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Use of Remote Sensing to Evaluate and Monitor the Condition of Prehistoric Earthen Structures

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Research Report

on the

Use of Remote Sensing to Evaluate and Monitor the Condition of Prehistoric Earthen Structures

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Report Prepared
by

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Introduction

In 1996, a proposal entitled “Use of Remote Sensing Images to Evaluate and Monitor the Condition of Prehistoric Earthen Structures” was submitted the National Center for Preservation Technology and Training by the Society for American Archaeology. The intent of the proposed research was to use historic aerial photographs to evaluate the effectiveness of using them as a data source to detect and document change in prehistoric earthen structures through time. There was some reason to believe that photogrammetric methods could serve as a basis for detecting changes in such archaeological remains, since they had apparently been used for such purposes by Blank (1985) at the Hopeton earthworks, part of Hopewell Culture National Historic Park in Ohio. The research was also to entail the assessment of a number of photointerpretive, photogrammetric, and digital mapping techniques including stereo photointerpretation, digital photogrammetry, digital imaging and image processing, and CAD and GIS technologies in monitoring earthworks and similar cultural resources. The Hopeton earthworks was to be “revisited” using these methods, as well as two other sites at Hopewell Culture NHP. A grant for the research was received from NCPTT later in 1996.

A number of factors contributed to delays in conducting the research, including widespread flooding in the area during the summer of 1997 which required postponing

fieldwork. Following fieldwork in late 1997, photointerpretation and mapping was carried out at Ebert & Associates' laboratories in Albuquerque, NM in the spring of 1998. Plans to compile, publish and distribute a detailed report and graphics through the National Park Service's Office of the Departmental Consulting Archaeologist in Washington proved unrealistic, and this report is being produced to describe the research and its results.

In 1985, Dr. John Edward Blank of the Cultural Resources Research Laboratory at Cleveland State University undertook a study and prepared a report for the Ohio Historic Preservation Office in which he described the use of photogrammetric methods to map and make measurements of changes through time in what was then Hopeton National Historic Landmark in Ross County, Ohio. Blank concluded on the basis of photogrammetric measurements that after 1957, the width of the expression of walls in aerial photographs increased at a rate of approximately 0.3 m (1 foot) per year, and their height or elevation decreased by 0.03m (0.1 feet) per year due to plowing and attendant "soil scatter and soil movement" (Blank 1985:60).

It is difficult to evaluate Blank's exact photogrammetric methods based on his 1985 report. He used 10 sets of stereo aerial photographs dating between 1938 and 1985, at scales from, according to a table in his report, 1:2,400 to 1: 15,840. A mirror stereoscope and parallax bar were used to obtain elevations from the aerial photographs, which were "entered into an IBM Personal Computer-AT coupled to a 20 Mbyte harddisk using an American Optical Complot Digitization Tablet and a Microsoft Optical Sensing Mouse"

(1985:25). Apparently the digitizing tablet and/or the mouse were used to record x-y coordinates of the points at which elevations were measured using differential parallax with the parallax bar. Control points in the photographs included the junctions of roads and railroad tracks.

Using a method of estimating photogrammetric measurement accuracies that can be expected in geologic mapping set forth by Ray (1960), Blank estimated that his measurements should be accurate to within 0.61 to 16.1 meters horizontally, and 0.02 to 0.52 meters vertically (spot measurements) or 0.03 to 0.79 meters (for contour measurements).

Our intent in the NCPTT-sponsored research was to incorporate more modern, digital techniques of photointerpretation, photogrammetry and mapping in analyzing changes in prehistoric earthworks through time, starting with the Hopeton Earthworks and then to further test the methods at two additional sites in the area, the Hopewell Mound Group and Seip Earthworks. We were surprised when we ordered aerial photographs and examined them under stereoscopes to find that little vertical expression was discernible at any of the sites, even in the earlier aerial photographs we obtained. This impression was borne out when we visited the sites in the field. Although due to access problems we were not able to visit the Hopeton site on the ground, we had difficulty even finding expressions of the walls of the Hopewell Mound Group and Seip Earthworks on the ground, either by virtue of elevation, soil, or vegetative differences.

In the field, we collected photogrammetric control data using submeter-level, differentially corrected GPS, marking the control points on the aerial photographs. When we returned to the laboratory, analytical photogrammetric software[1] was used to attempt to measure elevations. The R-WEL software calculates, on the basis of the fit of photogrammetric control points and the scale of the aerial photographs, a minimum spot elevation increment, and with none of the aerial photos we obtained was this increment adequate for the measurement of heights of the walls or other genuine[2] prehistoric features at any of the three study sites. On the basis of this and what we subsequently learned during the course of photointerpretation and mapping described in this report, an early conclusion was that Ray's (1960) methods of estimating expectable mapping accuracies from aerial photographs may be inappropriate for application to the sort of photogrammetry Blank undertook, and that the directionality he found in his measurements of what he perceived as progressive deterioration of features at the Hopeton Earthworks may have been fortuitous. Blank's (1985) report does contain a wealth of information about the effects of agricultural techniques and their evolution on earthen structures, much of which suggests in fact that there was little "elevation" that could be expected of walls and many other features at these sites by the time aerial photographs of them were first taken.

This report, then, does not detail the use of photogrammetric contour or elevational mapping in monitoring the deterioration of prehistoric earthen structures using aerial photographs. Instead, it sets forth a method by which historic aerial photographs can be

[1] DMS (Desktop Mapping System) ver. 4.1 by R-WEL, Inc., Athens, GA.

used in a process of "cumulative" photointerpretation and mapping to obtain information about the nature of prehistoric earthen structures, and other archaeological sites visible by virtue of soil and crop marks.

The Study Site

The three study sites were chosen in consultation with the National Park Service's Departmental Consulting Archeologist and Hopewell Culture National Historical Park.

Seip Earthworks

Situated on the second and third terraces north of Paint Creek, a major tributary of the Scioto River, the Seip earthworks include a square and circle of roughly equivalent areas joined by a larger irregular circle. Together these enclosures cover an area of 121 acres. Walls are estimated to have been more than 3 m high and 15 m wide with the perimeter of the enclosure stretching for 3 km. Sections of wall appear to have contained redeposited cultural remains (Greber 1997:213; see also Greber 1980b). Within the enclosure three conjoined mounds (Seip-Conjoined) lie to the northeast of a large oblong mound (Seip-Pricer Mound) in the center of the irregular circle (see Mills 1909). The larger mound is estimated to have measured 85 by 50 by 10 m and is surpassed in size only by the Central Mound of the Hopewell Group. Excavated in 1925-26 by Shetrone and Greenman (1931), the mound yielded 122 burials that included both extended burials and cremations. The Central Mound was completely reconstructed after excavation. The site undoubtedly consists of multiple occupation components as detailed by Greber

[2] As contrasted with features "reconstructed" by archaeologists, for instance the huge central mound at the

(1997:209-210). More than 20 smaller mounds, pits, wooden structures and other deposits also occur at Seip. Excavation of nonmortuary structures in this locale (Baby and Langlois 1979) has revealed square and rectangular houses constructed of double and single post walls. Ten radiocarbon dates from a densely occupied area inside the major enclosure range from A. D. 100-500. (Greber 1997:210).

Most of the land on which the 236 acre Seip Earthworks Unit is located has been extensively farmed and was managed as a historical site and road side rest area at the Seip Mound State Memorial. In 1992 Seip Earthworks were authorized for acquisition by the National Park service as part of a larger national historic park. In 1996 earthwork remnants visible on the ground surface included the three conjoined mounds, a portion of the east side of the irregular circle and the reconstructed Seip-Pricer Mound (USDI 1996).

Hopeton Earthworks

The NPS Hopeton Earthworks Unit consists of a 232 acre site that includes multiple earthwork remnants located on a terrace east of the on Scioto River 1.5 miles east of the Mound City Group. The Hopeton and Mound City works were constructed between 150 B.C. and A.D. 500. Prominent is a square measuring 300 m or less (see Thomas 1894:474) on a side joined on the north to a circle of a slightly larger diameter. Smaller circular features adjoin the square on its east side. Linear parallel earthworks extended west-southwest toward the river for a distance of 800 meters from the northwest corner of

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Seip Earthworks.

the square. The walls of this latter feature were about 50 m apart and terminated at the terrace edge. The walls of the square were described (Squier and Davis 1848:51) as a clayey loam berm 4 m high by 16 m wide lacking a ditch on either side. The walls of the circle, although they had been reduced through plowing, averaged 1.5 m high at the time they were recorded by Squier and Davis. The smaller circles measured 1 m high and were accompanied by an interior ditches.

The Hopeton Earthworks Unit was included in the Hopewell Culture National Historical Park in 1992 along with the Hopewell Mound Group, Seip Earthworks and High Banks Works. By 1995 a declaration of taking initiative of 134 acres at Hopeton yielded a settlement agreement between the NPS and Chillicothe Sand and Gravel Company enabling acquisition of the area (see Cockrell 1999:340). Earthwork remnants visible on the ground in 1996 include the southwest corner of the square and the southwest portion of the circle where it abuts the north side of the square (USDI 1996).

Hopewell Mound Group

The Hopewell Mound Group, also called Clark's works after a former landowner and, initially, the North Fork Works by Squier and Davis (1848), is located on the north fork of Paint Creek. The perimeter earthworks forms a parallelogram more than 900 m from east to west and 600 m from north to south. The northwest wall of the outer earthworks in slightly rounded and the south wall followed a terrace edge above the drainage. The outer wall measured 2 m high and more than 11 m wide at the base (Squier and Davis

1948:27) and enclosed an area of 111 acres. A square enclosure measuring approximately 280 m on a side abuts the east side of the parallelogram. Within the larger enclosure are circular and a D-shaped earthwork feature. The D-shaped earthwork surrounds 7 mounds, three of which form a continuous earthwork known as the Central Mound, or Mound 25 (Moorehead 1922:Pl 467; Shetronel926:Fig 21). Greber and Ruhl (1989:38) place the length of the Central Mound which is the largest known Hopewell tumulus at approximately 150 m in 1850 and the height of the mound at its east end at 9 m. The width at that time varied from 30 to 45 m. They (Greber and Ruhl 1989:39) estimate that after 75 years of farming and archaeological excavation maximum mound height was less than 4 m in 1923.

Three major series of excavations began at Hopewell in 1845 with the work of Squire and Davis (1848), followed by Moorehead (Moorehead et al. 1891-1892) in 1891-92 and Shetrone (1926) between 1922 and 1925. Squier and Davis tested at least 4 of the mounds. Moorehead excavated in 14 mounds and, according to Greber and Ruhl (1989:65), possibly several others. Shetrone reexamined previously excavated mounds and recorded additional ones. Cross-referencing specific mounds between the three excavations can be confusing and is not always possible as detailed by Greber and Ruhl (1989:14-17). Squier and Davis illustrate 15 numbered mounds. On the 1892 map of the Hopewell site by Clinton Cowen in Greber and Ruhl (1989:Fig.2.1) mounds are lettered a through z with a few depicted as unlettered, while Moorehead recorded and numbered 38 mounds (Greber and Ruhl 1989:16).

In 1996 earthwork remnants visible on the 300 acre unit's surface (USDI 1996) include the east and west sides of the parallelogram, the Central Mound and Mound M as depicted by Greber and Ruhl (1989:Fig 2.1). The southern edge of the earthworks has been truncated by Sulphur Lick Road. Residences and outbuildings south of the road cover earthwork features in this area.

Methodology

Obtain Aerial Photographs

Aerial photographs were obtained from government and private sources. The aerial photos used in the research detailed in this report are listed in the following tables. The abbreviations ODOT for Ohio Department of Transportation, and USGS for United States Geological Survey are used in the tables. For each of the sites on each aerial photo overflight date, stereo coverage was obtained for as much of the site as was available. All aerial photographs obtained were black-and-white paper prints.

Hopeton Earthworks

Date	Scale	Source	Frames
January 1, 1950	1:12,000	ODOT	278-V-4-43 278-V-4-44
April 1, 1962	1:12,000	ODOT	2252-3-53 2252-3-54 2252-3 -55 2252-3-107
April 6, 1975	1:80,000	USGS	2-2 2-3
February 24, 1976	1:6,000	Henderson Aerial Surveys	10-262 10-264
June 1, 1982	1:12,000	ODOT	7255-4-66 7255-4-67
April 8, 1988	1:40,000	USGS	575-192 575- 193
May 26, 1993	1:4,800	ODOT	9180-1-7 9180- 1-8 9180- 1-9 9 180-1-10 9180-1-11 9 180-1-12 9180-1-13
February 1, 1994	1:12,000	ODOT	9249-1-17 9249-1-18 9249-1-19

Hopewell Mound Group

Date	Scale	Source	Frames
November 1, 1951	1:9,600	ODOT	368-V-74 3 68-V-75 368-V-77 3 68-V-78 368-V-79
April 1, 1962	1:12,000	ODOT	2251-3-219 2251-3-220 225 1-3-221 2251-4-243 2251-4-244
May 7, 1974	1:80,000	USGS	4-9 4-10
February 24, 1976	1:6,000	Henderson Aerial Surveys	7-212 7-2 14
April 18, 1979	1:80,000	USGS	1-15 1-16
March 9, 1985	1:80,000	USGS	150-135 150- 136
April 8, 1988	1:40,000	USGS	574-82 574-83
February 1, 1994	1:12,000	ODOT	9249-1-17 9249-1-18 9249-1-19

Seip Earthworks

Date	Scale	Source	Frames
August 4, 1949	1:12,000	ODOT	239-V-3-24 23 9-V-3 -25 23 9-V-4-3 3 23 9-V-4-34
October 1, 1950	1:9,600	ODOT	307-V-3-36 307-V-3-37 307-V-3-38
April 1, 1962	1:12,000	ODOT	2252-1-22 2252-1-23
February 1, 1970	1:6,000	ODOT	4436-1-8 4436- 1-9 443 6-1-10
May 7, 1974	1:40,000	USGS	4-33 4-34
February 24, 1976	1:6,000	Henderson Aerial Surveys	2-53 2-55
October30, 1979	1:40,000	USGS	2-75 2-76
March 8, 1985	1:80,000	USGS	150-146 150- 148
April 4, 1988	1:40,000	USGS	574-204 573-205

Produce Digital Files

The areas covered by each of the sites in each photo year were scanned to produce digital image files to serve as a base for photointerpretive mapping. Scanning was done with a Microtek Scanmaker 9600XL scanner at 400-4800 dpi resolution in 8-bit grayscale mode. The files were saved in uncompressed TIF format.

Digital Image Processing

Each image file was processed in Adobe Photoshop[3] to optimize the visibility of indications of the earthworks and associated features in the aerial photographs. Unsharp masking was used to sharpen edges in the images, i.e. the places where dark-to-light gradations change most abruptly. The gamma point of the image's histogram was adjusted to provide maximum visibility of that portion of the gray scale that was judged by the interpreter to be imparting the most relevant culturally related information. Then the contrast and brightness were adjusted for the best obtainable visibility of the features associated with the earthworks.

[3] Adobe Systems, Inc.

Image Registration

Next each of the images was registered to real-world coordinates (metric UTM projection in NAD27) in AutoCAD with CAD Overlay software[4]. CAD Overlay allows an image to be brought into the AutoCAD environment and scaled and rotated to match coordinates to another image, a drawing, or entered coordinate points. In order to register the images, the appropriate USGS Digital Raster Graphic (DRG) map was first brought into the AutoCAD drawing. DRG's are scanned images of USGS 7.5-minute topo sheets stored in a GeoTiff format which contains coordinate data. Each image file was then brought into the drawing and registered to the DRG. The resulting images were exported to GeoTif format, each with an additional world file (*.wrl), which is required for coordinate registration by ArcView[5].

Photointerpretation

The details contained in the aerial photographs indicating the locations of walls, mounds the other associated features at each of the sites were photointerpreted by simultaneously using both an optical stereoscope, and the digital image on the computer screen. A Bausch and Lomb Zoom 240 stereoscope mounted on a Richards light table and also equipped with halogen top-illumination was used to stereoscopically examine the aerial photo prints. At the same time, the digital image was viewed on an adjacent computer monitor in AutoCAD/CAD Overlay, and the boundaries of the patterning noted by the

[4] Both products of AutoDesk, Inc.
[5] ESRI, Inc.

photointerpreter digitized by drawing lines around it on the digital image to produce polygons for export into ArcView.

Optical stereoscopes, particularly sophisticated ones like that used in this research, are probably the best way to view aerial photos for photointerpretation. The clarity of the image they provide, coupled with the 3-dimensional view of the landscape that can be seen through them, is critical in interpreting subtle indications of surface or buried cultural features. One major drawback of stereoscopes, however, is that only one person can look through them at a time. Having a digital image to view concurrently allows multiple photointerpreters to look at and discuss features among themselves. In addition, one can zoom in on features of interest, and draw lines (vectors) precisely defining them in the CAD environment.

While aerial photointerpreters sometimes go to great lengths to attempt to describe what it is they are seeing in aerial photographs, in practice this is difficult if not futile. Photointerpretation is often described as an "art and a science" (for instance, by the American Society of Photogrammetry and Remote Sensing)(Colwell 1997:3), and its success depends on many relatively unquantifiable factors, such as the experience of the photointerpreter. Several photointerpreters at Ebert & Associates, Inc. worked on this project, some of who had decades of experience interpreting archaeological data in aerial photos, and others with only a few years' experience.

What one is seeing in the aerial photos used in this research, and in fact in all aerial photos, are patterns of light and dark (or color, in color images) recorded by the film. There are many things on the ground that can cause things to be lighter or darker in aerial photos - shadows, variations in lighting, differences in vegetation from place to place, recent rainfall, soil color and reflectance, and snow, to name just a few. Natural conditions change radically between overflights through time, so what one sees in one aerial photo is never exactly the same as in another. Photographic properties such as film type, exposure times for film and paper prints derived from it, and vignetting and other lens effects also cause radical variation between aerial overflights and the photographs they produce through time.

The resolution of aerial photographs is affected directly by the scale of the photos; in smaller scale aerial photographs, small objects are more difficult to see. In addition, small objects or areas in small-scale aerial photos are harder to examine with optical stereoscopes, because as optical magnification is increase, the light efficiency of the optics decreases, requiring increasingly bright illumination. Small areas of aerial photographs can be digitally scanned at high resolution, and highly enlarged, but details will be “fuzzy.” While things look fuzzy in an enlarged small-scale image, however, important details often can still be discerned. In this study, data was obtained from aerial photos as small in scale as 1:80,000.

In some of the aerial photographs interpreted in the course of this study, the surface of the ground has been recently plowed, and the grayscale variations that are seen in them are

due to differences in soil color, texture, and possibly moisture retention or lack thereof. In other photos, crops are growing on the sites and it is variation in the pattern or intensity of their growth that provide indications of where portions of the earthworks and associated features were in the past. Particularly in Europe and England, "aerial archaeologists" have depended upon crop marks to reveal traces of Roman forts and Medieval field patterns (Ebert 1984). Agricultural crops usually appear very uniform from the air, being of course entirely a single and very uniform kind of plant, and very variations can reflect extremely subtle differences in soil depths, drainage, or fertility. In other aerial photos interpreted in the course of this study grass or weeds covers the sites, in some cases also showing indications of the locations of site features.

Import Polygons into Arc View

Once all of the patterning photointerpreted from the aerial photographs of the sites was traced in AutoCAD/CAD Overlay, the closed vectors as well as the registered image files were imported into Arc/Info and ArcView. The GIS software packages allow a number of levels of manipulation and analysis which enhanced the research reported upon here. Since all of the images and the outlines of patterning photointerpreted from them were registered to the same coordinate system (UTM NAD27), the coverages for each site accurately overlay each other in the GIS database, allowing the analysis and quantification of area of patterning interpreted, the coincidence of patterning on the ground, and the like. In addition, the versatile cartographic capabilities of the GIS

software allowed the efficient production of the photos, maps and overlays which are included with this report.

Photointerpretive Summaries

The following brief summaries outline what was seen for each of the sites in each photo date, including discussions of land use at the sites through time, the quality of each of the aerial photographs, and other factors relevant to photointerpretation.

These discussions were designed to be used with reference to the Photointerpretive Maps compiled for each of the sites and included with this report. A historic map from Squier and Davis's reprinted 1848 study (McGraw 1992) is first presented for each site. Next, a composite of all of the photointerpretations made in the course of this research for each site is included, followed by an "thumbnail index" of photointerpreted patterning at the site through time, separated by overflight date. Large, scaled maps from the GIS database of the patterning interpreted for each aerial photo date are then presented, with the registered photograph from which they were interpreted shown on the facing page for comparison. It should be borne in mind that the printed images made from the digital image files are usually of lower quality that the corresponding image would be viewed on a computer screen, and for this reason not all of the details described in the photointerpretive summaries are necessarily easily visible in the hardcopy prints.

Hopeton Earthworks

Eight aerial photo dates were examined for Hopeton Earthworks, spanning a period from 1950 to 1994. The maximum area of features observed at the site was 42,509 square meters in 1988 and the minimum was 5,679 in 1994. Hopeton was the last mound group to be incorporated into the National Park System in 1979 (NPS 1999). Land use in the vicinity of Hopeton has been diverse, including agricultural fields, a black walnut plantation, and a hardwood forest. Blank identified wheat, corn, pasture, hay and soybean production in the area (1985). Three private residences and a gravel removing operation, which has stripped large areas of land around the mound since the 1980s, also abut the site (NPS 1999).

Ground-disturbing activities at this site included plowing over a period of at least 60 years, in addition to the construction of agriculture-related infrastructure such as roads, tanks and buildings (Blank 1985). In addition, a bulldozer razed a portion of the wall of the feature (NPS 1999).

The general plan of the feature as photointerpreted during the current project appears similar to the Squier and Davis map, although the 1848 rendition is overly symmetrical. Squier and Davis' parallel walls which form a "corridor" structure leading off toward the southwest from the main structure are not visible in any of the aerial photos although there is the hint of a possible similar construct leading southwest from the southwest corner of the square enclosure. The patterning interpreted from the aerial photographs

also suggests the existence of a number of features associated with the earthworks not detected by Squier and Davis.

The table below summarizes the area of photointerpreted patterning for each photo date.

Photo Date	Area of Photointerpreted Patterning (m^2)
January 1, 1950	25,235.23
April 1, 1962	18,389.94
April 6, 1975	16,770.65
February 24, 1976	16,233.09
June 1, 1982	31,376.49
April 8, 1988	54,926.48
May 26, 1993	18,544.22
February 1, 1994	5,679.23

November 1, 1950

This aerial photo depicts the entire Hopeton study area, exhibiting high resolution and contrast. The original negative scale is 1:12,000. Land use at this time is clearly agricultural with portions of the feature in pasture, wheat or plowed but fallow states. Even unaided observation of this photo reveals the outline of the Great Circle, the west and south edges of the square, and two smaller circles along the east side of the square. The east wall of the square is apparently obscured by a field boundary in this aerial photo.

April 1, 1962

The air photo is of reasonable quality—quite sharp but of somewhat high contrast. The original negative scale is 1:12,000. Land use continues to be agricultural and plowing activity is evident since the previous photo. Examination of the photo reveals the north and east outline of the Great Circle, and portions of the west, south and east border of the Square. The eastern wall of the square is slightly curved, in contrast to its depiction in Squier and Davis' map and something borne out by the other aerial photos we photointerpreted in this effort. The southern portion of Squier and Davis' northernmost circle, lying some distance from the Great Circle and less easterly than they show it, is visible as well.

April 6, 1975

The entire Hopeton study area is depicted in this photo. The photo is of poor quality due to the small scale, 1:80,000, of the original negative, but still shows details of portions of the Great Circle and square quite clearly. Land use appears very similar to the 1962 photo. No additional features were photointerpreted.

February 24, 1976

This photo is of considerably higher quality than the 1975 photo, due to its much larger scale (1:24,000); however, it reveals a similar paucity of features. While the

southernmost circle outside the square's eastern wall reappears on this photo, large segments of the east boundary of the Great Circle and Square are not visible.

June 1, 1982

This photo is of high quality. Land use continues to be agricultural, with plainly visible furrows running east to west across most of the Square. Much patterning indicative of possible features not mapped by Squier and Davis are seen in these photo frames, including a double wall for the northernmost detached circle, and a number of features within the Great Circle and the square. The "E" shaped feature inside the Great Circle seems suspicious, and in fact may be the remnants of archaeological or other disturbance at some time in the past. In the map for this date we have distinguished among "walls" and "discolorations;" walls are patterning that corresponds with walls in the Squier and Davis map.

April 8, 1988

This photo is only of fair quality for photointerpretation, having a rather small negative scale of 1:40,000. Interestingly, though, it revealed the largest area of features for any Hopeton photointerpretation. This is probably because the expression of the earthwork's walls is much wider than in other aerial photographs examined during the course of this research, and also because of the appearance of seven areas shown as "discolorations" in the ArcView map. The long, dark soil discoloration beginning near the southeast corner

of the square may be due to some subsurface drainage anomaly. The large, surprisingly symmetrical circle and the two parallel lines at the southwest corned of the square are quite clear in the stereoscopic and digital images, and must logically be cultural in nature.

May 2, 1993

This photo does not extend north of the northern boundary of the Great Circle. For the remainder of the area it is a high resolution, clear photo with an original negative scale of 1:4800. Photointerpreted features include most of the Great Circle, the Square and one of the exterior circles. A linear feature trending north to south and roughly bisecting the Square that has not previously been interpreted also appears in this photo, and may be associated with plowing patterns. In his 1985 report, Blank projects that the walls comprised by the “Great Circle” and “Hopeton Square” will degrade sufficiently that they will not be detectable, by his estimate, in 1995. These features are quite apparent on the 1993 photo, however.

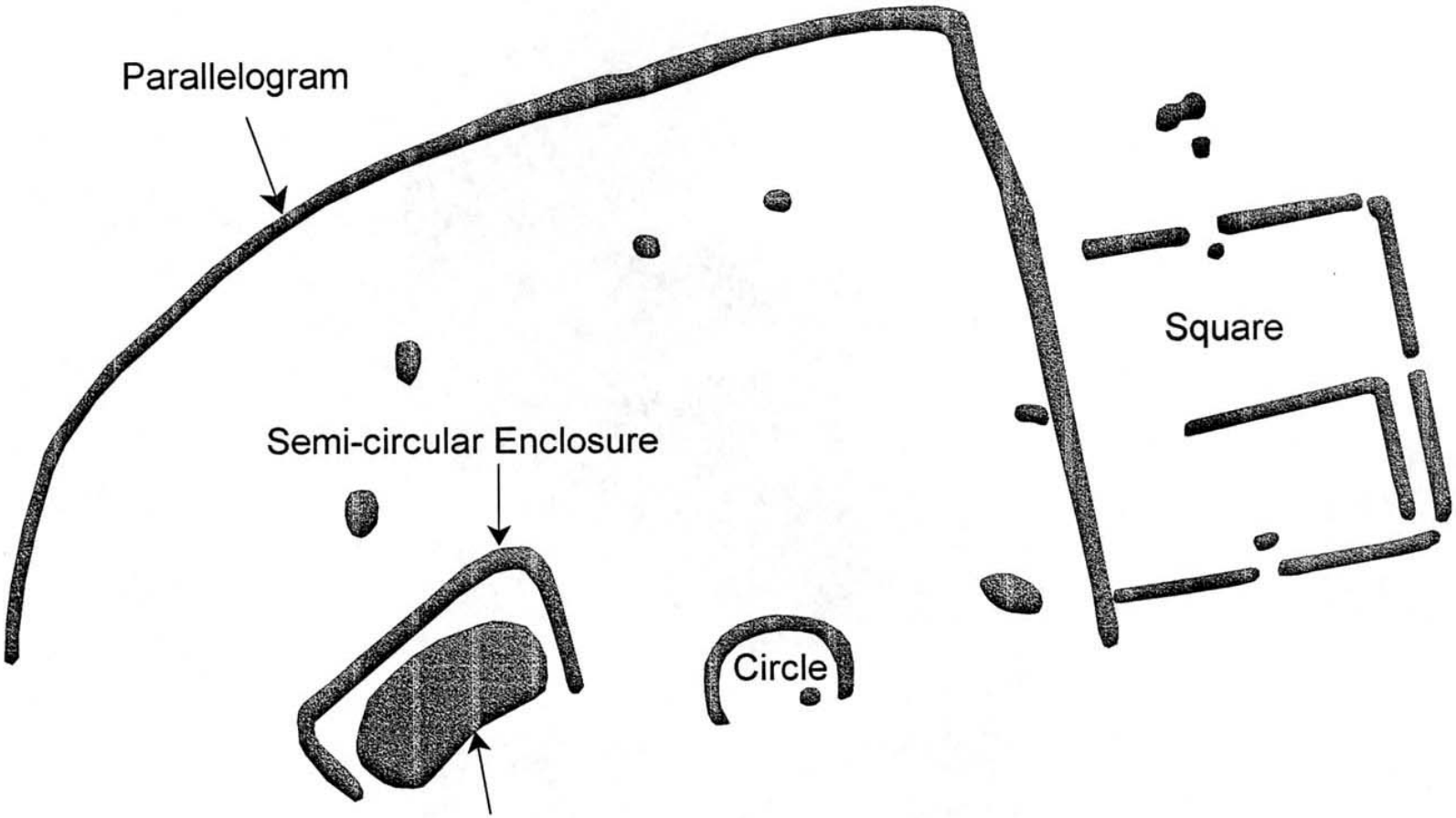
February 1, 1994

Less than one year later, only a scant outline of the Great Circle and limited portions of the Square are visible on the photo, though there has not appeared to be a major change in land use. The photo is of similar quality to the 1993 photo, so the differences in visibility of indications of the earthwork’s wall must be due to intervening weather conditions and the lack of growing vegetation.

Hopewell Mound Group

Eight aerial photos of Hopewell Mound Group, spanning a period from 1951 to 1994, were examined during this research effort. The maximum area of features observed at the site was 65,932 square meters in 1976, and the minimum was 8,384 in 1994, however this photo provides only partial coverage for the latter year. The minimum area of features on a photo with complete coverage is 12,745 in 1974. Photointerpreted features include walls and mounds. Land use includes agriculture (hay fields) and a hardwood forest which covers the east and west boundaries (NPS 1999). A number of private residences are located in the area.

The general plan of the feature as photointerpreted during the current project is similar to Squier and Davis' plan of the North Fork Works, as they referred to Hopewell, however the circle and parallelogram's southern borders are truncated by a highway which traverses the area. To facilitate comparison, Squier and Davis' (1848) nomenclature is adopted here, as illustrated in Figure 1.



Correlation of Squier and Davis (1848) features with current features as shown on 1962 photograph

The table below summarizes the area of photointerpreted patterning for each photo date.

Photo Date	Area of Photointerpreted Patterning (m^2)
November 1, 1951	30,655.97
April 1, 1962	54,322.89
May 7, 1974	12,745.26
February 24, 1976	65,932.94
April 18, 1979	38,800.60
March 9, 1985	53,093.21
April 8, 1988	56,464.57
February 1, 1994	8,384.62

November 1, 1951

This is a high quality photo in terms of both sharpness and contrast. The original negative scale is 1:9600. Agricultural activity is apparent through time from furrows visible on the ground surface. Features visible in this photo include the east border of the parallelogram, the entire square, most of the circle, and the semi-circular enclosure and the joined mounds. The “stepped mound” in the semi-circular enclosure is a reconstruction. The semi-circular enclosure appears more rectilinear than semi-circular in this photo, and in fact through our entire photo sequence.

April 1, 1962

This aerial overflight revealed the maximum area of features for any photointerpreted year for this site. It is a high quality photo with a negative scale of 1:12,000. Photointerpreted details include a prominent rectilinear feature not defined on the Squier

and Davis (1848) map that falls within the square. There are dark patterns visible on the ground surface that suggest the presence of water at or near the surface. This is the last date that the small circle feature appears in any of the photointerpretations.

May 7, 1974

This is an extremely poor quality photo in terms of contrast and clarity. Its original negative scale is 1:80,000 that probably accounts for this at least in part. The only photointerpreted feature for this year is the northeast corner and portions of the north and east walls of the parallelogram. This is the smallest feature area for any photointerpreted year.

February 24, 1976

This is an excellent photo for interpretive purposes with an original negative scale of 1:24,000. The only feature previously interpreted that does not appear in this photo is the circle feature near the southeast corner of the parallelogram. A small rectangle just north of the main rectangle abutting the parallelogram's east edge appears only in this photointerpretation. The east side of the parallelogram and the walls of the square are expressed in the vegetative patterning visible in this photo as parallel, dark lines separated by a lighter center.

April 18, 1979

Features interpreted on this rather low-quality photo at an original 1:80,000 scale include only the parallelogram and square. A single small mound was also recorded near the south edge of the features.

March 9, 1985

Though similar in quality to and of the same scale as the previous photo (1:80,000), this image reveals a greater number of features, notably the semi-circular enclosure and several mounds not visible in 1979.

April 8, 1988

This is another high quality photograph, with wide gradations in the tone of vegetative and/or soil patterning that reveals the walls of the parallelogram as a wide (c. 35 meters), light colored swath against a darker background. The walls of the square, on the other hand, are narrower and dark, and much less easily seen.

February 1, 1994

This aerial photo is of low resolution and contrast, only partially covers the site, and reveals only the east wall of the parallelogram, and one mound, very faintly.

Seip Earthworks

Nine photos were examined for Seip Earthworks, spanning a period from 1949 to 1988. The maximum area of features observed at this site was 85,089 square meters in 1949. The minimum was 29,234 in 1974. Photointerpreted features include walls, mounds and depressions. Seip is surrounded on the east and west by agricultural fields, Paint Creek on the south and west, and wooded hills more distantly to the north and south (NPS 1996).

Elements photointerpreted during the current effort closely resemble those identified by Squier and Davis (1848, Plate XXI, No. 2), with a number of additional features. The site occupies two river terraces above Paint Creek, located just to its west.

The table below summarizes the area of photointerpreted patterning for each photo date.

Photo Date	Area of Photointerpreted Patterning (m^2)
August 4, 1949	85,089.68
October 1, 1950	35,641.56
April 1, 1962	76,322.17
February 1, 1970	46,032.51
May 7, 1974	29,293.04
February 24, 1976	52,485.54
October 30, 1979	22,092.63
March 8, 1985	39,852.59
April 4, 1988	52,486.06

August 1, 1949

This photo is of excellent quality. The original scale of this negative is 1:12,000. Interpretation of this photo revealed the largest area of features for any year at this site, although it does not reveal more than a small portion of the western circle of the earthwork. Also apparent is a right-angled feature falling within the western circle which is not contained in the Squier and Davis map but which is reflected in a number of the other aerial photo years we interpreted in the course of this effort. Another partially rectangular feature which extends from inside the western circle, eastward into the eastern circle, can be seen which does not appear in any other aerial photo date.

October 1, 1950

While this aerial photo is of high clarity and resolution, only portions of the two circles of the earthwork are detectable, as well as four mounds and two depressed areas. The latter are visible by virtue of stereo photointerpretation.

April 1, 1962

This aerial photograph allowed the photointerpretation of portions of the two circles and of the square, including a small upside-down L-shaped feature in the square's southwest corner not noted by Squier and Davis, but seen in this and some of the later aerial photos.

A slightly different variation on the rectilinear patterning within the western circle is also visible.

February 1, 1970

This aerial overflight did not cover the entire site, and revealed only portions of the eastern circle, a small segment of the western circle, and two mounds.

May 7, 1974

The 1:40,000 scale of this aerial overflight has clearly affected the resolution of the image, which is poor. Only two segments of the earthworks and a single mound are visible.

February 24, 1976

The 1:6000 scale aerial overflight in 1976 offers far better resolution than the 1974 photos, but not much more detail is actually discernible. The square and the gaps in its walls, however, are quite clearly seen as is a previously uninterpreted detail of the rectilinear patterning falling within the western circle.

October 20, 1979

Another small-scale (1:40,000) aerial overflight, with very low contrast, in 1979 shows only portions of the eastern circle and the northwestern part of the square.

March 9, 1985

This aerial overflight, at 1:80,000 scale, shows only a few features of the earthwork even though its contrast is quite good. The feature south of the earthwork, which is labeled as a "wall" in the photointerpretive map, is only seen in this photo year.

April 8, 1988

The most recent aerial photo date for the Seip Earthworks used in this research had a negative scale of 1:40,000 but presents useful contrast for defining a significant portion of the western circle and a feature within it. While only a small segment of the eastern circle is visible, more detail can be seen in the northern and western portion of the square.

Discussion and Conclusions

Throughout the process of the aerial photointerpretations at the three sites, we were quite aware that the features we were seeing were expressed in radically different ways in literally each of the aerial photographs, for instance the east wall of the parallelogram at

the Hopewell Mound Group. In some photographs only portions of it appear faintly (1951); in others (1962, 1974) it appeared as a dark line against the light background of the field. In 1976, the wall is expressed as two parallel black lines approximately 25-30 meters apart, with a lighter area between them. In 1979 and 1988 the same feature is light against a dark background, undoubtedly vegetation, and in 1988 the light zone indicating the wall is very wide, on the order of 50 meters in some places. Interestingly, the parallelogram's east wall aligns with the direction of plowing in the field in which it lies in all photo years used in this study, so it is unlikely that it "increased" in width due to being "smeared" by tillage. The area of features photointerpreted for each photo year in each of the sites varies wildly through time as well, not directionally as would be the case if what we are seeing were deteriorating or "going away."

These observations, and others made on nearly all features at all sites, suggest that what we are seeing in the aerial photos from date to date is probably patterning in vegetation and soils that changes qualitatively between photos. Part of what one sees or doesn't see seems to be due to photographic quality, largely scale differences but also the ways in which the photographs were exposed or printed. The rest of the differences in feature expression and visibility must be attributable to environmental factors. It appears that spring and summer photos present better photointerpretive opportunities than winter images, which would make sense, although this is blurred by scale differences. Other environmental factors are undoubtedly even less possible to measure or control for, for instance rainfall, vegetative stress, soil moisture at the time and aerial photos were taken, and probably many other factors as well. In short, aerial photographs taken through time

at a single site are not very comparable, and are not showing progressive deterioration in the sites which have been the subject of this research.

The information derived from photointerpretation of multiple sets of historic aerial photos, it was reasoned, is probably best viewed *cumulatively*, that is, by overlaying all of it, with each contributing to revealing the overall patterning at the sites. But when the photointerpreted polygons for each of the photo years for the three study sites were imported into ArcInfo and ArcView, and finally overlain so that one could see their composite configuration through time, the striking lack of correspondence among the features in terms of their spatial locations was an immediate cause for even greater surprise. The amounts of overlap of all features at each site through time is something that can be easily calculated in the GIS environment, and was found to be 38% at the Hopewell Mound Group, 30% at Seip, and just 26% for Hopeton. Since we did not photogrammetrically create planimetric maps or orthophotos in this effort, some differences in the spatial locations of features across sites as they appear in the photographs due to radial displacement can be expected. The three site areas are quite nearly flat, however, with intrasite ground elevation differences on the order of a maximum of 3m-6m, which would mean that spatial differences due to radial displacement should, in a "worst case" scenario (i.e. even at the extreme corners of the aerial photos) be no more than 6-10 meters in x-y location, and usually far less. It is clear that the locational differences in features from photo to photo and interpreted coverage to coverage in the photointerpretive maps is for some features far more than this.

It is also interesting that during the course of photointerpretation, at each of the sites, indications of features not identified by Squier and Davis in the maps they prepared on the basis of observations on the ground more than 150 years ago were detected (e.g. the rectilinear patterns within the western circle at Seip). What is more, the shapes of some of what must certainly be the "same" features mapped by Squier and Davis (for instance, the east wall of the square at Hopeton, and the semicircular enclosure around the joined mounds at Hopewell Mound Group) seem different from their representation on their maps.

Given the scope of the research reported on here, and perhaps given the scope of any research, it is not possible to determine whether all of the features photointerpreted in this effort are "really part" of the Hopewell-period earthworks or their associated features. In fact, it is quite certain that in some sense many features, particularly the mounds at the sites, are not "really" of Hopewell age, since they were excavated and rebuilt by archaeologists before aerial photos were even available. The history of the Mound City group outside of Chillicothe is a good example. At the onset of World War I, the area became part of Camp Sherman, an Army training center, and while a few mounds were saved, most of them were leveled to make was for barracks. After the war, from 1922-1925, Mills and Shetrone excavated all of the remaining mounds, and afterwards, restored the mounds to the conditions they were thought to have been in a century before. The charts of Squier and Davis were valuable in this project" (Silverberg 1968:271). The Hopewell Mound Group was the site of three major, intensive excavation efforts, by Squier and Davis in 1845, Moorehead in 1891-1892, and Shetrone

in 1922-1925 (Greber 1989). At Seip, the huge central mound was completely excavated between 1926 and 1928 by Shetrone and then totally reconstructed. Given all of this archaeological activity at the sites, it is quite likely that some of what we have photointerpreted at them may be the result of archaeological excavations, pits or trenches, as well.

But this does not explain the lack of overlap of some of the features at the sites which are unlikely to have been dismantled and then rebuilt by archaeologists. Some of the lack of correspondence may, as described above, be due to variation from photo date to photo date in radial displacement. Discrepancies in the control points used among photos to register them in the CAD environment may also be to blame for part of the lack of feature correspondence, because recurrent control points from year to year are not always detectable without some difficulty. Some of the ways certain features appear through time, however, is suggestive of a different explanation - they may, in fact, be composite, reconstructed and overlain in Hopewell times in slightly different ways. This may be particularly likely for features such as the smaller circles at Hopeton, and the expressions of the walls of the semicircular enclosure at Hopewell Mound Group, which exhibit lack over overlap very locally where other features at the site “shift around” much less.

If the sites were reused for perhaps different sorts of purposes during Hopewell time over periods of as much as 300-400 years, as is suggested for Seip by Greber (1997), it also stands to reason that earthwork walls and other features might quite likely be maintained, rebuilt, or even reconstructed in quite different places and forms, particularly at a site like

Seip which appears to have been located in a topography that made it susceptible to flooding and possibly large-scale erosion by Paint Creek.

The implications of these observations and conjectures are quite different than we had expected to be making when we set out to develop methods of "monitoring" the progressive deterioration of prehistoric earthen structures in Ohio in 1996, but they may ultimately be much more useful in understanding how aerial photointerpretation and mapping can be used to approach an understanding of earthworks in particular, and specifically the three study sites at Hopewell Culture National Historic Park. First, and most specifically, the sites studied and mapped in the course of this effort are not "going away" through time, as was implied by earlier investigators. They had probably deteriorated to most of the extent they were going to (barring purposeful destruction or environmental catastrophes) before aerial photographs even became available, and in fact before Squier and Davis mapped them, as is illustrated by their apparent inability to see some of their important details even on the ground, more than 150 years ago. One does not see directional changes in the aerial photographs, but instead greatly varying, non-directional, qualitative changes in the ways the walls and other features that make up these sites are expressed under different environmental conditions. Rather than using them to attempt to see deterioration of such sites through time, it is much more appropriate to combine what ones sees in as many aerial photos as can be obtained. Such "cumulative photointerpretation and mapping" reveals when combined in digital maps a "total picture" of the nature of and evolution of such sites throughout the time periods in which they were built and used, as well as afterwards.

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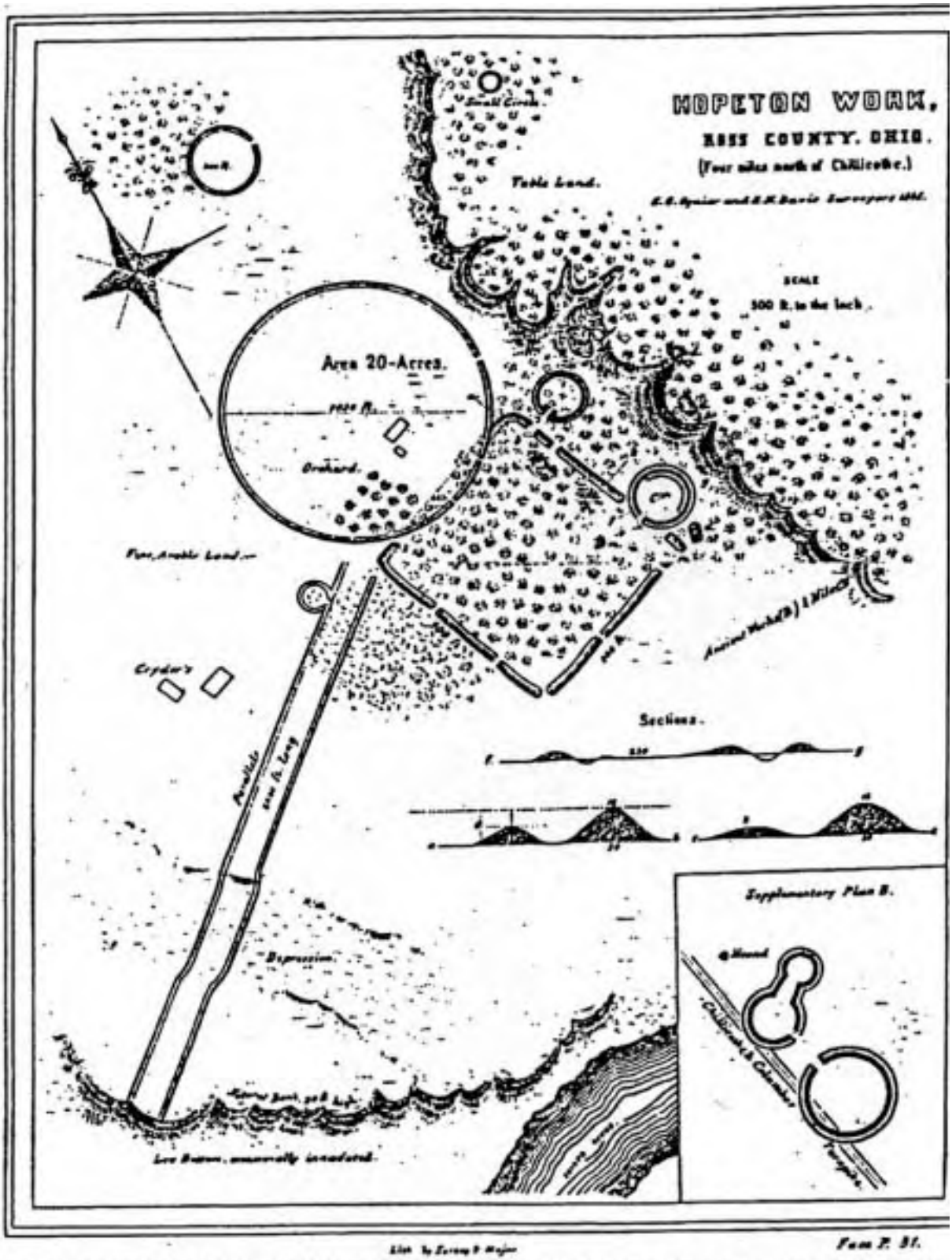
Hopeton Earthworks

Photointerpretive Maps



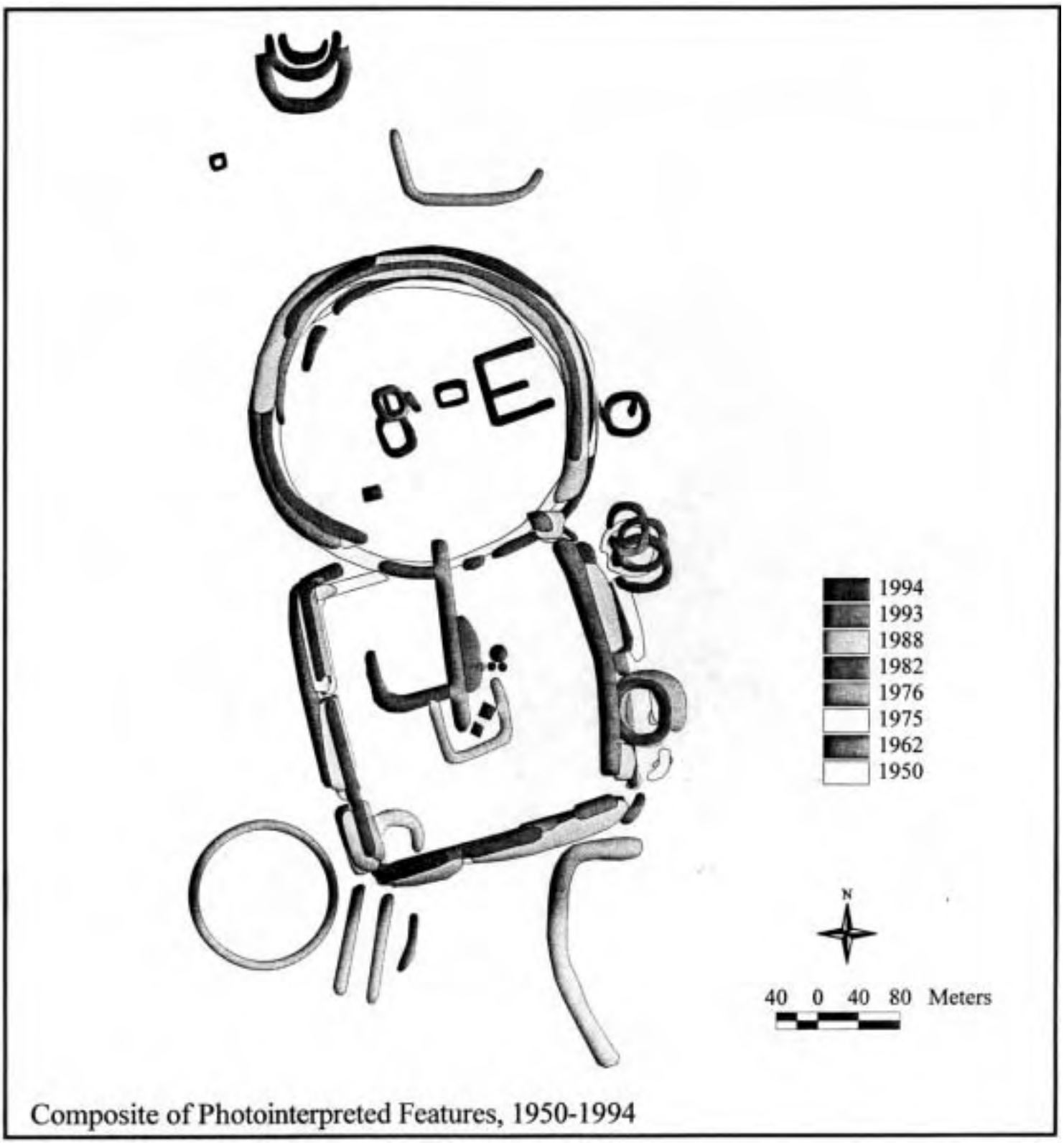
Plan P. 81.

ANCIENT MONUMENTS OF THE MISSISSIPPI VALLEY by E. G. SQUIER, A. M. and E. H. DAVIS, A. M.

Hopeton Earthworks

HOPETON EARTHWORKS

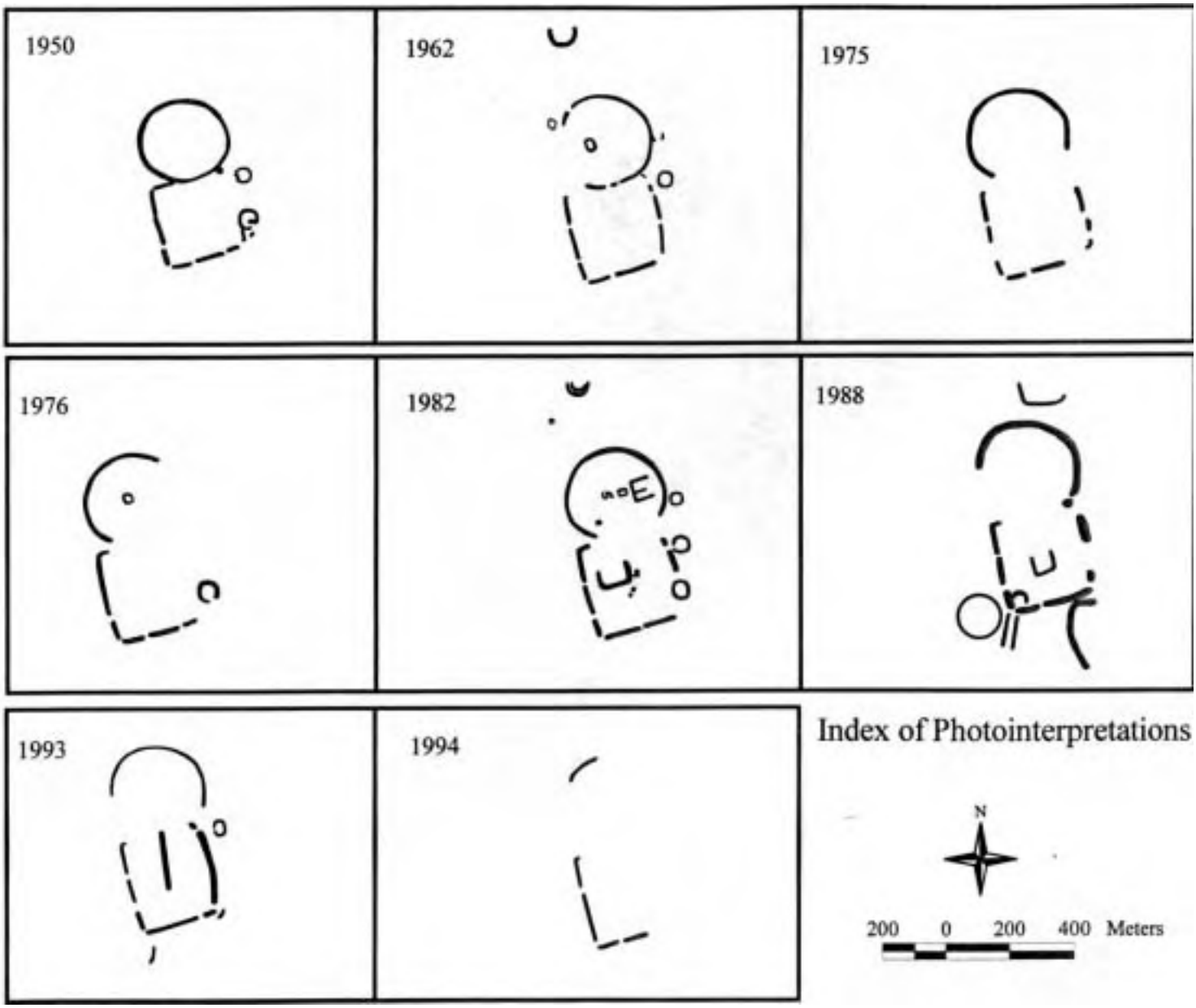
HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Composite of Photointerpreted Features, 1950-1994

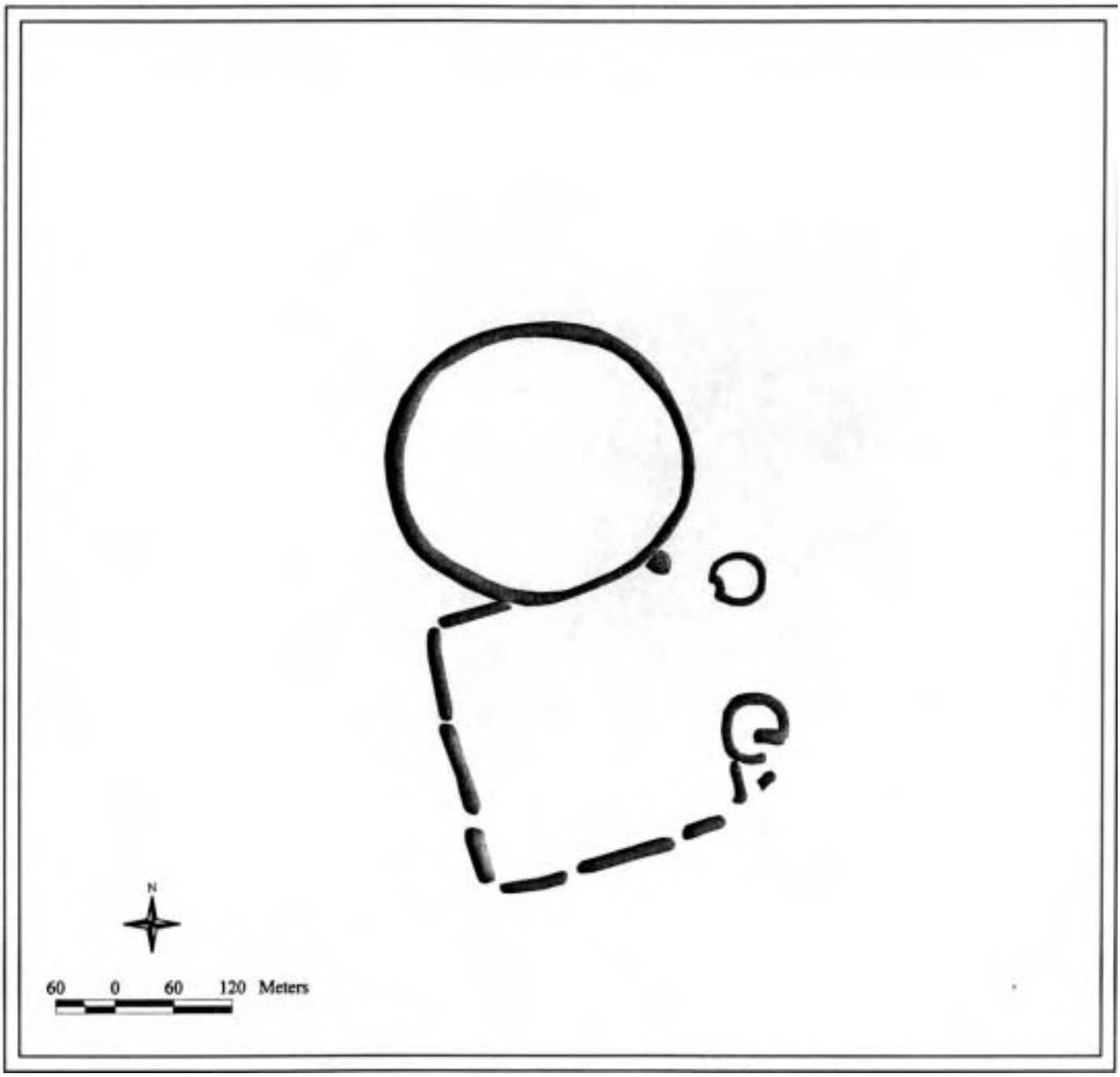
HOPETON EARTHWORKS

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



HOPETON EARTHWORKS - 1950

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



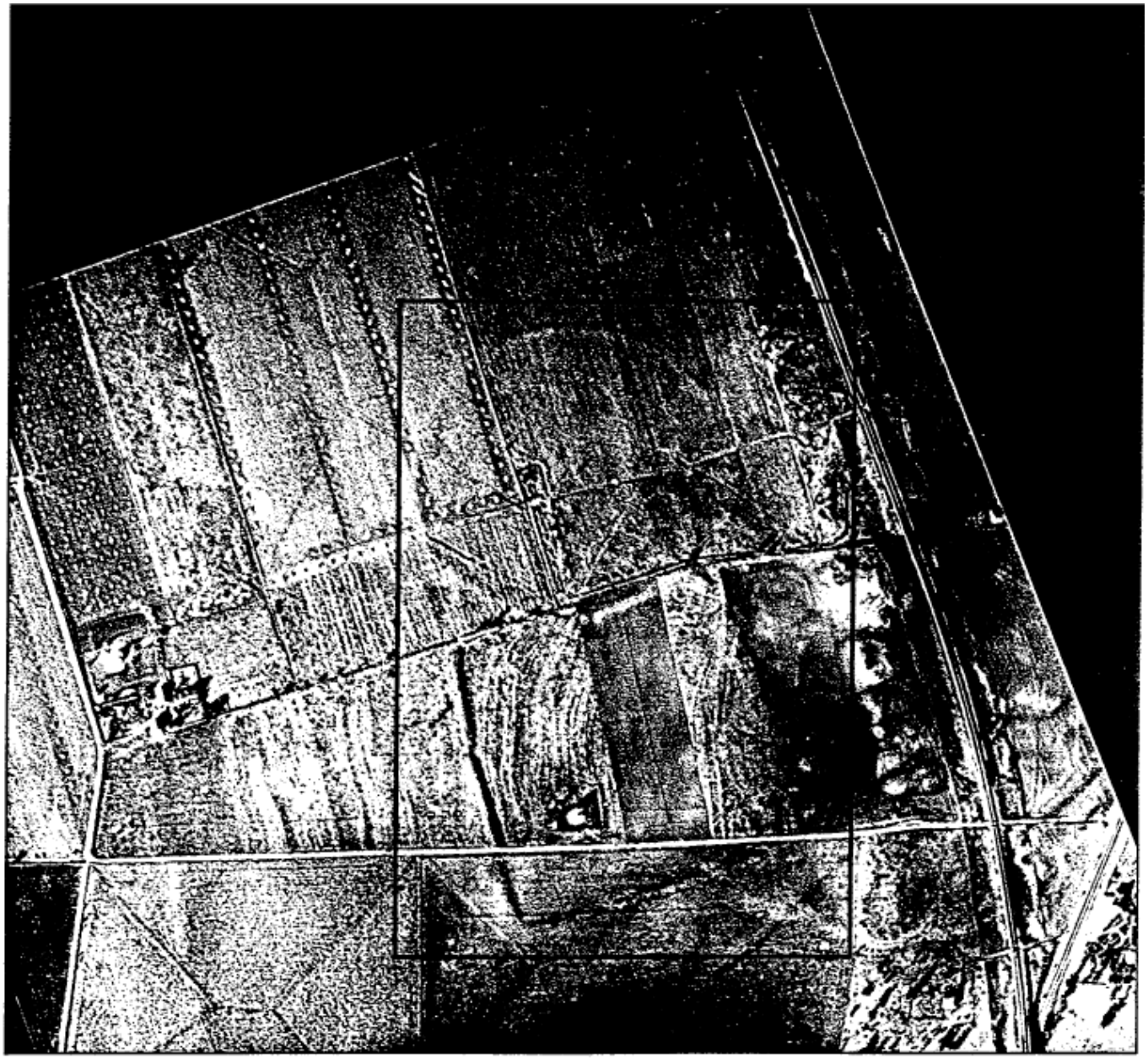
Features photointerpreted from 10/1/50
Aerial photograph

Legend

Wall

HOPETON EARTHWORKS – 1950

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Photograph Date: 1/1/50

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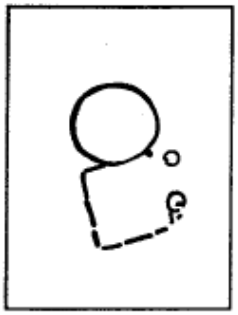
Photointerpreted features



HOPETON EARTHWORKS - 1962

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

Features photointerpreted from 4/1/62

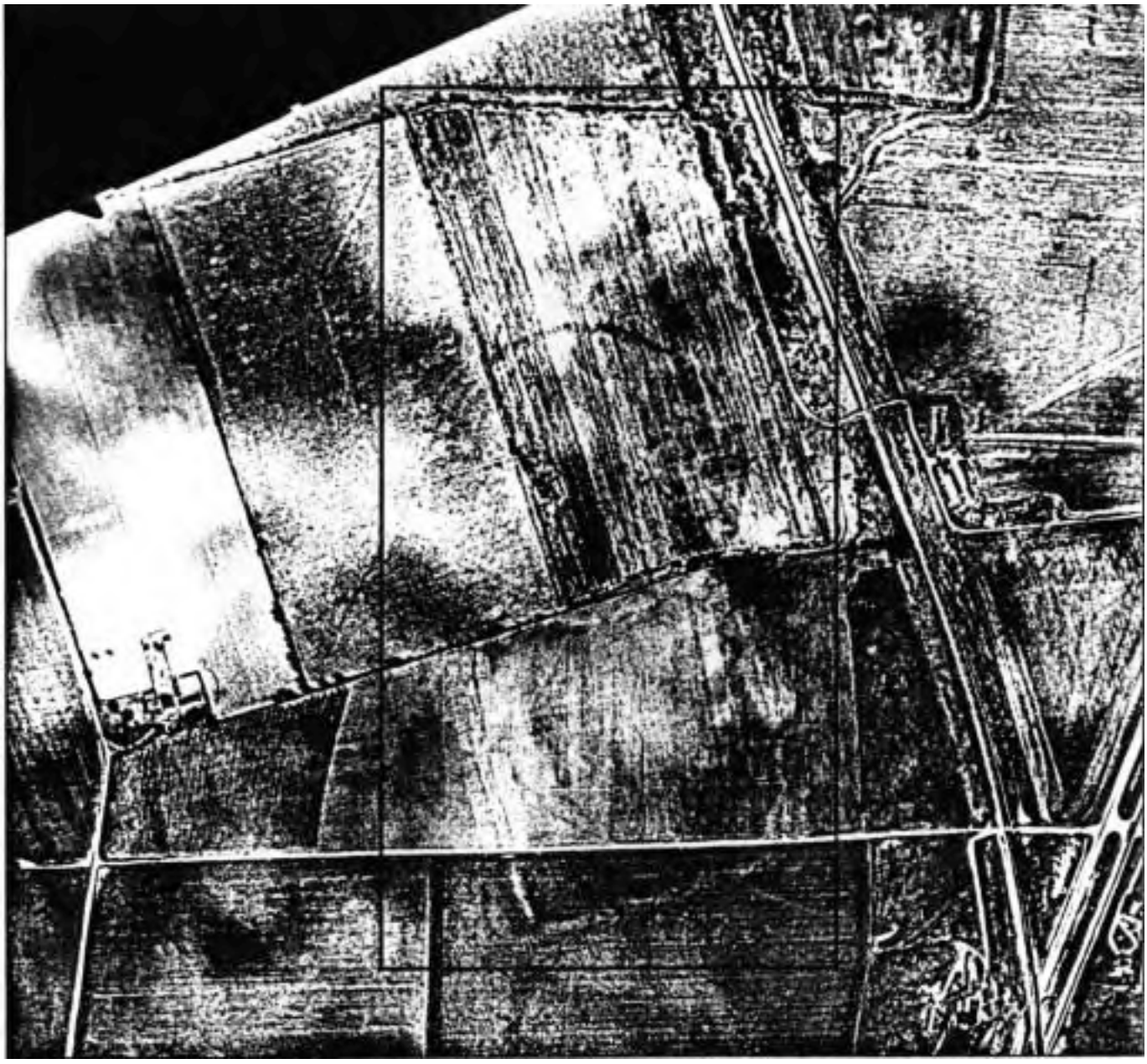
Aerial photograph

Legend

Wall

HOPETON EARTHWORKS - 1962

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



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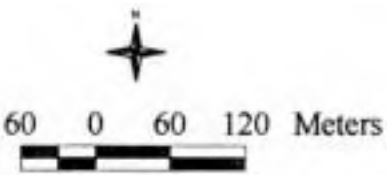
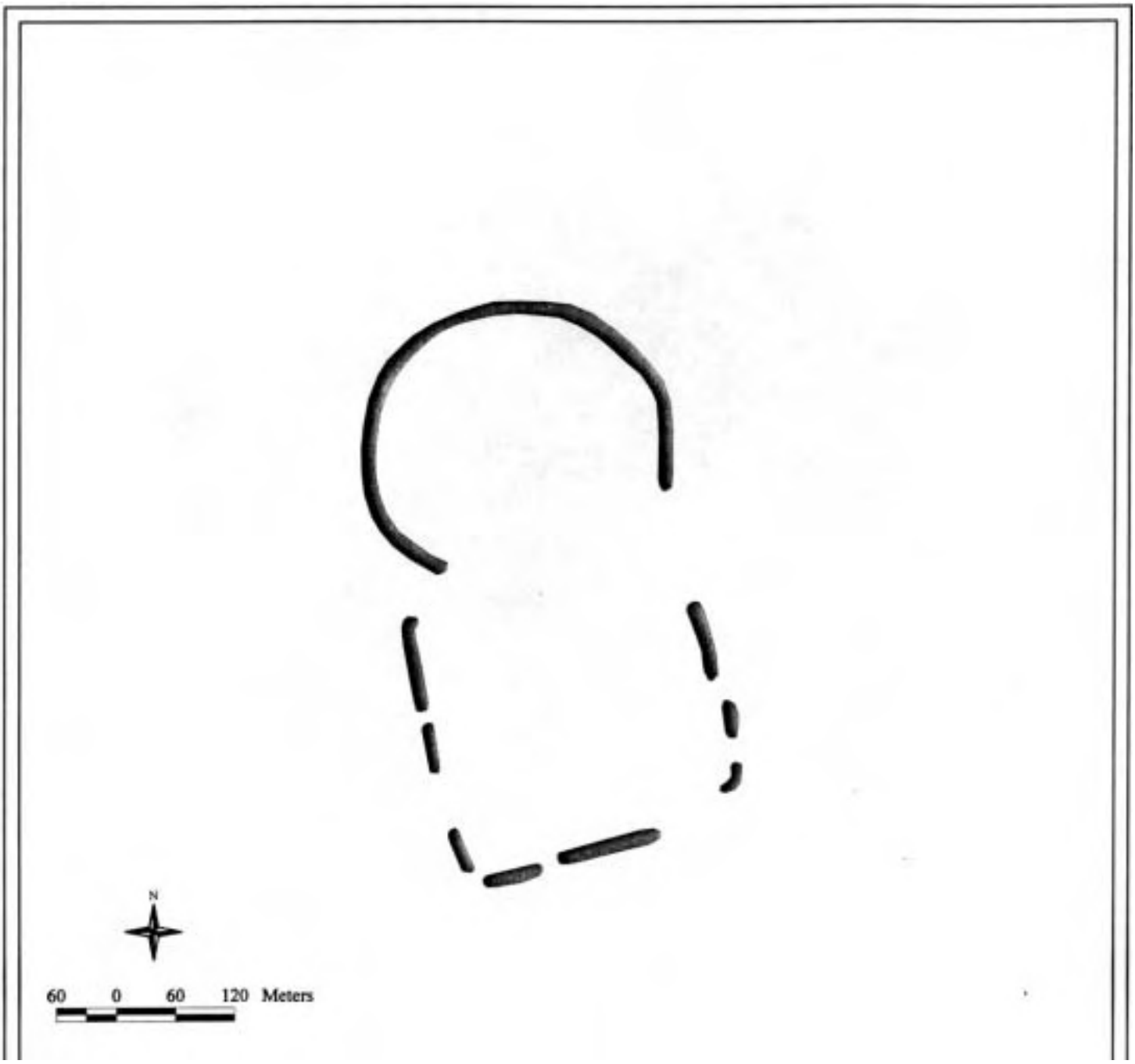


Photointerpreted Features

HOPETON EARTHWORKS - 1975

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 4/6/75

Aerial photograph

Legend

Wall

HOPETON EARTHWORKS - 1975

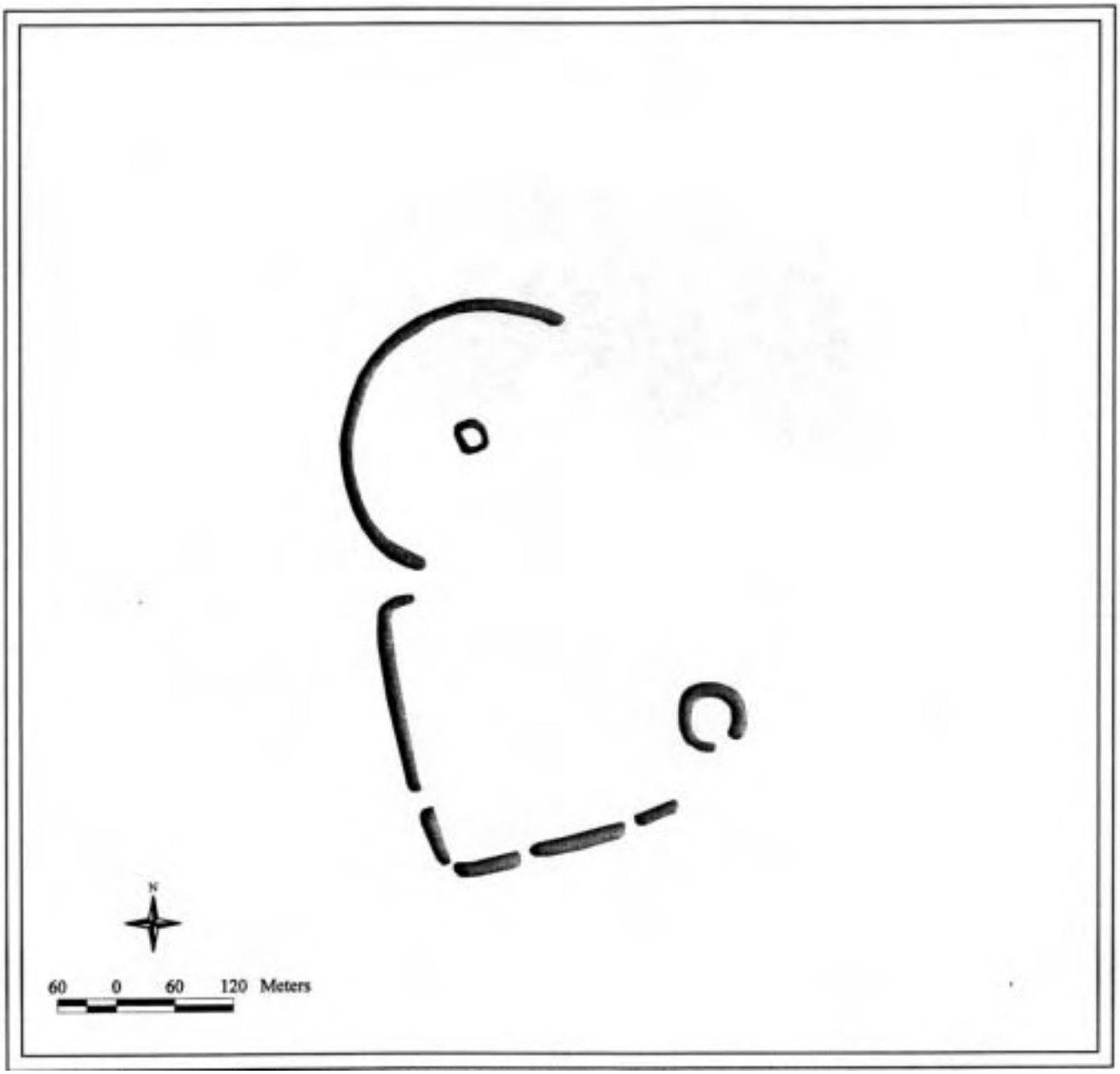
HOPEWELL CULTURE NATIONAL HISTORICAL PARK

Photograph Date: 4/6/75

Photointerpreted Features

HOPETON EARTHWORKS - 1976

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 2/24/76

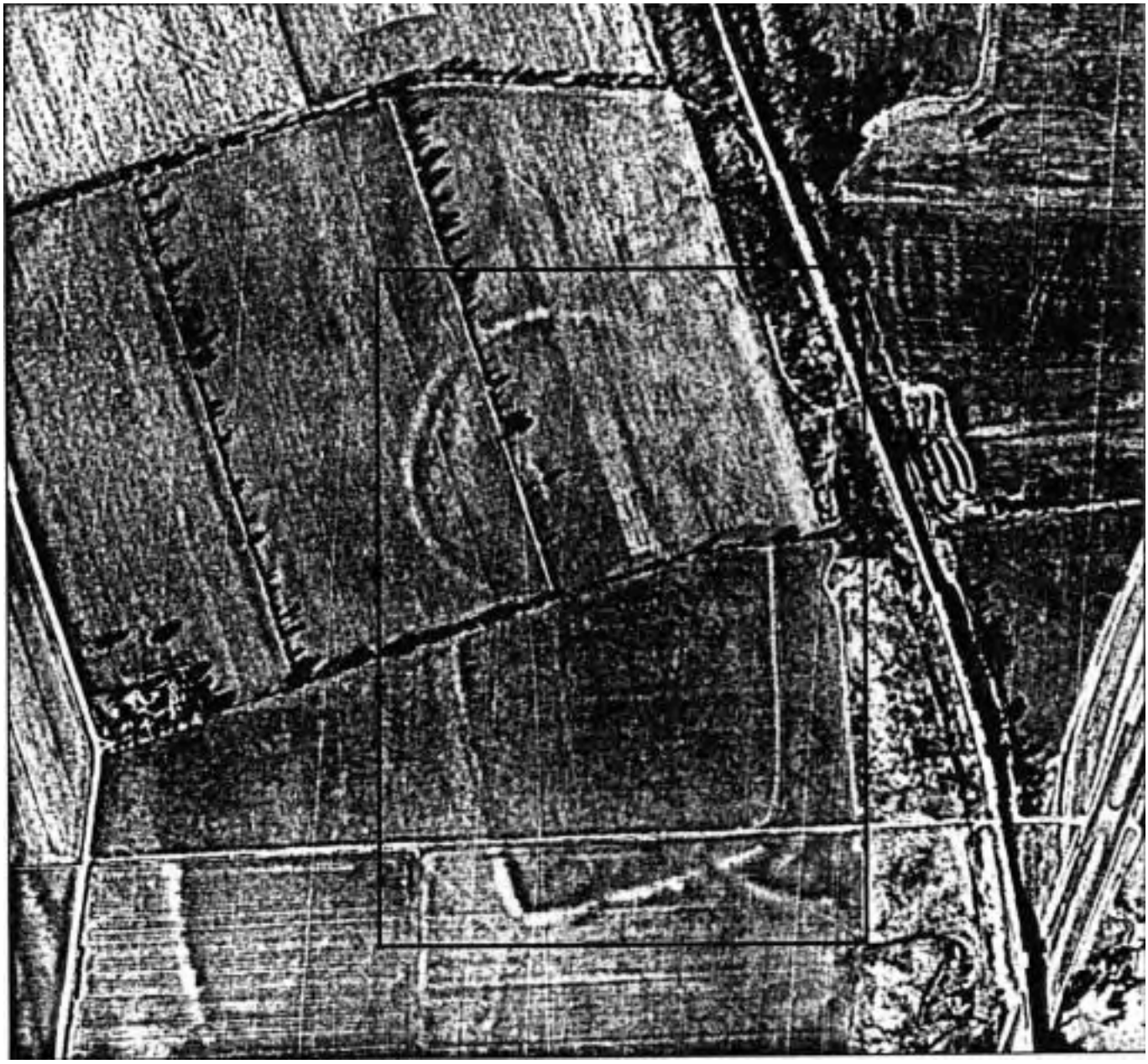
Aerial photograph

Legend

Wall

HOPETON EARTHWORKS - 1976

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



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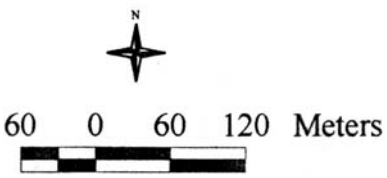
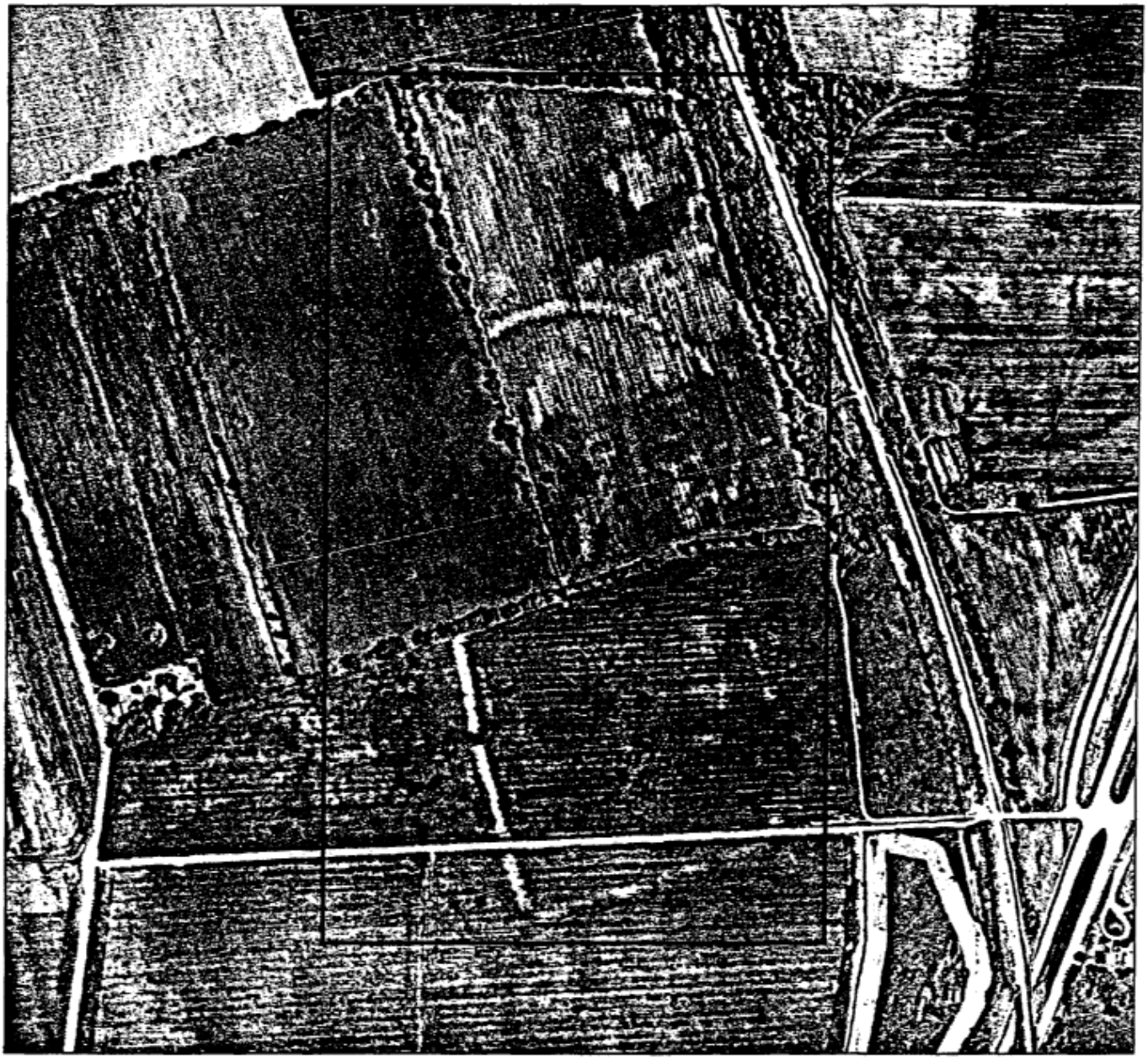
Photointerpreted Features



HOPETON EARTHWORKS - 1982

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



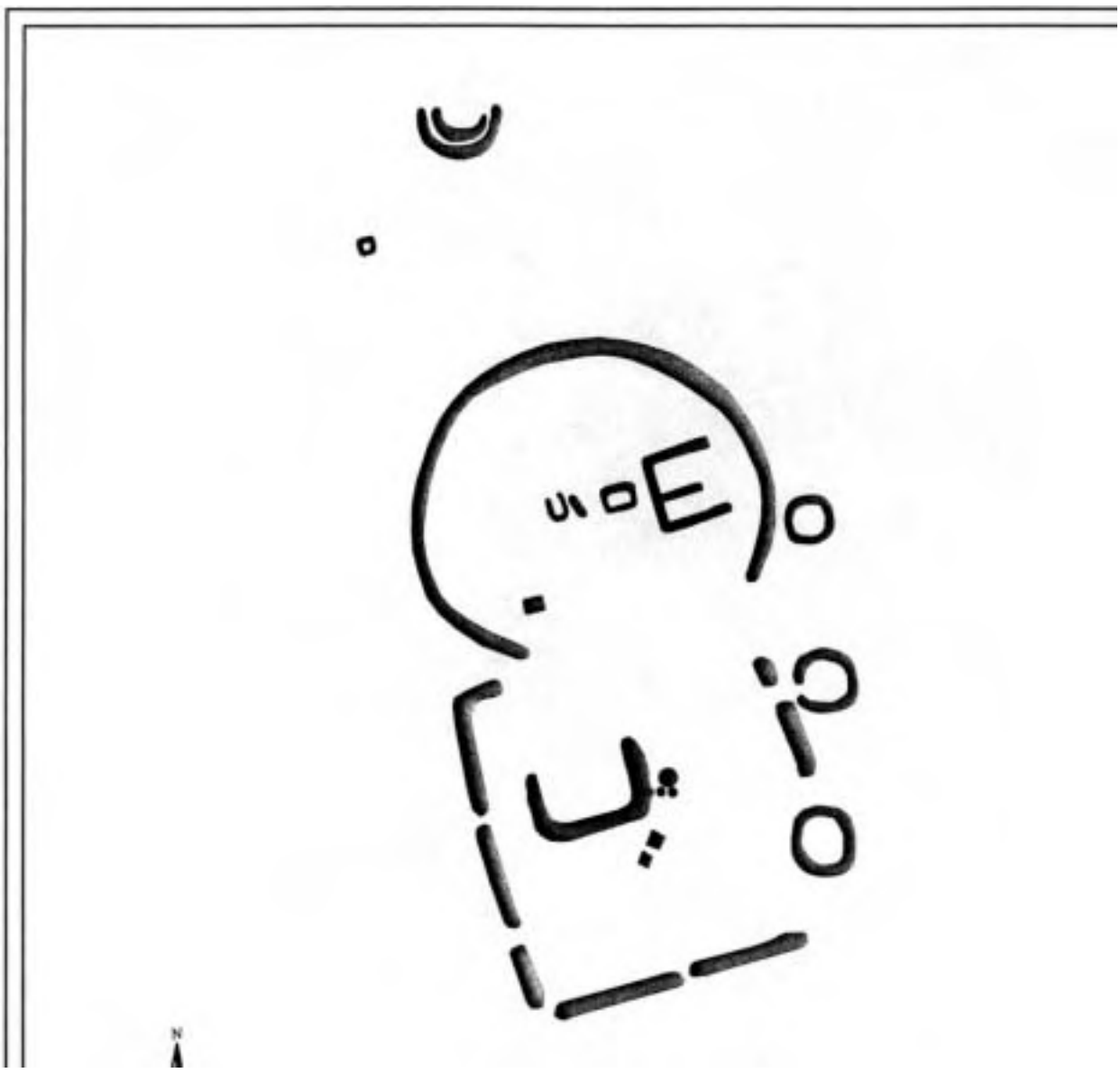
Photograph Date: 6/1/82

60 0 60 120 Meters

Photointerpreted features

HOPETON EARTHWORKS - 1982

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



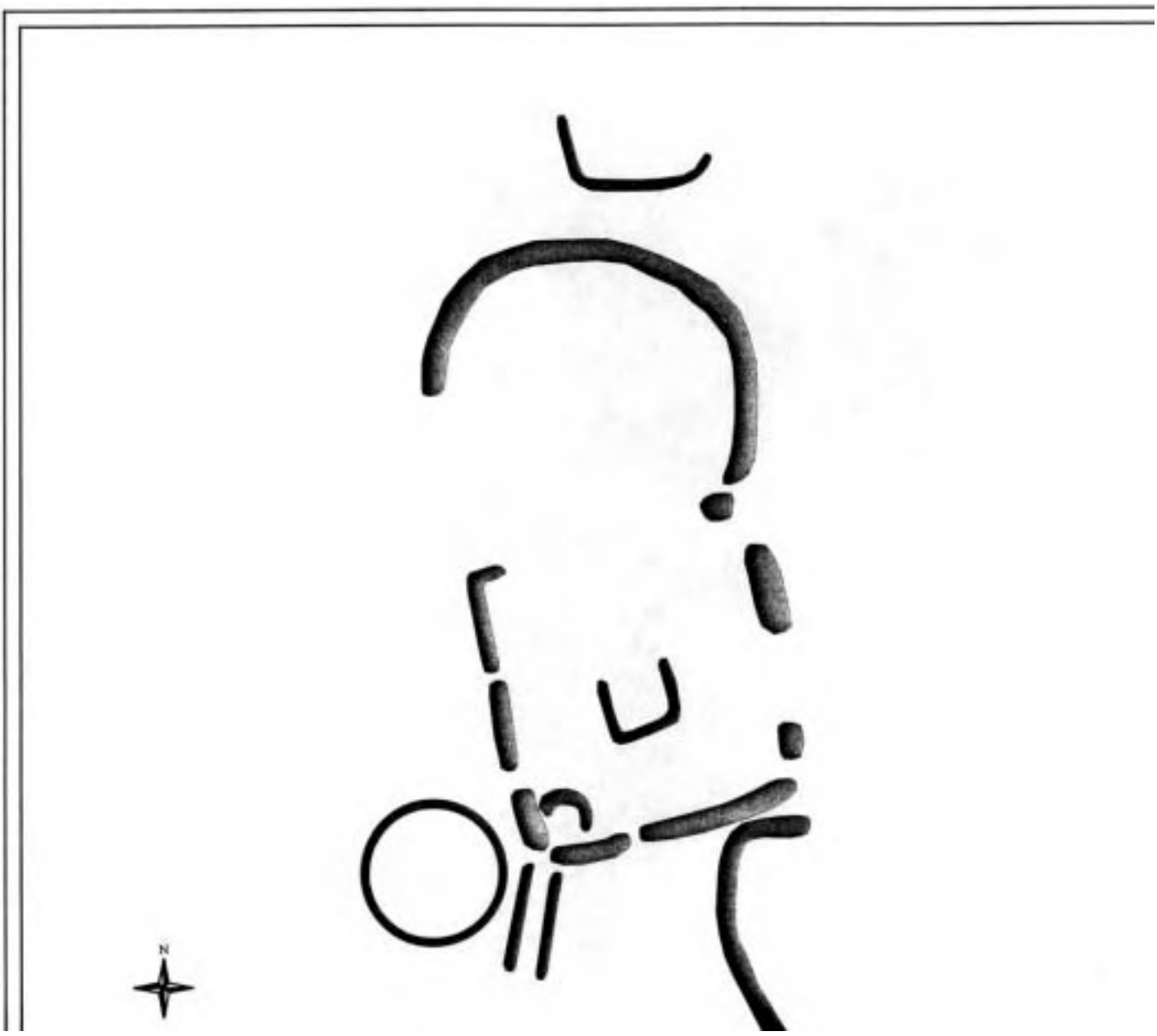
Features photointerpreted from 6/1/82
Aerial photograph

Legend
Wall
Discoloration

HOPETON EARTHWORKS - 1988

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

z



Features photointerpreted from 4/8/88
Aerial photograph

Legend

Wall

Discoloration

HOPETON EARTHWORKS - 1988

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

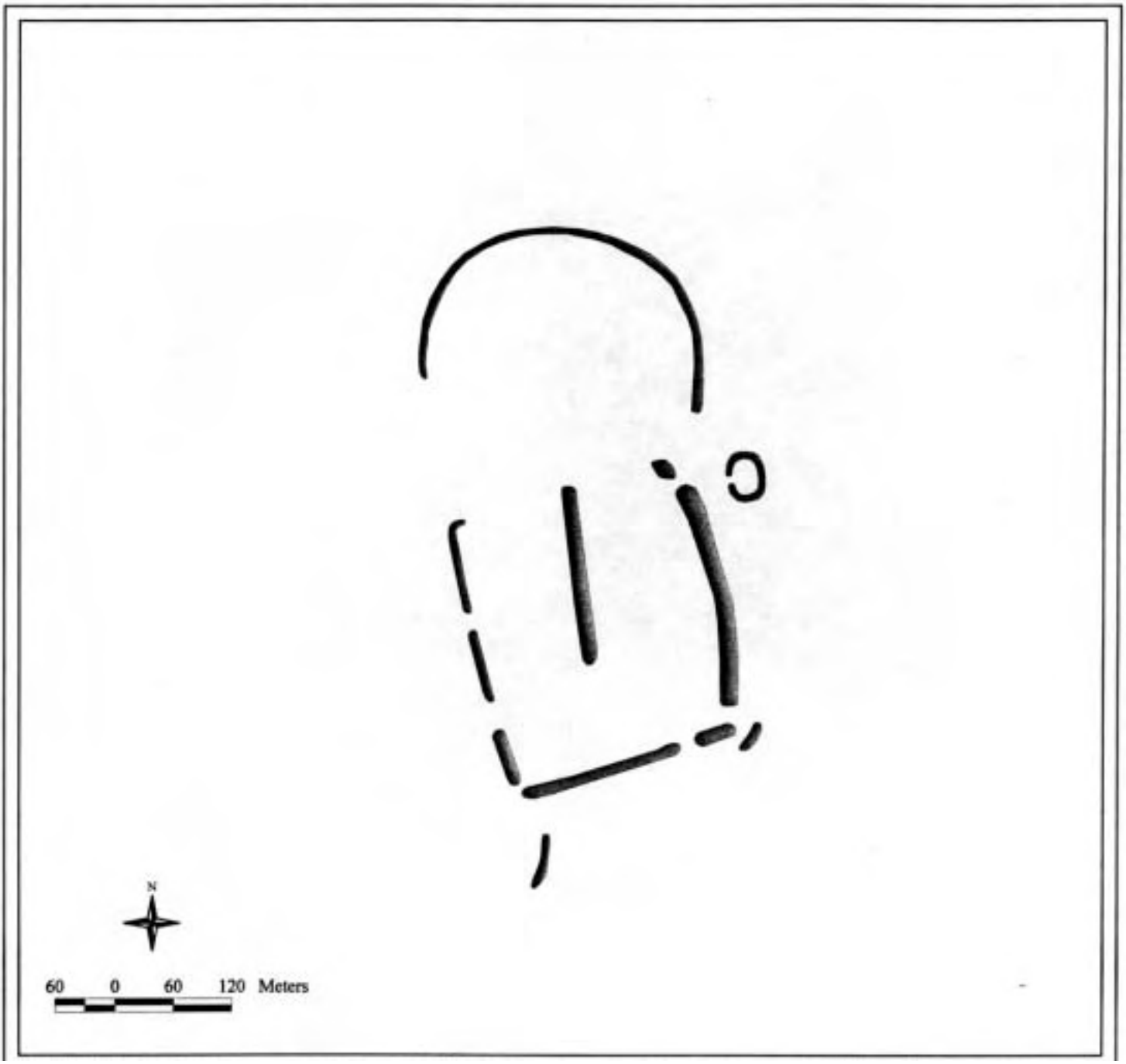
Photograph Date: 4/8/88

60 0 60 120 Meters

Photointerpreted features

HOPETON EARTHWORKS - 1993

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 5/26/93

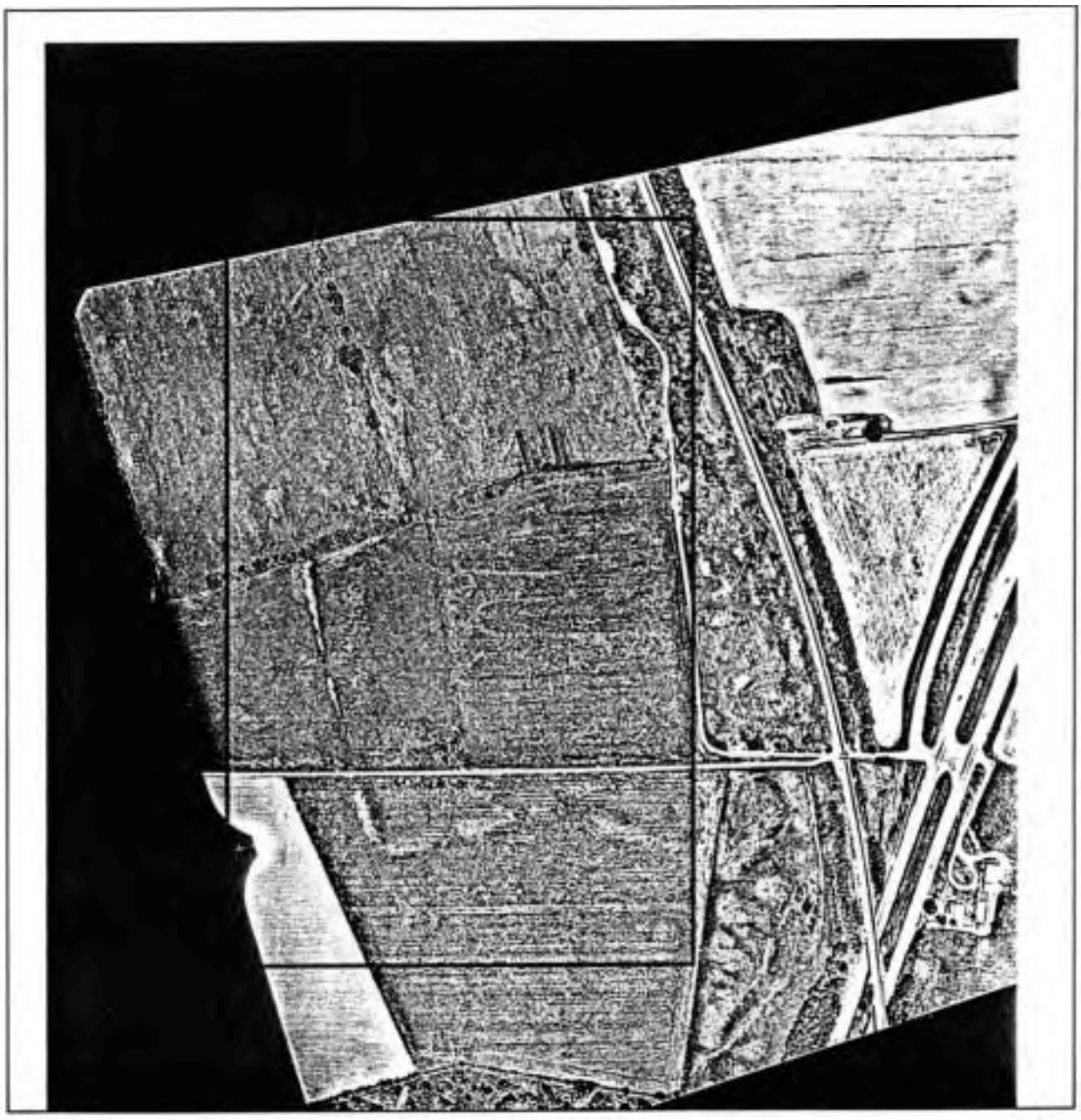
Aerial photograph

Legend

Wall

HOPETON EARTHWORKS - 1993

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



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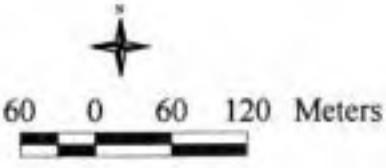
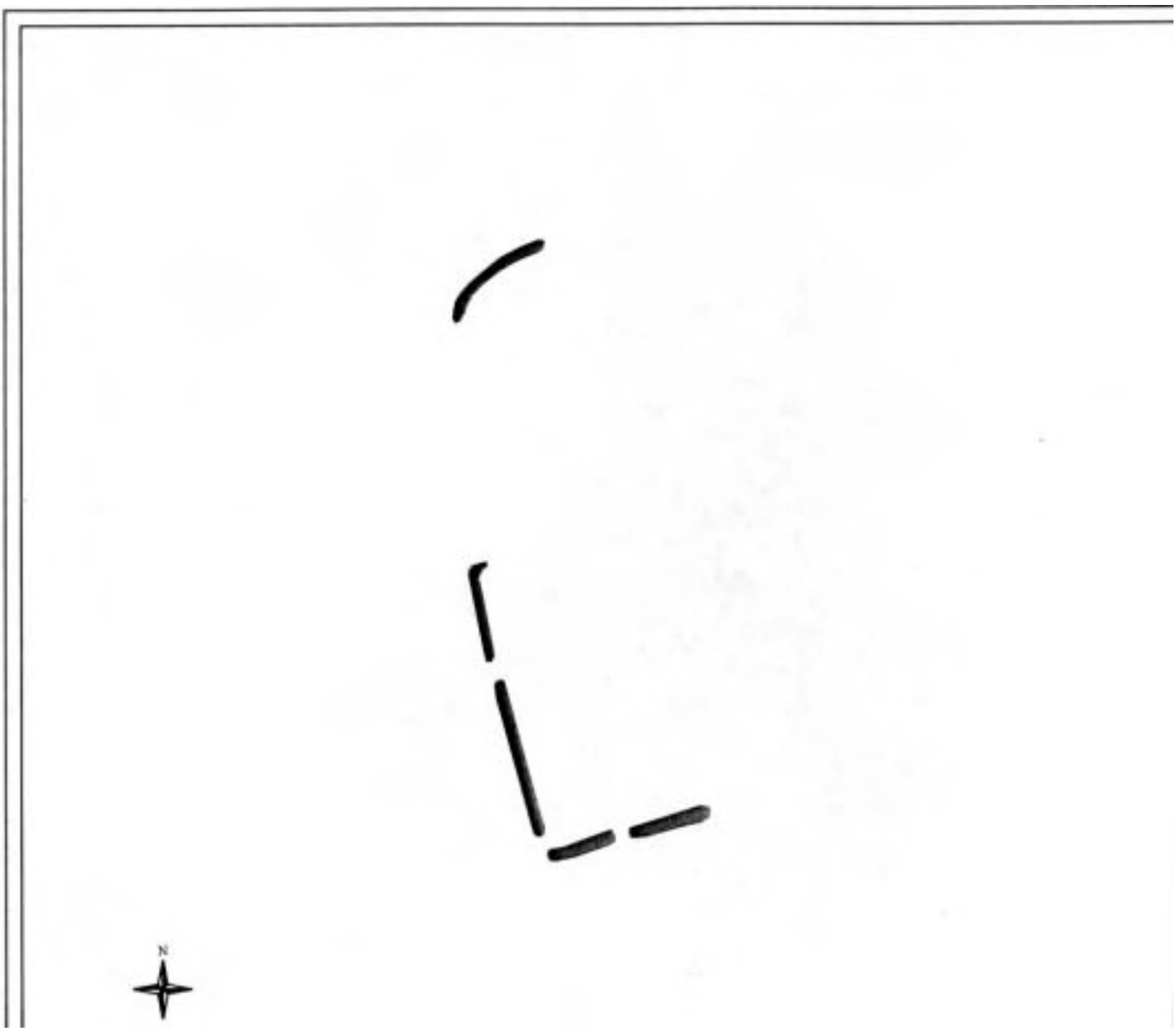


Photointerpreted features

HOPETON EARTHWORKS - 1994

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 2/1/94

Aerial photograph

Legend

Wall

HOPETON EARTHWORKS - 1994

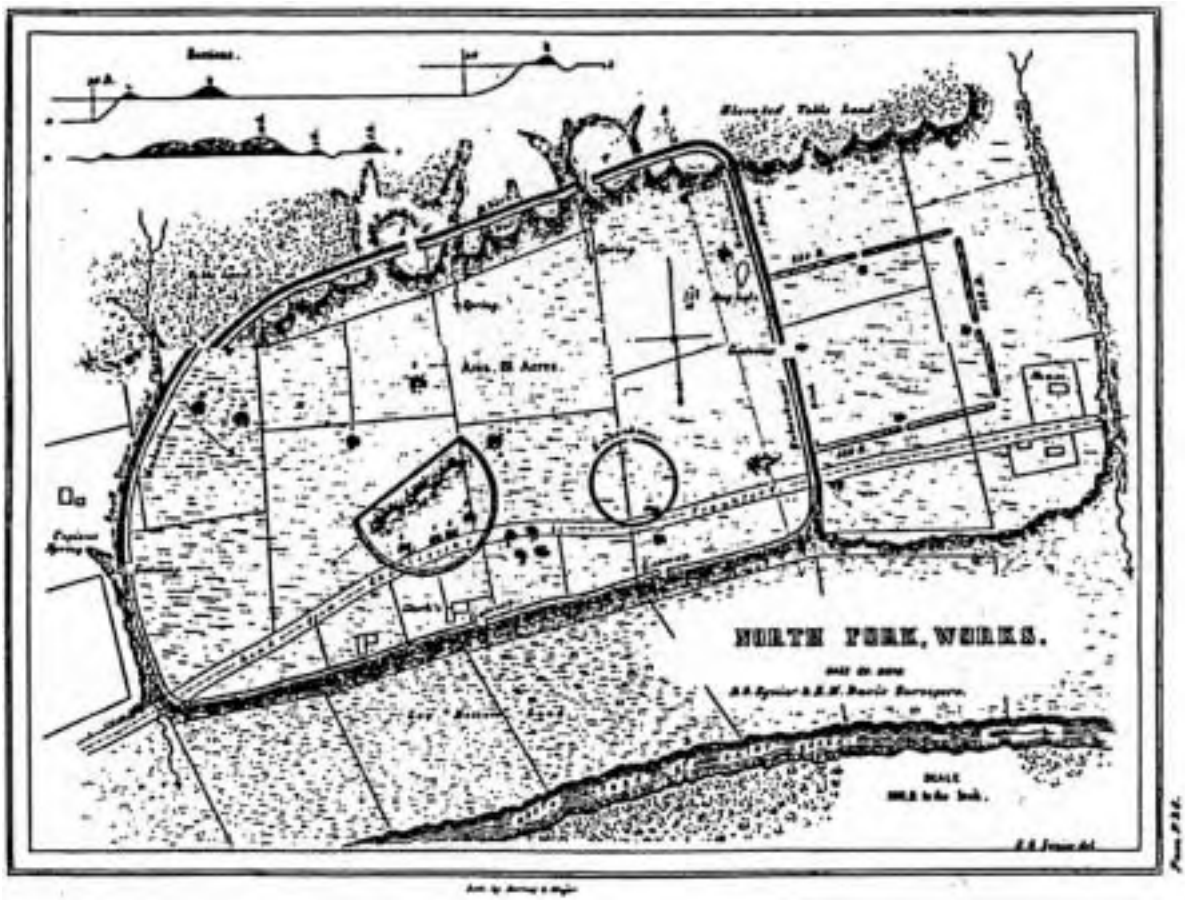
HOPEWELL CULTURE NATIONAL HISTORICAL PARK

Photograph Date: 2/1/94

Photointerpreted features

Hopewell Mound Group

Photointerpretive Maps



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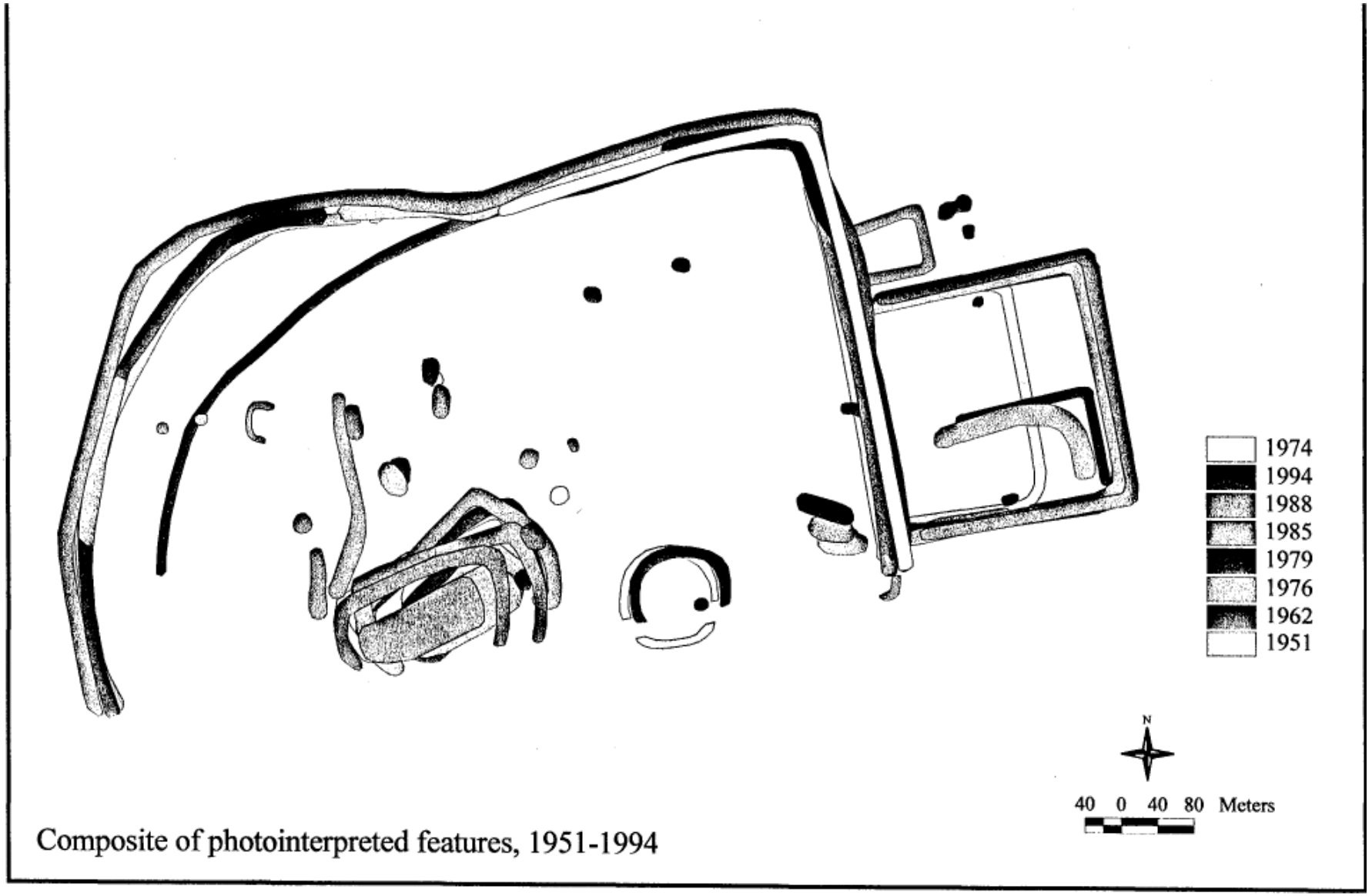
Hopewell Mound Group

HOPEWELL MOUND GROUP

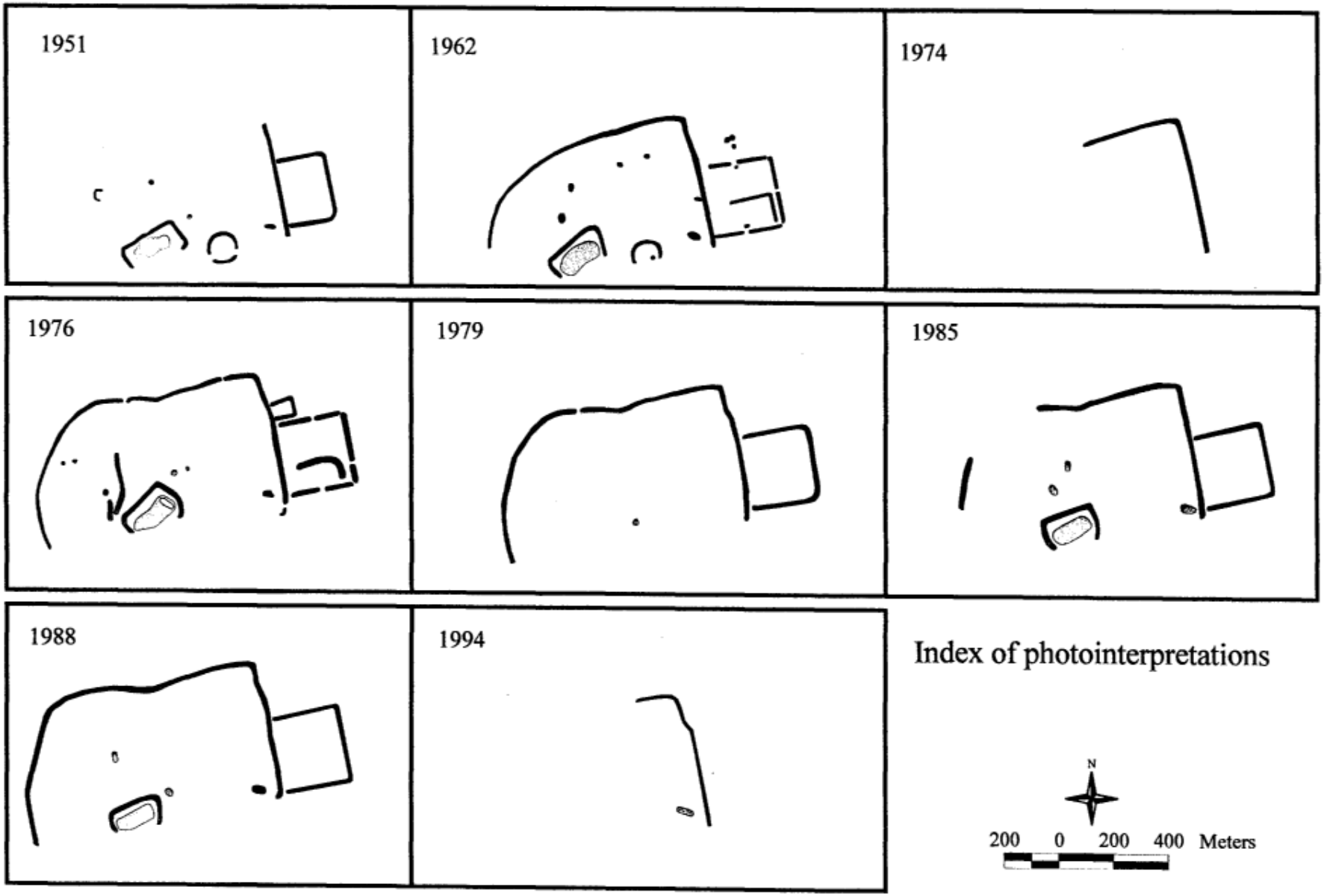
HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Composite of photointerpreted features, 1951-1994

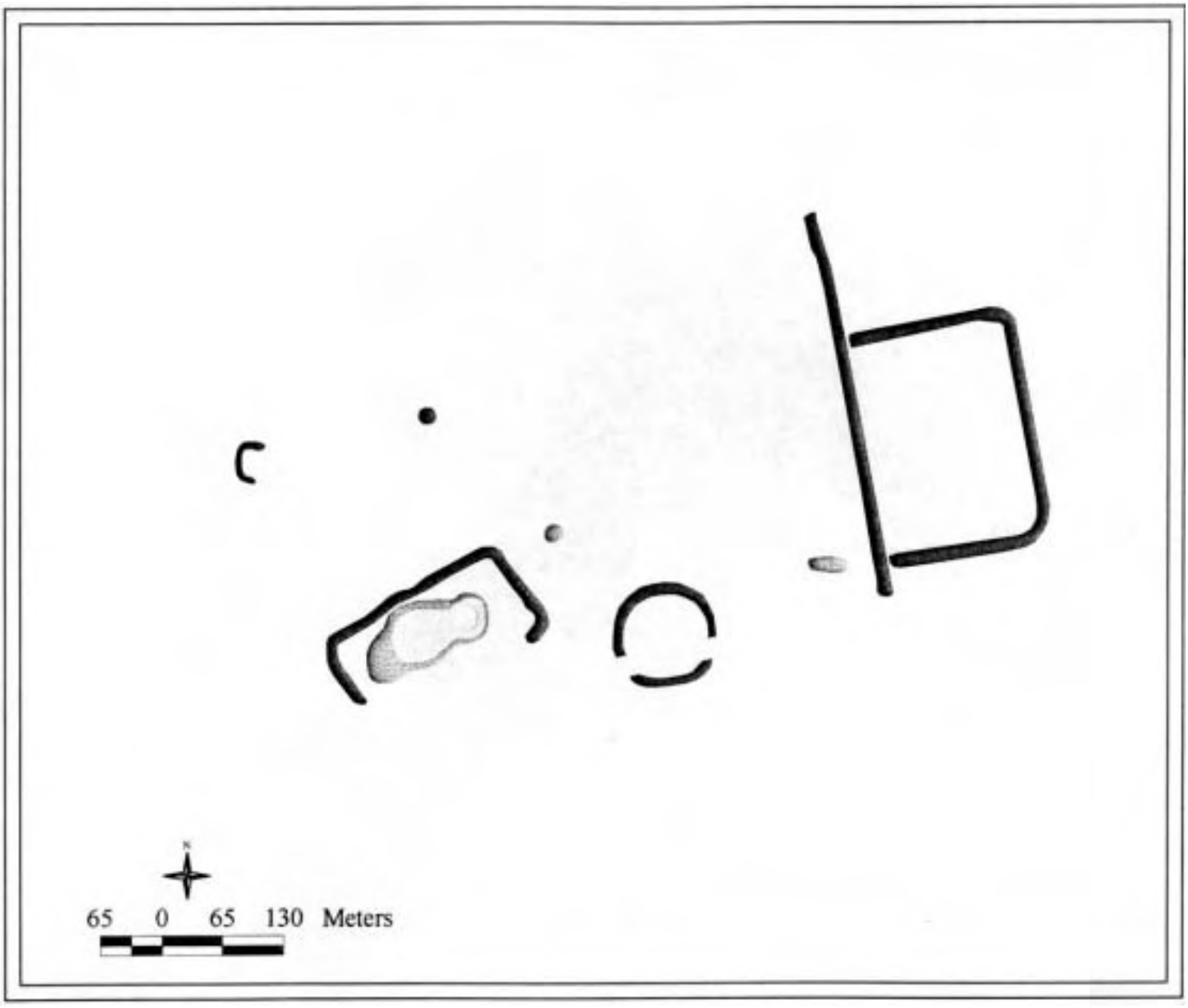
HOPEWELL MOUND GROUP

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



HOPEWELL MOUND GROUP - 1951

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 11/1/51
Aerial photograph

Legend

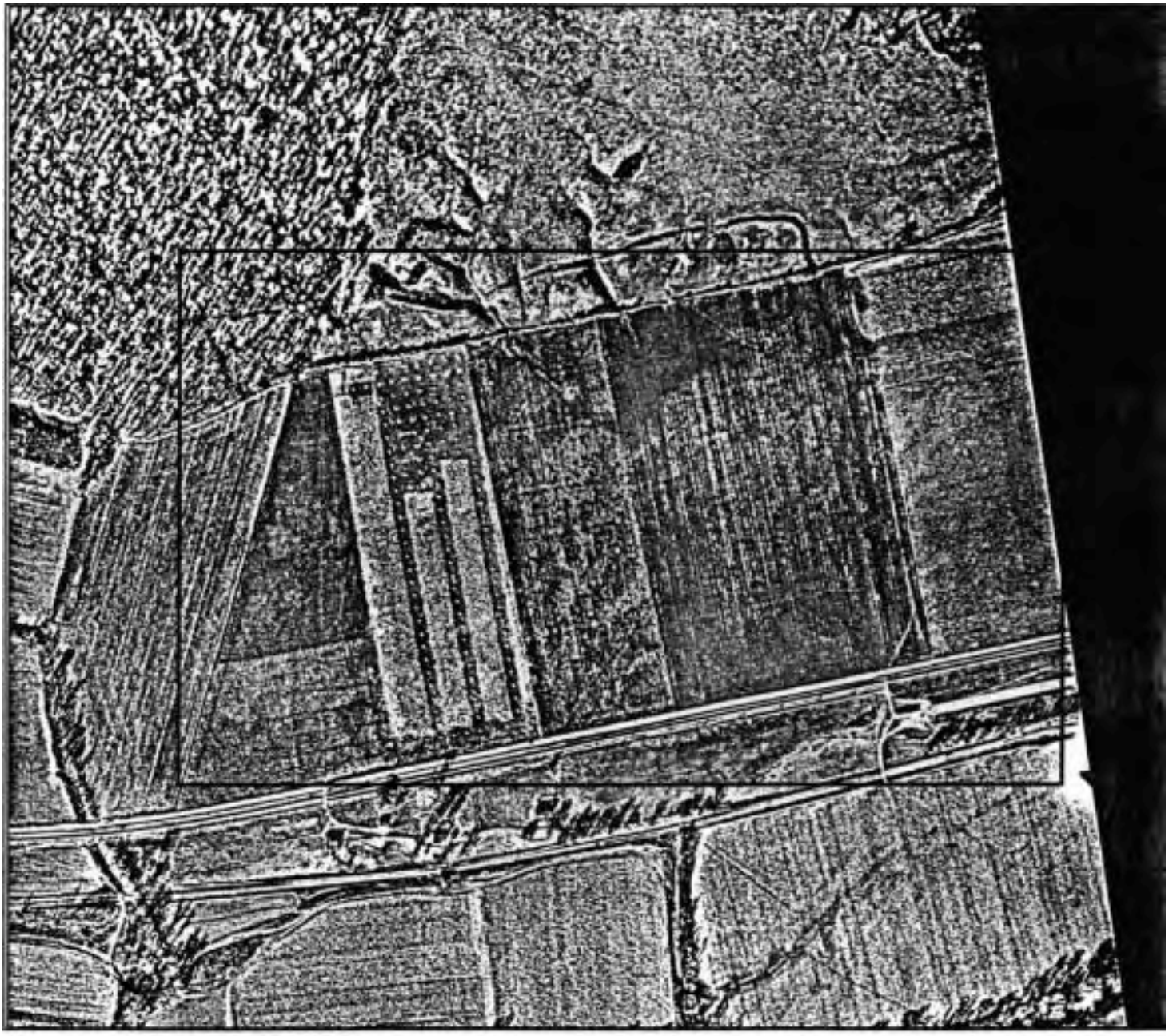
Wall

Mound

Stepped Mound
(lighter color indicates higher elevation)

HOPEWELL MOUND GROUP - 1951

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Photograph Date: 11/1/51

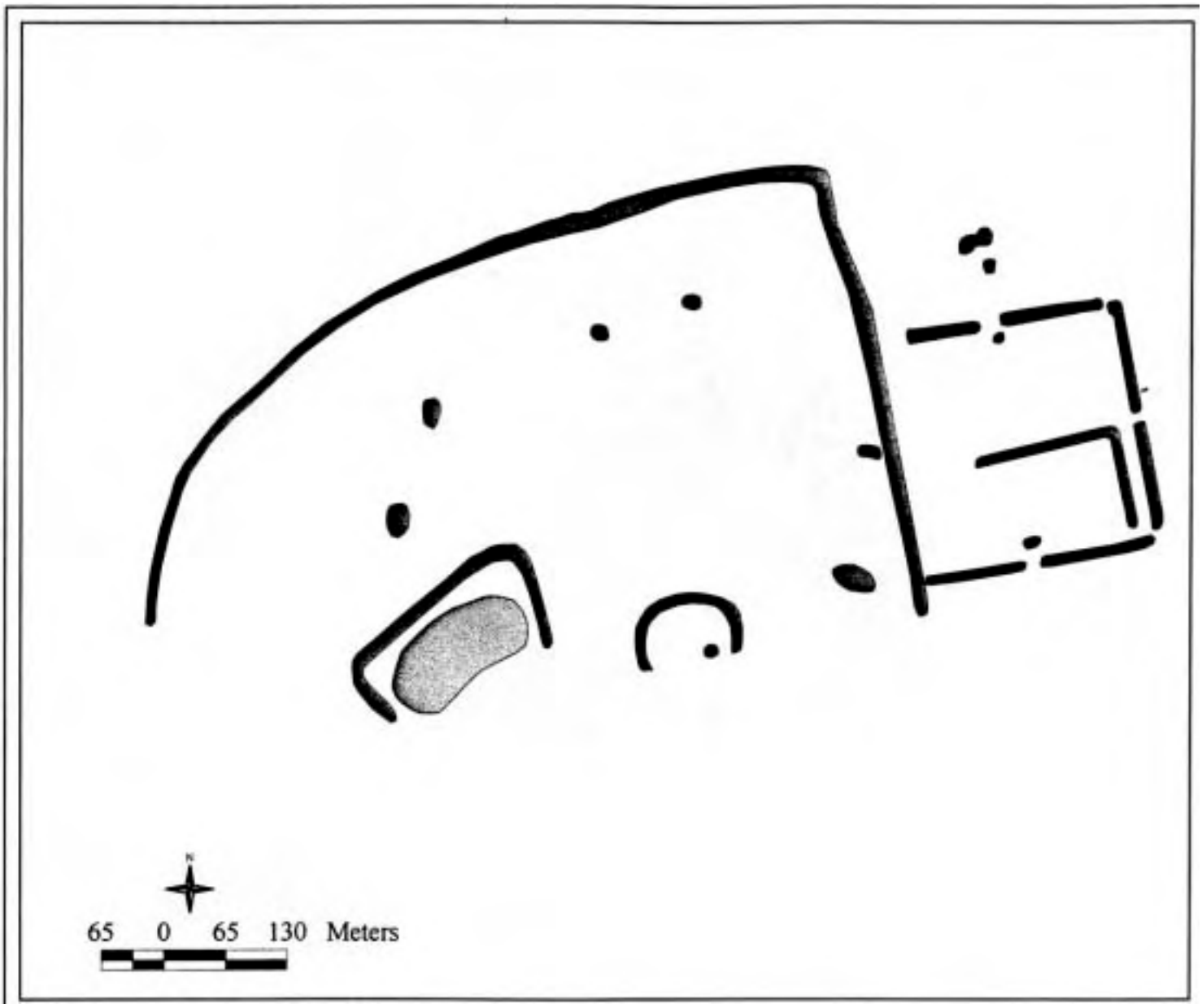
N

65 0 65 130 Meters

Photointerpreted features

HOPEWELL MOUND GROUP - 1962

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 4/1/62
Aerial photograph

Legend

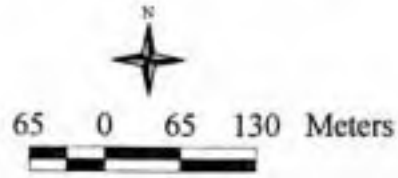
Wall

Mound

HOPEWELL MOUND GROUP - 1962

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

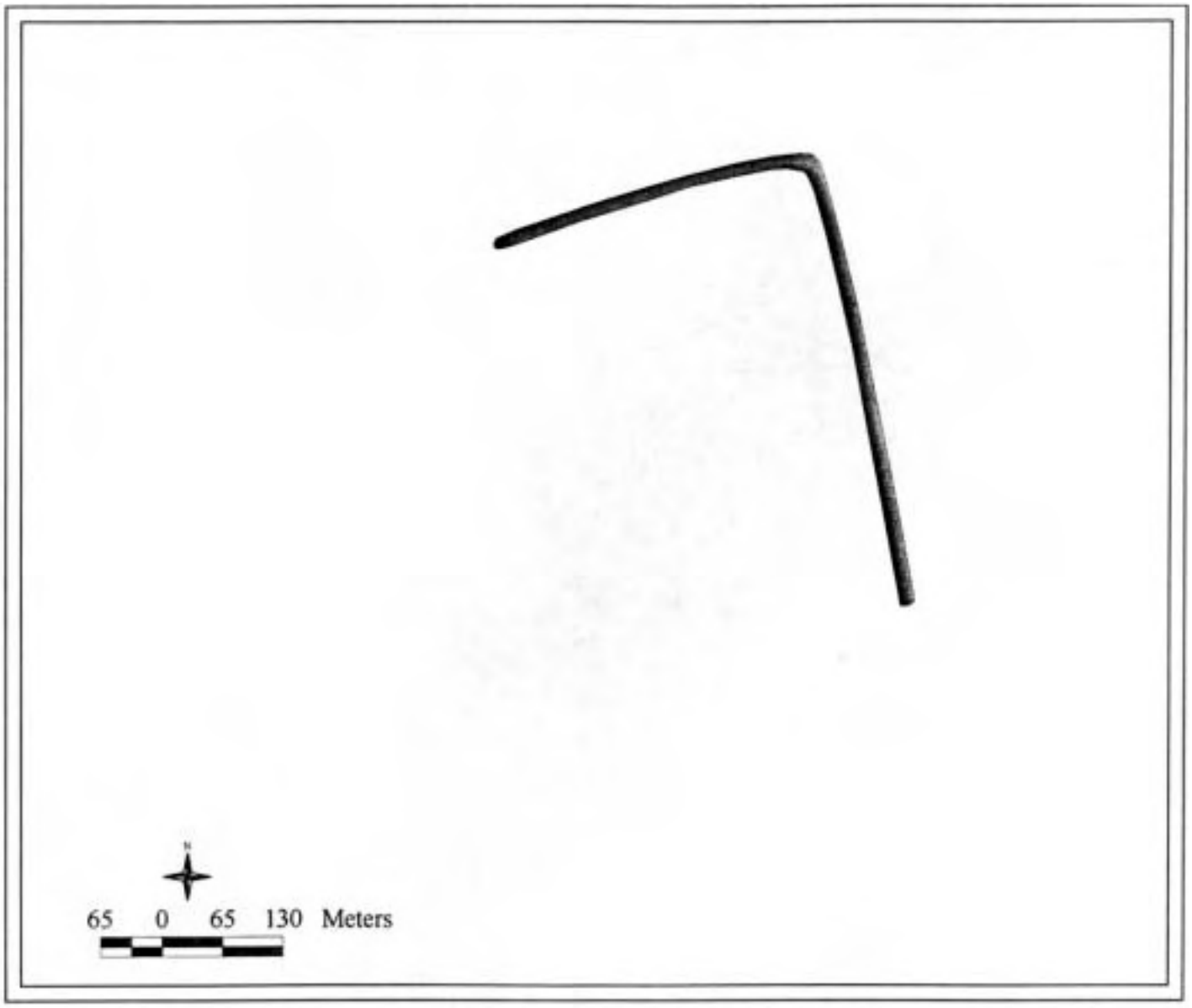
Photograph Date: 4/1/62



Photointerpreted features

HOPEWELL MOUND GROUP - 1974

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



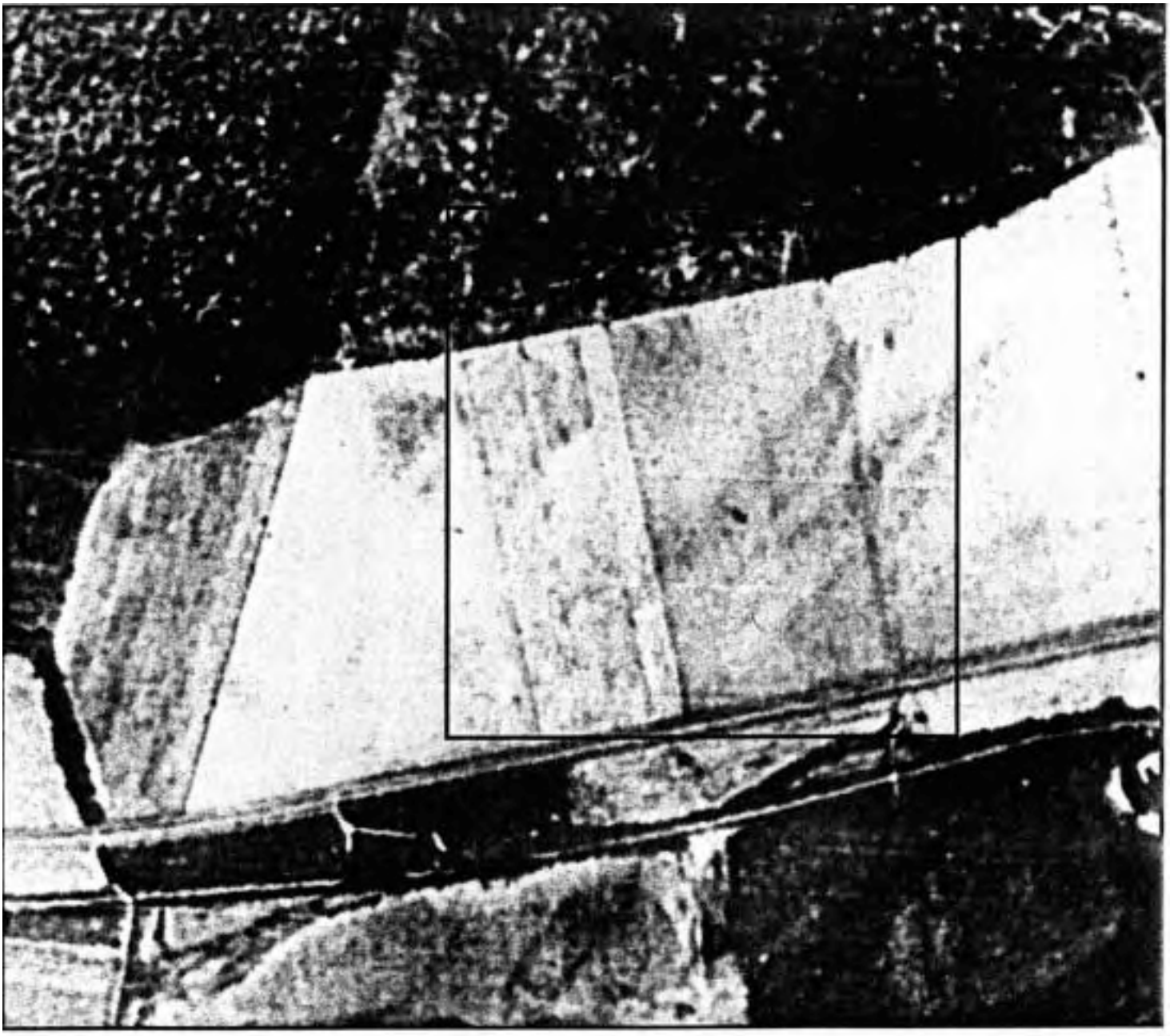
Features photointerpreted from 5/7/74
Aerial photograph

Legend

Wall

HOPEWELL MOUND GROUP - 1974

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

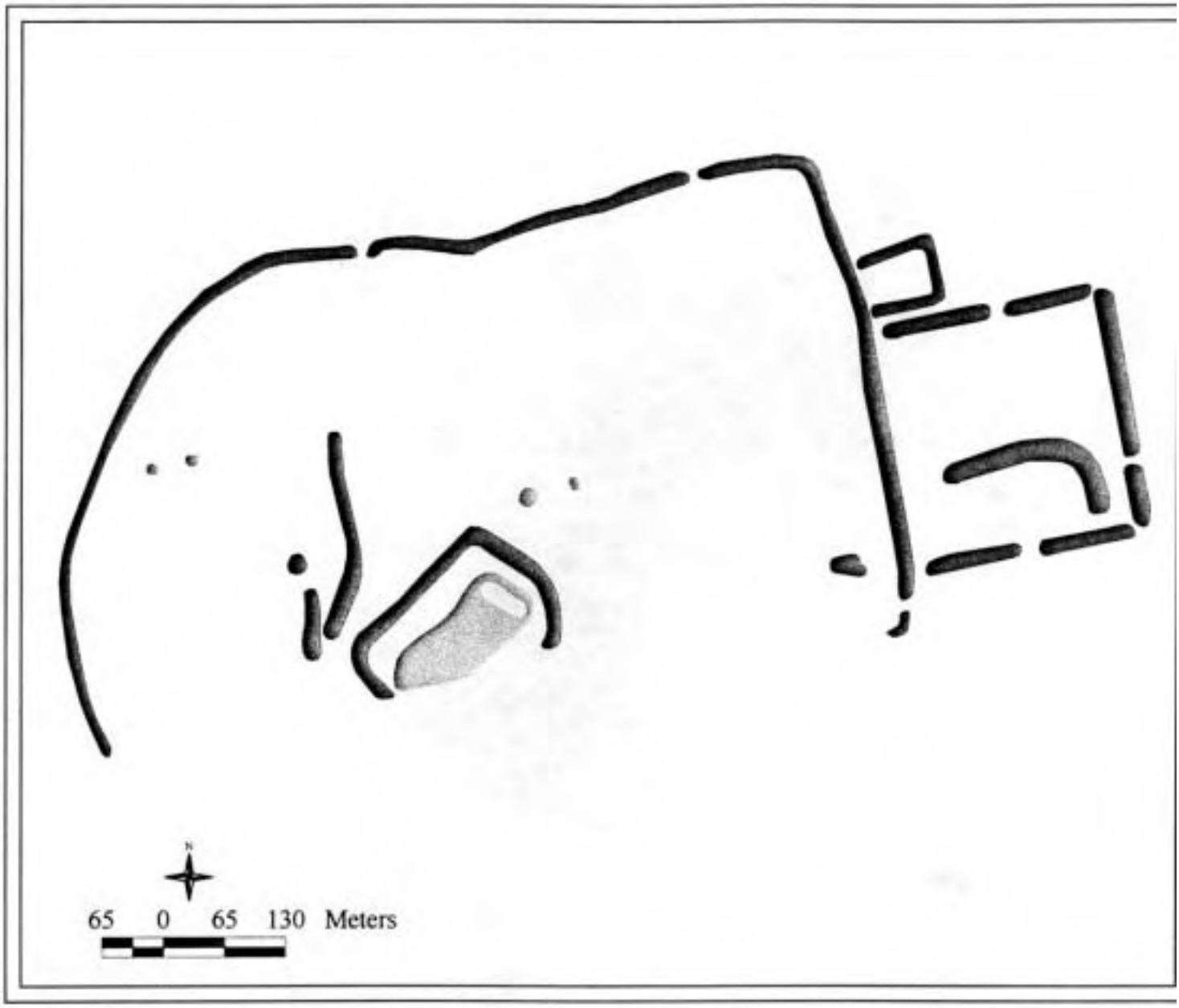


Photograph Date: 5/7/74

Photointerpreted features

HOPEWELL MOUND GROUP - 1976

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 2/24/76
Aerial photograph

Legend

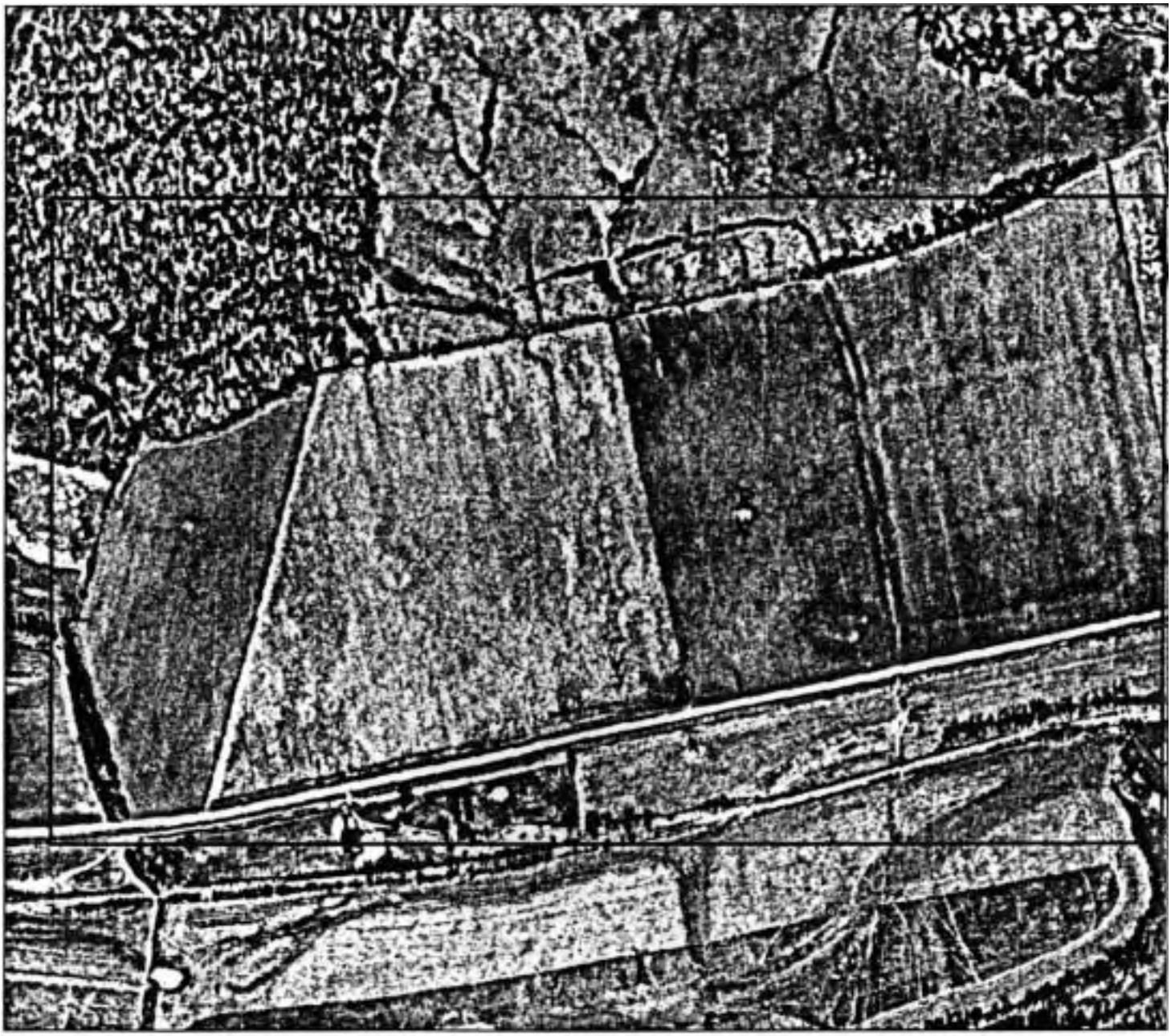
Wall

Mound

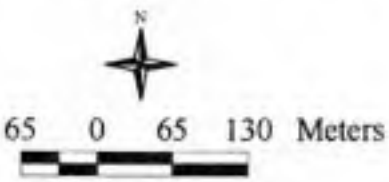
Stepped Mound
(lighter color indicates higher elevation)

HOPEWELL MOUND GROUP - 1976

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



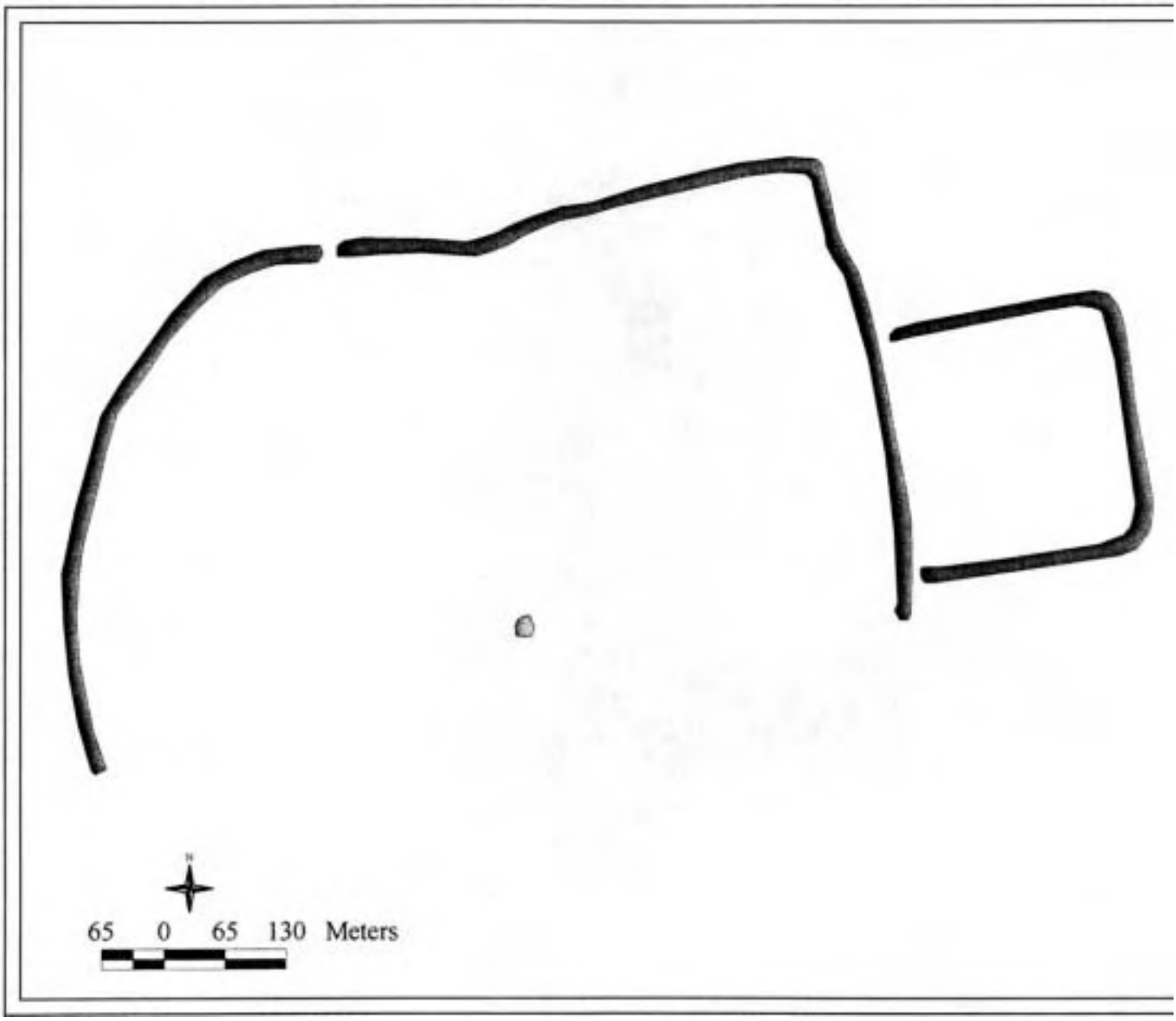
Photograph Date: 2/24/76



Photointerpreted features

HOPEWELL MOUND GROUP - 1979

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 4/18/79
Aerial photograph

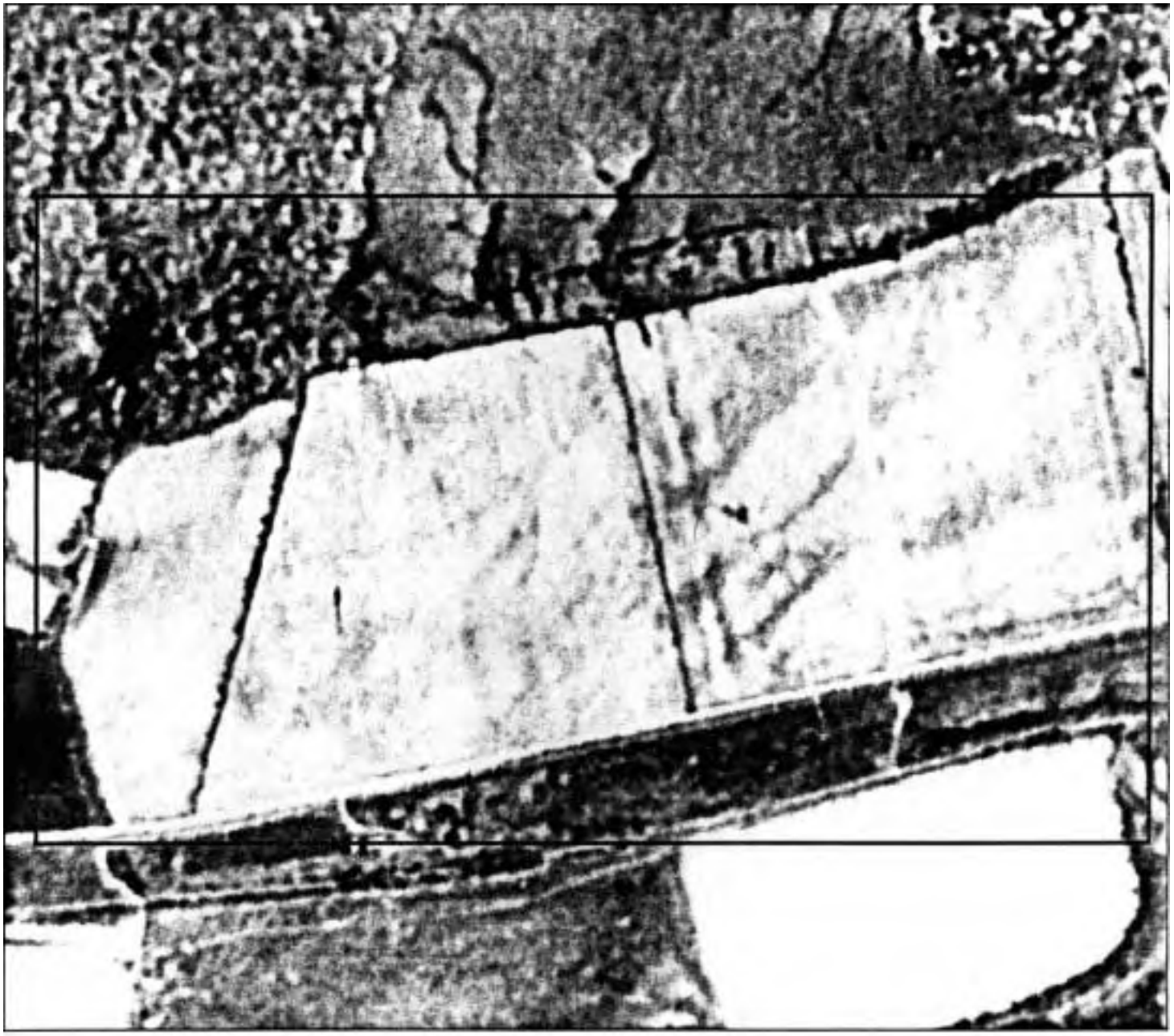
Legend

Wall

Mound

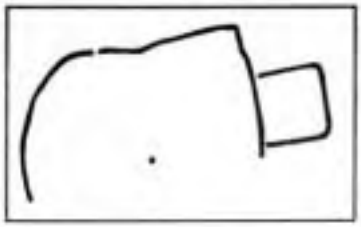
HOPEWELL MOUND GROUP - 1979

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



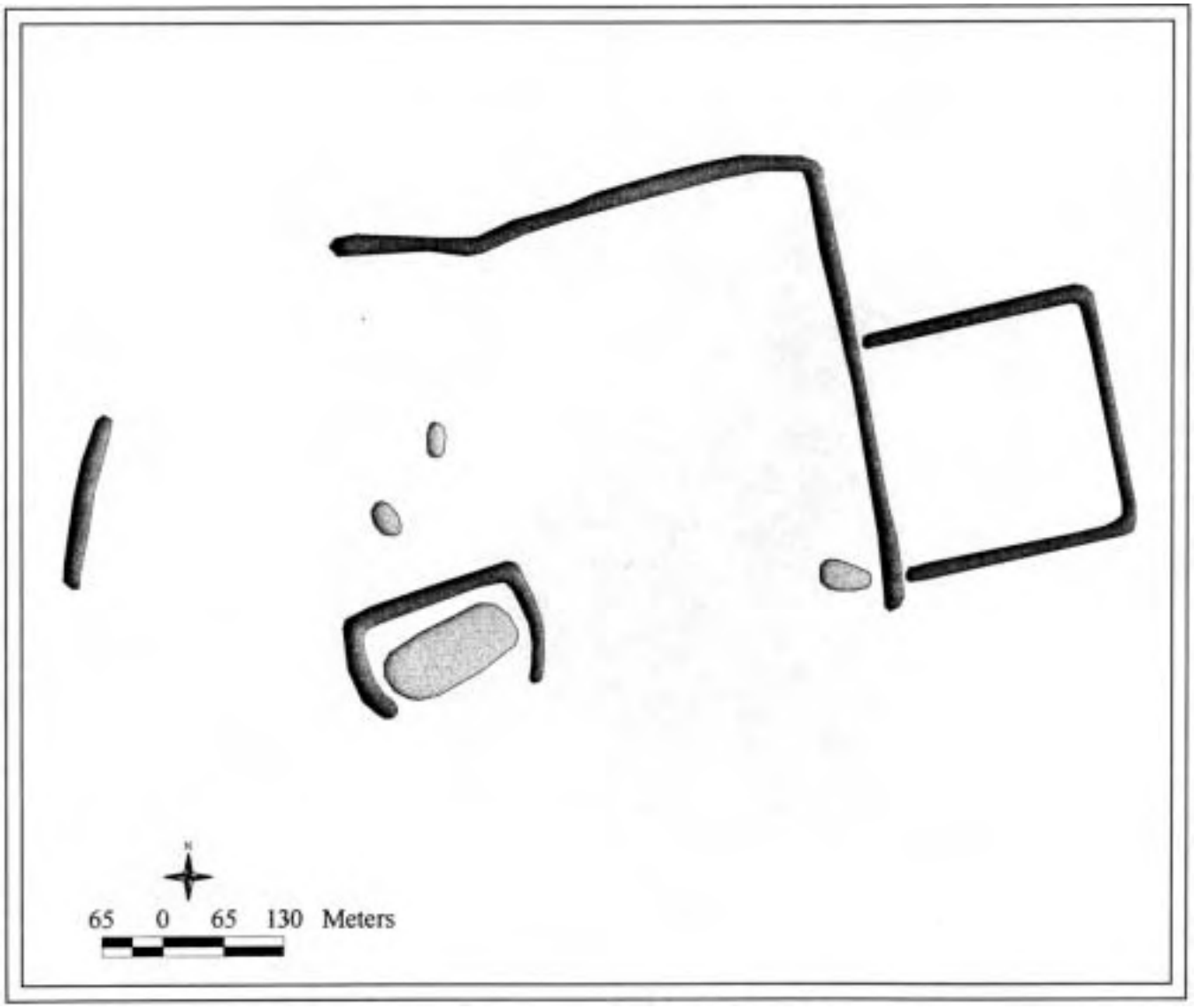
Photograph Date: 4/18/79

Photointerpreted features



HOPEWELL MOUND GROUP - 1985

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 3/9/85
Aerial photograph

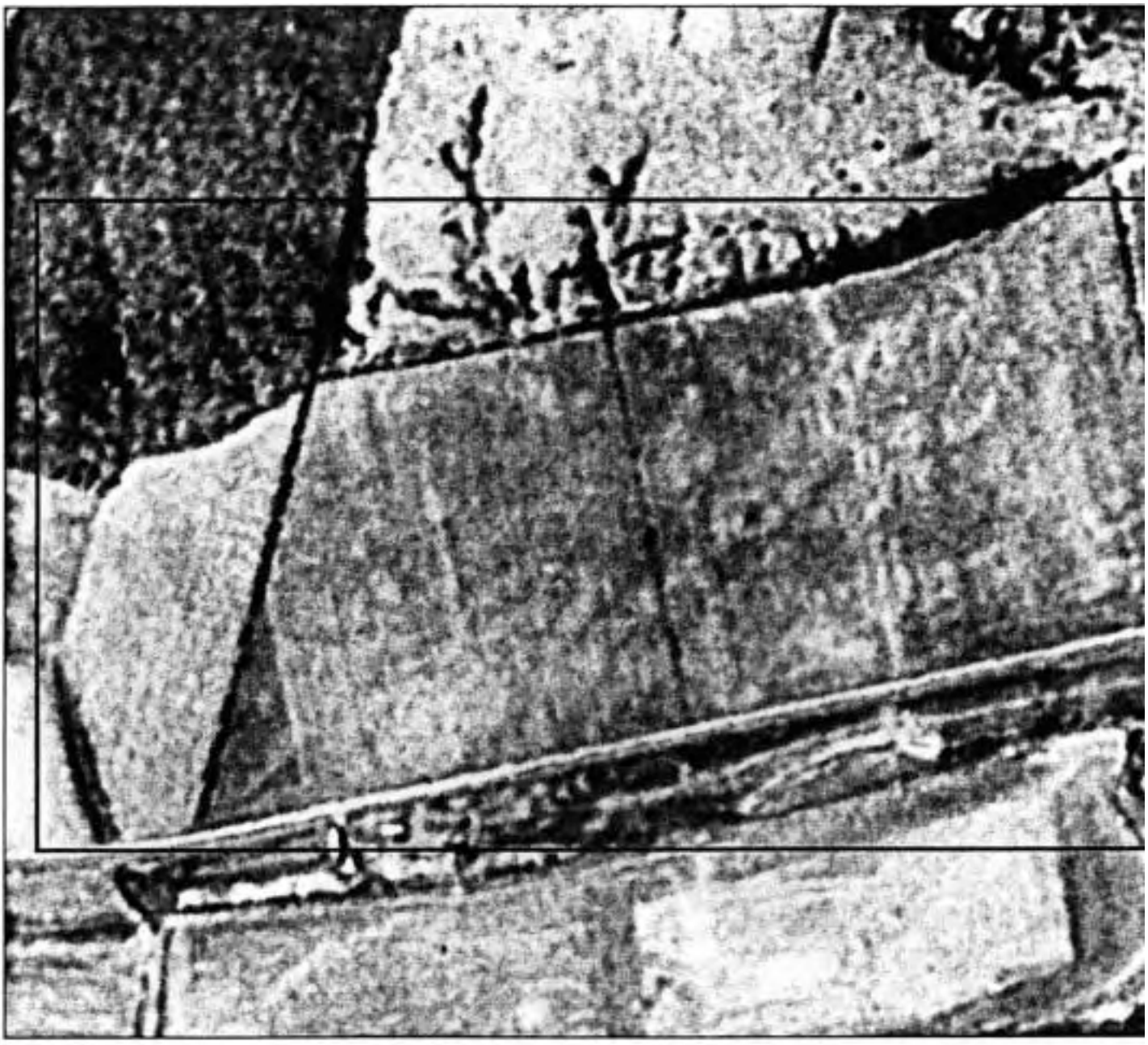
Legend

Wall

Mound

HOPEWELL MOUND GROUP - 1985

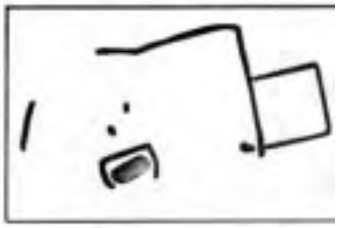
HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Photograph Date: 3/9/85

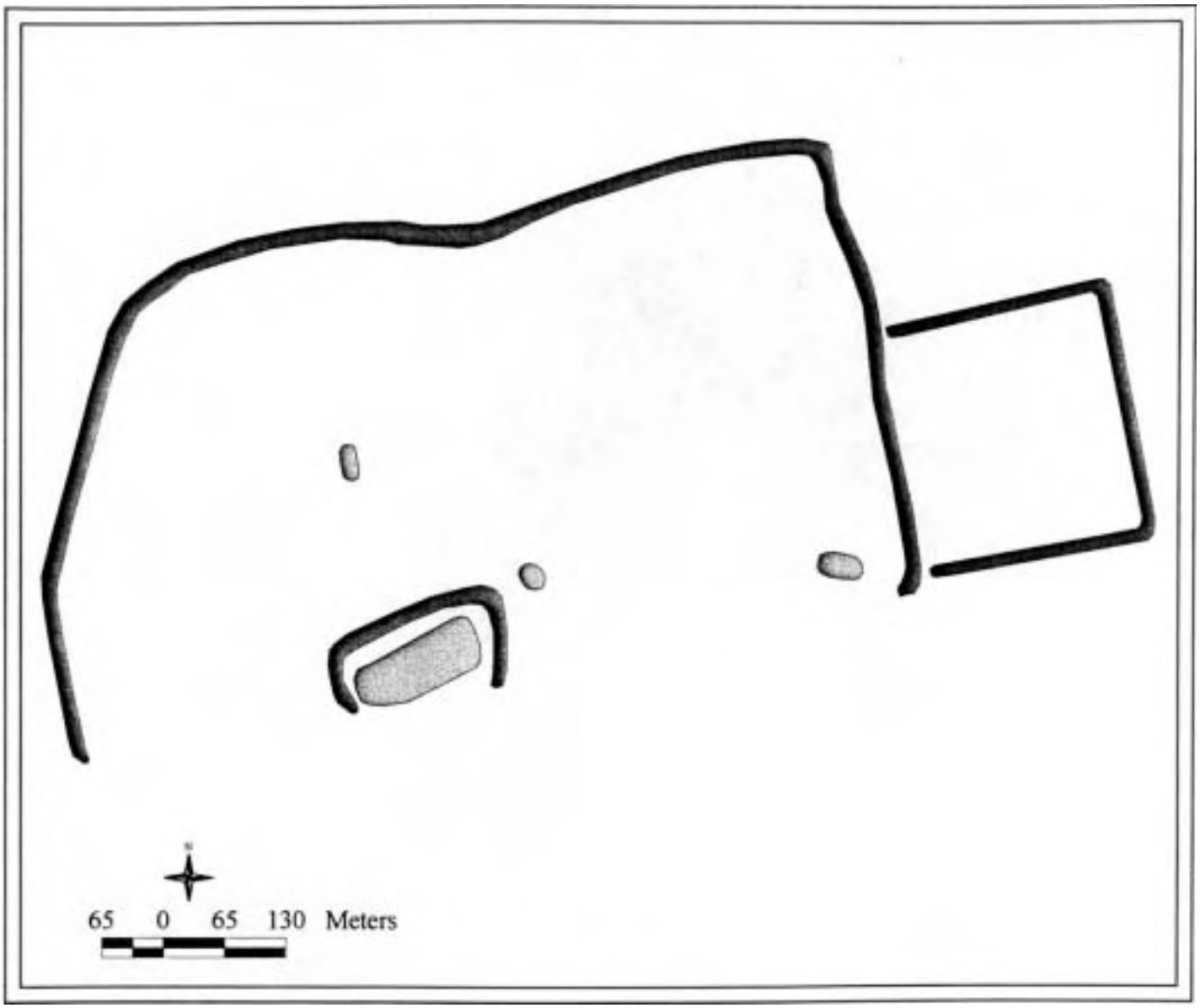
65 0 65 130 Meters

Photointerpreted features



HOPEWELL MOUND GROUP - 1988

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 4/8/88
Aerial photograph

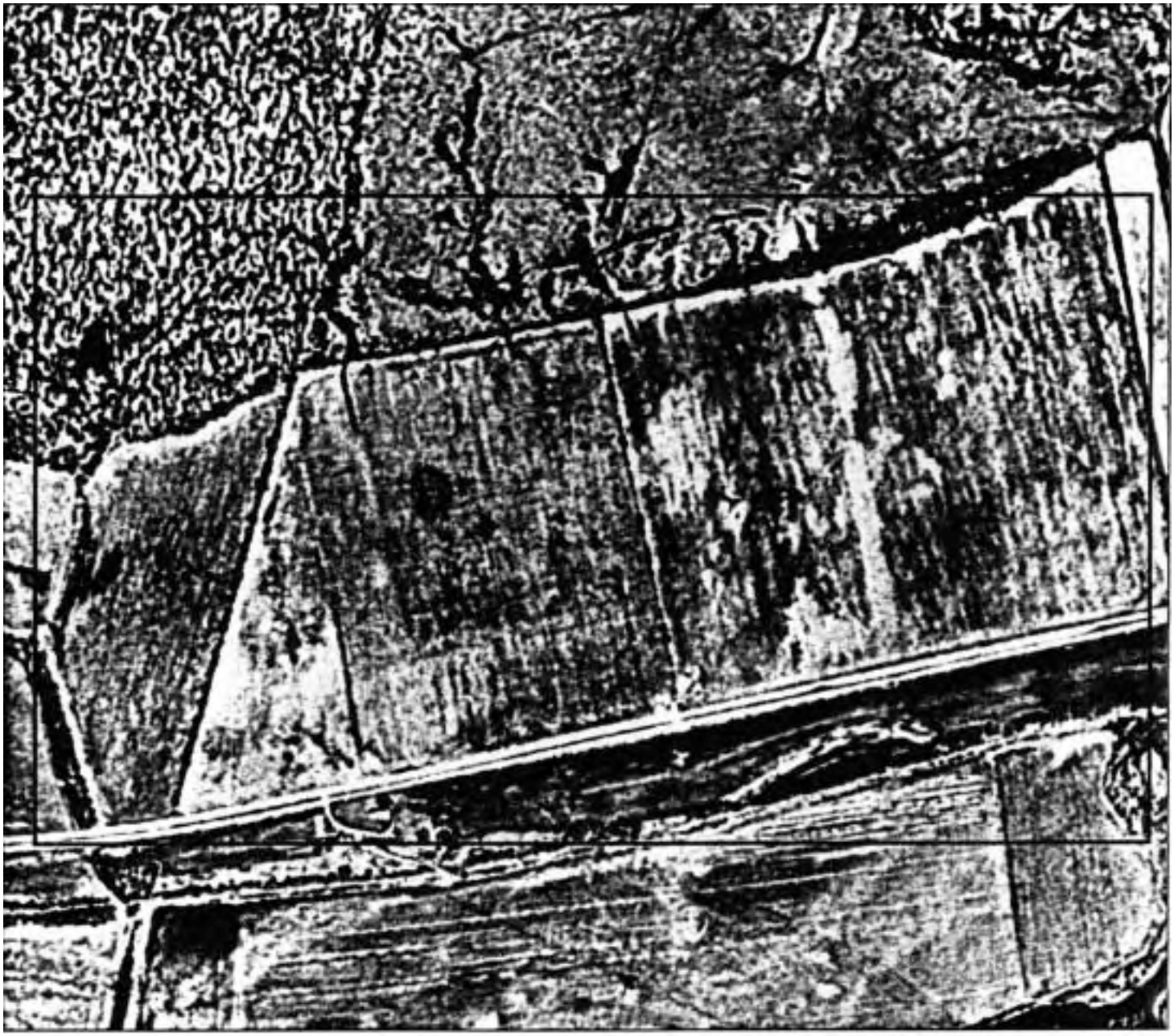
Legend

Wall

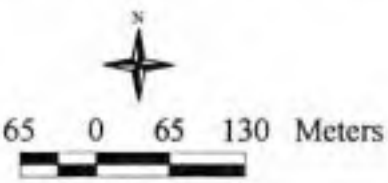
Mound

HOPEWELL MOUND GROUP - 1988

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



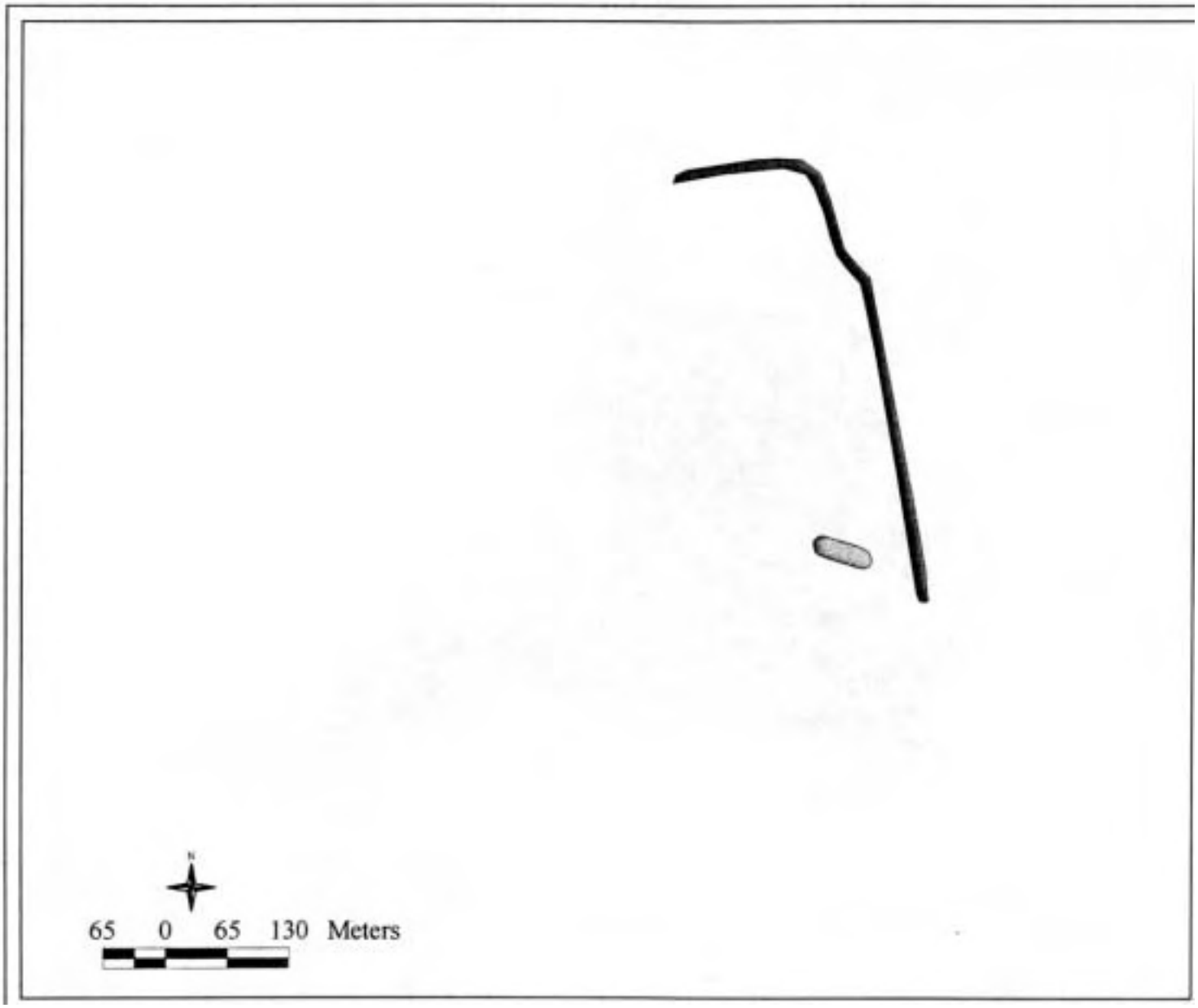
Photograph Date: 4/8/88



Photointerpreted features

HOPEWELL MOUND GROUP - 1994

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 2/1/94
Aerial photograph

Legend

Wall

Mound

HOPETON EARTHWORKS - 1994

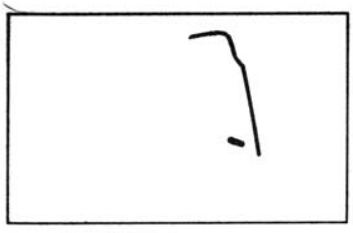
HOPEWELL CULTURE NATIONAL HISTORICAL PARK

Photograph Date: 2/1/94

N

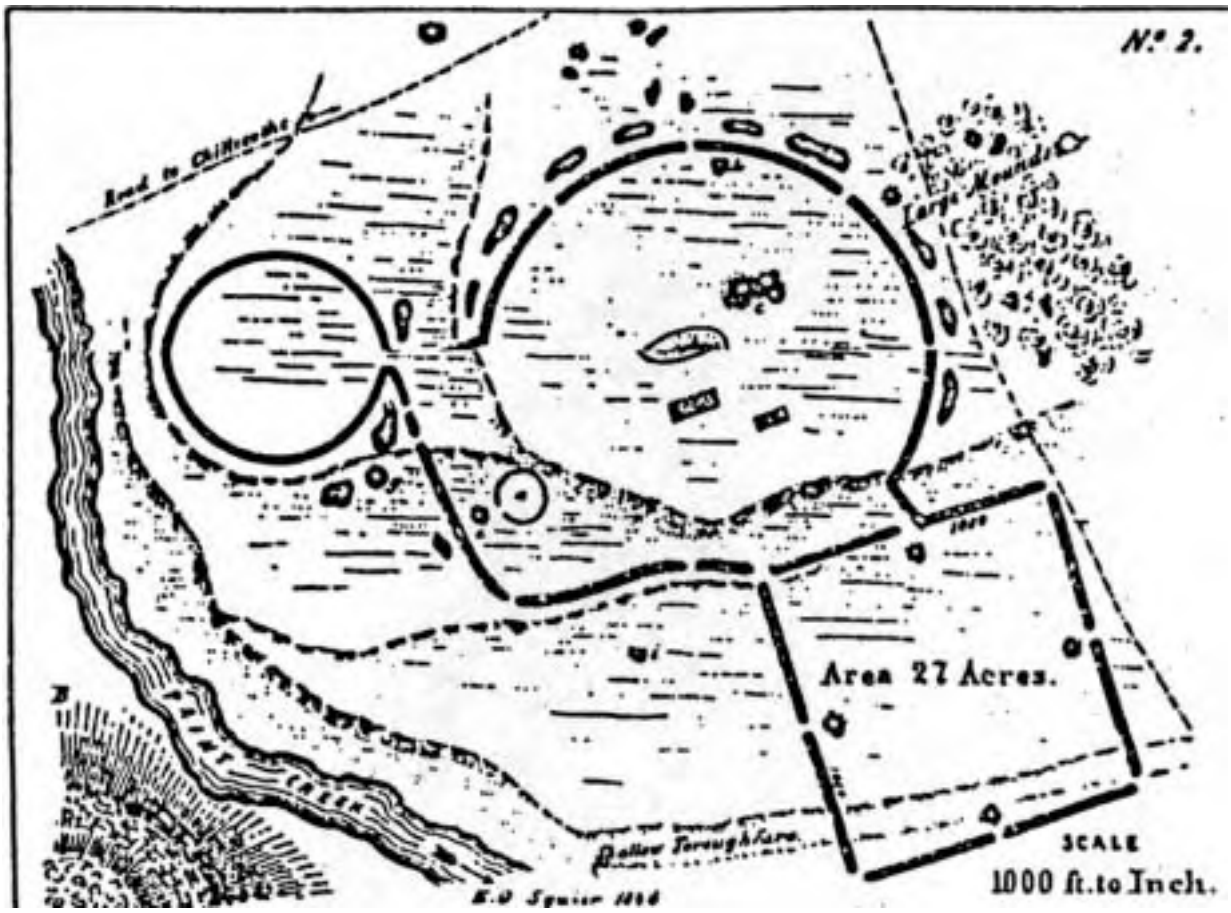
65 0 65 130 Meters

Photointerpreted features



Seip Earthworks

Photo interpretive Maps

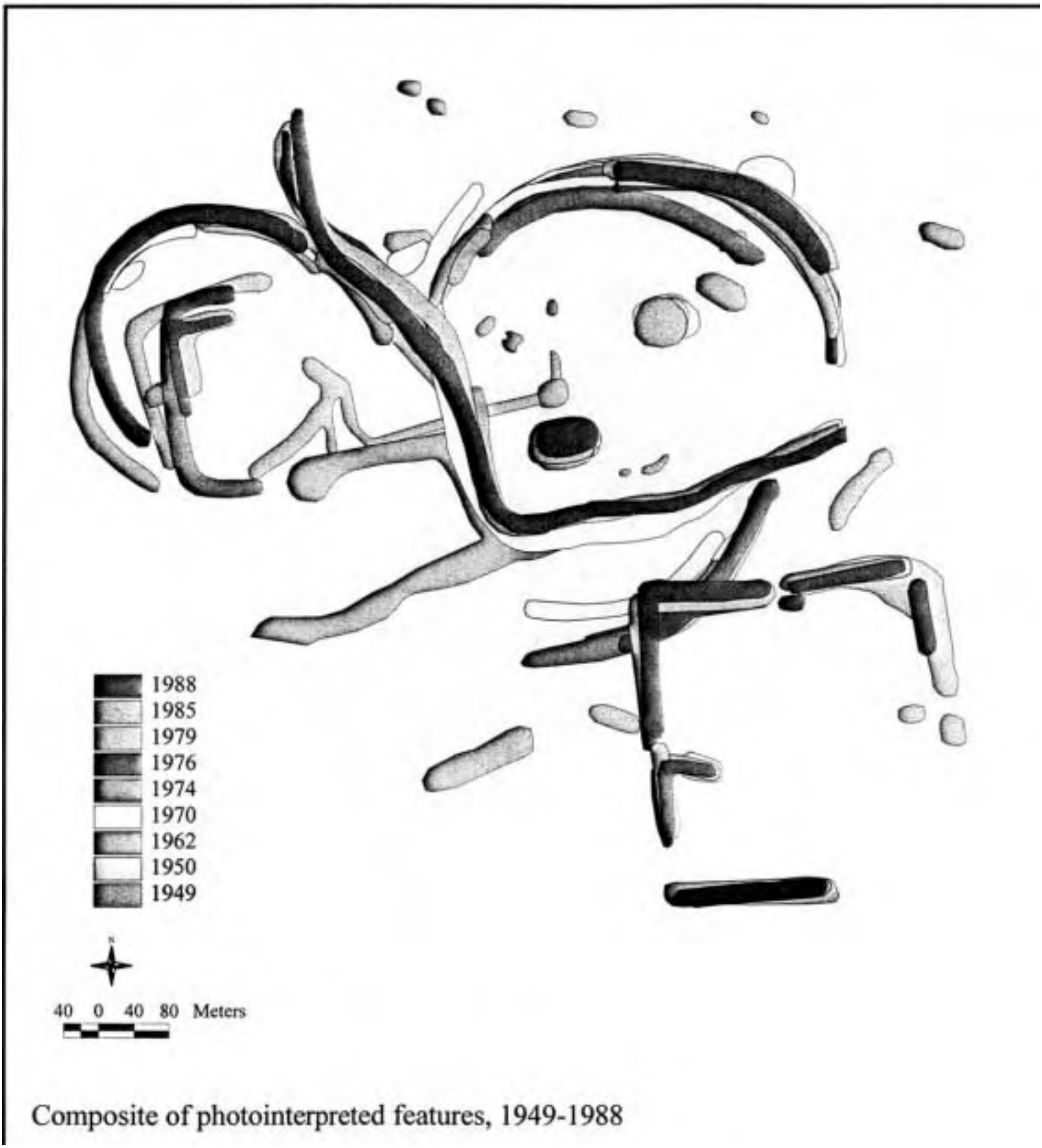


Seip Earthworks

Squi.re and Davis (1848), Plate XXI, No.2

SEIP EARTHWORKS

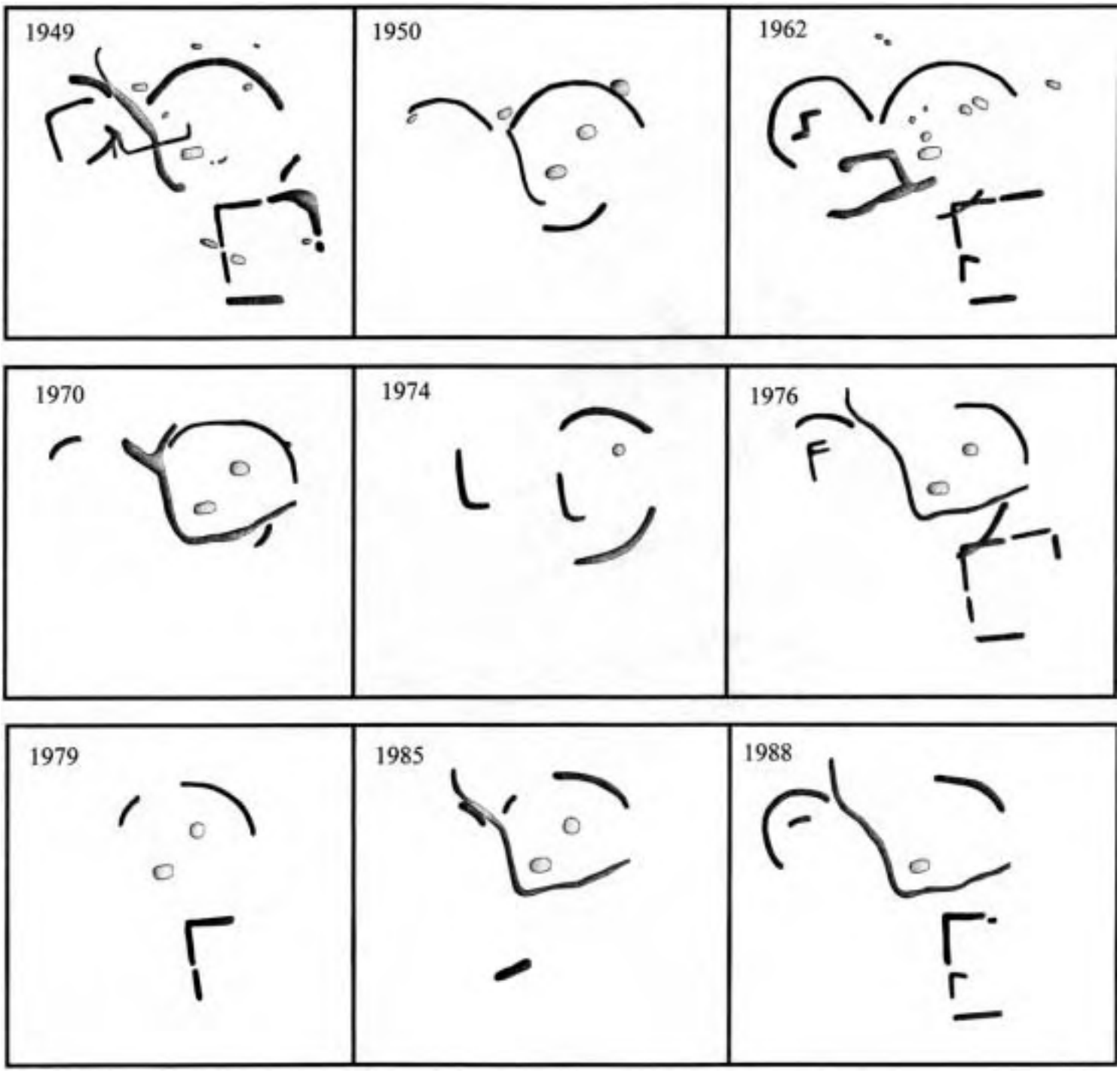
HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Composite of photointerpreted features, 1949-1988

SEIP EARTHWORKS

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

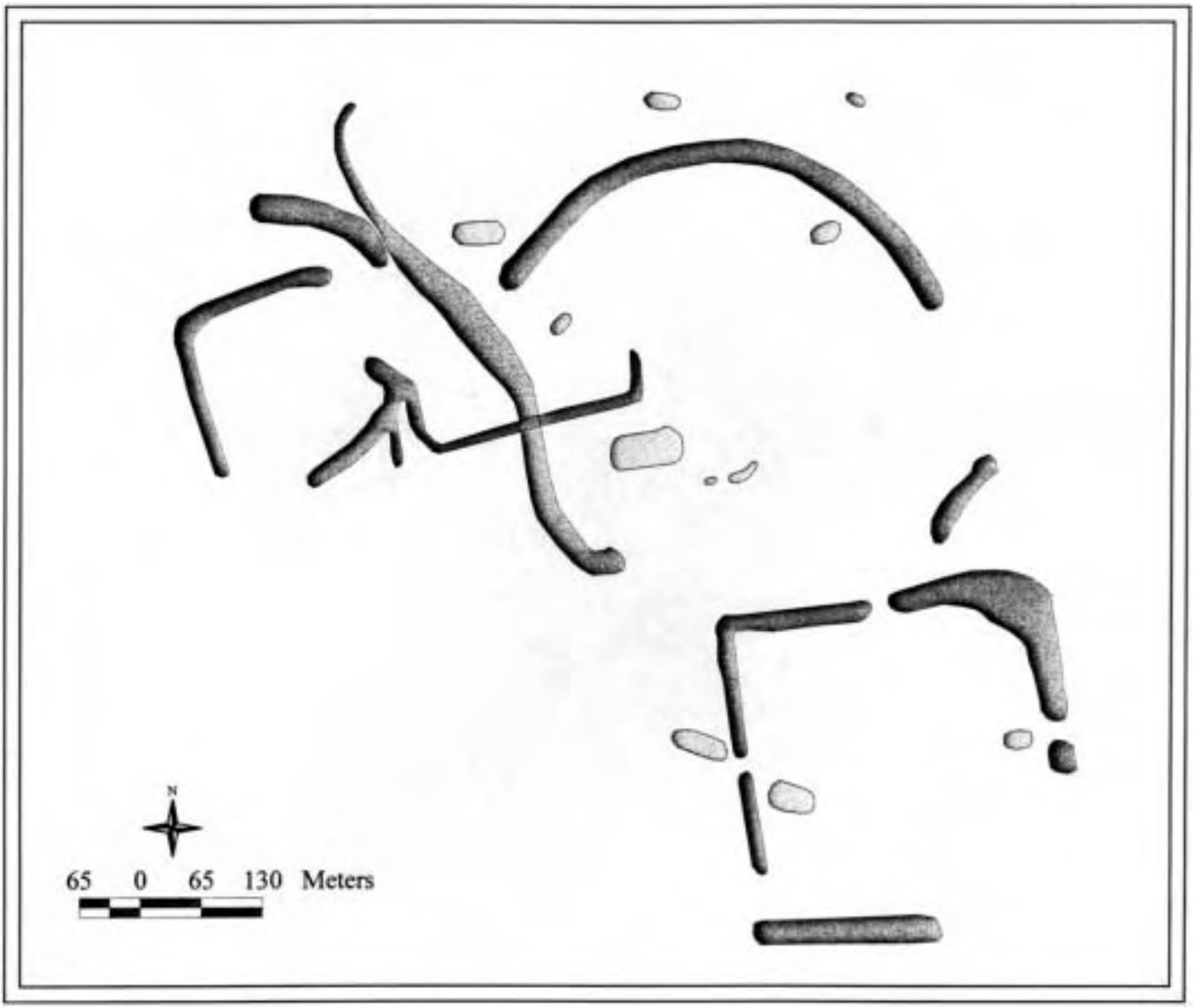


Index of photointerpretations

200 0 200 400 Meters

SEIP EARTHWORKS - 1949

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



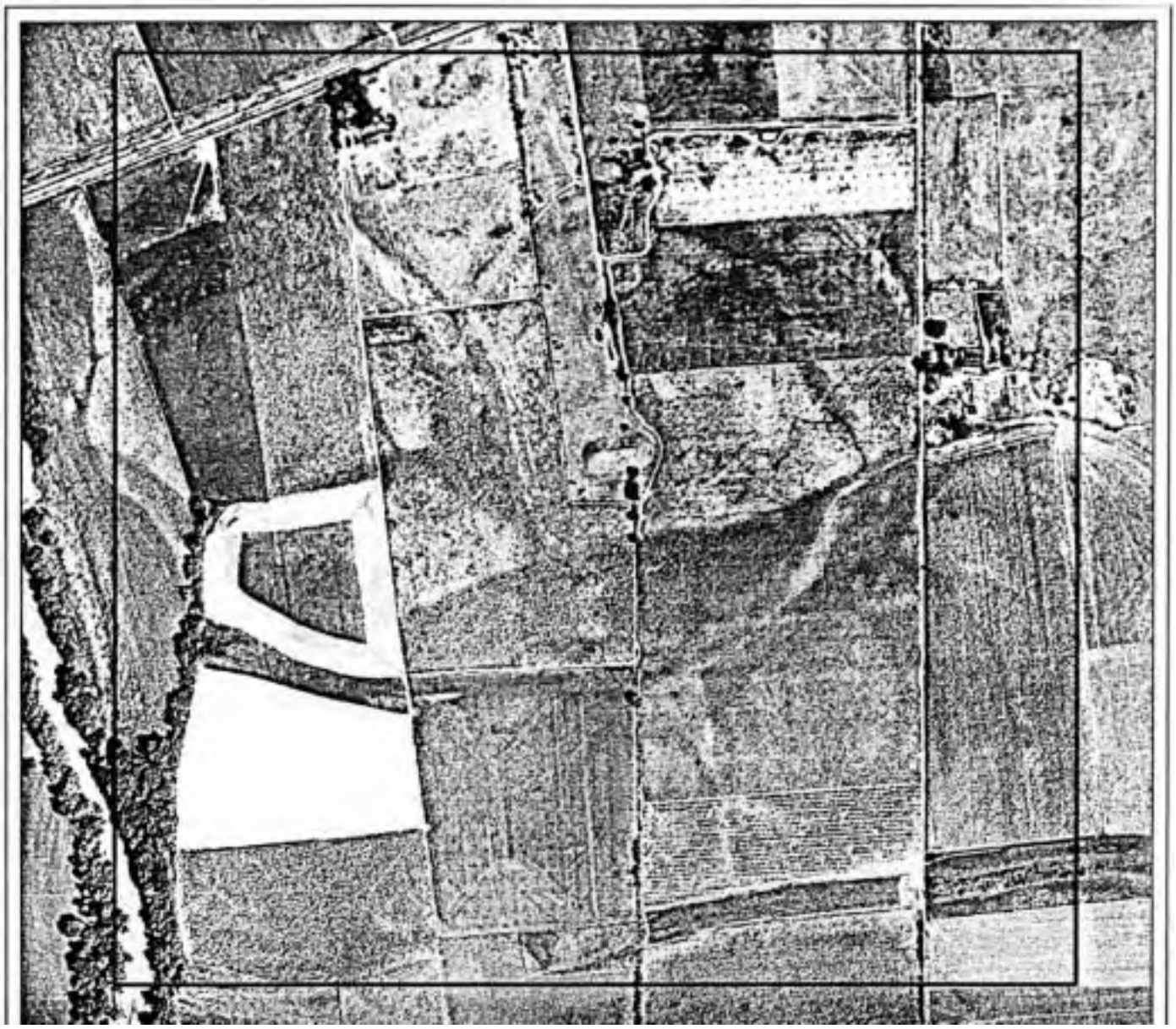
Features photointerpreted from 8/1/49 aerial photograph

Legend

- Mound
- Depression
- Wall

SEIP EARTHWORKS - 1949

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Photograph date: 8/1/49

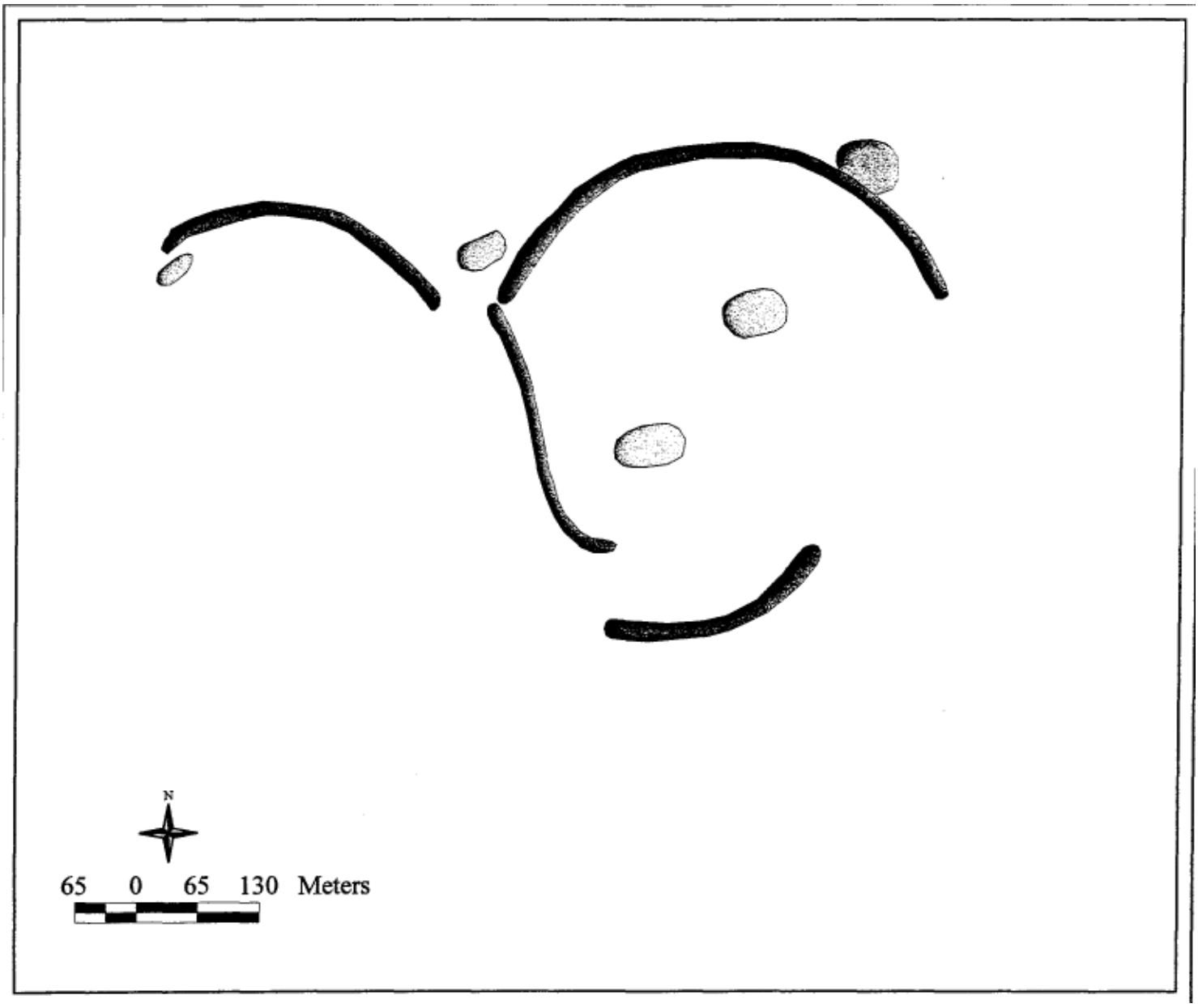
Outlined area indicates extent of Photointerpreted features

Potointerpreted features

65 0 65 130 Meters

SEIP EARTHWORKS - 1950

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



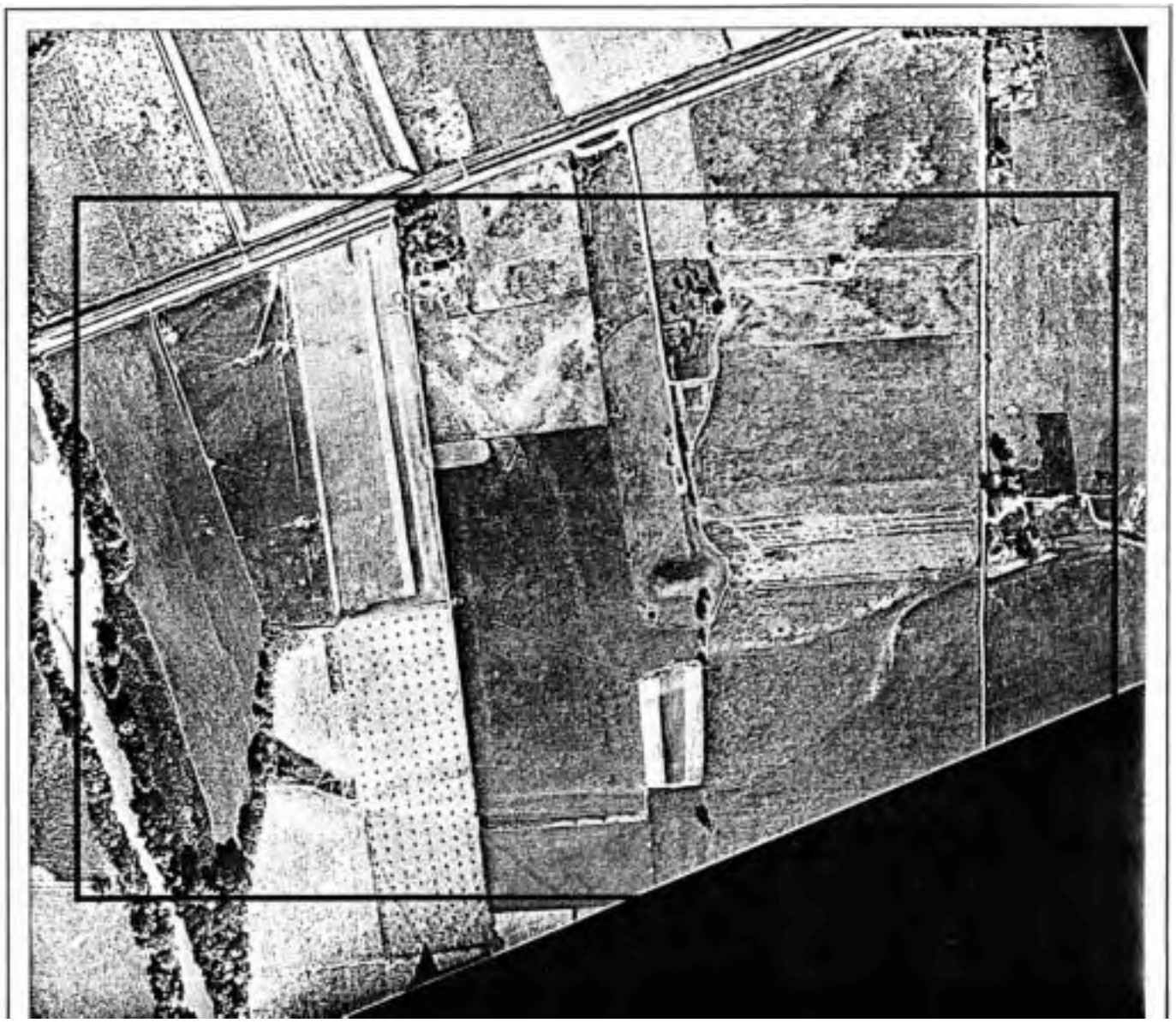
Fetures photointerpreted from 10/1/50
Aerial photograph

Legend

- Mound
- Depression
- Wall

SEIP EARTHWORKS - 1950

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



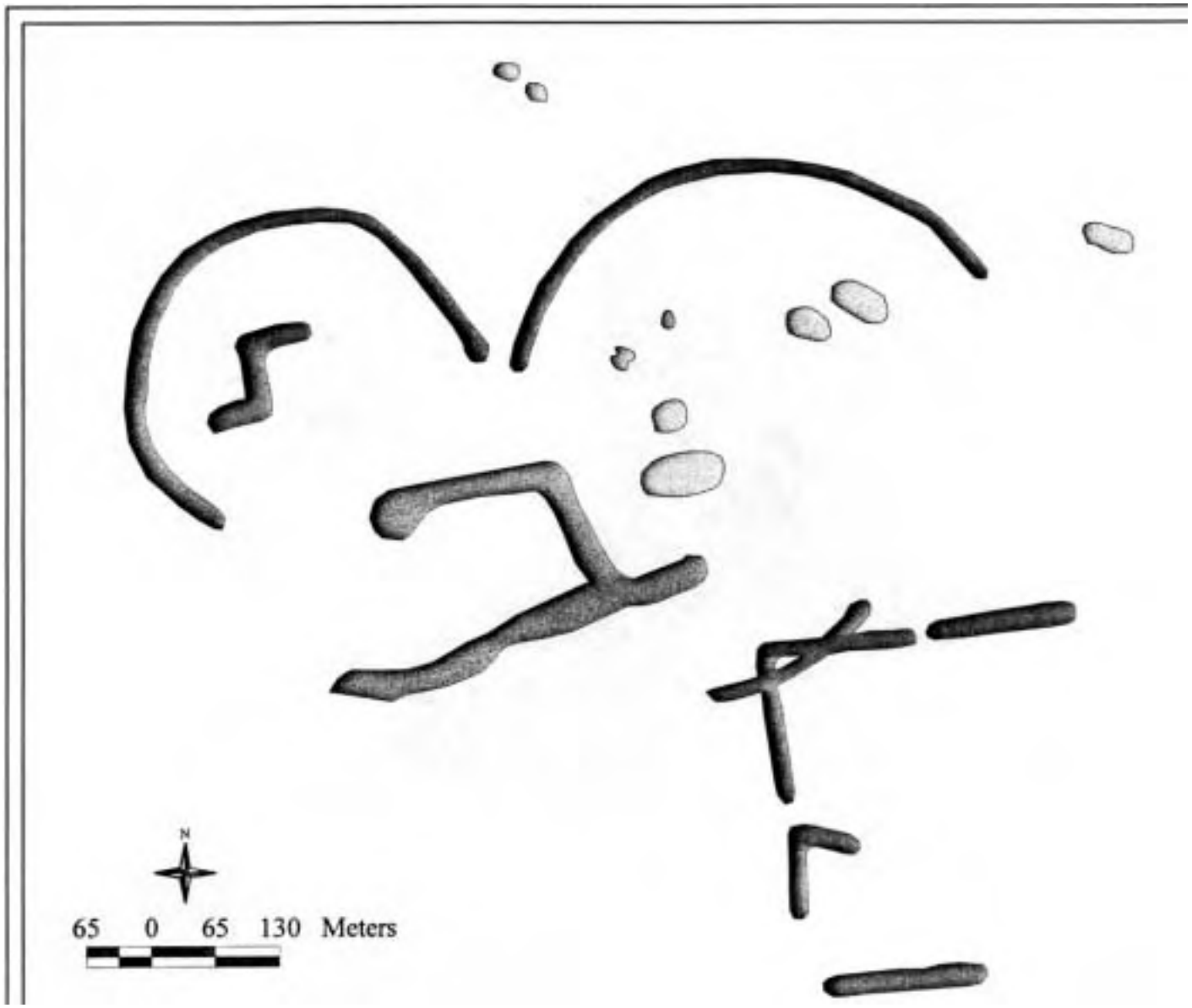
Photograph date: 10/1/50

Outlined area indicates extent of

Photointerpreted features

SEIP EARTHWORKS - 1962

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



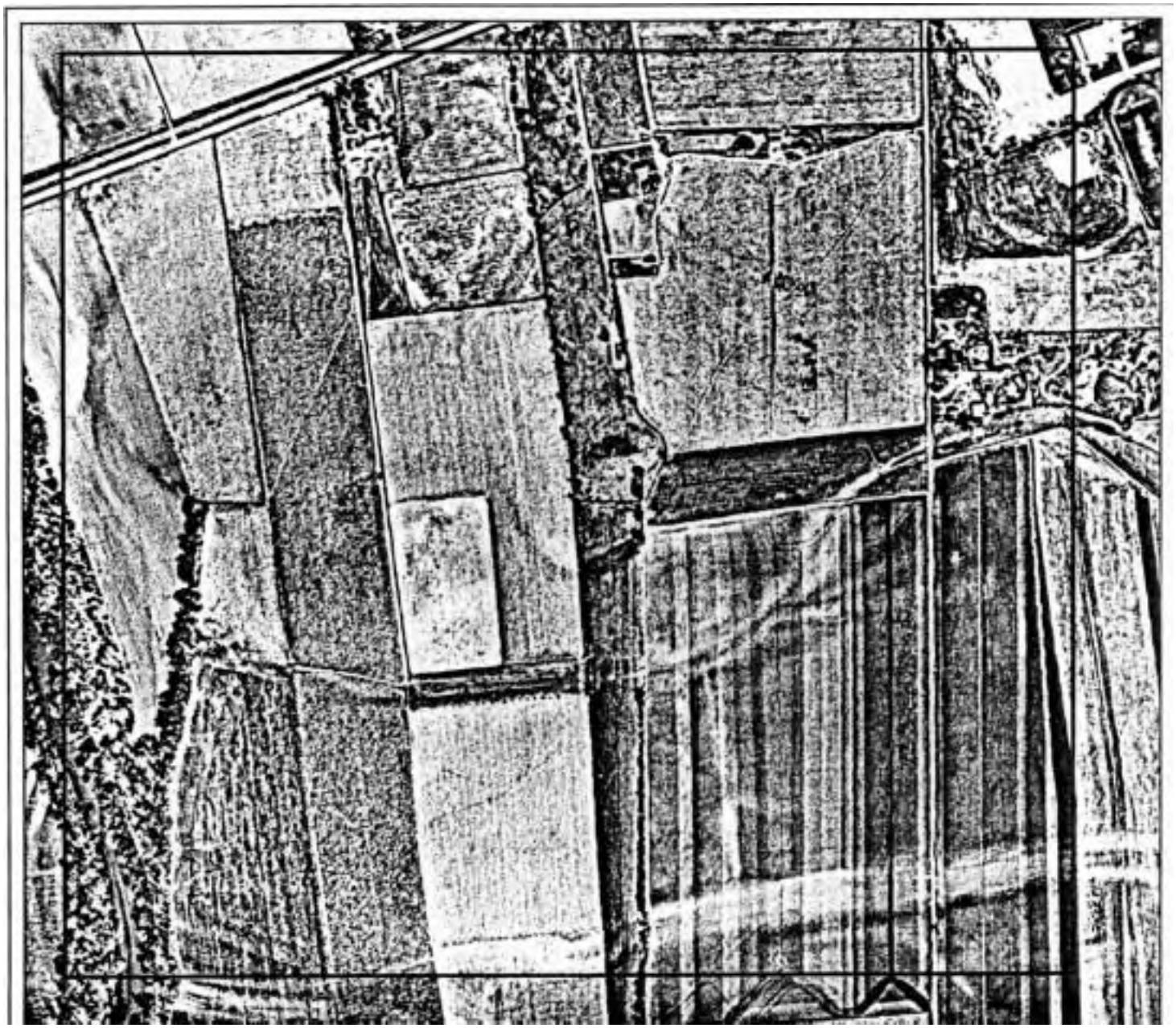
Features photointerpreted from
4/1/62 aerial photograph

Legend

- Mound
- Depression
- Wall

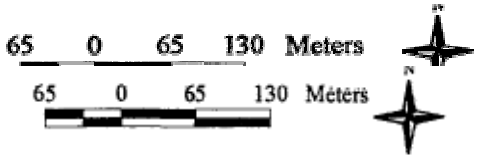
SEIP EARTHWORKS - 1962

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Photograph date: 4/1/62

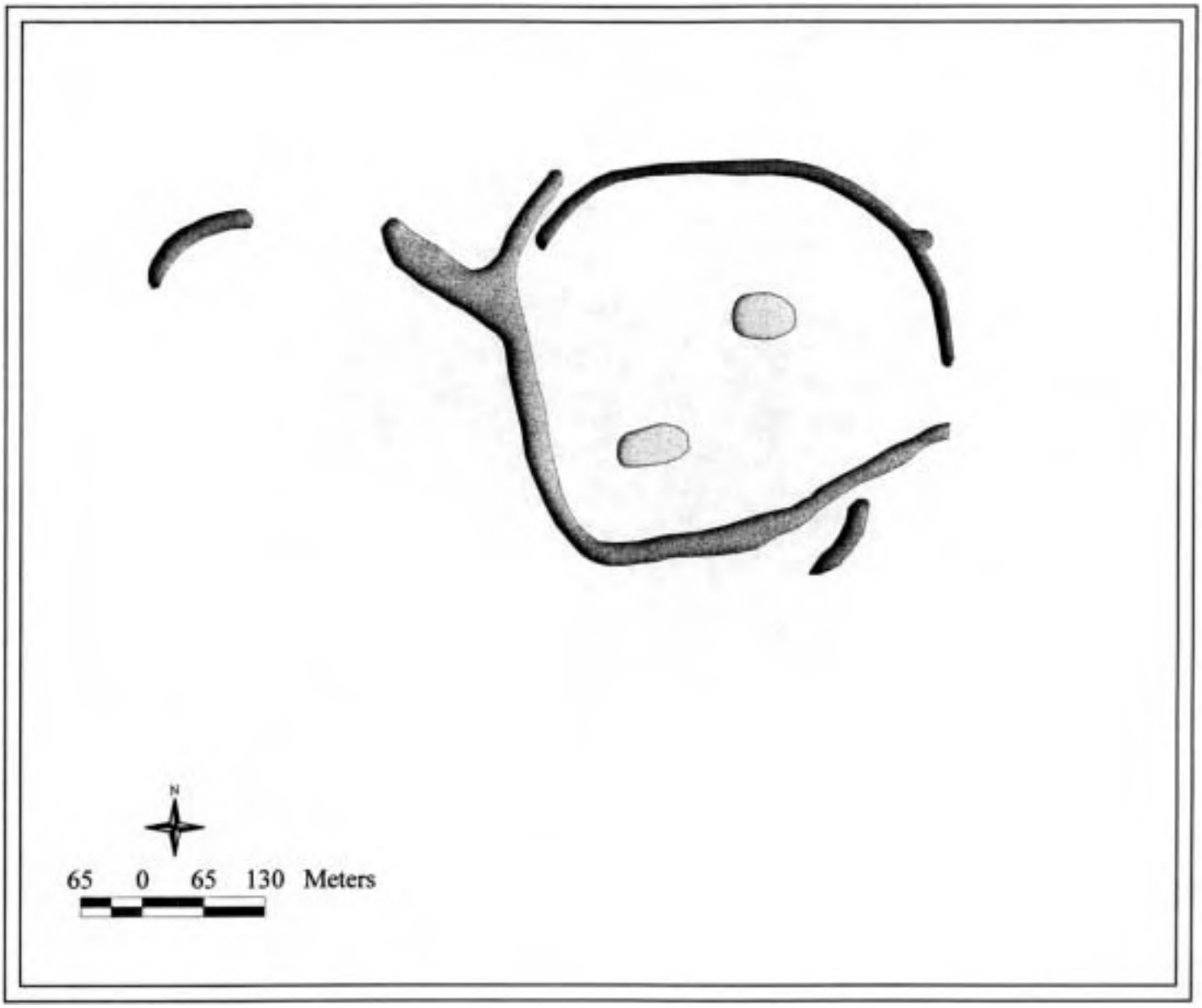
Outlined area indicates extent of
Photointerpreted features



Photointerpreted features

SEIP EARTHWORKS - 1970

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

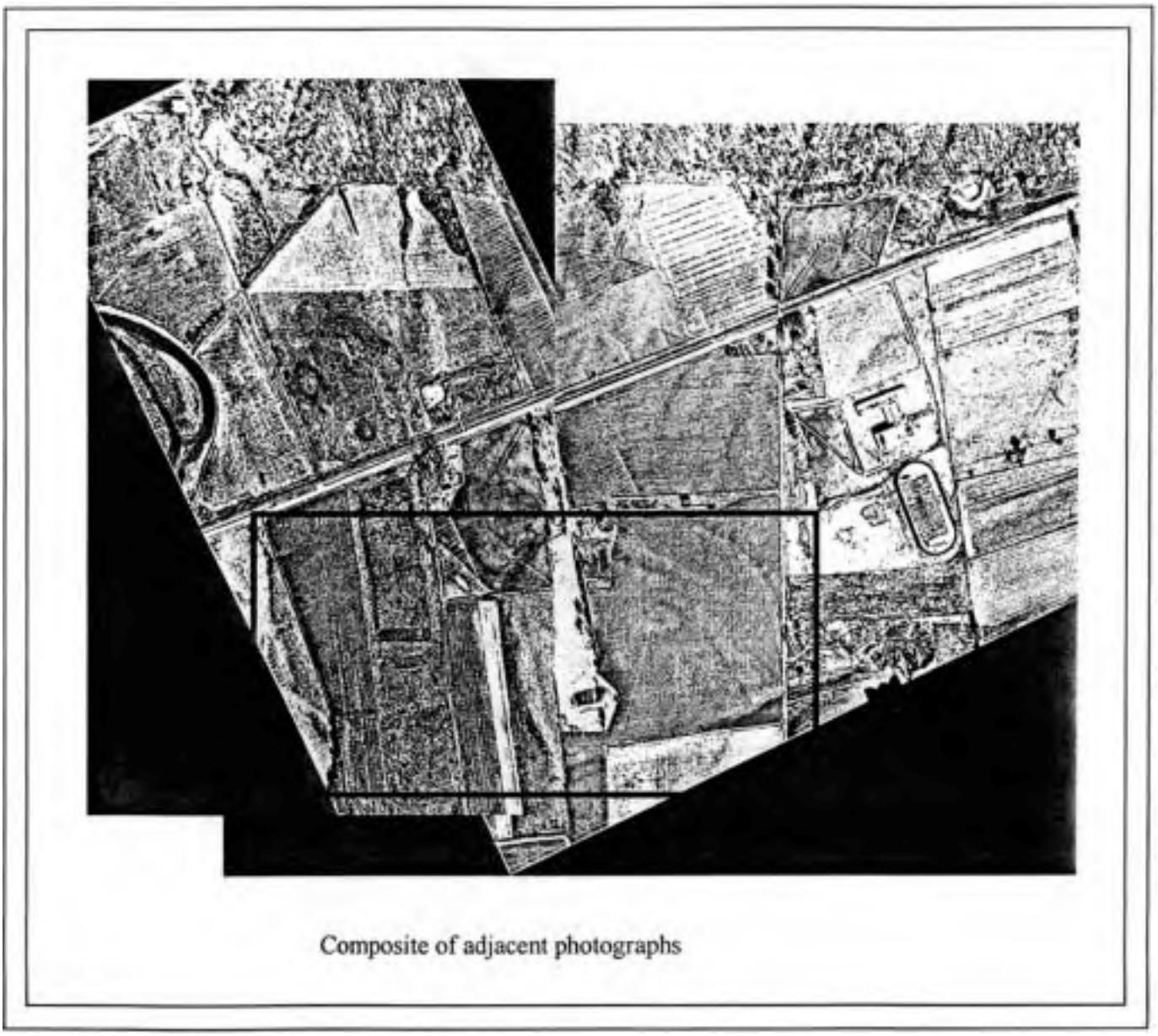


Features photointerpreted from 2/1/70 aerial photograph

Legend

- Mound
- Depression
- Wall

SEIP EARTHWORKS - 1970



Composite of adjacent photographs

Photograph date: 2/1/70

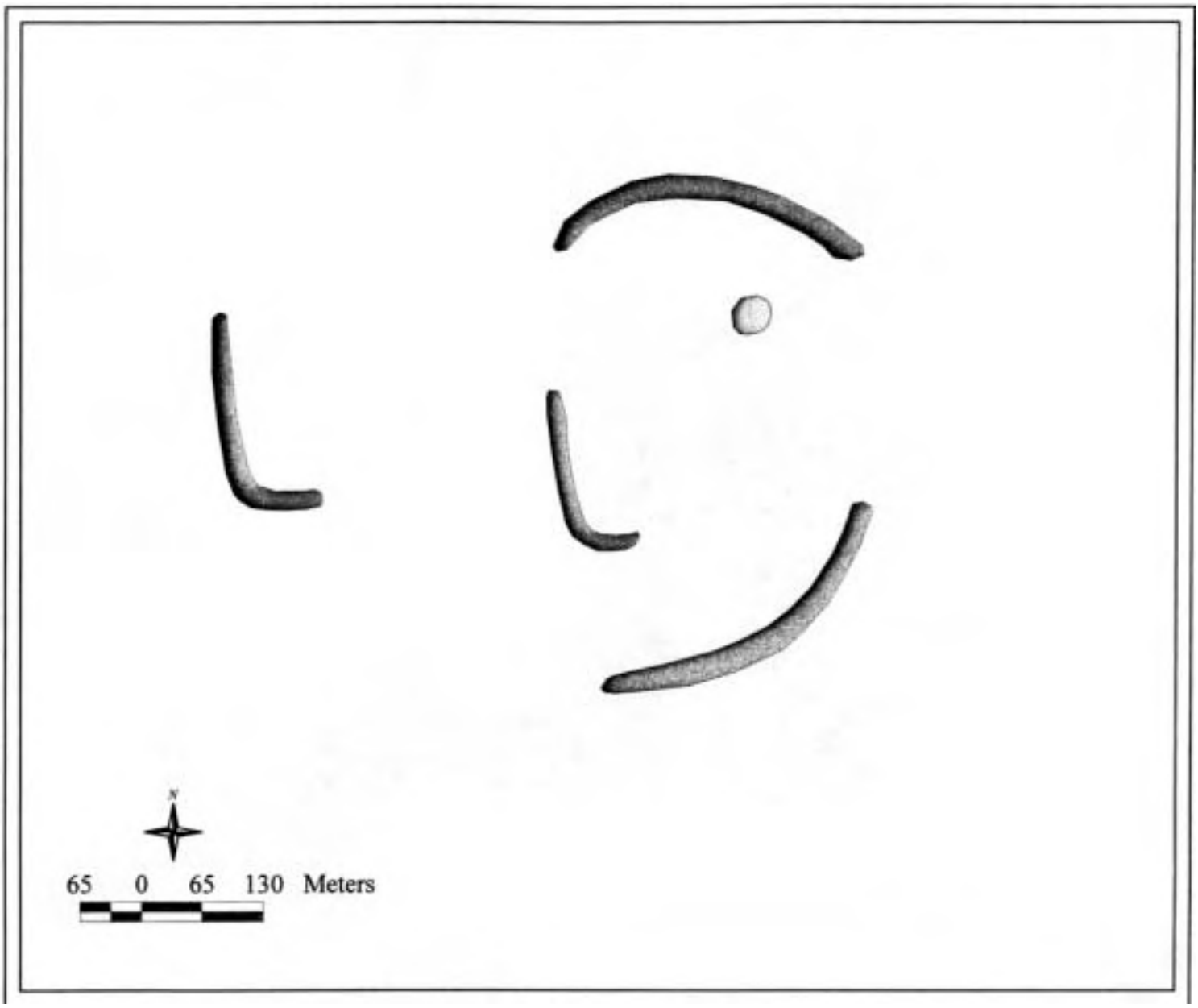
Outlined area indicates extent of photo interpreted features

Photointerpreted features

100 0 100 200 Meters

SEIP EARTHWORKS - 1974

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Features photointerpreted from 5/7/74 aerial photograph

Legend

- Mound
- Depression
- Wall

SEIP EARTHWORKS - 1974

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

Photograph date: 5/7/74

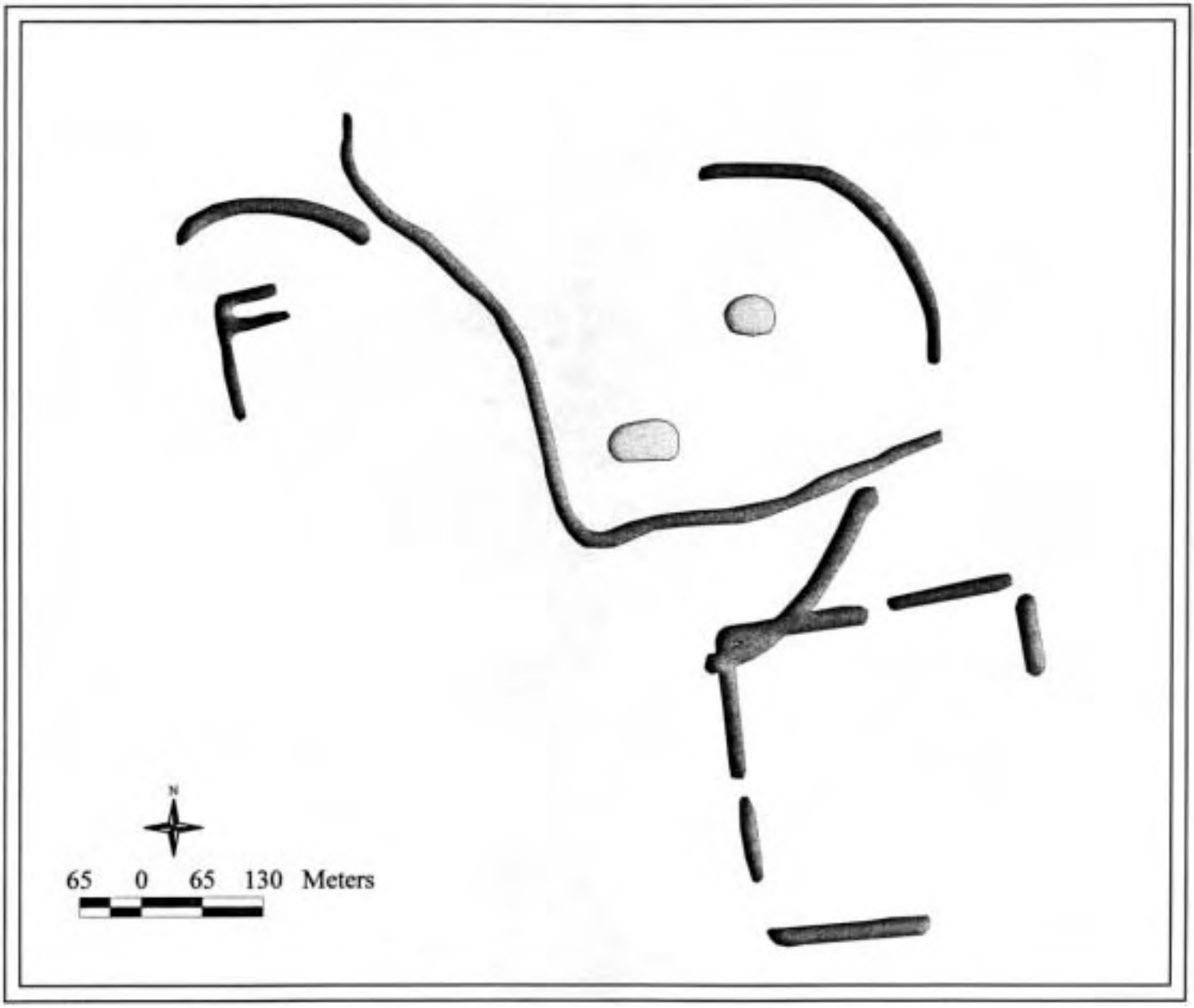
Outlined area indicates extent of photointerpreted features

65 0 65 130 Meters

Photointerpreted features

SEIP EARTHWORKS - 1976

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



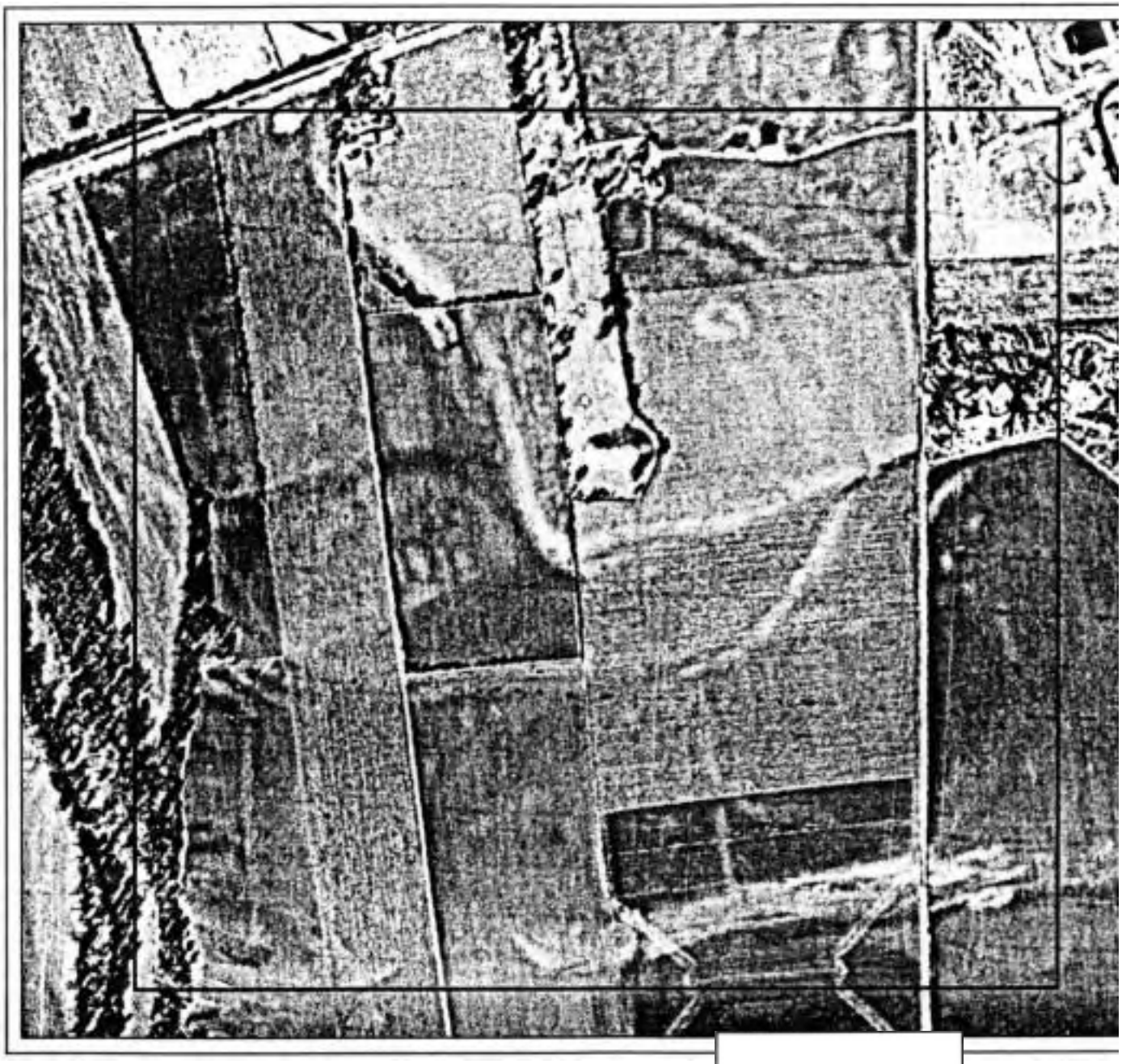
Features photointerpreted from 2/24/76 aerial photograph

Legend

- Mound
- Depression
- Wall

SEIP EARTHWORKS - 1976

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Photograph date: 5/7/74

Outlined area indicates extent of photointerpreted features

Photointerpreted features

65 0 65 130 Meters

N

SEIP EARTHWORKS - 1979

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

Features photointerpreted from 10/30/79
aerial photograph

Legend

Mound

Wall

SEIP EARTHWORKS - 1979

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

Photograph date: 10/30/79

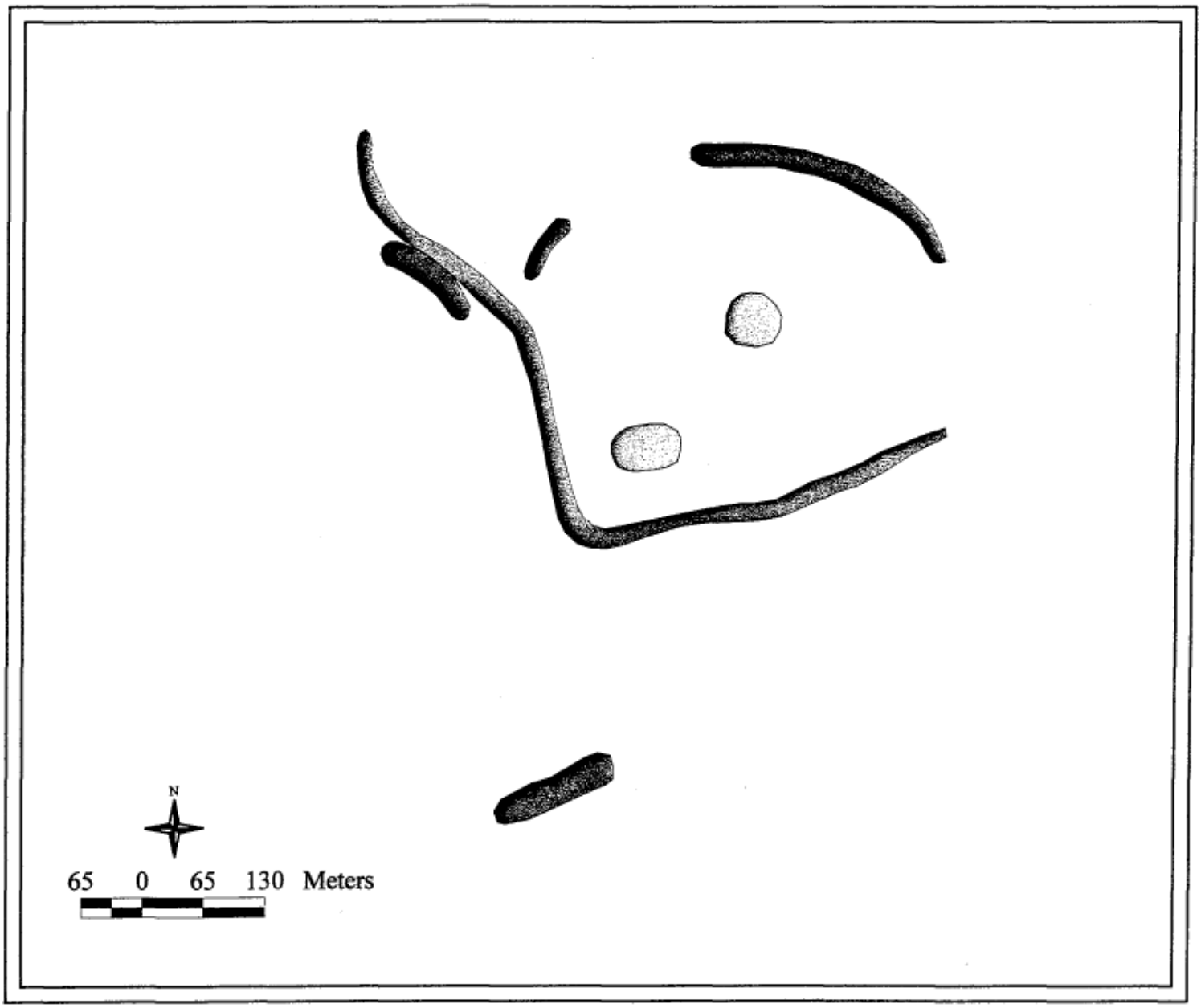
Outlined area indicates extent of photointerpreted features

65 0 65 130 Meters

Photointerpreted FEATURES

SEIP EARTHWORKS - 1985

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



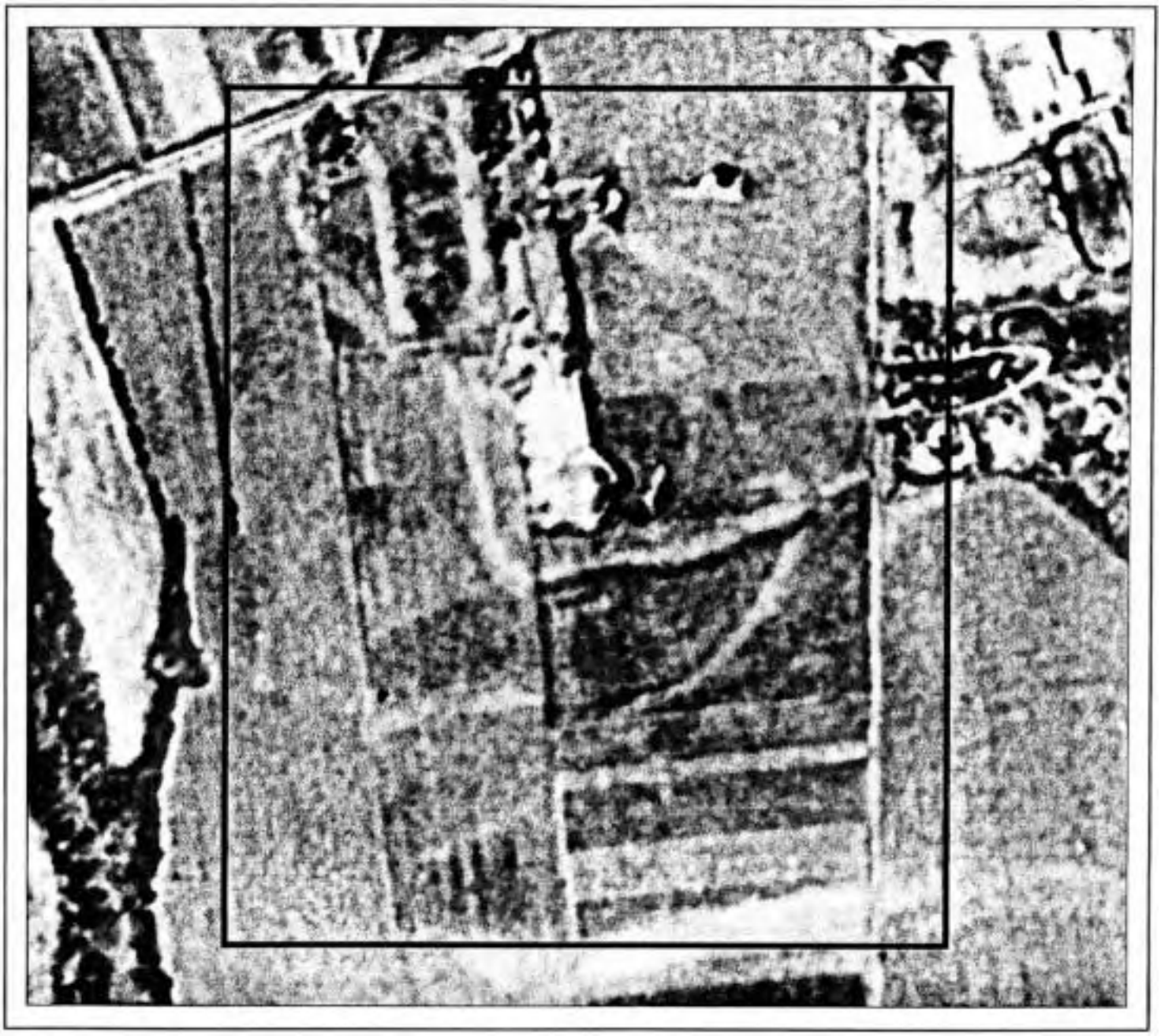
Features photointerpreted from 3/9/85 aerial photograph

Legend

- Mound
- Wall
- Depression

SEIP EARTHWORKS - 1985

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



Photograph date: *3/9/85*

Outlined area indicates extent of photointerpreted features

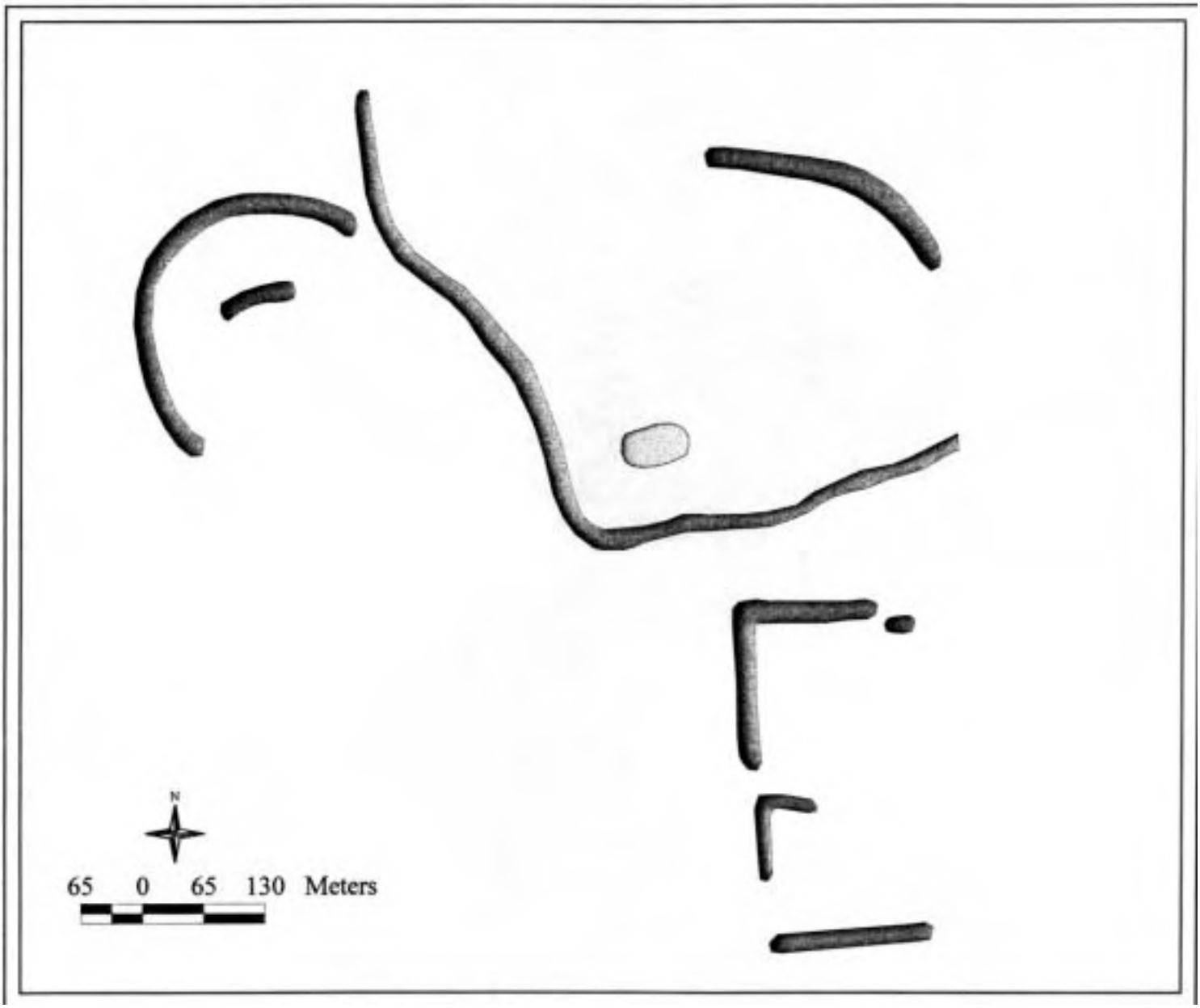
6 65 0 65 130 Meters

N

Photointerpreted features

SEIP EARTHWORKS - 1988

HOPEWELL CULTURE NATIONAL HISTORICAL PARK



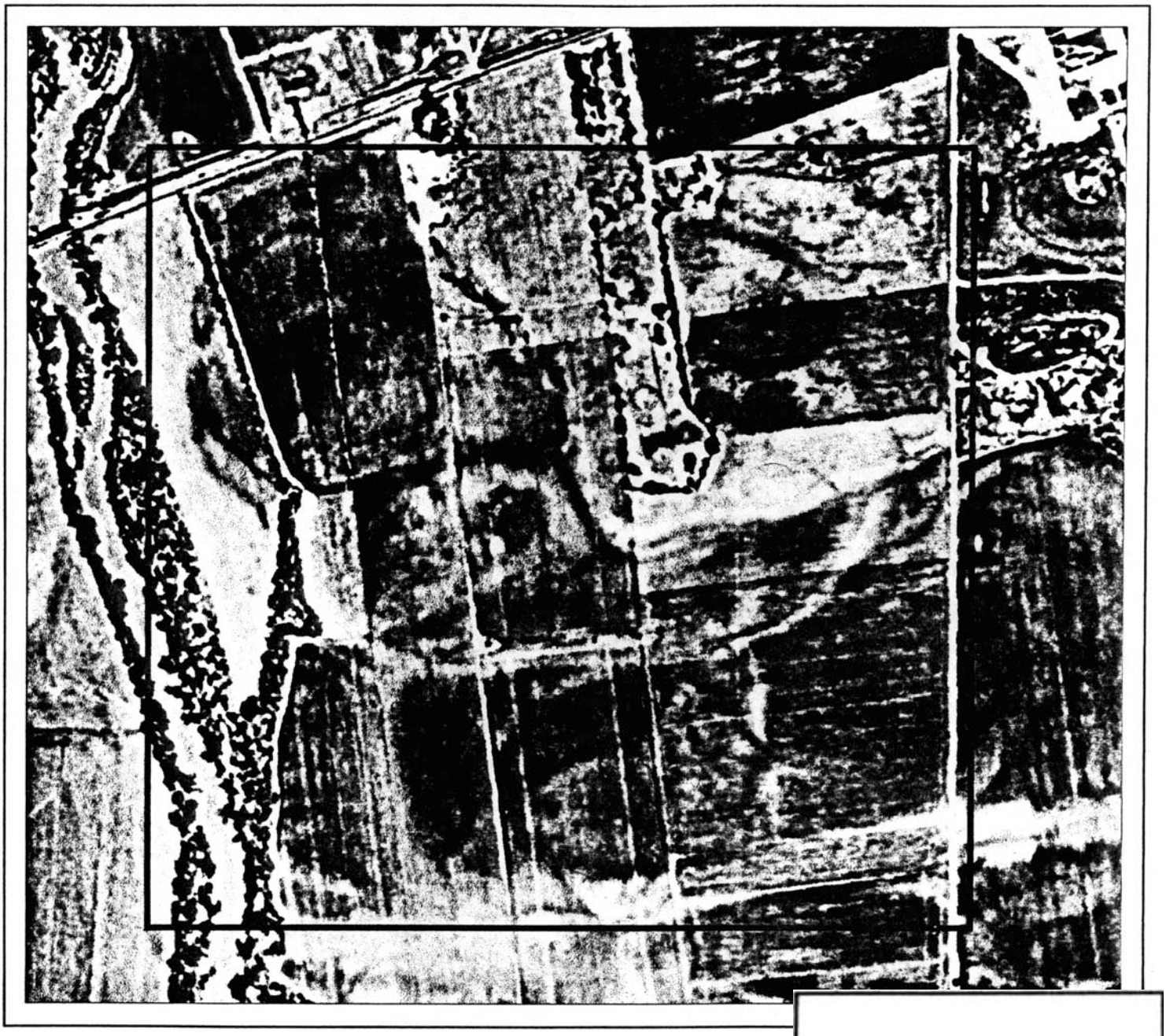
Features photointerpreted from 4/8/88 aerial photograph

Legend

- Mound
- Wall
- Depression

SEIP EARTHWORKS - 1988

HOPEWELL CULTURE NATIONAL HISTORICAL PARK

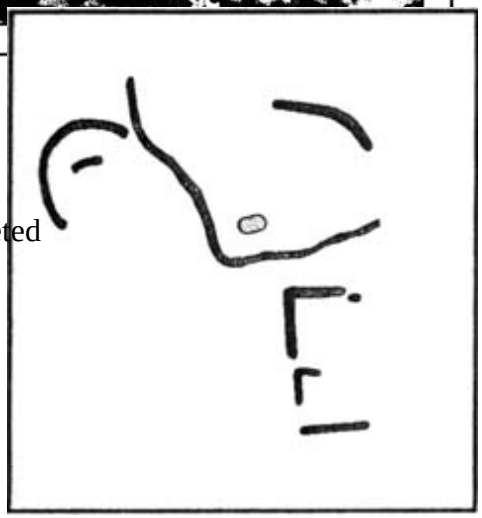


Photograph date: *4/4/88*

Outlined area indicates extent of photointerpreted features

65 0 65 130 Meters

N



Photointerpreted features

Photograph date: 418/88

Outlined area indicates extent
of photointerpreted features

Photointerpreted
features