Digital Videography: Recording, Preserving, and Disseminating Archaeological Data

Grant Number MT-2210-7-NC-016

by

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Anne Arundel County Trust for Preservation, Inc.

and

The Lost Towns of Anne Arundel Project
Anne Arundel County Department of Planning and Zoning
P.O. Box 6675
Annapolis, MD 21401

Submitted to

The National Park Service
and
The National Center for Preservation and Training Technology

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ABSTRACT

Aided by a grant from the National Center for Preservation Technology & Training, National Park Service (Grant Number MT-2210-7-NC-016), to the Anne Arundel County Trust for Preservation, *The Lost Towns of Anne Arundel Project* acquired a digital video camera, graphic equipment and three-dimensional modeling software. Project staff use this equipment, with computer image capture and processing technologies, to record, preserve, analyze, and disseminate high quality archaeological and architectural data from two Colonial Period town sites in Maryland: Providence (1649—1680) and London (1683—1783). The resulting images constitute a database for three-dimensional modeling and analysis, museum exhibits, video production, and broadcast journalism. This paper describes the cost—effective application of digital photography and computer modeling to the collection, analysis, storage, and presentation of archaeological and architectural data.

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1. INTRODUCTION

Developments in high-quality digital video cameras and consumer grade computer hardware and software have revolutionized the video industry, creating unparalleled opportunities for archaeologists, architectural historians, and historic preservationists. Developments in digital imaging will change the ways in which they collect and record data, and promote the dissemination of findings both within the historic preservation community and out to a public that has, in recent years, become enamored with archeology. This dynamic, flexible technology will take its place in the archaeological toolkit, providing a means for modeling data and testing hypotheses.

The Lost Towns of Anne Arundel Project, in cooperation with the Anne Arundel County Trust for Preservation, uses digital imaging technologies to create three-dimensional (3D) graphics, edit digital video, and store graphical data. We are beginning to use 3D graphics and to produce videos for cable television. Perhaps the most exciting applications of digital imaging are the animated 3D models that we have developed to test hypotheses and to share our findings with scholars and with the public.

This report summarizes the results, to date, of digital videographic research conducted by *The Lost Towns Project*, conducted with a grant from the NCPTT (MT2210-7-NC-016) to the Anne Arundel County Trust for Preservation. Project staff and interns have used equipment and software purchased with the grant money to explore digital videographic technologies for digital recording, preservation, analysis, and dissemination of archaeological data. We also are beginning to develop animated 3D models to assist Anne Arundel County's Department of Recreation & Parks and the London Town foundation to plan the reconstructions of archaeologically recovered buildings and landscapes.

The report is divided into seven sections: project objectives; methodology; hardware; software; data storage; implementation; and conclusions. It describes the project's latest results and evaluates competing technologies in digital video storage, manipulation, data dissemination, and three-dimensional modeling. Graphical modeling of landscape reconstructions at London Town historic park grew out of this NCPTT funded project, but—because of its preliminary nature—this research will not be addressed in this report.

Project Background

The Lost Towns of Anne Arundel Project is a collaborative research and public education effort of Anne Arundel County, the Anne Arundel County Trust for Preservation, Inc., and the London Town Foundation, Inc., encouraging public participation in the archeological exploration of colonial town life in Maryland, USA. The 12 person professional staff, aided by a large cadre of dedicated volunteers, uses sophisticated geophysical survey techniques along with more conventional archaeological methods to explore two early colonial town sites on the Western Shore of the Chesapeake Bay: Providence (1649—1 680) and London (1683—1783). Five years of archival research, archaeological testing and excavation, laboratory processing, and analysis has yielded a large body of high quality data from twelve domestic and commercial sites (e.g., Gibb and Beaman, in press; Gibb and Luckenbach 1997; Luckenbach 1997, 1995; Luckenbach and Gibb 1995*;* Thomas and Lindauer 1999; Paape 1999; Moser, Gibb, and Persinger 1997; Persinger and Gibb 1996; Plumley 1999).

Recent expansion of the project, in conjunction with the London Town Foundation's historic site development and interpretation, has greatly accelerated the rate of data recovery; including, since the latter half of 1996, excavation of stratified archaeological features. Standard VHS taping, although useful for recording aspects of excavation not amenable to conventional recording techniques, has not provided the high quality images necessary for analysis and public outreach. Moreover, magnetic videotaping raises a number of long—term image conservation issues, partially resolved through optical storage media.

In conjunction with the Anne Arundel County Trust for Preservation, Inc. (a nonprofit institution chartered under the provisions of Section 501[3]c of the Internal Revenue Code), The Lost Towns Project applied for and received a grant from the NCPTT to explore the application of digital videography to archaeological research and information dissemination.

Objectives

Funded in part through a $15,000 grant (1997), from the National Center for Preservation Technology and Training, the National Park Service, *The Lost Towns of Anne Arundel Project* began evaluating digital recording to document archaeological sites. The conditions of the grant specified that the project design a means of recording, displaying, and disseminating digital video (DV) and still images, and that our findings appear in a clear concise report. The principal goal of the project is to identify a suite of hardware and software tools that, taken together, can meet the educational and scholarly needs of historic preservationists and archaeologists in a cost-effective manner. While not the ideal system for commercial video production, the flexibility and cost effectiveness of this suite of tools make it an attractive option for archeologists and architectural historians.

DV recording enables archaeologists to record daily field activities, adding to, but not supplanting, conventional field notation. DV production also provides a means of conveniently distributing information. Visual media—such as television, film, and videos for the general public and for school programs—long have been used for educational purposes. Some data, such as digital still photographs and three-dimensional models of artifacts, features, and buildings, can be shared with other archaeologists, both over the Internet and at conferences. This technology represents an advance in our ability to analyze data, particularly through three-dimensional modeling and computer aided drafting (CAD). Finally this project provided a means of educating members of our own field about the capability, reliability, and costs of an integrated video editing system.

Specific goals of the project include:

1. Capture and store additional digital images of artifacts and archaeological features;
2. Create three—dimensional models of archaeological features;
3. Develop virtual historic standing structures from London and Providence archaeological data;

4. Assist the London Town Foundation in providing access to portions of London and Providence, in compliance with the Americans with Disabilities Act;
5. Provide video images to broadcast journalists and film makers; and
6. Disseminate research results and interpretations via the Internet.

To reach these goals the following products have been completed:

1. A digital video archive of excavations in both low and high intensity light;
2. A library of digital raster still images in both low and high intensity light;
3. Three-dimensional models of historic standing structures created from conventional and digital raster images;
4. Three-dimensional models of select artifacts created from conventional and digital raster images;
5. Development and broadcast of a television video, *Unearthing Lost Towns*, in cooperation with Anne Arundel County's cable television studio, incorporating animated 3D models;
6. Development of a 3D model of the Robert Burle House (1660s—1680s) for use in Maryland's Archeology Month poster;
7. An illustrated article on the digital videography project published in the Maryland Archeology Month Calendar (Moser and Corder 1999);
8. A scholarly paper on the digital video graphy project presented, with animated images, at the Annual Meeting of the Society for Historical Archaeology in Salt Lake City, Utah (Moser, et al., 1999); and
9. A digital videography demonstration at the 1998 annual meeting of the Vernacular Architecture Forum in Annapolis, Maryland.

Mobilization

Acquiring state-of-the art technology requires considerable research, the prospective operators learning about the use and development of computer hardware, software, digital video production, storage, and file format compatibility, specialized vocabularies and concepts—just to name a few issues. Some members of our staff already were conversant in Geographic Information Systems (GIS), Computer Aided Drafting (CAD), Global Positioning Systems (GPS), and a variety of other software applications.

Project staff sought the assistance of Michael Hannon, producer of the county public access cable television channel. He guided the project team in product selection and use, and led the team in filming and producing a half-hour video for the public access channel that introduces *The Lost Towns Project.* The video includes some of the project's initial attempts at 3-D modeling of artifacts and buildings. The producer also provided access to the county's videographic facility, including an editing deck.

We examined recent issues of a number of journals specifically dedicated to video production and digital video, and conducted a World Wide Web search for manufacturers of video cameras, equipment, and computer systems, evaluating costs, capabilities, and compatibility. Product research delayed equipment purchases by several months, the initial purchases beginning in November of 1997.

2. METHODOLOGY

The goal of this project is to create an affordable DTV (Desktop Video) editing system capable of capturing DV (Digital Video) for long term storage and dissemination. The products of this DTV included a digital database of sites on which *The Lost Towns of Anne Arundel Project* conducts ongoing archaeological research. We also have investigated the feasibility of creating 3D computer-generated models of artifacts and archaeological features, using grant-purchased hardware and software to render models of buildings slated for reconstruction at London Town.

Excavations are planned around filming (as they are around all forms of data recordation), and all significant features digitally recorded in the same fashion in which we had videotaped excavations. One significant difference involves the creation of three— dimensional control fields—placement of point provenienced, labeled pins within the excavation—to insure accurate three-dimensional integration of images. Similarly, cleaning and conservation of poorly preserved and potentially significant artifacts are filmed, indexed with artifact images, and linked to computerized artifact catalogues.

Currently all digitally recorded data are cataloged, indexed, and archived on Iomega *JAZ* cartridges or on Sony Mini-DV Cassette tapes. We are beginning to archive images on CD—ROMs, but may turn to DVD when that technology becomes available. Copies of all images may be curated by the Maryland Historical Trust (to be negotiated). The collection of compact disks will serve as a library whence staff can retrieve images for report production and 'clips' for exhibit and television videos.

3. EQUIPMENT

Creating a viable video editing system in this era of increasing technological innovation requires a firm grasp of many fundamental issues relating to the use and development of computer hardware, software, and video. Extensive research preceded equipment purchase.

We purchased a Pentium II, 233 MHz. computer with a Windows NT 4.0 operating system. This system contains a digital transfer technology referred to as FireWire. FireWire(tm)(IEEE-1394) technology is a high-speed cable that connects digital camcorders and DVCRs to computers. This technology allows digital data transfers between system devices without the transmission loss incurred while copying conventional magnetic videotapes, thereby preserving image and sound quality.

We purchased a Sony DCR-VXI000 digital video camera, enabling the video production to remain digital from capture through the editing. To facilitate the efficient operation of this system we purchased several compatible software packages: Adobe Premiere, a video-editing package; AutoCAD version 14; and PhotoModeler. Each program assists in developing and presenting 3D graphics for scientific and educational use.

Sony DCR-VV1000 Video Camera

The first purchase necessary to this project was a video camera. The technology and functionality of the camera then determined the DTV (Desktop Video) editing suite we could use. The first decision was whether to purchase a DV or a Hi8 camera. There are two differences between them. The first difference between the two is resolution. A Hi8 camcorder records images at 400 lines of resolution: DV camcorders record at 500 lines of resolution. Hi8 camcorders record to tape using an analog format: DV camcorders record in a digital format. To edit non-linear video on the desktop it must first be converted to a digital signal with a digitizing card (PCI). This digitizing process usually introduces defects or (generation loss) into the video. Recording the images in DV and then transferring them to the DTV eliminates generation loss. Whether digitized analog video, or native DV format, once the video is loaded into the computer the resulting digital file can be accessed like any other computer file, or transferred with no loss of quality to another medium (an important issue given the curation issues confronting conventional magnetic tape).

These two factors led us to purchase a Sony DCR-VX 1000 Video Camera (Figure 3-1). This camera is a ‘high—end’ consumer model, which possesses many of the features of professional equipment, including; 1 8nimlsecond speed with a 1/3” charge coupled device, l0X (5.9 to 59mm) lens, 1/4 to 1/10,000 shutter speed control for use in subdued light, AC power adapter, and a directional microphone (5—6°). In addition to capturing video, this camera is capable of capturing digital still images. Unfortunately, this capability is redundant since the still images are captured at the same quality as full motion video: one can achieve higher resolution digital still images with a less expensive digital still camera, or with digitized 35mm camera images.

When we purchased this video camera, few DV cameras were both affordable and FireWire (IEEE 1394) capable. The market, however, offers an increasingly wide variety of cameras that meet these specifications. Sony's DCR-VX 1000 is a very capable and rugged camera, frequently used by professional broadcast journalists. One of its greatest disadvantages is the fixed zoom lens. Video image quality is as subject to the quality of camera lenses as it is to quality of its charge coupled devices (CCD). Consequently, newer cameras such as the Canon XL1 may be more appropriate for digital recording of archaeological sites. This camera (using an EF Adapter) can use select 35mm camera lenses, a considerable benefit for anyone already owning Canon equipment. This camera was released just months after the purchase of our Sony DCR VX-l000 camera, and would likely have been selected, had it been available at the time we purchased the Sony.

Figure 3-1. Sony DCR-VX 1000 Digital Video Camera.

We also purchased an extra battery pack, tripod, camera bag, and a dozen mini-DV cassette tapes, all, of which are necessary for the effective use of the camera. Initially most of the work anticipated at the inception of this grant focused upon the capture and long term storage of video files; however, since then we have developed a procedure for transforming 2-D images into 3D objects.

Digital Video editing and 3D animation require different hardware than that used by most conventional computer applications. In video playback, the computer processes 36 megabytes of data for every second of video. This seems large but is somewhat misleading, as it is unnecessary during the editing process to preview video at full speed. However, because of the large quantities of data processed, the computer must have a correspondingly large storage capacity. During the final stages of video editing it is necessary to render all of the segments and frames in the composite video into a single continuous product which can be printed to videotape. A fast processor, large quantities of RAM and Video RAM, facilitates editing.

Hard Drives

Digital video editing requires more sophisticated hardware than typically used in most computer applications. NTSC (North American Television and Video Standard). Digital Video is captured at nearly 30 fps (frames per second). Every second of video is composed of thirty individual images, and each frame of video is approximately 1.2 MB in size (at 720 x 480 resolution). This represents a tremendous quantity of data for the computer to process for every second of video playback.

Two types of hard disks generally are used in computers: IDE (also called ATA) and SCSI. IDE hard disks generally are larger and more cost effective than SCSI drives; however, an IDE interface to the hard disk is not capable of high-speed data transfer. Digital video and other high-performance applications, such as those used in servers and workstations, require the higher transfer speeds and bandwidth only available with SCSI drives. SCSI drives also read from, and write to, the disk simultaneously.

To adequately store and process large quantities of streaming data (such as in video editing) a 7,200-rpm disk ensures that frames are not dropped during recording or playback *(PC Magazine* July 1998, Table 1-1). Faster disks such as a 10,000-rpm disk Cheetah and forthcoming 1 [2],000-rpm disks will ensure even faster data transfer rates. Other important performance data which should be scrutinized before purchasing hard drives are the ability of the computer to locate data stored on the hard disk (average seek time) and the time it takes to position the disk head over a particular sector of the disk (average access time).

Table 1-1. Hard disk performance as measured by PC Labs *(PC Magazine* July 1998).

	Best Measured Transfer Rate[1]	ZD Business Disk Winmark 98[1]	ZD Jogie-End Disk Winmark 981	ZD Business Winstone 98
Quantum Fireball, 5,400 rpm	9,495	1,100	3,090	22.8
Seagate Barracuda, 7,200 rpm	15,100	1,630	4,500	23 7
Seagate Cheetah, 10, 00rpm	17,400	2,100	5,375	24.3

RAID Disk Configuration

To further increase the performance, efficiency, and cost effectiveness of the SCSI hard disk system, we purchased two 4.4-Gigabyte SCSI Cheetah (10,000 rpm) drives. We then arranged these drives in a RAID configuration. This configuration provided 8.8 Gigabytes of storage space, operating faster than a comparably priced single 9 Gigabyte SCSI drive.

Invented at the University of California at Berkeley in 1987, RAID is an acronym for Redundant Array of Inexpensive, or Independent, Disks. In this system multiple hard drives, usually SCSI drives, work together as a single disk, writing data across several hard disks, performing faster and with greater security *(PC Magazine,* November 4, 1997). Initially, six varieties of RAID were designed, each having different characteristics and purposes; additional RAID variations, however, have been introduced.

Until recently, RAID storage technology was used primarily in upper midrange to high-end computing applications. This was due primarily to the higher cost and integration complexity of RAID technology and a lack of understanding of the benefits of RAID technology. Decreasing hardware costs, with increased performance and ease of use, have brought RAID into the realm of affordable video-editing applications. The RAID system consists of"an external deskside or rackmount subsystem that contain{s] a RAID controller, its supporting hardware, and a number of disk drives. The RAID controller is connected to a host computer with an interface cable using technologies such

‘Measured in thousands of bytes per second.

as SCSI. The RAID controller interfaces to the disk drives using several separate SCSI interface channels"(Ferrari, Internet).

The most useful form of RAID in video editing is called RAID 0 (Figure 3-2). This system divides large files such as video (.AVI) files into several parts, then writes that data across two or more disks. This technique, known as striping, allows faster reading of data from several disks since the file can simultaneously read into memory from each disk, rather than the heads of one drive traversing a single disk. RAID 0 provides higher performance and is extremely useful in applications that draw on significant quantities of data. However, if one of the drives fails, then data written across both disks are lost.

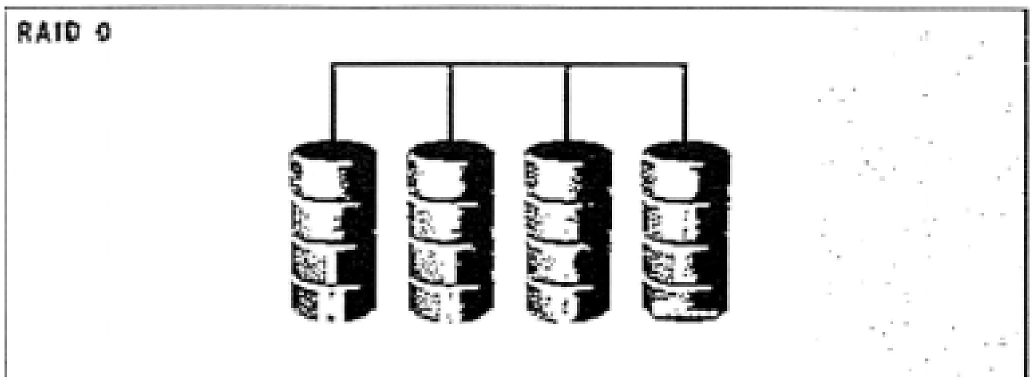

Figure 3-2. Organization of data storage on four hard drives in RAID 0 configuration.

Other forms of RAID write data twice, simultaneously, to two or more drives, the second disk, an exact duplicate of the first, providing no performance increase but a great deal of added safety: If the first hard disk fails, the second is available for use. RAID 3 configurations spread data across several drives and store parity information on only one. RAID 3 is probably the best choice for fast workstations. RAID 5 distributes both data and parity information across at least three drives, and is the best compromise between performance and data security. It is mainly used in servers and workstations running critical applications *(PC Magazine,* November 4, 1997).

In purchasing a RAID disk system it is important to have matching quality between the components of the system such as the internal ribbon cables, connectors, terminators, etc. Poor quality in these components can result in a breakdown in signal integration *(DV Magazine* 1998). The hard disk speeds attained in computers using SCSI RAID systems create tremendous amounts of heat, requiring additional heat sinks and cooling fans. Hot-swappable drives, and internal vs. external drives, and vibration, should be considered when purchasing a RAID disk system. For more information on hard disk drives and RAID systems visit http://www.seagate.com, and http://www.artecon.com (Mermell 1998).

Fire Wire (tm)(IEEE-1394)

One of the critical components in a video editing system is the interface between the camera and the computer. Until recently most video editing required the use of a video editing deck. With the introduction of more powerful computers, and video editing boards, computer aided video editing became possible. The board permits the transfer of analog video to the computer, where it is digitized a single frame at a time. While revolutionary, this process causes the degradation of image and sound quality, often introducing “artifacts,” or imperfections. Digital video cameras have introduced a new form of data transmission, creating images in a digital format (.AVI file) and negating the need for conversion.

We selected DPS Spark as the means of affordably transferring, broadcast quality DV to our computer. This equipment permits movement of data from one storage device to another without alteration or degradation. The data then is transmitted from edited tape back to the DV camcorder for TV viewing or for recording directly to a VCR. FireWire eliminates the analog video digitization process of video capture hardware by transferring already digital DV data from DV tape to a hard drive. Despite repeated transfers, video and audio remain equal to the original DV source. DV technology provides near-Betacam SP quality on the desktop as well as a choice of display sizes; including, 90 x 60, 180 x 120, 360 x 240 or full DV resolution at 720 x 480.

At the heart of this complete editing system is FireWire(tm)(IEEE-1394) technology, a high-speed cable that connects digital camcorders and DVCRs to computers. DPS Spark (IEEE-l394) PCI bus adapter connects to a DV camcorder using the FireWire connector, thereby transferring digital audio and video to the hard drive in real time, without analog-to-digital conversions. Once loaded into the computer these video files can be manipulated using Adobe Premiere 4.2, a video editing software bundled with the DPS Spark card.

4. SOFTWARE

We evaluated the software packages on the basis of cost, reliability and the inclusion of features necessary for completing the tasks outlined by the grant. We decided on four software packages.

Adobe Premier 4.2

We chose Adobe Premiere 4.2 as our video editing software: it is designed for low and middle end budgets, and it is bundled with the DPS Spark FireWire interface card. Adobe Premiere stitches together multiple video clips, saving them as .AVI files. Each clip can be placed into proper sequence, allowing the creation of a continuous video file. In addition, Adobe Premier allows addition of effects to the video. These effects create smoother transitions between clips and add continuity to the video. Fades, wipes, scrolling, text formatting for credits and subtitles, and other effects and transitions help produce a compact, visually pleasing multimedia experience. This package provides a great deal of flexibility and many features otherwise available only in high—end video production. This product is included among a suite of graphic products produced by Adobe. We currently use Adobe PhotoShop 5.0 for editing still raster images, also among the leading products available to the consumer. The products produced through this process are very useful for education and public outreach, to the missions of *The Lost Towns Project* and the Anne Arundel County Trust for Preservation.

PhotoModeler Pro 3.0

Creating 3D images requires multiple programs. We capture images or scenes using either the Sony digital video camera, or a conventional 35mm camera with inserted fiducials. We transfer the images to the computer through the FireWire interface, or a Hewlett Packard Photosmart Photo Scanner. PhotoModeler Pro uses multiple photographs of an object or scene, using information about the camera and the lenses, and extracts measurements. Points in each are photograph marked with unique reference numbers and the common reference points between photographs are manually referenced to one another. Once completed, the computer can process the spatial relationships of the data and generate a 3D model of the object or scene (Figure 3-3). Project staffers use PhotoModeler Pro 3.0 and AutoCAD R.14 to create 3D images.

PhotoModeler Pro 3.0 converts a series of digital (raster) still images into three-dimensional wire frame models. These images can then be exported to AutoCAD for further integration and manipulation. Accompanying calibration software increases accuracy by accounting for systematic errors in a particular camera model, achieving with an approximately *95%* confidence interval a precision close to *85%* of the image's resolution under near optimal photographic conditions. PhotoModeler Pro 3.0 generates high quality 3D data of real-world objects and scenes. A few of it's advanced features include automatic camera orientation, surface drawing, enhanced file export, enhanced photo-texturing, cylinder and curve modeling, and multimedia tutorials.

Archaeologists can use PhotoModeler to:

- Model artifacts, particularly fragmentary objects and building reconstructions

- Perform morphological measurements
- Document excavations
- Record shipwrecks and other submerged sites
- Document standing historic structures for conservation and preservation

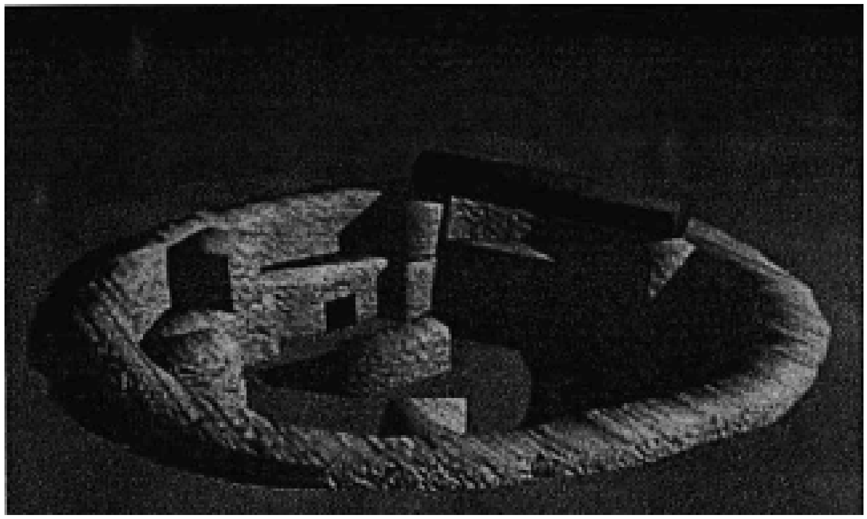

Figure 3-3. PhotoModeler image downloaded from the Internet.

Light Wave 3D

LightWave 3D is a professional graphics-modeling program and, at approximately $2,000, and is less expensive than functionally comparable packages; e.g., 3D Studio MAX and Softimage. Fortunately, we were able to obtain access to LightWave through the Arnie Arundel County video production studio. LightWave 5.0 consists of two applications: Modeler and Layout. Modeler creates wire frame models, adds textures and lighting effects, and then transports the models to Layout for animation.

Modeler offers four simultaneous viewports in which to design and construct objects. Although well-regarded by graphics artists, LightWave is a difficult program to learn. Relatively simple tasks are convoluted in LightWave:

> Unfortunately, neither Modeler nor Layout let you easily edit your curve tangents, which made fine-tuning our path difficult. Modeler has spline controls, but in Layout you can specify only the tension, continuity, and bias parameters. The most frustrating aspect of Modeler, however, has to be its lack of any grouping or named selection set tools. To create our lamp, we had to place every segment on a separate layer and export each one as a separate object so that we would be able to animate them late... [and] LightWave's inverse kinematics tools are far less flexible than either Softimage's or 3D Studio MAX's.(Grunin 1997).

LightWave's advantages include an excellent "renderer, which has a nice selection of controls, textures, and output quality choices. It lets you generate several variants and preview them before you choose the one you want to apply" (Grunin 1997).

Another of Lightwave's principal advantages lies in the fact that it is available for many operating platforms and runs on both Windows NT and Windows 95.

5. DATA AND PRODUCT STORAGE

Archaeologists and historic preservationists are concerned with data storage and preservation. The difficulty lies in preserving, in perpetuity, data that has no other media for storage. A good deal of the video footage shot by *The Lost Towns Project* documents portions of excavations, that are not content rich, yet provide important contextual data not amenable to standard recording practices (notes, still photography). Filming archaeological excavations addresses one the greatest concerns within the field of archaeology—the destruction of archaeological sites through excavation.

Archaeology is a destructive science, disassembling non-renewable resources to collect data necessary to our understanding of the past. The principal investigators of archaeological sites carry the sole responsibility for interpreting the finds, and reporting them to the academic community and to the general public. Unfortunately, many excavations are not interpreted until years later; or worse, the results of many excavations are never reported. The capture and long term storage of video assists in the recollection of details years after the excavations are complete. Even more important, video provides an opportunity to other archaeologists to finish site reports, or to revisit and review interpretations. Videography in any form, however, is not a substitute for standard recording, analysis, and reporting practices.

The next section briefly explores the merits of various storage technologies. Each method has advantages and disadvantages, and there is no method for correctly storing digital data. We recommend a number of options for data storage, but storage solutions should be tailored to the individual project.

DV Tape

The best method for storing large video files, in terms of expense and space, remains the DV cassette tapes on which the images were first recorded. DV cassette tapes, a magnetic medium, are subject to the same failures as 1.44-MB floppy disks and hard disks. Magnetic media are particularly susceptible to temperature and humidity extremes, as well as strong magnetic variations. In addition video written to DV cassettes is compressed using a software code which our equipment compresses at a 5:1 ratio, thus, increasing the storage capacity of the tape by a factor of five. Unfortunately, this compression technique is a form of lossy compression. Lossy compression slightly degrades digital data with each compression/expansion cycle. In the case of DV cassettes, each cassette can be opened from thirty to fifty times before image quality begins to seriously degrade. The physical deterioration of materials, from which the magnetic tape is made, also remains a problem. In spite of these problems, DV cassette tapes remains the most cost-effective method for short-term video storage.

Removable Drives

Removable storage drives also store digital data and they are relatively inexpensive; e.g., SparQ and Syjet drives manufactured by SyQuest, and the JAZ drive manufactured by Iomega. These drives store between one and two Gigabytes of data; the new Iomega JAZ drive has doubled its capacity to 2 GB, SyQuest will soon manufacture a 4.7 GB Quest drive more expensive than the disks offered by Iomega. Regardless, a portable drive is nearly essential for any desktop video editing solution, and greatly improves the performance of any computer system. Practical transporting of video files demands portable drives.

CD-R/R W

One of the newest and most exciting forms of storage media is the R/RW CD ROM. Unlike magnetic media, CD-ROM technology uses optical technology to store data. CD-R/RW technology uses a laser to write data to an optical compact disk (CD). This form of data storage is more stable than magnetic media. Temperature and humidity do not affect data stored on CD-ROM, nor is it subject to data degradation; however, it is susceptible to very high temperatures and physical destruction. Currently CD-R/RW recorders are available for about $200, with very inexpensive CD-RIRW disks (about 1/6 cent per MB). These CDs can store about 650 MB of data. Current CD-R/RWs feature 2X to 4X write speed and 16X to 24X read speeds. Writing a CD on a 2X CD-R takes approximately thirty-six minutes and eighteen minutes on a 4X CD-R. Yamaha and TEAC brands are both highly rated, while Plextor Ultra-SCSI drives are recommended for A/V professionals *(PC Graphics & Video,* September 1998).

The greatest difficulty with CD technology is the limited storage capacity of the disks (650 MB). Uncompressed video files (*.AVI) take a large amount of space. A single CD will only store several minutes of uncompressed video. As of this writing, we have just acquired a CD—RIRW and are using it to archive still images and to copy short film segments between a computer and an editing deck.

DVD

Another technology under development is recordable DVD. Recordable DVD may be the single best answer to long term video storage. DVD technology is still in its infancy, with no consensus for standardizing the format. In fact, contention between standards organizations may lead to competing formats such as occurred between VHS and Beta during early VCR development. Right now several groups are vying for supremacy in writable DVD, including DVD-ROM, DVD-RAM, DVD-R, DVD+RW, and DVD-RW. DVD-R is currently available with a capacity of storing approximately 3.9 Gbytes (Troop 1998).2 Without going into the differences between each of the technologies, standardization likely will occur within the industry, one of these standards coming to the forefront in the next few years. What is clear, from the information currently available, is that writable DVD can hold large quantities of data. Most of the drives will cheaply store over 3 GB of data, with higher storage capacities to follow in the near future, with later versions promising to store up to 17 gigabytes of data.

Writable DVD holds the promise of storing large files on an archivally safe medium. The Lost Towns Project is currently storing its digital data, including video on Iomega JAZ tapes, and is just beginning to back-up critical files on writable CD-ROM. As the issues of DVD format and compatibility resolve themselves, we envision storing all digital data on writable DVD, for long-term archival storage.

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[2] A Gbyte is a measurement of storage capacity different from a GB or Gigabyte. 4.7 Gbytes is equivalent to 4.38 gigabytes (GB).

6. IMPLEMENTATION

Integration of the software and hardware components required testing to calibrate the photographic equipment with the PhotoModeler software. First, an approximate camera default value was created. This includes information about the camera type, focal length, format size (height and width in millimeters), principal point, and lens distortion. The computer uses these default camera values to determine the three—dimensional coordinates within an object or scene. Several of the values discussed above are derived from formulas and tests that are described in Appendix A.

Testing

Following these calibrations, several digital still images of objects were captured as tests for the software. The chosen objects were geometrically simple shapes designed for ease of manipulation, but still enabling testing and evaluation of the camera and software. PhotoModeler either succeeds or it fails to create a 3D model during processing. The processing can fail in several ways: orientation failure, warping, or skewing. These usually are easily remedied and only require patience and persistence to repair (Figure 6-1).

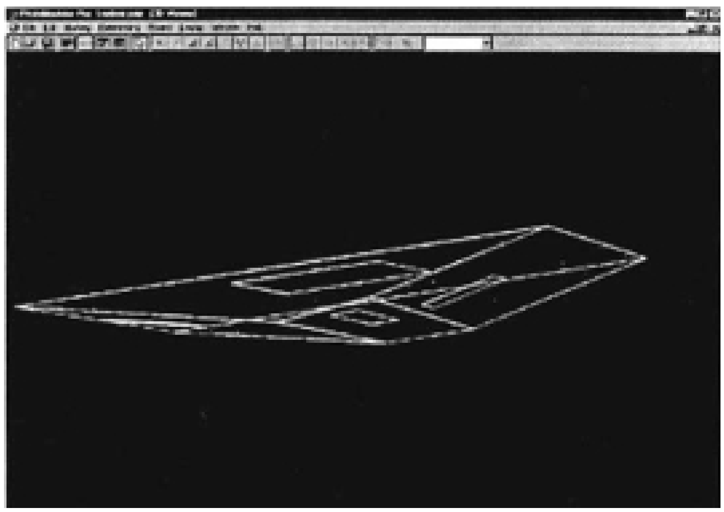

Figure 6-1. A warped three-dimensional model of a box produced by incorrect camera parameters.

Initial tests did not go well. Three-dimensional objects generated by PhotoModeler using digital still images were warped and skewed. Subsequent testing and communication with Photomodeler technical support revealed that the initial mathematical computations of the parameters were incorrect, leading to processing errors (Figure 6-2).

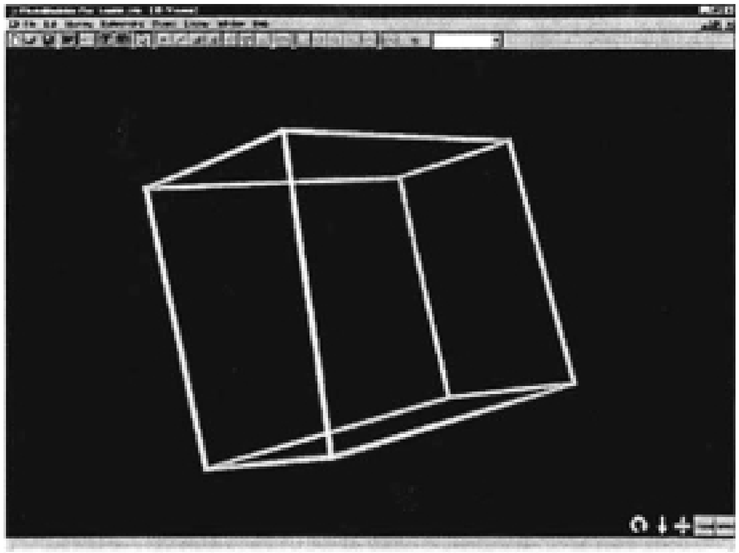

Figure 6-2. Three-dimensional test image of a box exhibiting slight warping.

While sorting out digital camera parameters, other methods were applied to continue testing the PhotoModeler software. These tests used a 35mm camera and fiducial inserts supplied by the manufacturer. Fiducial inserts are crosshairs inserted into the film plane of the camera, thereby, imprinting the crosshairs onto photographs taken with the camera. We used a Ricoh 35mm camera. It is important to use only one camera with a fixed focal length for each project. The computer can only process one set of parameters for each set of photographs. We used conventional 35mm Kodachrome slide film developed by a conventional photo processing facility. Any type of film of any format can be used; however, each must be calibrated to the computer. The slides were scanned at a resolution of 300 dots per inch (dpi) using a Hewlett Packard Photosmart scanner.

Once scanned, the fiducial crosshairs imprinted on the film serve as a scale which, in conjunction with the camera parameters, assists in processing three-dimensional objects or scenes. Our conventional 35mm camera produced higher quality three-dimensional images than did the digital video camera, even after setting the correct camera parameters. These differences reflect image quality. The digital video camera captures still images at 75 dpi. Kodachrome 64 film captures images at a much higher resolution. For this project the full resolution of Kodachrome film was limited by our scanner, which captures images at a maximum of 1200 dpi.

After resolving the calibration and resolution difficulties, the staff began work on three principal projects to examine the potential of the desktop video editing and 3D animation systems. These projects were designed not simply as tests, but also were intended to produce products suitable for public education and broadcast. These three projects include a 3D interpretive reconstruction and 3D animation of the Rumney’s tavern cellar (c.1710—1730s) and Robert Burle dwelling (c.1660—1680), and the virtual reconstruction of artifacts recovered from Rumney’s tavern.

Rumney's Tavern ***(18AN48)***

One of the first significant tests for the system involved the creation of a three-dimensional model of the Runmey's Tavern cellar. *The Lost Towns of Anne Arundel Project* began excavations at Rumney's tavern in 1996. The team began by excavating fifty-five 5—ft by 5-ft Squares, removing the plowzone and exposing features that intrude into the subsoil. Excavations exposed nine postholes with molds and a trash—filled cellar hole measuring approximately 18 by 16—ft at its surface and, as the excavations eventually revealed, 1 0—ft long at its base. Excavators divided the cellar into four quadrants and excavated stratigraphically to the cellar floor, a distance of about 5—ft below the current grade. Three of the four quadrants have been excavated as of this writing.

Analysis of the first two quadrants revealed two principal trash layers; the lower of the two dating to c. 1715, the higher to c. 1730. The combined ceramic assemblage ($n2^4$ minimum vessels) yielded a mean date of 1721 (Figure 6-3). White salt-glazed stoneware vessels, other than slip-dipped tankards, are absent from the assemblage, suggesting a terminal deposition date of the early 1730s. Mean pipestem dates calculated for six beds within the southeast quadrant of the cellar ranged from 1730 to 1739 (sample sizes ranging from 19 to 77) using Hanson's (1971) regression formula for the early 18th century (Gryczkowski, et al., 1998). Pipemaker William Manby's (c. 1689-1740) initials appear on two bowl fragments, the only marked pipes in the tavern assemblage.

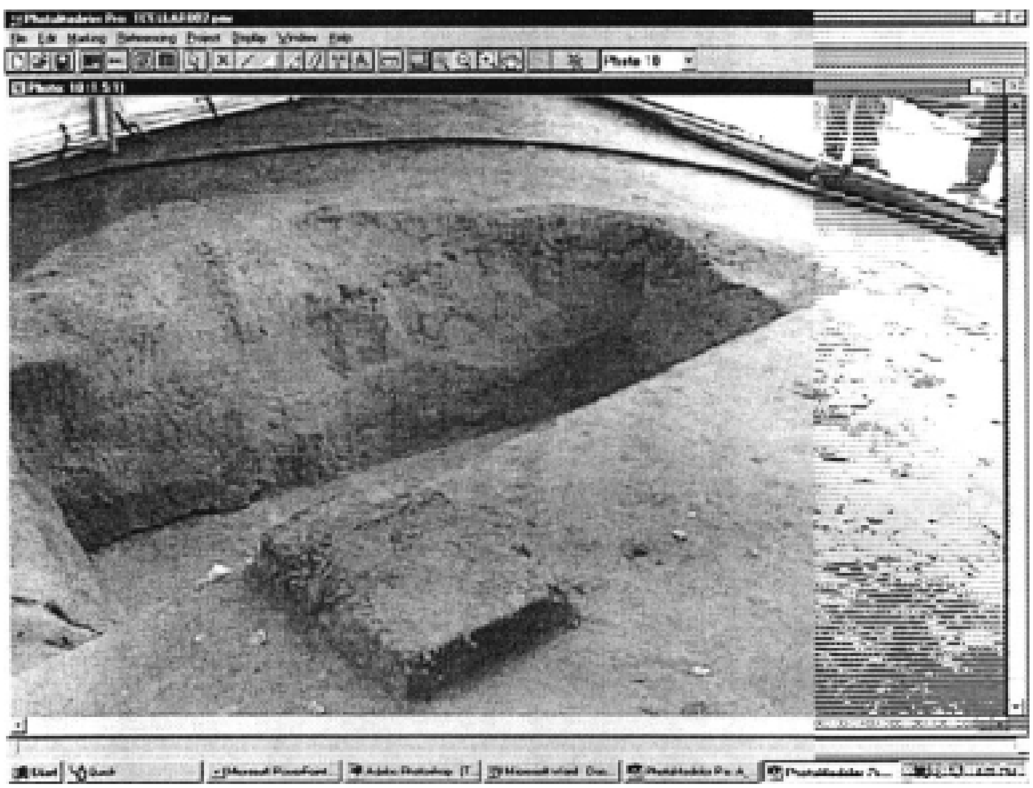

Figure 6-3. A digital photograph of the Rumney's Tavern cellar. Note east half of cellar has been excavated.

Historic documents Suggest that this cellar was associated with a tavern operated by Edward and Elinor Rumney, and later by Stephen West. In 1709, the Provincial Court granted Edward Rumney, ship carpenter, a license to operate a tavern in London. Rumney had owned land on the north side of the South River, selling it sometime in the 1690s. Precisely when he settled in London remains undetermined, but he may have taken up Lot 87 on Scott Street as early as the 1690s. In 1711 he mortgaged the lot to Charles Carroll, but still operated the tavern, and even made improvements to the structures on the lot (Anne Arundel County Land Records PK: 375, 06 July 1711). Rumney continued to apply for, and receive, licenses to operate an ordinary through 1718. He described himself in his 1713 application as a ferryman (Anne Arundel County Judgments, November 1713: 154, 156). Charles Carroll, Jr., foreclosed on Rumney's mortgage in 1720 and leased, then sold, the property to Stephan West, Sr., in September 1723. Although the tavern cellar filled by about 1735, archaeological evidence suggests abandonment of the building perhaps as late as third quarter of the 18th century.

The object of this project was to accurately reconstruct, in three-dimensions, the east half of the Rumney' s cellar. Prior to photographing and video-recording the excavation area was re-trowled, cleaned, profiled, and mapped. The walls of the cellar were highlighted using 3" long steel pins with colored plastic heads. The pins were pushed into the subsoil to mark the location of major changes in cellar contours. The pins~ assist the PhotoModeler operator by enhancing the visibility of the cellar's irregular contours and referencing the same physical point in space among multiple photographs. These visual references greatly assist in marking the photographs (Figures 6-4 and 6-5).

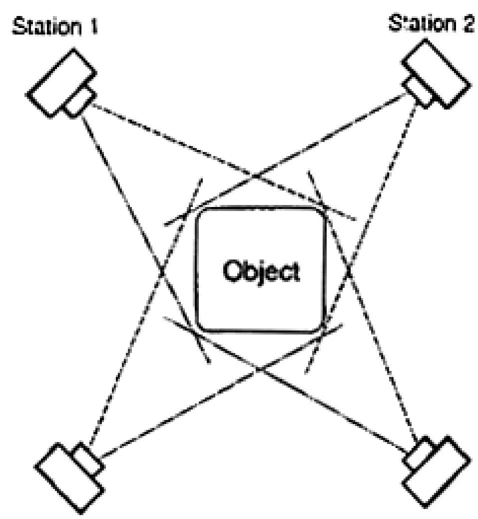

Figure 6-4. Top view of suggested camera orientations for photographing objects for PhotoModeler (Eos Systems Inc. 1997).

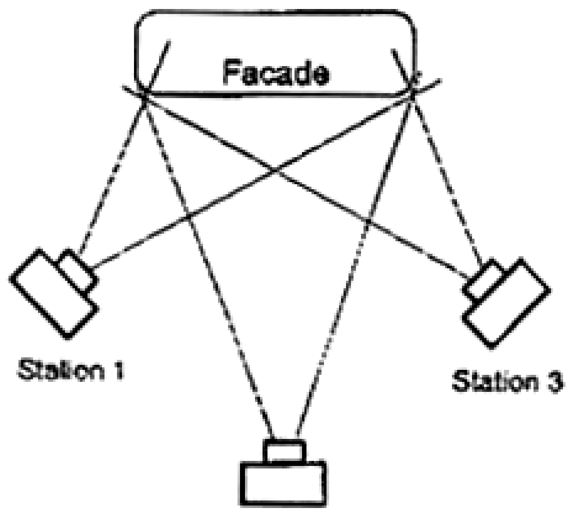

Figure 6-5. Top view of suggested camera orientations for photographing facades for PhotoModeler (Eos Systems mc, 1997).

The cellar was photographed and video-recorded in February and March of 1998. The PhotoModeler user manual suggests the following photography guidelines:

- shoot as close to right angles as possible, take at least three photographs;
- shoot all important points on at least three photographs;
- overlap adjacent photographs;
- take photos from above and below the object;
- take many photographs, but begin using only four until others are necessary; and
- measure the distance between two clearly visible points.

To ensure that we captured a sufficient number of photographs with overlapping points, we photographed the cellar within points all around its perimeter (Figure 6-6).

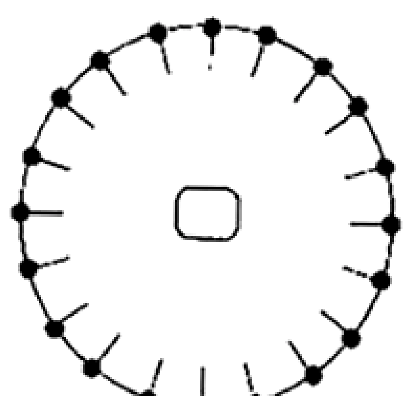

Figure 6-6. Top view of suggested camera positioning to photograph in a 360 degree ring (Eos Systems Inc., 1997).

The software generates the object or scene by projecting straight lines from the camera position, through the point on the film or CCD (Charge Coupled Device), and out into space. The intersection of two rays defines the point position (Figure 6-7; Eos Systems Inc. 1997).

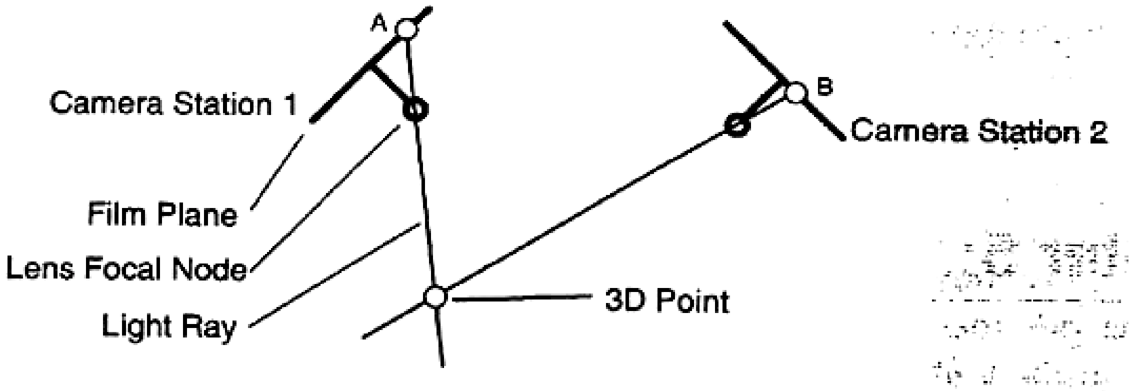

Figure 6-7. Method used by software for computing 3D points.

Images were loaded into the computer and imported into a new PhotoModeler project. PhotoModeler saves the work in a project file, but it does not save each photo. Instead the software links the location of each photo with a reference to the project file. Following importation, each photograph is marked with points designated by a unique reference number (Figure 6-8).

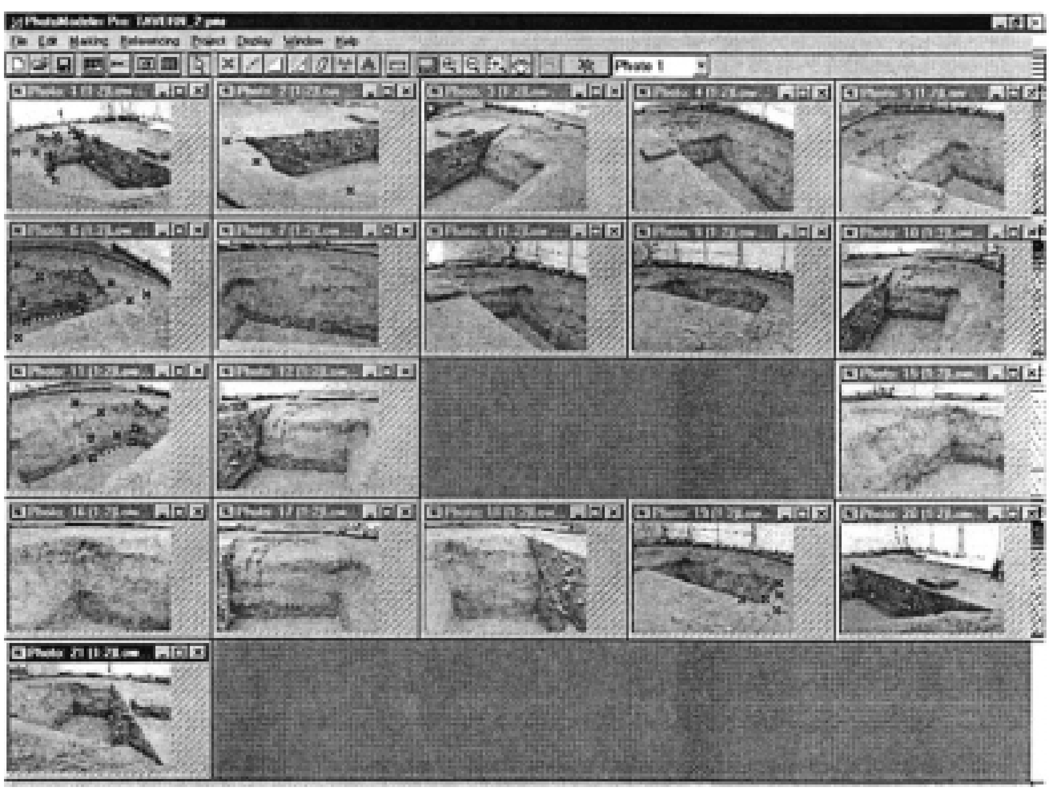

Figure 6-8. PhotoModeler screen illustrating point marking.

The operator then common references photographs with common points. The computer processes the spatial relationships and generates a 3D model of the object or scene (Figure 6-9).

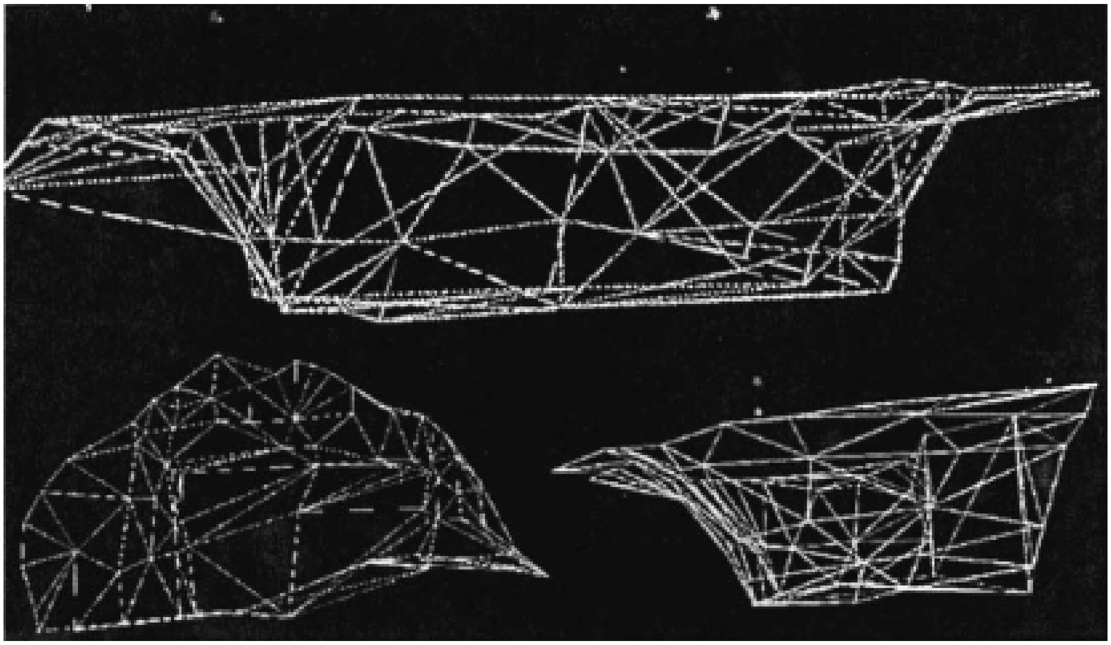

Figure 6-9. Wireframe model of the cellar from the front, top, and side in Photomodeler.

We exported the wireframe model to AutoCAD via a 3D *.dxf (drawing exchange format) capability (Figure 6-10).

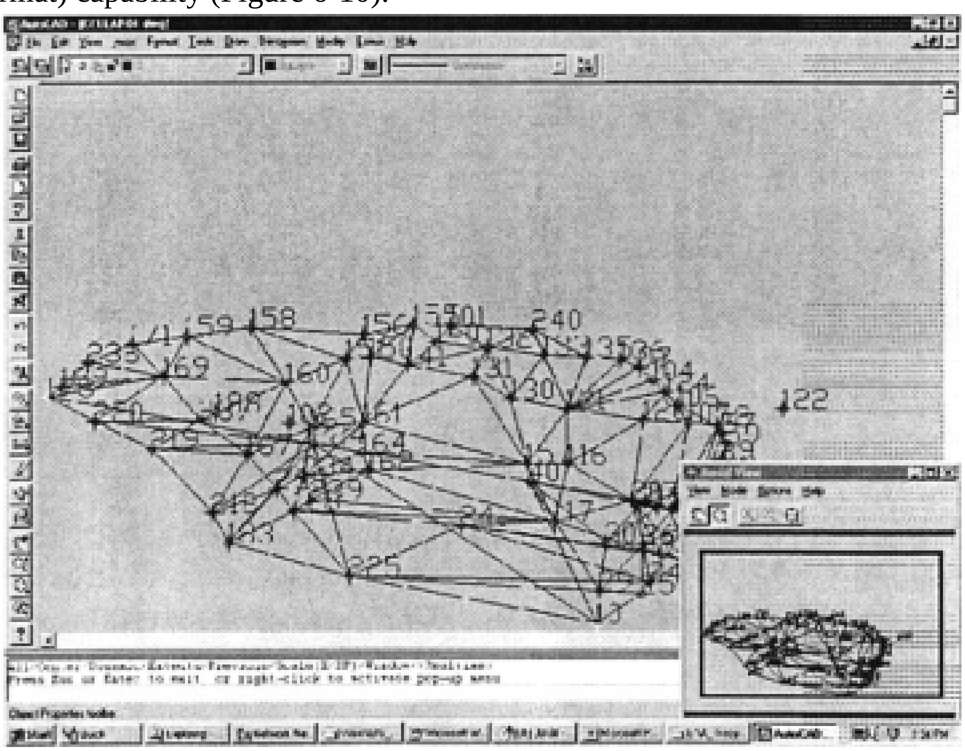

Figure 6-10. Rumney's cellar model shown in AutoCAD.

The resulting wireframe was then imported into the LightWave software (Figure 6-1 1). In the LightWave program surfaces, texture, and color were added to the cellar model. These features added realism to the model.

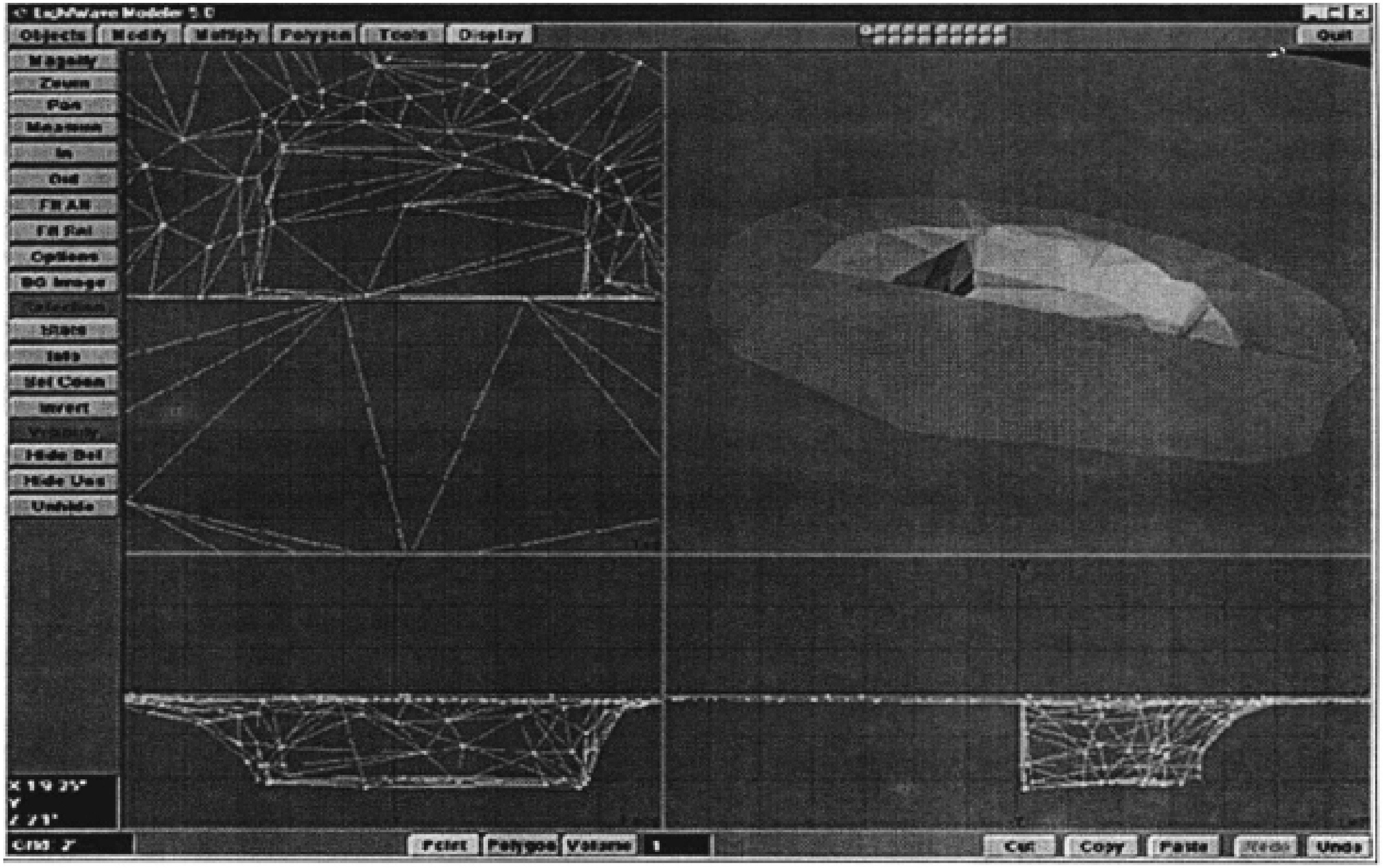

Figure 6-11. LightWave Modeler construction window with east half of cellar.

Following the completion of the cellar model, the project staff began reconstruction of the building above the cellar. Remember, this was an earthfast building constructed on as few as nine wooden posts set into the ground. The underlying cellar was nothing more than a rectangular hole with earthen walls and floor. The posthole pattern, created when the colonists first dug, then refilled holes in which they set upright wooden posts, provided the building's dimensions and orientation. Additional information on the building derives from the architectural artifacts recovered from the cellar hole and the surrounding plowzone. Additional information was drawn from other archaeological sites and from standing historic buildings dating to the same period (Carson, et al., 1981). The model's roof pitch, door and window locations, and chimney placement represent typical features for the time and place.

The first step in creating the Rumney' s tavern was to recreate the structure's footprint with its posts and interrupted sills. Next we created a single vertical section with its supports and appropriate bracing in LightWave, then copied it and placed the copies in the model as if they were prefabricated sections. Copying such elements saved a great deal of time and tedious effort, and contributed to a growing library of templates for modeling other buildings (Figure 6-12).

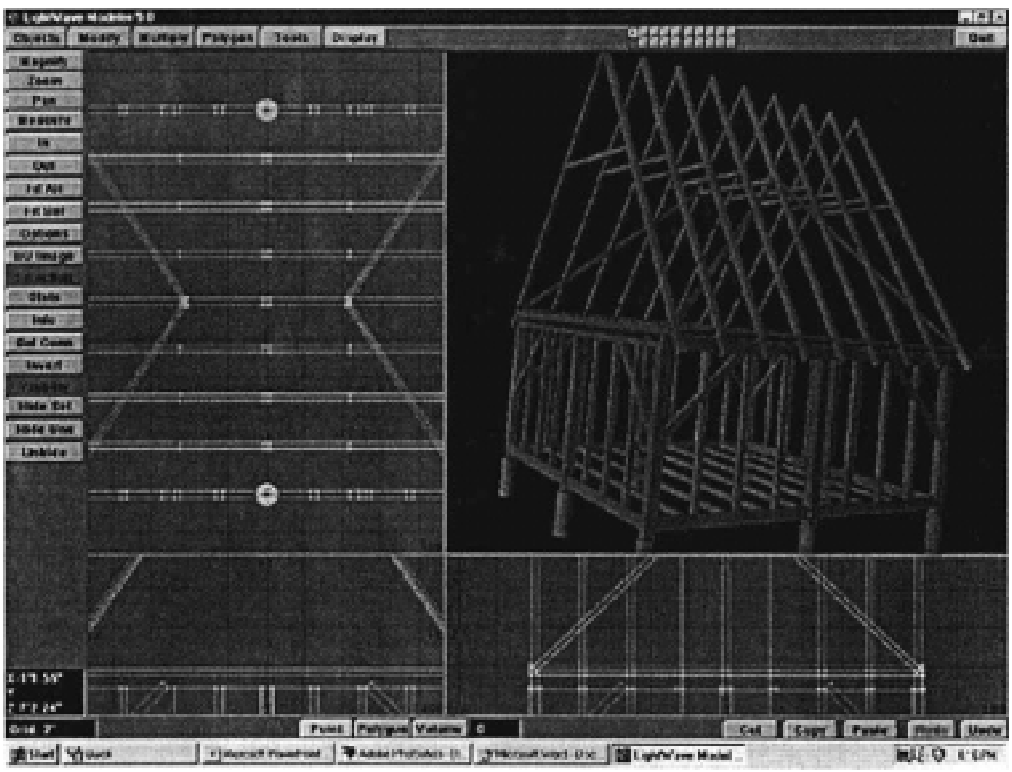

Figure 6-12. LightWave Modeler construction window showing completed framing.

Once the lower framing (the sidewalls and upbracing) were completed, the upper framing was created. We created one roofing truss, then copied it at the appropriate spacing recorded for surviving early eighteenth-century structures in Maryland and Virginia (Figure 6-13).

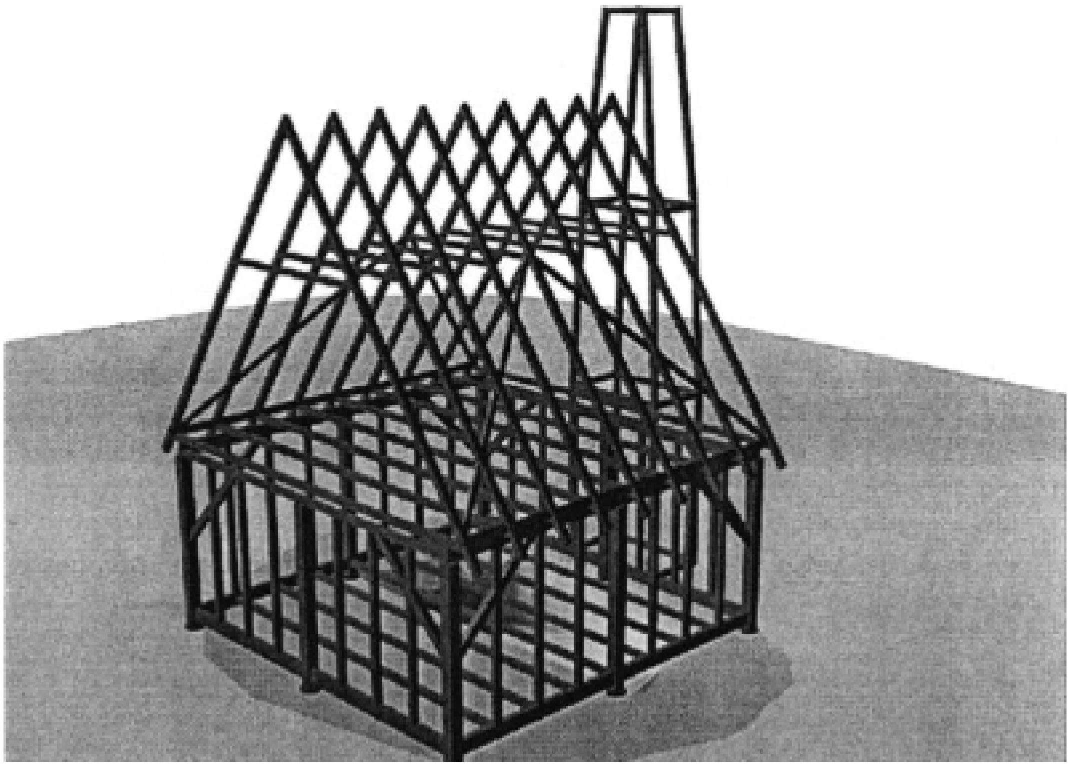

Figure 6-13. Rendered version of the Rumney's tavern with integrated cellar and framing.

Details, such as a wattle and daub chimney and an exterior wall, were added using this same process. The exterior wall is a surface on which further detail can be added. For instance, a texture created from a picture of an historic building exterior can simulate exterior riven clapboard siding. The operator maps that texture to the surface. This picture can be modified to create a weathered appearance, then applied and attached to the exterior wall surface of the model; in essence creating a photorealistic model of the structure. Once the model is constructed such final touches as smoke from the chimney and flickering candles can be added. The framing model was then integrated with the cellar model creating a composite image of the cellar, framing, and chimneys.

The final process involves animations, Through LightWave's Layout module motion, lighting, and camera paths are added. For instance, the camera zooms from a distant point to a detailed "walkthrough" of the tavern. Once the camera positions and the lighting effects are added, the program begins the rendering process. Computer rendering of animation effects takes hours to create just a short movie sequence. Creating even a two-minute animation of the tavern required leaving the computer on over night. The animation is a raster graphics file that cannot be modified. To make modifications to the tavern animation, the changes have to be made in the model, which then has to be reexported to layout program. The rendering program then has to be run again. Due to the time involved in creating and rendering these movie clips, *The Lost Towns Project* has rendered only four significant movie clips.

Robert Burle 's dwelling (18AN826)

Excavations at the Burle' s Town Land site were extensive and systematic, consisting of well over 200 5-ft x 5-ft excavation units. Robert Burle, county surveyor, patented 100-acres in Providence in 1662, although he may have occupied the tract as early as 1649/50. He lived there until his death in 1676, leaving the plantation to his youngest daughter, Rebecca. Rebecca Burle married Humphrey Boone in 1680 and the couple may have moved their household to Boone's land in the northern part of Anne Arundel County, effectively abandoning the site for at least two generations.

Situated at the head of a small drainage on a terrace overlooking Burley Creek, Burle's Town Land lies partly within a plowed field and partly within an eighteenth to nineteenth—Century family cemetery. Graveshafts have disturbed seventeenth-century deposits, damaging some portions of the principal dwelling. However, because the core of the site lies within this cemetery, large portions have escaped plowing.

The principal dwelling measured 59-ft x 20-ft with a four to six room plan. The structure appears to have consisted of two sections (a "duplex"), each an inverted mirror image of the other. Each section had an interior wattle and daub chimney centrally located along either the west or east wall.

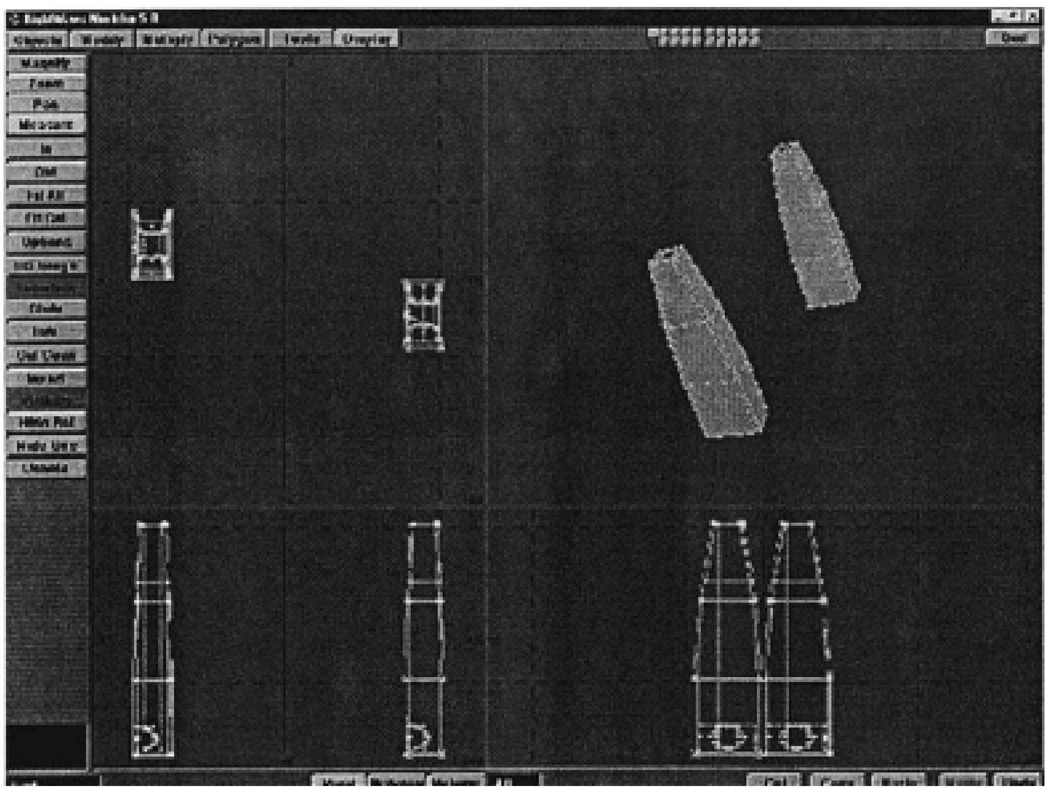

Figure 6-14. LightWave model of wattle and daub chimneys.

The vertical support posts likely were raised in tied pairs using bent construction, and tied into an interrupted sill (Figure 6-15). The exterior most likely was riven clapboard, while burned daub impressions and lathe nails indicate interior split lathing.

The dwelling was decorated in an unusual manner. Large quantities of red clay "pantiles," or roofing tiles, fragments of *estrikken* tiles—red bodied earthenware floor tiles with white slip under green or yellow lead glaze—and blue and white Dutch tinglaze earthenware, or "delft" tiles were recovered from the site. The two wattle and daub chimneys are typical of seventeenth-century Chesapeake architecture. Two marked window leads were recovered from the Burle site, as well as a nearly intact quarrel with glazing, indicating one or more casement windows. One of the marked window leads bears the fragmentary inscription —SON of BRIS-. This is the mark of John Mason of Bristol, England, for which the only known associated date is 1647. This approximates the ca. 1650 settlement date for the Buries Town Land site.

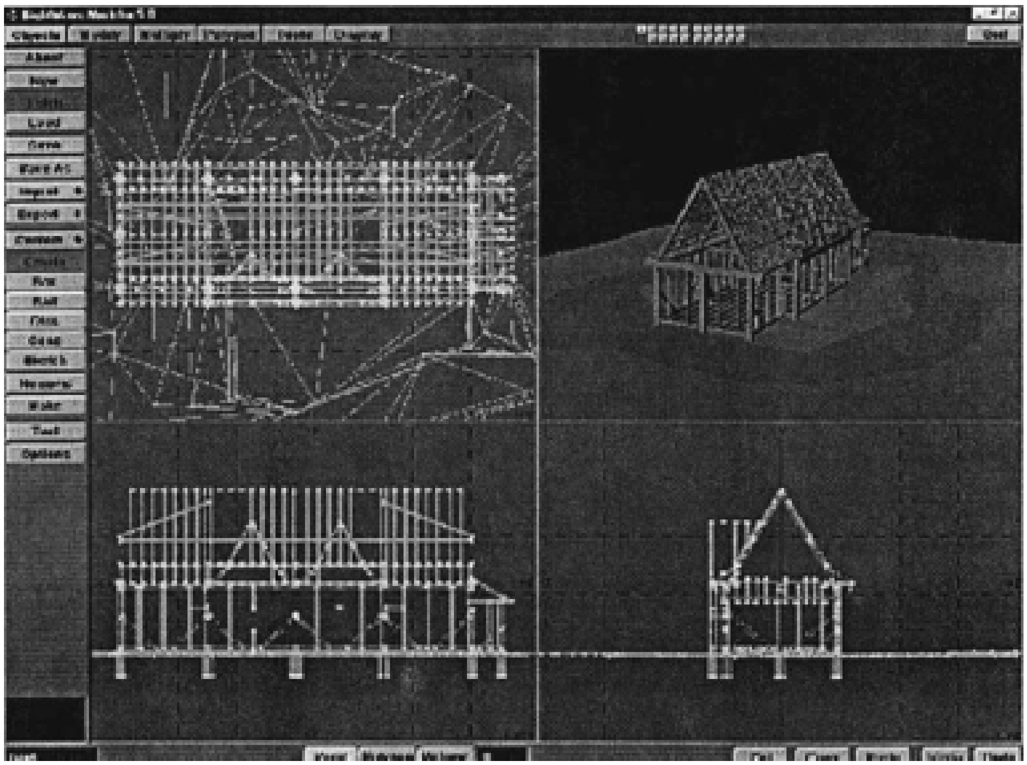

Figure 6-15. LightWave model of the Burle house

Virtual reconstruction of the Burles Town Land site used slightly different methods than those used in reconstructing Rumney's Tavern. PhotoModeler was not used at the Burle site. Instead, AutoCAD planviews were created from archaeological data to delineate the footprint. Like the Rumneys, Robert and Rebecca Burle built their house on earthfast posts, with smaller posts erected to create two wattle and daub chimneys. Spatial analysis of artifacts helped determine placement of doors and windows (Figure 6-16).

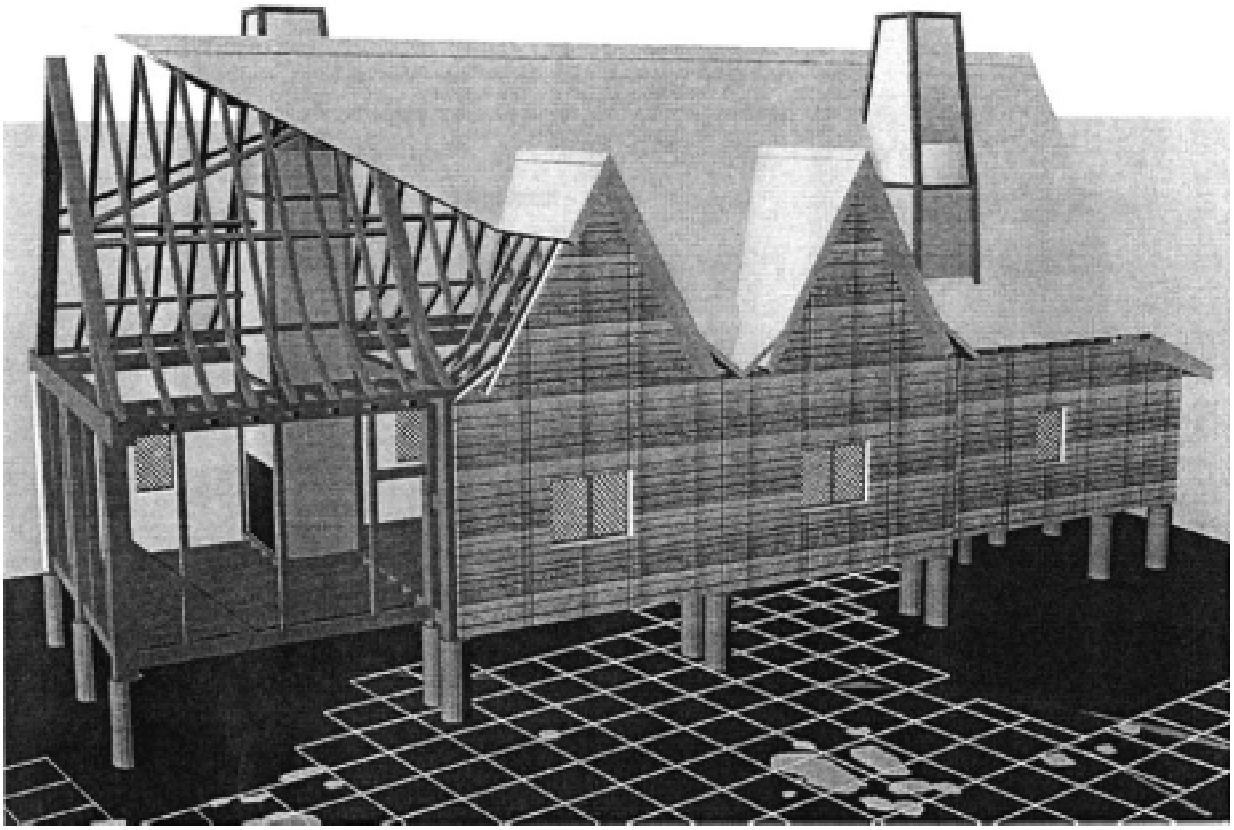

Figure 6-16. Reconstruction of Burle house superimposed on the archaeological grid.

The AutoCAD method of reconstructing the Burle house was generally more effective than the PhotoModeler method used to recreate Rumney' s cellar. It is less labor intensive, but less accurate. Reconstructing a rectangular object (the Burle house) was not difficult. Reconstructing a less regular object such as the tavern cellar is more difficult and best approached with PhotoModeler. The programs complement one another.

Rumney's Tavern Artifacts

In addition to modeling architectural and structural features, smaller objects such as artifacts also can be modeled. We began modeling several reconstructed ceramic and glass vessels from the Rumney's tavern using two methods to import information about shapes, sizes, and textures of the artifacts.

One method used scanned line drawings in Targa (tga) format, imported into LightWave, their profiles digitized. We then used LightWave's lathe tool to extrude a cylindrical object from the profile. This technique produces an idealized version of the object, artificial in appearance, because the image is perfectly cylindrical and symmetrical: hand-blown glass vessels and wheel-thrown ceramics are not perfectly shaped. These vessels are not exact reproductions of objects from Rumney's tavern cellar hole, but they are close.

Textures and surfaces were created from scanned or digital photographs. The photographs were then retouched to remove lines from breakage, or other imperfections.

These textures were then appropriately scaled and mapped to the object. Figure 6—17 is an example of a line drawing and a photograph illustrating the materials used to create a three-dimensional eighteenth-century wine bottle. Notice the asymmetry of the neck in the right hand version typical of many period bottles.

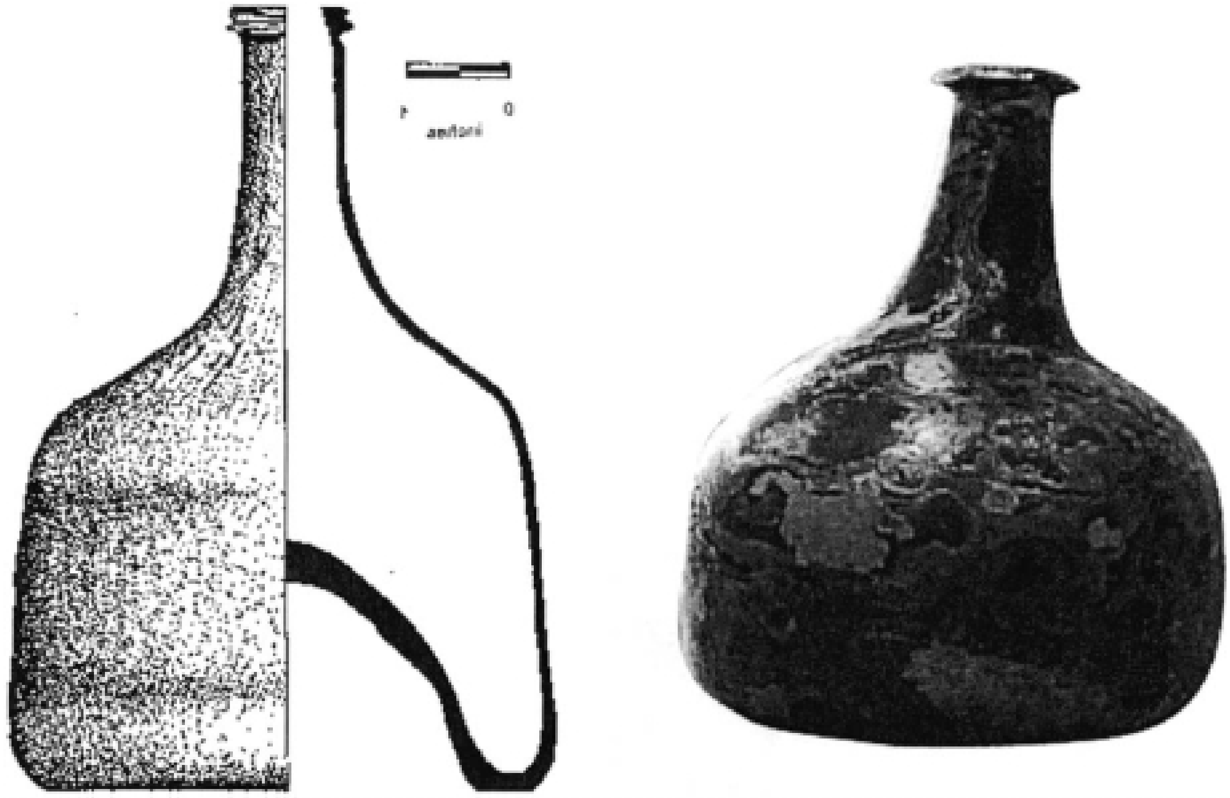

Figure 6-17. Line drawing and photograph of two mallet bottles from Rumney's Tavern.

The other method of creating three-dimensional models of artifacts uses scanned photographs of artifacts, digitized as 2D images within the LightWave program, and then extruded as a 3D object. The digital photograph of the pharmaceutical vial below (Figure 6—18) is an example of a 3D object created with this process (animated in digital format). Both methods successfully created 3D models (Figures 6-19, 6-20, 6-21).

We have discussed the value of this technology, demonstrating its practicality in creating, storing, and disseminating images for public education, and scholarly discussions. In addition to these concepts discussed in previous chapters, the 3D images produced by this project have an additional value; hypothesis building. In the final chapter we discuss our overall evaluation of the technology, and its application to archaeology.

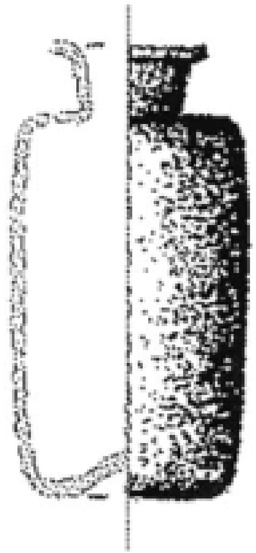

Figure 6-18. Pharmaceutical vial recovered from Rumney's tavern.

Figure 6-19 Reconstructed Rumney' s tavern artifacts shown in context of use.

Figure 6-20. Reconstructed ceramic vessels recovered from the Rumney's tavern cellar.

Figure 6-21. Reconstructed ceramic and glass vessels recovered from Runmey's cellar.

7. CONCLUSIONS

New, affordable digital recording technologies hold great promise for archaeological research in terms of analysis, data preservation, distribution, and in conveying findings—through images—to the public. High-quality graphics are no longer the sole domain of SGI graphics workstations, and continued advances in computers and software serve to make 3D imaging and DTV more accessible to archaeologists. This technology is a valuable educational tool, for educating school children, university students, and the general public.

Although the technology used in the production of 3D graphics is available and cost-effective; this technology is not for everyone. Each program has a steep learning curve, requiring significant training before it becomes an efficient tool for archaeological research and education. Despite the high degree of technical ability and computer literacy among project personnel, much of the effort of this project was spent learning how to integrate and use the four major programs and two of their add—ons: Adobe Premiere, Adobe Photoshop, AutoCAD, AutoCAD walkthrough, PhotoModeler Pro 3.0, and LightWave. Computer Graphics Arts intern Tracy Corder, from the University of Maryland—Baltimore County, greatly enhanced the project. Although Mr. Corder has since left the project as he nears graduation, two new interns from the same campus, Bette Lowhan and Michael Rinker have taken his place in a considerably expanded program 3D modeling and animation.

As a part of our public education and outreach program, these models have proved invaluable, and have met with great success. Several of these 3D scenes were made into movie clips that appeared in a public access cable documentary broadcast, *The Lost Towns Project: Unearthing the Past.* In 1999, many of these images will be displayed on the Internet, as part of the London Town Foundation's and *The Lost Towns Project's* interpretive and educational programs. 3D images of the Robert Burle house and of artifacts from Rumney's Tavern were featured in Maryland's 1999 Archeology Month poster and Calendar.

Many of these images will be used by the London Town Foundation for the reconstruction of buildings and landscapes at London Town; using our image library to plan and justify their designs. Institutions engaged in reconstruction, including the National Park Service, should find this technology vitally important in their reinterpretations of archaeological sites, restorations of village sites, and reconstructions of past landscapes and streetscapes (e.g., Jameson 1997). Museum educators, challenged to interpret closed archeological sites, 'sites without sights' (Davis 1997), will find this technology indispensable; provided the data have been carefully collected, recorded, archived, and made accessible by those excavating sites. Not just for public outreach, this technology has been used to collect high quality data for use and dissemination to professional scholars. 3D models created by *The Lost Towns Project* staff aid in analyzing stratigraphic relationships within and among features.

Perhaps most important for *The Lost Towns Project*, 3D modeling can be used to test theoretical models, hypotheses, and simple relationships, a direction that we are just beginning to explore. Adopting this technology will not significantly alter the methods archeologists use to excavate and record data, but it will alter the ways in which they analyze and interpret data.

Video-editing and 3D modeling are affordable to archaeologists, and becoming more so every day. Although impressive, the technology purchased through this grant cannot compete with professional quality studio and editing equipment. Just as digital recording is not a replacement for conventional recording methodology, neither is it a replacement for 'high-end' professional video equipment and editing studios. Rather this equipment augments the tools available to archaeologists to record, interpret, and disseminate archaeological data among scholars, without relying on expensive film studios.

> Computer modeling has brought vanished buildings from the exclusive domain of archaeologists and architectural historians into the realm of the general public. These reconstructions should be viewed with a degree of skepticism, however. Although the images may look polished and convincing, they do not represent absolute truth. The modelers of destroyed buildings work with incomplete information and must make educated guesses to fill in the gaps. The viewer can't always tell what was documented and what was guesswork. But for the experience of exploring another culture or a lost building, nothing to date surpasseses these digital re-creations *(Novitski 1998).*

In conclusion, we see the growth of virtual reality, digital video, and the Internet as positive advances, offering American households a more expansive, more sophisticated view of the world. Archaeologists and historic preservations must become at least as technologically savvy as the average householder if we expect to grab and hold their attention. Just as important, multimedia environments can help scholars achieve more sophisticated and comprehensive views of the past.

> Space may not be the final frontier for PC graphics, but it certainly bears further exploration in the software arena. From static images to games to virtual worlds on the World Wide Web, 3D environments increasingly pervade our computing lives. The ability to circumnavigate objects adds a higher degree of realism and elegance to the ideas you convey, whether you're flying through an architectural design for a client or creating alien landscapes for entertainment (Grunin 1997).

Complex digital technologies are not 'fix—alls,' and there are many issues that require extensive research and discussion; ethics, long—term preservation of data, protocols for hypothesis testing with animated 3D models, to name but three. But this is a powerful and exciting new technology that now lies within the reach of many historic preservation and archaeology groups. *Carpe diem.*

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An Application Discussion
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APPENDIX

Appendix A. Camera calibration formula.

The image was digitized by a Sony DigiCam DCR VX 1000 digital video camera, then measured in Adobe Photoshop. The total number of pixels in the whole image were determined to be 720 pixels wide by 480 pixels high (720 = Sx, 480 = Sy). The total number of pixels taken up by the 8.5 by 11 inch paper (11 = Px, 8.5 = Py) were calibrated by selecting the pixels with the “magic wand tool” to produce an image size of 422 pixels wide by 361 pixels high (422 = Nx, 361 = Ny). The distance from the piece of paper to the location of the camera’s imaging chip (just behind the back of the lens) was measured to be 21 inches (D = 21). These factors were plugged into the following calibration formulas using a Focal lens size of 59mm (f= 59).

(W)idth=Px/D * f/Nx * Sx

(H)eight = Py / D * f Ny * Nx

W= 11”/21” * 59mm/422 * 720 52.728mm

1.) 11”/ 21” = .52380

2.) .52 * 59mm = 30.904mm

3.) 30.9mm / 422pixels = .07323 mm/pixel

4.) .07323 * 720 52.728mm

H = 8.5” / 21 * 59 / 361 * 480 = 31.753mm

1.) 8.5” / 21 = .4047

2.) .4047 * 59mm = 23.880mm

3.) 23.880 / 36lpixels = .0661 mm/pixel

4.) .066lmm/pixel * 480pixel = 3 1.753mm

Tape	Site	Description	Time Code	Comments
Tape 1	Edmondo Site	Edmondo Site(I8AN)	0:00-20:05	Site overview and cellar excavation.
Tape 1	Grunwald Site	Site overview, plowzone, excavation	20:05-30:31	
Tape 2	Hancock's_Resolution (18AN)	Digital Stills (Standing Structure)	00.00-00.57	
Tape 2	William Brown House (18AN 48)	Digital Stills (Standing Structure)	00:00-1:18	
Tape 2	PhotoModeler	Test	0:00-0:30	
Tape 2	PhotoModeler	Test	0:00-0:06	
Tape 2	PhotoModeler	Test	0:06-0:30	
Tape 2	Allum_Works	Site Overview	0:01-7:11	
Tape2	Swan Cove (18AN934)	Pit Feature Overview	7:11-10:57	
Tape 2	Londontown Water Survey	Remote Sensing Survey	0:00-47:27	Views of the Shoreline.
Tape 3	PhotoModeler	Video Test	0:00-0:38	
Tape 3	PhotoModeler	Ceramic Chamberpot	0:00-0:39	
Tape 3	Steward Shipyard	Test Block A	0:00-1:01	
Tape 3	PhotoModeler	William Brown House-South Facade	0:00----	
Tape 3	PhotoModeler	William Brown House-East Façade		
Tape 3	PhotoModeler	Outbuilding		
Tape 3	PhotoModeler	Monument Stone	3:34	
Tape 3	Londontown (18AN48)	Public Dig Day	3:34-5:47	Screen Shots
Tape 3	Londontown (18AN48)	Brown House Basement	0:00-2:30	
Tape 3	Londontown (18AN48)	Well and Outbuilding	0:00-2:50	
Tape 3	Lost Towns Video	Composite Demo Clip	0:00-0:2:51	Jason and Tracy
Tape 3	Swan Cove (18AN934)	Remote Sensing Survey	0:00-6:38	Radar Images of cellar (very good)
Tape 3	Lost Towns_Video	Final Demo	0:00-2:28	
Tape 3	Larrimore Site (18AN	Larrimore Cellar	0:00-2:09	
Tape 4	Rumney's Tavern (18AN48)	Photomodeler Project	0:00-6:06	Unenhanced Control Points
Tape 4	Rumney's Tavern (18AN48)	Photomodeler Project	0:00-2:36	Enhanced control points
Tape 4	Rumney's Tavern (18AN48)	Pollen Analysis Explanation	0:00-9:25	
Tape 4	PhotoModeler	Tobacco Barn	0:00-1:11	
Tape 4	Rumney's Tavern (18AN48)	Cellar	0:00-4:11	SW Quad. May 12, 1998 3H_description_of 4C and 4B
Tape 4	Wye Plantation	Captains house	0:00-5:33	
Tape 5	Londontown (18AN48)	University of MD Held School	0:00-33:17	Field School Tour
Tape 6	Londontown (18AN48)	Rumney's Tavern	00:00-10:13	SW Quad. Strat. F.
Tape 6	Londontown		10:15-10:29	Digital Stills
Tape 6	Londontown (18AN48)	Rumney's Tavern	10:29-11:24	Video
Tape 6	Londontown		11:24-11:43	Digital Stills
Tape 6	Londontown (18AN48)		11:43-12:44	Video Discussion Fade Out

Tape 6	Londontown (18AN48)		1 2:50-21:09	Pigskull Discussion
Tape 6	Londontown (18AN48)	Rumney's Tavern	21:13-23:40	SW Quad. Bed I Strat 1 H in process
Tape 6	Londontown (18AN48)		23:40-24:32	Artifacts
Tape 6	Londontown (18AN48)		24:32-25:10	Digital Stills
Tape 6	Londontown (18AN48)		25:10-29:28	
Tape 6	Londontown (18AN48)		29:28-30:32	Bernie Water Screening
Tape 6	Londontown (18AN48)		30:32-31:32	Rumney's Excavation
Tape 6	Londontown (18AN48)	Rumney's Tavern	21:32-34:29	SW Quad. March 13, 1998 end of Strat H
Tape 6	Londontown (18AN48)		34:29-35:21	
Tape 6	Londontown (18AN48)		35:21-36:32	Digital Stills
Tape 6	Londontown (18AN48)	Rumney's Tavern	36:32-42:09	Rumney's SW Quad. WR Stoneware Mug
Tape 6	Londontown (18AN48)		0:00-3:55	SW Quad. Bed 3A & 3B
Tape 6	Londontown (18AN48)		0:00-1:41	English Ladies Tour
Tape 6	Londontown (18AN48)		1:41-1:54	Digital Stills
Tape 6	Londontown (18AN48)	Rumney's Tavern	1:54-3:46	SW Quad. Strat E. April 21, 1998
Tape 6	Londontown (18AN48)		3:46-4:07	Digital Stills
Tape 6	Londontown (18AN48)	Rumney's Tavern	4:10-6:33	SW Quad Strats. 3E & 3F removed, base of 3E & 3F
Tape 6	Londontown (18AN48)		6:33-8:03	Digital Stills
Tape 6	Londontown (18AN48)	Rumney's Tavern	8:07-15:33	Rumney's Tavern
Tape 6	Londontown (18AN48)		00:00-00:37	Beginning of Univ. of MD Field School Lecture