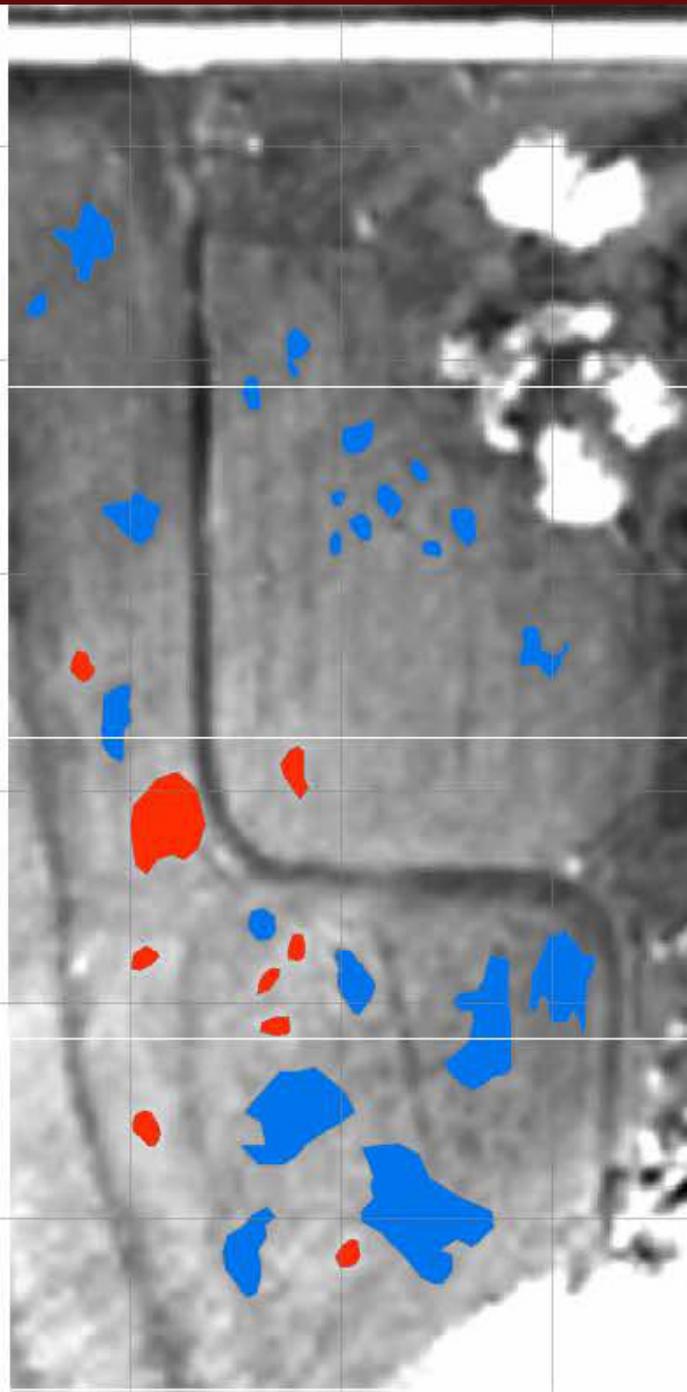
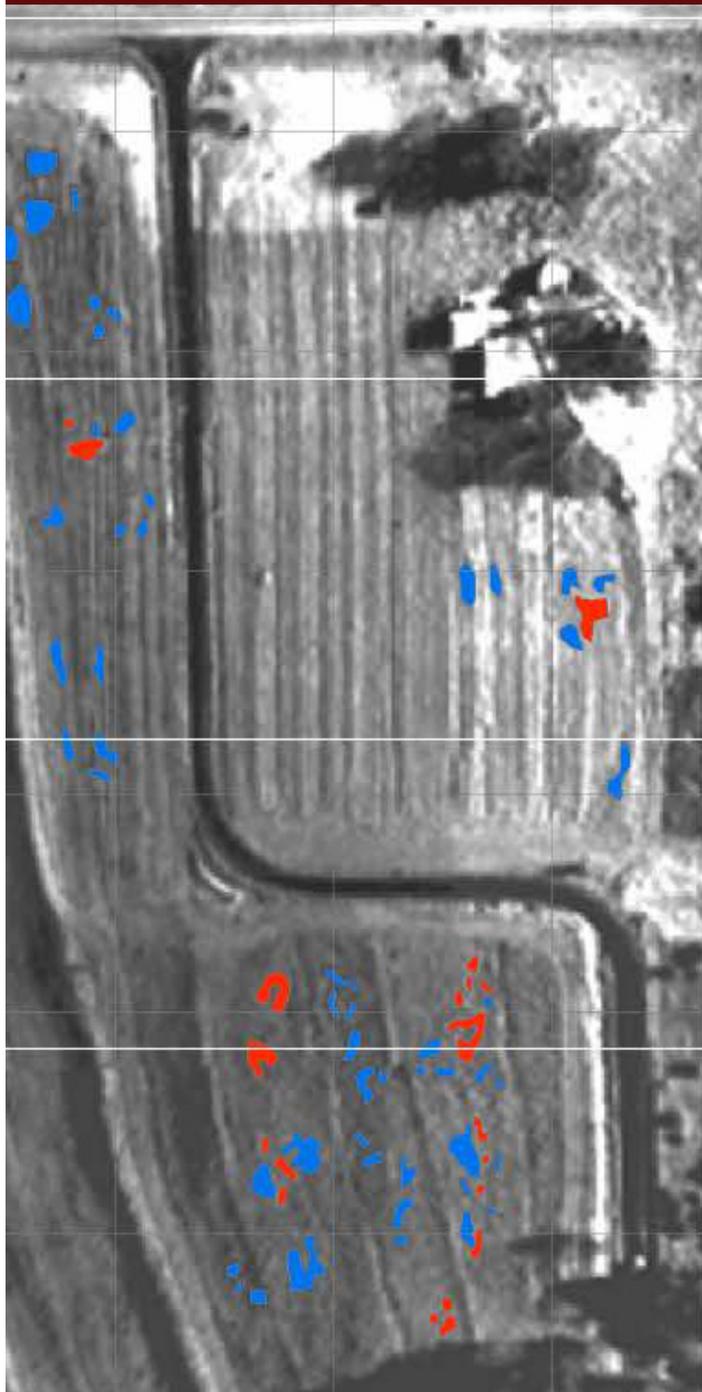




# Aerial Thermal Survey of New Philadelphia, Illinois Town Site | 2009-03

University of Illinois



National Park Service  
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**Narrative Final Report  
NCPTT 2007 Grants**

**Aerial Thermal Survey of New Philadelphia, Illinois Town Site  
Grant No. MT-2210-07-NC-02  
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## Executive Summary

New Philadelphia, Illinois was the first town platted and legally registered by an African American in the United States. Founded by Frank McWorter, a former slave, in 1836, this town grew as a demographically integrated community through the late nineteenth century. New Philadelphia was platted in a grid pattern with 42 acres of space, divided into 20 blocks, 144 lots, alleyways, and several streets. The town population reached a peak of approximately 160 people, 29 households, and merchant and crafts operations listed in the 1865 federal census. New Philadelphia was bypassed by a new railroad in 1869 and the population declined steadily thereafter. By 1885, the status of the community as a town was eliminated and large tracts of the land were put into agricultural use. Today, no structures from the town remain above ground, and the town site is covered by prairie grasses and agricultural fields.

The National Center for Preservation Technology and Training (NCPTT) awarded funding of \$14,800 to test the usefulness of low-altitude aerial surveys employing high resolution thermal imaging at New Philadelphia. This method was employed at the town site in 2008 for a new and specific purpose: determining whether this technology can detect the grid pattern of an historic town site buried beneath 1-2 feet of agricultural fields and prairie grasses. The success of this technique will provide an extremely useful resource for applications on numerous similar sites throughout the nation.

Dr. Tommy Hailey of Northwestern State University in Natchitoches, Louisiana, and Mr. Bryan Haley of the University of Mississippi, have pioneered the techniques used in combination in this survey, and they collected and processed the survey data utilizing a powered parachute ultralight aircraft and a high resolution thermal camera. The data sets were geo-referenced and integrated using spatial mapping programs, such as Geographic Information Systems software, and the creation of mosaic imaging representations. The survey results were then examined in relation to a geo-referenced version of the 1836 town plan and other comparative data. Dr. Christopher Fennell of the University of Illinois at Urbana-Champaign served as principal investigator and provided overall coordination of the project. Overall, the survey technique proved successful for identifying probable sub-surface locations of buried foundation remains within the 42-acre town site.

## Introduction

New Philadelphia, Illinois was the first town platted and legally registered by an African American in the United States. Founded by Frank McWorter, a former slave, in 1836, this town grew as a demographically integrated community through the late nineteenth century. New Philadelphia was platted on undeveloped prairie in a grid pattern with 42 acres of space, divided into 20 blocks, 144 lots, alleyways, and several streets (Figure 1). The town population reached a peak of approximately 160 people, 29 households, and merchant and crafts operations listed in the 1865 federal census. New Philadelphia was bypassed by a new railroad in 1869 and the population declined steadily thereafter. By 1885, the status of the community as a town was eliminated and large tracts of the land were put into agricultural use. Today, no structures from the town remain above ground, and the town site is covered by prairie grasses and agricultural fields.



*Figure 1. 1998 high-altitude photograph of New Philadelphia town site, with overlay of 1836 plat (U.S.G.S. archives, overlay by C. Fennell).*

The National Park System Landmarks Committee confirmed the national historic importance of the town site of New Philadelphia, on October 29, 2008. The Landmarks Committee voted unanimously to recommend the property for National Historic Landmark (NHL) status to the National Park System Advisory Board. In turn, the Advisory Board reviewed the nomination on December 3, 2008, and recommended its approval to the Secretary of the Interior, who holds final authority to make the designation. Listed among more than 83,000 historic properties on the National Register of Historic Places in 2005, New Philadelphia, upon final approval by the Secretary of the Interior, will join the elite group of approximately 2,500 historic sites deemed to be *exceptionally* significant to our country's history. The historic town site qualifies for NHL status for its high degree of archaeological integrity and the potential it holds to provide scientific information of major importance (King 2008; Gaumer and Quimby 2006; U.S. Department of the Interior 1998, 1999). This nomination received official support from U.S. Senators Barack Obama and Richard Durbin; U.S. Representatives Ray LaHood and John Shimkus; Illinois Senators Deanna Demuzio, Emil Jones, Jr., and John Sullivan; and Illinois Representative Jil Tracy, among others. Upon final approval by the Secretary of the Interior later this year, the New Philadelphia town site will be formally designated as a *National Historic Landmark* with significant archaeological resources.

Federal and state census records, tax records, and deeds from the nineteenth century provide extensive data about New Philadelphia's past residents. However, such historical documents do not provide a specific spatial map of household and merchant locations. Archaeological survey and excavations can map those locations in much greater detail to provide a richer data set for the social history of this community. The 1836 plat provides a plan for the town, including a grid pattern of streets, alleys, and lots, but the question remains as to whether this design was followed as the town developed. Indeed, nineteenth-century newspaper reports during the town's existence indicated that town residents did not adhere to planned property lines in their building activities. Limited archaeological excavations at the town site, funded by the National Science Foundation's program of Research Experiences for Undergraduates, have also uncovered early structures for which documentary evidence from deeds and other historical records provided no indications.

A number of archaeological survey and prospection methods have been employed previously at the New Philadelphia town site by collaborating researchers. These survey

methods have included a pedestrian survey and surface collection of a large portion of the town site. Dr. Michael Hargrave, of the Construction Engineering Research Laboratory and U.S Army Engineer Research and Development Center in Champaign, Illinois, has also conducted 6.5 acres of surface-based geophysical surveys at the town site utilizing electric resistivity and magnetic gradient sensors (Hargrave 2006). Due to the large size of New Philadelphia as platted, it is not practical to attempt surface-based geophysical surveys of the entire town site.

The National Center for Preservation Technology and Training (NCPTT) awarded funding of \$14,800 to test the usefulness of low-altitude aerial surveys employing high resolution thermal imaging at New Philadelphia. This method was employed at the town site in May 2008 for a new and specific purpose: determining whether this technology can detect the grid pattern and structural remains of an historic town site buried beneath 1-2 feet of agricultural fields and prairie grasses. If successful, this technique will provide an extremely useful resource for applications on numerous similar sites throughout the nation.

Dr. Tommy Hailey of Northwestern State University in Natchitoches, Louisiana, and Mr. Bryan Haley of the University of Mississippi, have pioneered the techniques used in combination in this survey, and they collected and processed the survey data utilizing a powered parachute ultralight aircraft and a high resolution thermal camera. The data sets were geo-referenced and integrated using spatial mapping programs, such as Geographic Information Systems software, and the creation of mosaic imaging representations. The survey results were also examined in relation to a geo-referenced version of the 1836 town plan and other comparative data. Dr. Christopher Fennell of the University of Illinois at Urbana-Champaign served as principal investigator and provided overall coordination of the project.

Additional information about the New Philadelphia Archaeology Project is available on the internet at <http://www.anthro.uiuc.edu/faculty/cfennell/NP/> (Fennell 2008a). The following discussion of this survey project and its results is provided by Bryan Haley's report entitled "An Investigation of New Philadelphia Using Thermal Infrared Remote Sensing," available online at <http://www.anthro.uiuc.edu/faculty/cfennell/NP/2008ReportMenu.html> (Haley 2008).

## **Methods and Materials**

A thermal infrared survey of the New Philadelphia town site was conducted in May 2008. A Destiny 2000 Powered Parachute (PPC), piloted by Dr. Tommy Hailey, was used as a platform for an Agema 570 thermal infrared camera for the survey, operated by Bryan Haley. The goal was to identify anomalies that might be related to the historic occupation of the town.

### ***Thermal Infrared Methodology***

A target is discernible in thermal infrared data only if the physical properties of the materials differ enough to produce a contrast. These properties include conductivity ( $k$ ) and volumetric specific heat ( $C_v$ ), which is the amount of heat stored per volume over a given period of time (Perisset and Tabbagh 1981:170). Using  $k$  and  $C_v$ , a single property called thermal inertia ( $P$ ) can be expressed as  $P = \text{the square root of } (k C_v)$  (Perisset and Tabbagh 1981:170). The higher the thermal inertia, the more resistant the material is to changing temperature. For soils, thermal inertia increases with the amount of moisture because the conductivity increases.

The real utility of an archaeological prospection technique is in delineating buried targets. For thermal infrared, the properties of a superficial layer covering a feature and the surrounding matrix are critical. A thermal anomaly is attenuated as either the conductivity or the depth increases. Therefore, wet soils and deep features are not ideal. The maximum target depth that can be detected diurnally is probably around 40 centimeters (Ben-Dor et al 1999:124). Long term studies may be able to reveal targets as deep as 2 meters in some cases (Nash 1985:77), but the data is very difficult to collect.

The thermal behavior of a material over time is dynamic. For short term studies, the diurnal heating cycle creates the most important temperature changes. The best time for maximum anomaly contrast is just after sunrise or just after sunset, although the exact time is difficult to predict. The anomaly amplitude will also be inverted between these times (Ben-Dor et al. 1999:118).

One other important consideration is the ground cover on the survey area when the data is acquired. Bare earth is desirable and it has yielded relatively subtle, prehistoric Native American features (Haley 2004). Thermal infrared has been used infrequently on vegetation-covered sites,

although recent research (Kiesow 2005) suggests that it may be used to enhance crop marks on Roman villa sites.

### ***Survey Area Description***

The ground cover varied considerably at the New Philadelphia site during the time of the flyovers. A small area, just to the east of the turnoff to the road into the site, was mowed to a height of a two inches or less. The ground in this area also appeared to be affected by cars repeatedly parking there. To the west of the road into the site, the grass was mowed recently, but it had grown up taller than the first area. Tracks caused by mowers were also visible there. The rest of area was in tall grass, mostly between one and three feet in height. To the east of the main site core, town blocks were staked out and they were highlighted with types of grass. In other areas, mostly to the northwest and southeast of the site core, shrubs and trees were present. To the west, terraces were visible and it was apparent a considerable amount of soil modification had taken place. There was water pooling around some of these features. In short, the ground cover conditions were not optimal for thermal infrared survey.

### ***Research Design***

The Destiny 2000 Powered Parachute (PPC) is a two-seat experimental aircraft that is ideal for archaeological reconnaissance. The PPC is a low speed, minimal vibration, and flexible altitude aircraft – all essentials for the acquisition of high quality images (Hailey 2005:74). Also, the two seat configuration allows for passenger in the front seat to focus on flying the passenger in the back seat to acquire images (Hailey 2005:74). One limitation of the aircraft is the need for surface winds of less than approximately 12 miles per hour (Hailey 2005:76).

An Agema Thermovision 570, a broadband thermal infrared camera manufactured by Flir Systems Inc., was used for data acquisition and operated by Bryan Haley. The Thermovision 570 is capable of measuring differences of temperature to .2 degrees Celsius and at wavelengths of 7.5 mm to 13  $\mu\text{m}$  (FLIR Systems 1996:8-1). The camera has a 24 by 18 degree lens and produces a digital image composed of 320 by 240 pixels with a Focal Plane Array detector (FLIR Systems 1996:8-1). When used at an altitude of 100 meters, the camera and lens

combination produces a field of view of 42 by 32 meters and a spatial resolution of about 13 centimeters at (FLIR Systems 1996:8-3).

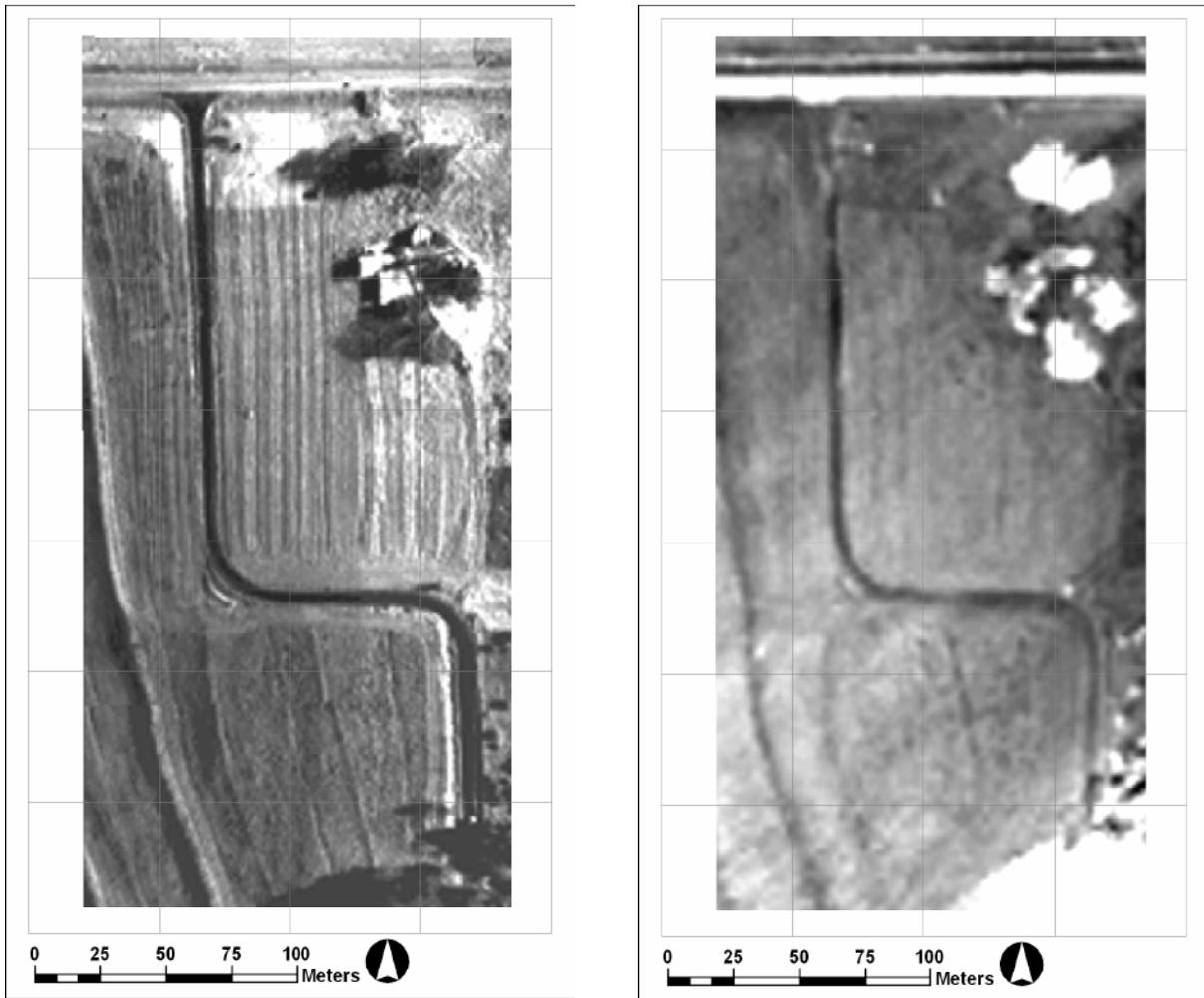
To allow the images to be georeferenced to a standard coordinate system, targets constructed of aluminum flashing were placed around the survey area. The positions of these targets were determined using a Trimble ProXRS differential Global Positioning System (GPS). The images were georeferenced using a combination of ArcGIS 9.2 and Erdas Imagine 8.7 software, generally using a first order or second order polynomial transformation. In these cases the images were near vertical, allowing the simply transformation method. In some cases however, flight lines forced images to be taken from an oblique angle, requiring a rubber sheeting method to be used.

Since it is difficult to predict the best time to acquire thermal images to reveal targets of a certain depth, images were taken during both morning and evening flyovers. The best two sets were taken at the New Philadelphia town site on the morning of May 16, 2008 and the evening of May 17, 2008.

### **Results and Discussion**

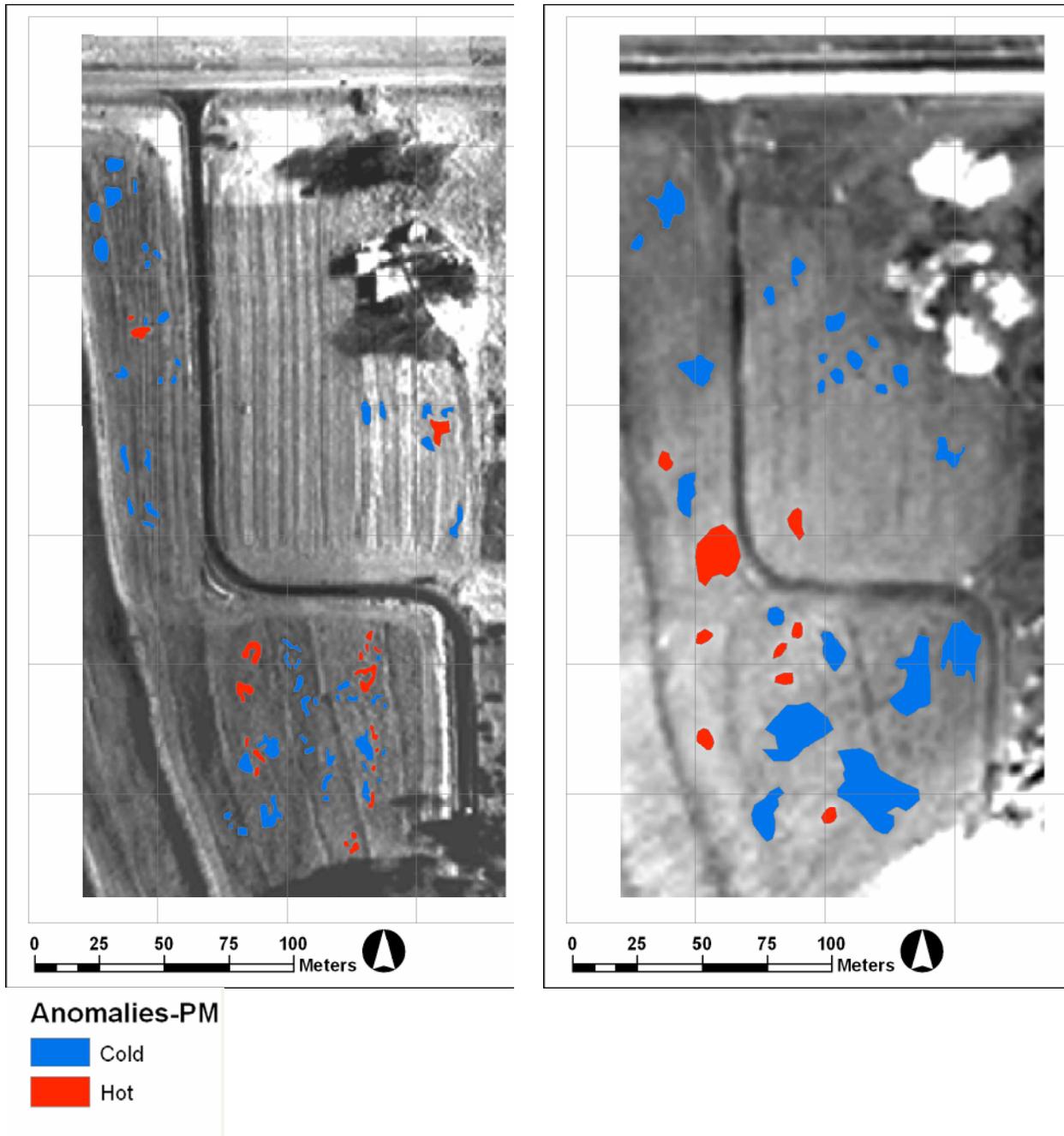
Image composites for morning and evening data obtained at New Philadelphia are shown Figure 2, below. There is a considerable amount of variation between the two data sets. The morning image is dominated by surface features and, as a result, it is difficult to identify anomalies that might be archaeologically significant. There is extensive shadowing visible to the west of the trees and this is probably highlighting the surface features.

Unfortunately, it was not possible to avoid shadowing in the morning data. Flying earlier, before the sun is high enough to cause shadowing, would decrease the amount of heat that penetrates into the ground. The chances that buried archaeology would be visible are very small. Flying late enough in the day to eliminate shadowing would not be safe.



*Figure 2. Morning (left) and evening (right) thermal infrared composite images (Images by Bryan Haley).*

The surface features were deemphasized in the evening data since flights were just before or just after sunset. There are more features of potential archaeological significance in this data than the morning data.



*Figure 3. Morning (left) and evening (right) thermal infrared composite images with anomalies identified (Images by Bryan Haley).*

Anomalies were identified as hot or cold and coded on vector layers (Figure 3) for both data sets. Only anomalies that were not related to obvious surface features were included. Features such as stone foundations, characterized by low conductivity and low thermal inertia, should be visible as positive or hot targets in the morning and negative or cold targets in the

evening. A pit is a type of anomaly that might show the converse thermal behavior (negative in the morning and positive in the evening).

Bryan Haley also created a database display, using Geographic Information System (GIS) software programs, of these data sets for the resulting analysis. The GIS database consists of two raster (the thermal infrared composites in Erdas Imagine format) and two vector (the interpretation polygons in ESRI shapefile format) files. In addition, an ArcMap document was created that contains all four of the data sets.

A series of oblique images were also collected, covering areas away from the site core. These areas were not included in the composite image since these down-slope areas are heavily disturbed and the extreme oblique angle of these images.

### **Conclusions**

The thermal infrared survey of New Philadelphia yielded a number of anomalies that may be related to the nineteenth-century occupation of the site. Only subsurface testing can fully explain these. The success of the survey may be limited by the ground cover at the site. To give thermal infrared surveys the greatest chance for success, data should be collected in bare earth or, if that is not possible, the vegetation should be short and even across the survey area.

The results of the thermal infrared survey conducted in May 2008 by Bryan Haley and Tommy Hailey were partially investigated through ground-based excavation work in an Archaeological Field School conducted at New Philadelphia in the summer of 2008. A more systematic testing of the precise locations of the aerial thermal anomalies identified by Haley and Hailey will be undertaken in future field seasons through targeted ground-based geophysical surveys, soil core sample surveys, and excavations. The New Philadelphia Archaeology Project sponsors summer field schools for such ongoing investigations, with funding support from the National Science Foundation's program of Research Experiences for Undergraduates (for 2008-2011).

Examining the data results of identified thermal anomalies depicted in Figure 3 above and in GIS data images provided by Haley and Hailey, our excavation team has observed a number of instances in which the locations of thermal anomalies appear to correlate with the

known locations of sub-surface foundation remains from past residences located within the town site. These correlations will be further analyzed and tested in upcoming field seasons.

Separate from this project supported by the NCPTT, Bryan Haley also served as a geophysical consultant with Time Team America's staff who investigated portions of Block 8 of the New Philadelphia town site in June 2008 in a search for the foundation remains of a small school house that served African American children in New Philadelphia in the mid-1800s. In addition to testing various forms of ground-based geophysical surveys conducted for the Time Team project in Block 8, Haley also analyzed the thermal infrared data in that area and the Time Team archaeologists ground-tested promising locations with excavations. A report on the results of Time Team's work on Block 8 is provided in Chapter 5 of the 2008 New Philadelphia Archaeology Report (Fennell 2008b).

Field school participants in the summer of 2008 also investigated an area of comparative data between ground-based geophysical surveys and the aerial thermal survey in the area platted as King Street along the north edge of Block 8. As discussed in Chapter 6 of the 2008 New Philadelphia Archaeology Report (Fennell 2008b), an electric resistivity survey conducted by Michael Hargrave (2006) showed a clear alignment of anomalies running east to west along the space of a side street within the town plan. This location was covered by a stone and gravel stretch of narrow roadway in a 1939 aerial photograph, but is today covered entirely in agricultural soils and vegetation, with no visible remains of the road on the ground surface. The thermal infrared survey did not produce data indicative of anomalies that would correlate with the space and configuration of such a roadbed. Excavations in the Summer of 2008 in a sampled space of the resistivity anomalies in King Street revealed a lens of gravel and stone from an early 1900s roadbed buried 1 foot below the current ground surface, and, beneath that, the remains of a late 1800s packed dirt roadway with wheel rut depressions. In comparing the thermal infrared data with the ground-based electric resistivity data, it is notable how clearly the remains of the road appear in resistivity survey results but not in the thermal infrared results. As we continue to investigate the thermal infrared anomalies in future field seasons, it may become clear that this aerial survey method is highly valuable and cost-effective for locating the buried remains of foundations to buildings, but cannot detect the more subtle remains of town infrastructure elements, such as buried roadbed remains.

## Acknowledgements

The researchers in this project wish to extend sincere appreciation to the participants of the New Philadelphia Archaeology Project and to the NCPTT for its generous support.

## References

Ben-Dor, Eyal, Juval Portugali, Moshe Kochavi, Michal Shimoni, and Lipaz Vinitzjy  
1999 Airborne Thermal Video Radiometry and Excavation Planning at Tel Leviah, Golan Heights, Israel. *Journal of Field Archaeology* 26:117-127.

Fennell, Christopher

2008a *Historical Landscapes of New Philadelphia*, University of Illinois, Urbana-Champaign, available at <http://www.anthro.uiuc.edu/faculty/cfennell/NP/>. Accessed December 29, 2008.

Fennell, Christopher

2008b *New Philadelphia Archaeology Report*, University of Illinois, Urbana-Champaign, available at <http://www.anthro.uiuc.edu/faculty/cfennell/NP/2008ReportMenu.html>. Accessed December 29, 2008.

FLIR Systems

1996 Agema 570, Operating Manual. FLIR Systems, Danderyd, Sweden.

Gaumer, Gerry and Frank Quimby

2006 Secretary Designates National Historic Landmarks. *U.S. Department of the Interior News*. U.S. Department of the Interior, available at [www.doi.gov/news/06\\_News\\_Releases/060927.html](http://www.doi.gov/news/06_News_Releases/060927.html). Accessed December 29, 2008.

Hailey, Tommy Ike

2005 The Powered Parachute as an Archaeological Aerial Reconnaissance Vehicle. *Archaeological Prospection* 12: 69-78.

Haley, Bryan S.

2002 Airborne Remote Sensing, Image Processing, and Multisensor GIS Analysis at the Hollywood Site, A Large Late Mississippian Mound Center. Unpublished Master's Thesis, Department of Sociology and Anthropology, University of Mississippi, Oxford, MS.

Haley, Bryan S.

2008 An Investigation of New Philadelphia Using Thermal Infrared Remote Sensing. 2008 *New Philadelphia Archaeology Reports*, available online at

<http://www.anthro.uiuc.edu/faculty/cfennell/NP/2008ReportMenu.html>. Accessed December 29, 2008.

Haley, Bryan S., Jay K. Johnson, and Richard Stallings

2004 The Utility of Low Cost Thermal Sensors in Archaeological Research. Report Prepared for the Office of Naval Research, NASA Grant NAG5-7671.

Hargrave, Michael L.

2006 *Geophysical Investigations at the New Philadelphia Site, Pike County, Illinois, 2004-2006*. U.S Army Engineer Research and Development Center, Construction Engineering

Research Laboratory, Champaign, IL.

<http://www.anthro.uiuc.edu/faculty/cfennell/NP/Geophys/geophysics.html>

Kiesow, Ulrich

2005 Thermal Prospecting on Vegetation, available at

<http://aarg.univie.ac.at/aerarch/papers/Thermal.pdf>. Accessed 4 August 2008. Archaeoflug.

King, Charlotte

2008 New Philadelphia Archaeology, Heritage, and National Historic Landmark Status.

*African Diaspora Archaeology Newsletter*, Dec. 2008, available at

<http://www.diaspora.uiuc.edu/news1208/news1208.html#5>. Accessed December 29, 2008.

Nash, David B.

1985 Detection of Bedrock Topography Beneath a Thin Cover of Alluvium Using Thermal Remote Sensing. *Photogrammetric Engineering and Remote Sensing* 1:77-88.

Perisset, M. C., and A. Tabbagh

1981 Interpretation of Thermal Prospection on Bare Soils. *Archaeometry* 23(2):169-187.

U.S. Department of the Interior

1998 rev. How to Apply the National Register Criteria for Evaluation. *National Register Bulletin* Number 15; U.S. Department of the Interior, Washington, D.C.

U.S. Department of the Interior

1999 How to Prepare National Historic Landmark Nominations. *National Register Bulletin*. National Park Service Cultural Resources, Washington, D.C.