the house. Data for the interior model were collected from 94 scans comprising 771,951,841 points. The dining room was scanned separately from 7 scans at a 4x higher resolution to capture intricate detail, comprising 268,464,534 points. Data for the exterior façade were collected over 27 scans comprising 55,847,608 points, however the presence of visitors precluded a more accurate scan schedule.

Figure 8: View of point cloud model of exterior façade.

Figure 9: View inside the dining room. This room was scanned intensively to capture the concentration of historical artifacts and detail.

Figure 10: View inside the Henry Clay bedroom.

Live Oak Allée

The Live Oak Allée was possibly the most complex, challenging, and rewarding elements scanned at Rosedown. It required multiple trials and errors both in the field and back in the laboratory. Ultimately drone photogrammetry was used to scan the top of the canopy, and the Faro Focus laser scanner was used on a Manfrotto 055 Aluminum 3-section tripod and a Seco 5321-17-ORG Extra-Tall Fiberglass Elevator Tripod. Instrument height of the laser scanner varied between scans to collect understory data at various angles for a more complete dataset. Data for the final model was collected over 131 laser scans and two drone flights, comprising well over 1-billion data points.

Figure 11: View inside the point-cloud model of the Live Oak Allée looking towards the house front façade.

Formal Garden

Photogrammetric data to create a digital model of the formal garden was collected on March 21st, 2021 using a DJI Phantom 4 Pro quadcopter and camera (FC550) with a 15 mm lens. A total of 56 images at 4608 x 3456 pixels each was processed through Agisoft Metashape Professional to create a point cloud model with 92,480 data points.

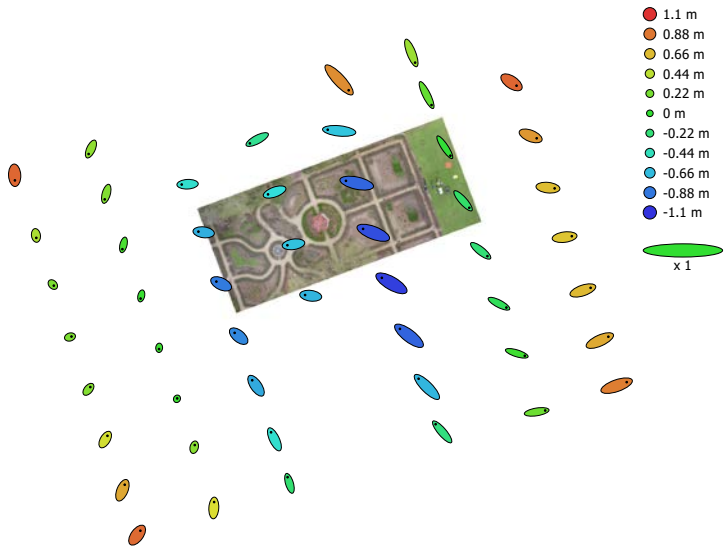

Figure 12: Camera locations and error estimates. Z-axis error represented by ellipse color. X/Y error represented by ellipse shape. Camera locations marked with black dot.

Figure 13: Screenshot of the formal garden model.

Rockery

The Rockery was scanned over two site visits in late winter and early spring. It was second most complex landscape element scanned, second only to the Live Oak Allée. A total of 26 scans around and on top of the rockery were necessary to get all its detail.

Figure 14: View of the Rockery model. This was second to the Live Oak allée in landscape complexity to capture. We were lucky to scan the rockery when the violets were in bloom.

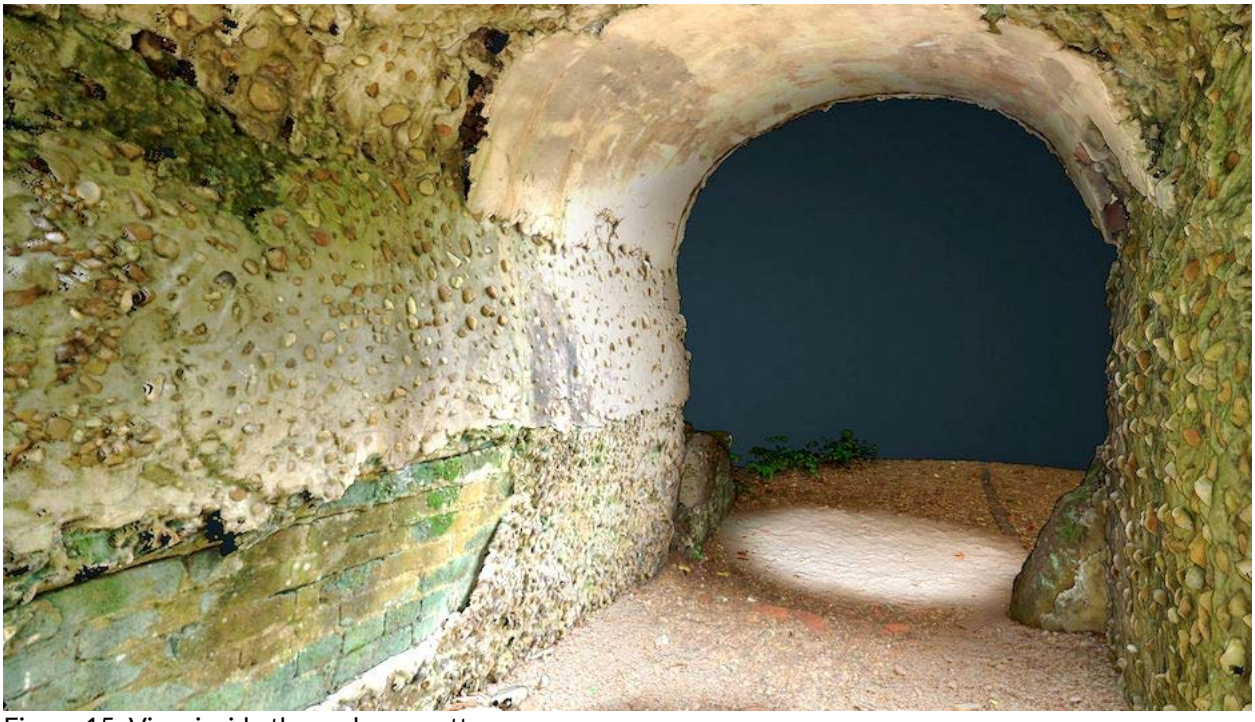

Figure 15: View inside the rockery grotto.

Summerhouse

The summerhouse in the formal garden proved an ideal architectural structure for digital scanning because its intricate handmade detail was better able to be recorded digitally than through conventional drawings. The summerhouse was first scanned with the terrestrial laser scanner in early March, 2021. A total of 41,176,644 points were registered over 7 scans inside and around the summerhouse. Data was then collected using drone photogrammetry on April 11th, 2021 using a DJI Phantom and an FC6310 camera with an 8.8 mm lens. The 229 images 4864 x 3648 pixels each resulted in 210,766 data points which were then stitched together into a point cloud model. The laser scanning proved favorable for all scans except for exterior roof details that were out of sight for the laser scanner.

Figure 16: A point-cloud model of the summerhouse in the south formal garden was created

Figure 17: Interior view of the formal garden summerhouse. The laser scanner captures detail that would be missed in conventional drawings.

Figure 18: ceiling detail of the summerhouse.

Object Photogrammetry: Martha's Screen

Data to create the digital model of Martha's screen was collected on March 7th, 2021 using a Nikon D5600 digital SLR camera with an 18mm lens. A total of 129 images at 6000 x 4000 pixels each were used to generate a point cloud with 106,203 data points.

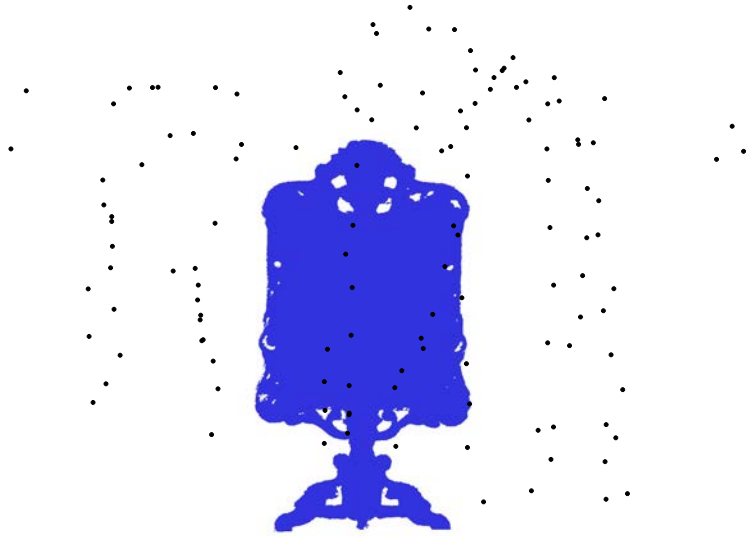

Figure 19: Camera locations and image overlap for model of Martha's Screen.

Figure 20: Model of tapestry screen allegedly created by Martha Washington. Object photogrammetry was created from pictures taken with a digital SLR camera.

Card Room Photosphere Photogrammetry

Photogrammetry using a 360° camera is one method that did not prove successful. We used an Insta 360 Pro 2 to take 20 images at 7680 x 3840 pixels and them attempted to create a point-cloud through Agisoft Metashape, but the resulting point cloud had too much noise in the form of extra points and occlusions, so the result was unsuccessful. We think this was an issue with the processing software and might be resolved my imputing more details on the lenses and other setting used inside the camera, which we did not have access to at present.

Figure 21: Screenshot of point-cloud generated from 360° camera photogrammetry. This proved unsuccessful because there was too much noise.

Bonus Materials

Although not included in the original project scope, several opportunities became available to collect additional data that the researchers incorporated into their work. These included digitizing architectural plans and photographs of the mid-20th century restoration, collecting GPS data points to accurately survey the site, and capturing 8K 360° photospheres and videos in the house and gardens. These materials are not currently publicly available, but have been provided to the Louisiana Division of Historic Preservation for archiving.

Photoshperes

Photoshperes are 360° images from a fixed viewpoint like the street view feature in Google Maps. The research team used an Insta360 Pro2 which employs 6 fisheye lenses to simultaneously capture a 360° view in 8K resolution. Several hundred photopheres were captured both inside the house and surrounding pleasure gardens.

Figure 22: 360° view of the front formal garden.

George Leake Restoration Plan Drawings and Photographs

The research team digitized copies of restoration plans by George Leake held by the Rosedown curator. These included six drawings outlined in the table below and an additional restoration planting plan for the formal garden (labeled the flower garden on the plans) by restoration landscape architect Ralph Ellis Gunn.

Sheet	Drawing
1	Site overview restoration plans
2	Interior existing conditions floor plans
3	First floor restoration plans
4	Second floor restoration plans
5	Exterior restoration section elevations
6	Interior section elevation and details

Table 4: George Leake restoration plans.

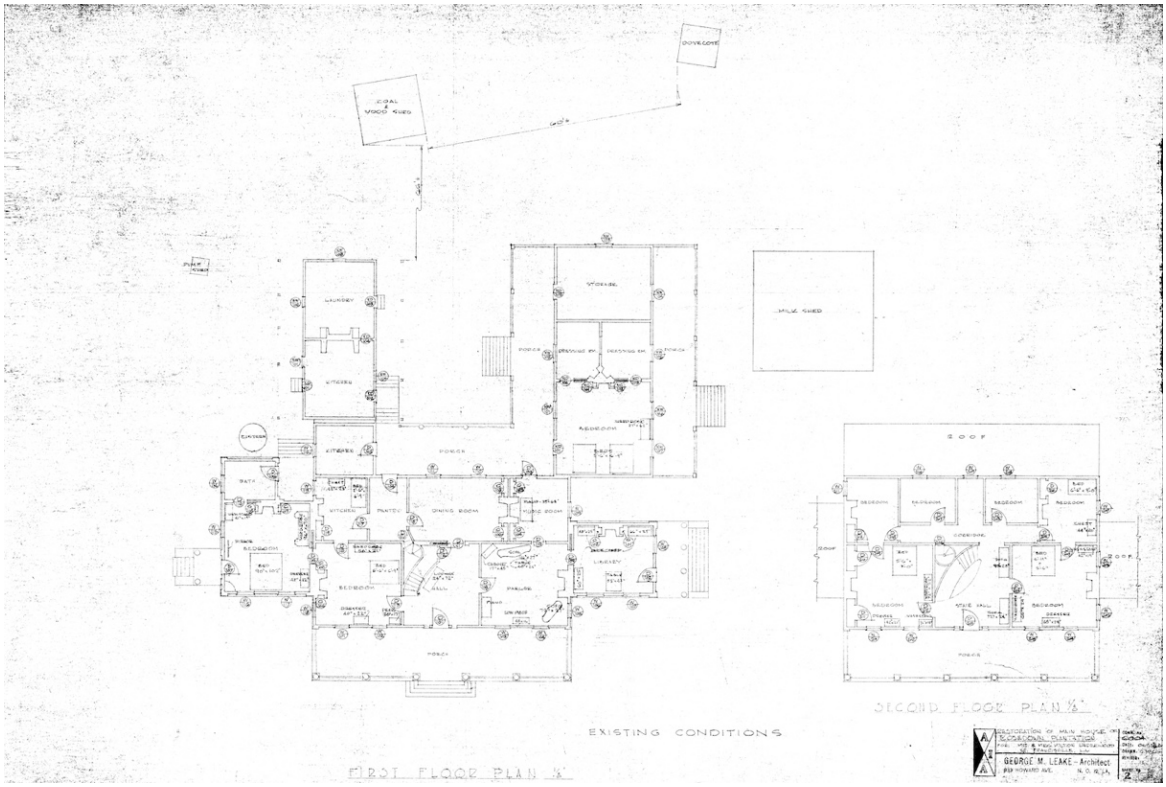

Figure 23: Drawing of existing conditions. Copies of eleven drawings by George Leake and Ralph Ellison Gunn were scanned for this project.

The research team also scanned more than 130 copies of photographs documenting the house before and during restoration. These photographs allegedly belonged to George Leake, but the research team is unable to verify this information. We also scanned a 10-page transcript of an interview with George Leake in March 1982. All of this material was generously provided by Rosedown curator Polly Luttrell.

Figure 24: Photographs of the restoration allegedly taken by George Leake (unconfirmed) were scanned as a part of this digitization project.

Research Presentations

Work from this project forms the foundation for several academic essays and scholarly presentations. These include:

- Nicholas Serrano and Brendan Harmon, "Digitizing Rosedown Plantation: Documentation Technologies for Landscape Ensembles." Paper presented at the Southeastern Society of Architectural Historians 39th Annual Conference in Natchez, MS., on October 1st, 2021. (https://sesah.org/wp-content/uploads/2021/11/2021SESAHabstractsNatchezMSconferenceFINAL.pdf)
- Nicholas Serrano and Brendan Harmon, "Digitizing Rosedown Plantation: Documentation Technologies for Landscape Ensembles." Paper presented to the Louisiana State University Department of French Studies International Study Day on Virtual Theatres in Baton Rouge, LA., on February 23rd, 2022
- Brendan Harmon and Nicholas Serrano, "The Complexities and Aesthetic Potential of Point Clouds as a Medium for Landscape Architecture." Paper Presented at the Council of Educators in Landscape Architecture in Santa Ana Pueblo, N.M., on 19-March-2022. (https://thecela.org/about-the-cela/cela-2022-annual-conference/)
- Brendan Harmon and Nicholas Serrano, "Point Cloud Aesthetics." *Journal of Digital Landscape Architecture* Issue 7 (2022) (peer-reviewed and accepted for publication) (https://www.dla-conference.com/journal/)

Figure 25: The researchers presenting about the Rosedown Scan project at the Southeastern Society of Architectural Historian 2021 annual conference in Natchez, MS. Image from October 2nd, 2021.

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