Geophysical Investigations at Holocaust Sites in Lithuania and Warsaw

A Multimethod Geoscience Approach to Mapping Mass Graves and Associated Sites of Atrocity Crimes

Geoscientists Without Borders

26-February 2020

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Hopefully all, or at least most of the main participants and contributors to this program are mentioned in the Section “The Human Element.” However, there are other individuals and organizations who provided very important support. Principal among these of course is Linda Ford, the Program Manager of Geoscientists Without Borders (GWB), and the entire GWB Committee whose names are unknown to us. GWB provided the largest portion of financial support for this project. We appreciate the large effort the GWB committee must have made in reviewing this and other projects, and in recognizing that this project is a geoscience application to an important humanitarian need. Following the acceptance of our application, though likely not connected, geoscience investigations at the mass graves of the 1921 Tulsa race riot, the identification over the summer of numerous Canadian residential school mass graves, the May 2019 publication of the acclaimed novel “Nickel Boys” which was inspired by the geophysical mass grave mapping at a Florida reform school, and various events that have since transpired both in Lithuania and Poland may suggest that the GWB committee’s decision was prescient.

The United States Embassy also provided funding for this project. This funding came through The U.S. Commission for the Preservation of America’s Heritage Abroad. Of particular note at these times regarding increasingly restrictive immigration laws in the United States, “The establishment of the Commission recognized that the population of the United States is mostly immigrants and their descendants. Because it is, the United States has an interest in the preservation of sites in other countries. These sites are an important part of the cultural heritage of many Americans.”

This report, as well as our previous two GWB reports on water exploration and training programs in East Africa, would not have come together without the extraordinarily capable and meticulous administrative assistance of Renée Vandal who puts everything together before any report sees the light of day beyond our office.

We would like to thank Richard Graham of Worley, a marine geophysics expert with more than 20 years of experience, for processing and interpreting the sidescan sonar imagery. Richard also gave us some much needed advice on field acquisition and provided us with far more plots than we have chosen to include in this report. Richard processed the sidescan imagery overnight in Calgary after we completed the data acquisition in Lithuania. This allowed us to choose a dive spot on the Kaunas Reservoir the morning after the field acquisition day. Richard’s overnight processing and interpretations also allowed us to speak with conviction in front of the filmmakers’ cameras on our second day in Lithuania.

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Ted Kelly made extraordinary efforts to build for us a rope gridding system that was highly visible, light, portable, non-stretching, compact, easy to manage, and intuitive. This local gridding system was critical to all our geophysical mapping work where we required close to centimetre accuracy. As well, the Bartington...
gradiometer and the TR/CIA resistance meter had no GPS coupling at all, making the local grids essential equipment.

Paula Chan (Claims Conference Saul Kagan Fellow in Advanced Shoah Studies completing a dissertation at Georgetown University) spent an entire day with our geoscience group assisting in providing clarity to the historical contexts of our various field sites in Lithuania. We continue to correspond with Paula regarding this project as well as her important work on the Extraordinary State Commission documents.

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In Pravieniškės, “Tadeo” Tautvydas Krilavičius, the assistant to the Mayor of Kaišiadorys accompanied us in the field and facilitated our access to the Prison. Tadeo also arranged for the doyenne (forewoman) of Pravieniškės town, Ernesta, to accompany us at the 1941 and 1944 Holocaust mass burials in Pravieniškės. Mantas Daubaras, a Lithuanian archaeologist with whom we have now worked with since 2015, assisted us with advice and field work at the Pravieniškės Prison.

Although he is mentioned in a later section, special thanks should be made to Dr. Richard Freund from Christopher Newport University (formerly of the University of Hartford) whose support over previous projects and previous years brought us to this project. Advisian geophysicists Dr. Alastair McClymont, Colin Miazga, Chris Slater, and Paul Bauman deserve a special mention for carrying out the bulk of the preparation, field work, and reporting. Josie Bauman of Quest University photo-documented all episodes of this project, as well as museum artefacts and excavation journal entries. The vast majority of the photographs in this report were captured by Josie. Dr. Harry Jol, along with his large contingent of students, carried out all the ground penetrating radar (GPR) work. By all student accounts, Harry’s Lithuania field programs continue to be a tremendous positive influence on the academic and professional journey of his students. Dr. Phil Reeder carried out much of the geospatial mapping.

Seequent, who has supported other GWB projects in the past, provided free use of their 3-D visualization and modelling software for this project. Paul Bauman Geophysics Ltd., who has also supported many previous GWB and other humanitarian projects in the past, provided all required geophysical, drone, and GPS equipment at no cost.

Finances for this project were managed through the University of Hartford and the Maurice Greenberg Center for Judaic Studies, and Christopher Newport University.
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Executive summary

This field program was carried out from July 7 through 21, 2019, in cooperation with geophysicists from Worley Canada Services Ltd., operating as Advisian in Calgary, and students and staff from Christopher Newport University (CNU), the University of Wisconsin at Eau Claire (UWEC), the University of Hartford, Duquesne University, and the Israel Antiquities Authority (IAA). Geophysical surveys, imaging from unmanned aerial vehicles (UAV), geochemical soil sampling, and archive searching were carried out at mass burial and Holocaust related sites in Lithuania and Poland.

The overall goal of this project was to explore the use of non-destructive or minimally invasive methods to identify and delineate mass burials created more than 75 years ago in a manner that ignored all aspects of international humanitarian law as well as basic human dignity. An additional aspect of this project was to continue from previous investigations in the use of geophysical methods to investigate Holocaust sites in a manner that may initiate further work including excavations and memorialization. Ultimately, historical knowledge and understanding from such investigations may promote historical reckoning and reconciliation, two foundation blocks to strengthening democratization and preventing a resurgence of fascism, anti-Semitism, and racism.

Specific objectives in Lithuania originally included: 1. Identifying the location and determining if remains are still present of the submerged Jewish shtetl of Rumšiškės, 2. Identifying and mapping the mass grave of the estimated 300 Jewish inhabitants of Rumšiškės 3. Identifying and mapping the 14 burial trenches at Fort IX, in Kaunas, where an estimated 50,000 Jews are buried. As field work progressed in Lithuania, other sites and objectives were added including 4. Investigating Jewish, Lithuanian, and Roma mass burials in Pravieniškės, 5. Investigating the subsurface remains of the Great Synagogue in Vilnius, and 6. Mapping the foundations of the destroyed brick Synagogue in Šeduva. In Warsaw, Poland, the objectives of the geophysical investigations included 7. Exploring for World War II arms caches buried by the Polish resistance in Łazienki Park, 8. Mapping buried objects in the gardens of the Bersohn and Bauman Children’s Hospital within the former Warsaw Ghetto, and 9. Investigating the subsurface architecture at Mila 18, the command bunker for the Jewish resistance inside the Warsaw Ghetto.

At Rumšiškės, the location of the destroyed and submerged shtetl was identified, though sidescan sonar indicated that few material remains survived. The mass grave at Rumšiškės was not confidently located. At Fort IX, archived information, UAV imagery, and geophysics together created a map of the burial trenches as well as improved the overall understanding of the site. Limited geophysical and geochemical surveys did not identify the mass graves at Pravieniškės. At Šeduva, radar clearly mapped the footprint of the brick Synagogue gutted in World War II and later levelled. At the Great Synagogue in Vilnius, geophysical surveys continued from previous work to add subsurface information which will then be used in prioritizing areas of future excavations. The discoveries at the Great Synagogue site in the heart of Vilnius have stimulated profound discussions that have resonated in Vilnius and beyond Lithuania.

In Warsaw, hundreds of buried metal features were mapped at both Łazienki Park and at the Bersohn and Bauman Children’s Hospital. At Mila 18, resistivity imaged likely void spaces which could be related to tunnels or the command bunker. Induced polarization (IP) imaged pieces of metal at depth that could be stoves, pipes, or arms caches. UAV spectral imagery delineated pre-War architecture and street plans.
## Acronyms and abbreviations

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<td>3-D</td>
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<tr>
<td>AGC</td>
<td>automatic gain control</td>
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<td>CNU</td>
<td>Christopher Newport University</td>
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<td>DC</td>
<td>direct current</td>
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<td>ERT</td>
<td>Electrical Resistivity Tomography</td>
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<td>Ground Penetrating Radar</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>GWB</td>
<td>Geoscientists Without Borders</td>
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<td>Ha</td>
<td>hectare</td>
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<td>ICP</td>
<td>inductively coupled plasma</td>
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<td>ICRC</td>
<td>International Committee of the Red Cross</td>
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<td>IAA</td>
<td>Israel Antiquities Authority</td>
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<td>IP</td>
<td>Induced polarization</td>
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<td>m</td>
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<td>mbgs</td>
<td>metres below ground surface</td>
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<td>(NIR</td>
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<td>nT/m</td>
<td>nanoTeslas per metre</td>
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<td>optical emission spectrometry</td>
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<td>POC</td>
<td>point of contact</td>
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<tr>
<td>POWs</td>
<td>prisoners of war</td>
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<td>SBES</td>
<td>single-beam echosounder</td>
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<td>SD</td>
<td><em>Sicherheitsdienst des Reichsführers</em> or Security Service of the Reichsführer</td>
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<td>SEG</td>
<td>Society of Exploration Geophysicists</td>
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<tr>
<td>shtetls</td>
<td>small Jewish towns</td>
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<td>sq. km</td>
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<td>sq mi</td>
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<td>Universal Transverse Mercator</td>
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<td>University of Wisconsin at Eau Claire</td>
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1 Background Information

1.1 Project Goals and Geophysical Need

The overall goal of this project is to use geophysical and other non-destructive methods to illuminate major elements of the beginning of the Holocaust, including the identification and delineation of mass graves. By “beginning of the Holocaust”, we mean the onset of state organized mass murder starting in Lithuania, almost six months before the more widely known mechanized mass murder methods implemented in the Nazi extermination camps in Poland, beginning in December 1941.

There are thousands of mass burials in Europe. In Lithuania alone, there are more than 200 documented mass burials associated with the Holocaust. By focusing on Fort IX and the nearby submerged shtetl of Rumšiškės (Figure 1-1), the technological approaches applied in this project will ride the relatively widely known drama of the history of Fort IX, the high profile of the Ninth Fort Museum, the declaration of Kaunas as a European Capital of Culture for 2022, and the existence in Rumšiškės of the Open-Air Museum of Lithuania. Three documentaries are already planned to emerge from this project.

Figure 1-1 Site location map showing, from north to south, Šeduva, Kaunas (Fort IX), Pravieniškės, Rumšiškės, Vilnius, and Warsaw

A complementary goal is to present a methodical, non-intrusive approach to studying Holocaust and mass murder sites, including the use of geophysical methods. This work of geophysical mapping of Holocaust mass grave sites continues from similar investigations done by much of this same group of geoscientists, archaeologists, and historians since 2008, including at the Nazi extermination camp of Sobibór in Poland.
(Bauman et al. 2010), the Ponar (McClymont et al. 2020) extermination camp in Lithuania, and other smaller and lesser known mass burial sites in Poland and Lithuania (Freund, R., 2019).

Because of the rapidly decreasing number of Holocaust survivors and witnesses to the events of World War II, and because of the sensitivity and often impossibility of excavating Holocaust mass graves and other mass burials, the use and importance of geophysical and other non-intrusive investigative methods will only increase with time in Europe and elsewhere. Indeed, the currently proceeding investigations of the 1921 Tulsa race massacre and mass graves are clear evidence of the relevance of this Geoscientists Without Borders (GWB) project beyond the borders of Europe.

1.2 Humanitarian Need

In the attempt to identify and delineate mass graves, and in the utilization of various technological approaches to doing so, this project is a direct effort to address international humanitarian law regarding mass graves. Among other sources, practices of carrying out mass burials are directly specified by the International Committee of the Red Cross (ICRC), The Geneva Conventions (Articles 17, 20, 120, and 130 addressing "collective graves"), and the 1999 NATO Standardization Agreement 2070 addressing "Group Burials."

There are 202 documented Holocaust period mass graves in Lithuania alone. At a single site, Fort IX in Kaunas, it is estimated that more, and perhaps far more than 50,000 victims are buried, most of whom were shot, including more than 9,000 that were shot in a single day.

The mass grave at Fort IX is one of the largest mass burial sites in the world. It is located on the grounds of the Ninth Fort Museum on the outskirts of Kaunas. Although Lithuania was liberated from the Nazis in World War II in 1944, and became independent from the Soviet Union in 1990, the country is only now making a painful examination of the pre-Soviet period covering World War II and the Holocaust. Studies like this one are critical in educating a new generation of Lithuanians that may have a broader and more balanced view of the history of their country than simply being victims of Soviet and Nazi oppression. As such, projects like the burial trench mapping at Fort IX, the sidescan sonar surveys at the submerged shtetl of Rumšiškės, and the continued investigations at The Great Synagogue in the very center of Vilnius are major steps toward complying with humanitarian law, educating a new generation, promoting democratization, and combating a resurgence in far right wing nationalism and neo-Nazism.

More broadly, by carrying out this program and promoting its exposure through the publishing of this report in the public domain, and through talks, multiple documentary movies, mainstream media, social media, significant student involvement, international partners, civic involvement, and even tourism, it is hoped that the methodical approach taken here, whether successful or not, can be a reference for others. Undoubtedly, studies at other mass grave and genocide sites, whether they be in Iraq, Syria, Rwanda, Spain, Columbia, Mexico, Ukraine, or even in close proximity to the Society of Exploration Geophysicists (SEG) at the site of the 1921 Tulsa race massacre, can benefit from some element of our work.

On June 18, 2019, the Junction Site in Southern Alberta was used as our pre-trip test site for our gridding equipment, geophysical equipment, and UAVs (Appendix A) for this GWB project. The Junction Site is a large, indigenous, pre-European contact campsite and buffalo killsite where extensive and ongoing excavations have been carried out.
1.3 The Human Element

Below is a list, certainly not inclusive, of those involved in the geoscience investigations included in this project:

- Paul Bauman of Advisian (geophysicist): Project Manager, overall technical lead, diver on Kaunas Reservoir, responsible for reporting, and main communication point of contact (POC).
- Dr. Richard Freund of Christopher Newport University (formerly of the University of Hartford, historian, Jewish Studies professor, and archaeologist): POC for managing funds, overall lead and coordinator of all phases of investigations occurring at these sites including the filming.
- Dr. Harry Jol of the University of Wisconsin Eau-Claire (UWEC; physical geographer): managed all ground penetrating radar (GPR) surveys, and all work carried out by UWEC.
- Dr. Phil Reeder of Duquesne University (physical geographer, cartographer, Dean of Science): coordinated various elements of cartography.
- Dr. Alastair McClymont of Advisian (geophysicist): carried out planning, geophysical field work, processing, and various elements of reporting.
- Colin Miazga of Advisian (geophysicist): carried out planning, geophysical field work, all UAV work, processing, and various elements of reporting.
- Chris Slater of Advisian (geophysicist): carried out planning, geophysical field work, processing, and various elements of reporting.
- Josie Bauman of Quest University, Canada (liberal arts and science student, photographer): geophysical field assistant, still photography of field work and museum artifacts.
- Dalia Grobovaite of the University of Calgary (Faculty of Arts): Translated 1960 to 1971 Fort IX Excavation Journals from Lithuanian to English.
- Elliot Matz: Descendant of family from the Rumsheshok (Yiddish of Rumšiškės) shtetl: initiator of project to include remnants of Jewish shtetl of Rumšiškės into Outdoor Open-Air Museum of Lithuania.
- Ross Hill (dive instructor): Descendant of family from the Rumsheshok shtetl, diver on Kaunas Reservoir.
- Loic Salfati of the French Institute in Lithuania (photographer, film maker): carried out documentary filming at Fort IX and Rumšiškės.
- Faina Kukliansky of the Lithuanian Jewish Community (Chairwoman): point of contact in the Lithuanian Jewish community, received frequent updates as well as participated in a presentation of the preliminary results of this project to the Jewish Community in Vilnius.
- Zigmas Vitkus of the Vilna Gaon State Jewish Museum (Director): received frequent updates of project.
- Jurate Zakaite of the Ninth Fort Museum, Kaunas (Director): Provided direction and assistance for field and archive investigations at Fort IX.
- Dr. Gintautas Zabiela of the Ninth Fort Museum, Kaunas (archaeologist): Provided direction to field investigations at Fort IX.
• Dr. Romas Jarockis of the National Living Museum (archaeologist): Provided advice at Rumšiškės.
• Rytis Titas (documentary film maker): making documentary film about the history of Rumšiškės.
• Rūta Vyžintaitė – Lajienė (documentary film maker): making documentary film about the history of Rumšiškės.
• Dr. Vladas Zulkus of the National Living Museum (archaeologist): Provided advice at Rumšiškės.
• Dr. Jon Seligman of the Israel Antiquities Authority (Director, External Relations and Archaeological Licensing): Directed all investigations at the Great Synagogue site in Vilnius. Organized volunteers and helpers from Lithuania, Israel, Russia, and the United States.
• Susan Cardillo of the University of Hartford (Assistant Professor of Communication): Directed University of Hartford filming at Rumšiškės and Fort IX.
• Kyle Conti of the University of Hartford School of Communications (student): Student director of documentary films on Rumšiškės and Fort IX.
• Becca Chien of the University of Hartford School of Communications (student): Worked on filming at Rumšiškės and Fort IX.
• Travis Girouard of the University of Hartford School of Communications (student): Worked on filming at Rumšiškės and Fort IX.
• Cameron Wingren of UWEC (Geospatial student, senior): GPR acquisition and processing.
• Hailee Jeffries of UWEC (Environmental Geography student, junior): GPR acquisition and processing.
• Joe Beck of UWEC (Environmental Geography student, senior): managed much of GPR acquisition, processing, and reporting.
• Kelly Jervis of UWEC (Environmental Geography student, senior): GPR acquisition and processing.
• Logan Bergevin of UWEC (Environmental Geography student, senior): GPR acquisition and processing.
• Madeline Fuerstenberg of UWEC (Journalism student, junior): writing various articles on women excavators of Fort IX and Geoscientists Without Borders, assisted in documentation of Fort IX artifacts and 1960 to 1971 Excavation Journals.
• Albert Stankowski of the Warsaw Ghetto Museum (Director): Facilitated all work in Warsaw.
• Andrew Nowicki of the Łazienki Museum, Warsaw (Director): Directed and advised on geophysical investigation in the Romantic Garden of the Royal Łazienki Park.
• Adam Wolniewicz of the Warsaw Ghetto Museum (Iconography Specialist): Advised on pre-World War II street planning in Warsaw.
• Piotr Lenartowicz of the Warsaw Ghetto Museum (Digital Collections Department): Provided technical direction for all work in Warsaw.
• Dr. Hanna Wegrzynek of the Warsaw Ghetto Museum (Deputy Director for Research and Exhibition Programming).
• Anna Kilian of the Warsaw Ghetto Museum (Communications).
1.4 Brief Synopsis of the Investigated Sites

All the investigated sites are described in greater detail below. Field work was carried out at 11 sites, if one also includes the Junction Site in Alberta that was used as our pre-departure equipment test site. Rumšiškės was a Jewish shtetl (village), with five centuries of Jewish habitation, where the entire Jewish population was killed over two months in 1941. The shtetl was submerged in 1959 by a Soviet era hydroelectric project. Fort IX, in Kaunas, is the site of one of the earliest and largest mass killings, where an estimated 50,000 Jews are buried in 14 unmarked trenches. The Praviënškės Prison was the site of the mass murder and burial of Lithuanian political dissidents and their families by the Soviets in 1941, prior to Nazi occupation. Near to the Praviënškės Prison are two mass burials of forced labourers, one of Jews, Soviet prisoners of war (POWs), and Roma, and a second of 250 French Jewish victims of the infamous Convoy 73.

Also investigated in Lithuania was the subsurface architecture of the single most iconic pre-World War II Jewish site in Lithuania, the Great Synagogue in the very centre of Vilnius. Subsurface investigations of a second razed synagogue in Šeduva were also carried out.

In Warsaw, Poland, field work was carried out at three sites over two days. In the Romantic Garden of the Royal Łazienki Park, Polish World War II resistance fighters buried arms caches intended for later combat against the occupying Nazis. Within the small gardens of the truly legendary Bersohn and Bauman Children’s Hospital located within the former Warsaw Ghetto, it is likely weapons, corpses, and undoubtedly many historically significant artefacts were buried. Equally legendary, also the subject of a Leon Uris book by the same name, and the setting of an intended Hollywood movie (with Brad Pitt portraying Mordechai Analewicz) and an historical documentary on Jewish resistance in World War II, Mila 18 was the command bunker for the Jewish resistance inside the Warsaw Ghetto. On May 8, the bunker became a mass grave for an estimated 150 Jewish resistance fighters.
2 Methods

2.1 Gridding

Data in each Twin Probe Resistance Meter (TR/CIA) and Bartington 601-2 Gradiometer grid were locally referenced by a marked rope grid with ropes spaced 2 m apart. Each rope was marked every metre for reference. The grid corners were georeferenced with a Trimble Geo7 GPS. In Lithuania, the grids were surveyed in by Dr. Phil Reeder with a total station. All local grid maps were then taken from their local coordinates to being georeferenced to the datum of WGS84, Zone 35N in Lithuania, and WGS84, Zone 34N in Warsaw.

GPR grids were also locally georeferenced. As with the resistance meter and the gradiometer, the grid corners were then georeferenced with a Trimble Geo7 GPS, and georeferenced to the datum of WGS84, UTM Zone 35N in Lithuania. No GPR data were collected in Warsaw.

Where possible, and as a further geographical reference aid, all geophysical maps have been superimposed on to high resolution (2 cm/pixel) Mavic Pro or M100 UAV orthophotos. Otherwise, Google Earth is used as a georeferenced backdrop.

2.2 Sidescan Sonar

A sidescan sonar sonde emits fan-shaped pulses, from a depth of about two thirds downward through the water column, across a wide angle perpendicular to the travel path of the sonde through the water. We suspended the sonde from a rope as there was no winch available, and so we could quickly move the sonde up or down through the water column as the shallow reservoir depth changed. The intensity of the acoustic reflections from the reservoir bottom, or features sitting on the reservoir bottom, is recorded in a series of slices running perpendicular to the travel path. When stitched together, the huge number of slices then form a monochromatic image of the reservoir floor and everything sitting on that floor.

For this program, we used the Imagenex YellowFin Sidescan Sonar. This system operates at three frequencies, though we operated at the lowest frequency of 260 kHz in order to maximize the range. We used a small, sport fishing boat as our acquisition platform. Two sub-meter Trimble Geo7 GPS units were used to guide the positioning of the boat and to track the positioning of the sonde.

2.3 Ground Penetrating Radar (GPR)

GPR is a shallow, non-invasive, subsurface investigation technique capable of mapping interfaces in a cross-sectional format. GPR measures the propagation time of high frequency electromagnetic pulses which are reflected from interfaces between materials of different electrical properties. Radar reflections can occur with abrupt changes in moisture content, grain size, porosity, or soil texture. Reflections can also result from the disturbance of the soil structure caused by the digging of pits or ditches, from energy scattering off discrete objects such as large pieces of pottery or lithic artifacts, or from internal reflections within void spaces or large pots.
This survey utilized a hand towed 500 MHz antenna system. In typical sandy soils, with a radar velocity of 0.10 metres/nanosecond (m/ns), 500 MHz antennas have a wavelength of about 12 cm. As such, they are capable of imaging features of a size on the order of 0.12 m, but can detect objects on the order of size of a quarter wavelength, or 0.03 m.

Generally, GPR data were collected as traces every 0.02 m along lines spaced 0.25 m apart. The digital profiles were downloaded, saved to an external hard drive, processed and plotted using pulseEKKO, GFP Edit and EKKO_Project software packages. Basic processing included automatic gain control (AGC), signal saturation correction, trace stacking (horizontal averaging) and point stacking (running average) as well as other routines when necessary.

These very dense vertical two-dimensional data sets (called sections) were gridded into volumes. The three-dimensional volumes were then horizontally “sliced” down in intervals of 0.05 m thickness. Time to depth conversion was done using a velocity of 0.100 m/ns.

### 2.4 EM61 High Resolution Metal Detection

The EM61 is a high-resolution metal detector that responds to both ferro (iron and steel) and non-ferromagnetic metal. The maximum depth of detection of an object the size, say, of a fuel drum is 3.5 metres below ground surface (mbgs). Significantly smaller objects will have significantly more shallow depths of detection.

The EM61 responds only to metal; there is no response to changing mineralogy or geology. The response of the EM61 is in milliVolts (mV), with larger responses being indicative of more metal or more shallow burial for a similar sized object. While the magnitude of the response will vary widely with the surface area, orientation, volume, depth of burial, metal content, and geometry of the body, a few broad interpretative generalizations can be relied upon. An object of, say less than 100 mV, is likely small, on the order of a handful of bullet shell casings. An object on the order of a few 100 mV could be a pistol, a rifle, or several weapons. Responses of more than 1000 mV or on the order of thousands of mV could be caches of weapons or individual large, heavy weapons.

Generally, the EM61 preserves the aspect ratio of a target. As such, for instance, a long, linear feature of a few metres may be gun barrels or a box of rifles. A square plate or a circular manhole cover will approximately preserve its shape, though the overall size of the geophysical anomaly will be somewhat larger than the actual buried feature.

One can have a very high degree of confidence that one will encounter metal when digging directly over the centre of an “anomaly” or target. In other words, “false positives” are very unlikely.

### 2.5 Soil Sampling for Total Phosphorus

Human activity on a site can alter the soil chemistry of a site. Mass burials, the crushing of bones, burning of bodies, the scattering of ashes, spreading of lime, the movement of soil, and other activities associated with the mass murders at Fort IX, for example, have undoubtedly altered the soil chemistry at the site. Construction activities, archaeological investigations, landscaping, dog walking, animal husbandry, and other human activities since 1945 have also affected the soil chemistry. While the soil concentrations of
many chemical elements and compounds can be indicative of human activity, including for instance carbonates, nitrates, and trace metals, phosphorus is of particular interest. Phosphorus is strongly associated with various human activities, phosphorus tends to fix (Carter 2016) in the soil (in contrast, for instance, with nitrates that are highly soluble and may migrate with rainwater infiltration and groundwater movement), and phosphorus tends to be persistent (i.e., it remains in place for millions of years after fixing in the soils).

Our phosphorus sampling program relied heavily on advice from Dr. Johanna Ullrich O’Keeffe (Ullrich O’Keeffe 2019, pers. comm.). Soil phosphorus exists primarily as compounds of phosphate and can be present in either organic or inorganic forms. Both forms occur naturally at low levels in most soils. Both organic and inorganic forms can be deposited and/or bedrock derived. Phosphates bond to receptors in the soil, generally bonding to iron and aluminum under acidic conditions, and to calcium under basic conditions. The greater the clay component in the soil, the more receptor sites that are available. The exact form that phosphate will take will depend on biological and geochemical conditions, with pH being an important factor. Phosphate retention is lost in very sandy soils.

Anthropogenic phosphates can be deposited in the soil in organic form (sources could include burials, human waste, ash, products of animal husbandry, animal and fish bones, organic fertilizer, etc.). Over time, these organic forms mineralize as they remain in the soil (Holliday and Gartner 2007). Mineralization rates can vary depending on the soil, but a general rule of thumb is 200 years. Most simple field methods (e.g. Eidt and Wood) test for relative levels of inorganic phosphates.

Phosphates translocate (i.e., move) within the soil profile, and a phosphate “shadow” can be found in the topsoil directly above affected buried horizons. As a result, soil samples needed to locate phosphate-rich, buried horizons need only be very small and taken from the top soil (about 20 cm below the surface usually suffices). The important element for this movement of phosphates is ground cover. Vegetation “pulls” phosphates from buried horizons, but cannot assimilate inorganic phosphates, causing mineralized anthropogenic phosphates to collect in the topsoil.

Given the above, the requirements for successful soil phosphorus delineation of a mass burial site include an anthropogenic source or sources of phosphorus, healthy vegetation cover to translocate phosphorus upward in the soil column, a significant clay content in the soils, at least two centuries of time, an understanding of phosphorus inputs unrelated to the investigation objectives, and minimal physical disruption to the soil column.

Of the mass burial sites from where we soil sampled in Lithuania, they all had large potential sources for anthropogenic inputs and they all had vegetation cover. However, most of the soils were relatively sandy, though usually there was some clay in the soil samples. None of the mass graves preceded 1941, so none were older than 78 years. Sources of other phosphorus inputs were unknown; for instance, perhaps the burial area near Fort IX has been fertilized in the past or used for grazing animals. And undoubtedly there has been significant disturbance at a significant portion of all the sites including major monument construction and landscaping at Fort IX, digging at Rumšiškės, industrial activity at the Pravieniškės Prison, and possible exhumations at the 1941 and 1944 mass burials near the Pravieniškės Prison.
Despite the above noted reservations, and because of the unlikelihood of gaining permission for exposing Holocaust mass burials, the investigators felt that soil sampling for phosphorus was worth attempting. The source contributions are indeed very large, with the processes of phosphorus release often being accelerated by burning and crushing. Though complete mineralization and translocation may occur over hundreds of years, mineralization begins immediately after burial. Although most of the soils we encountered were sandy, generally, there were some silts and clays present.

Because of the uncertainties of what forms of phosphates may be present, and because of possible contributing sources of phosphates other than those directly related to our objective of mapping mass burials, the investigators decided to analyze for total phosphorus. The strategy here was simply to assume that regardless of the various forms and sources of phosphates present, the total phosphorus concentrations in the surficial soils would be greatest over the mass burials. There was no intention to identify "use-of-space patterning"; we simply wanted to distinguish areas of mass graves from background areas. The very generous contribution of free analyses of total phosphorus by AGAT Laboratories in Calgary, with the facilitation of Dr. Lisa Neville of AGAT Laboratories, made this approach possible.

All soil samples were collected with a manual soil auger tube. The samples were taken as an approximate 1.5 cm diameter core over the depth of 0.15 mbgs to 0.20 mbgs. Each sample was placed into a labeled ziplocked plastic bag. Sample locations were georeferenced with the Trimble GPS unit to sub-decimetre accuracy after post-processing. All samples were couriered to Calgary from Vilnius in Lithuania. Samples were analyzed at AGAT Laboratories in Calgary using inductively coupled plasma (ICP) and optical emission spectrometry (OSE) techniques. Although only two grams of sample are required for this type of analysis, approximately 10 grams of each sample were acquired.

Assumed “background” samples were collected at each location. The choice of background sample locations was problematic as of course the precise locations of the mass burials were unknown, and we attempted to acquire background samples in reasonable proximity to our area of investigation so as not to be sampling from a significantly different geological environment or from an area with a very different history of use.

### 2.6 Electrical Resistivity Tomography (ERT) and Induced Polarization (IP) Cross-Sectional Imaging

ERT is a technique for mapping the distribution of subsurface electrical resistivity (or its inverse, conductivity) in a cross-sectional format. Resistivity data are collected through a linear array of electrodes coupled to a direct current (DC) resistivity transmitter and receiver, and electronic switching relays. The spacing between electrodes largely controls the horizontal and vertical resolution of the data (smaller spacing results in higher horizontal and vertical resolution). Similarly, the length of the array controls the depth of investigation (longer arrays yield greater investigation depths). Data collection is carried out in a sequential and automated fashion that takes advantage of all possible combinations of current injection and potential measurement electrodes. The data are downloaded to a computer for processing and analysis. The data are inverted (i.e. modelled) using a two-dimensional (2-D) finite difference or finite element inversion routine using the software package RES2D. The final product is a 2-D cross-section (known as a “true” geoelectric section) plotting resistivity (in Ohm-m), or conductivity (in milliSiemens per metre [mS/m]), versus depth.
IP is a second electrical imaging survey that is collected simultaneously, and with the same equipment as the ERT survey. While resistivity surveys image the subsurface in terms of its unit volume resistance to the passage of electrical current, IP images the subsurface in terms of its chargeability, which is loosely analogous to the ability of the subsurface to store electrical charge. While resistivity measurements are made while current is being passed through the subsurface, no current is actively transmitted during an IP measurement. Chargeability is measured in milliseconds (msec). The chargeability measurement is representative of the area under the voltage curve which rapidly decays after current is turned off. A chargeability section can be inverted (i.e. modelled) from the acquired raw IP data. Generally, sand and silt will have zero chargeability; clay may have a very low but measurable chargeability of a few msec. Metal objects, where present, will have chargeabilities of tens, hundreds, or thousands of msec, depending on the size, surface area, and depth of burial.

2.7 Twin Probe Resistance Meter/Council of Independent Archaeology (TR/CIA) Resistance Mapping

Resistance surveys are specific to archaeology as they provide high lateral resolution mapping in only the very near surface. It should be noted that resistance meters like the TR/CIA measure resistance, which is a bulk property, rather than resistivity, which is an intrinsic property (i.e. resistivity is the resistance of a unit volume of earth material). The TR/CIA was developed by the Council for Independent Archaeology in England.

The TR/CIA measures subsurface resistance by using a mobile array of two probes (hence, the “twin probe” array), including a current transmitting and voltage measuring probe. The transmitting probe sends current to a “remote” electrode planted at least 15 m (i.e. 30 X the 0.5 m electrode spacing on the mobile array) from the grid, and the voltage measuring probe references to a second voltage electrode also located at least 15 m from the grid. For each measure point, a known current is transmitted, a voltage is measured, and a resistance (in units of Ohms) is calculated according to Ohm’s Law:

\[
\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}
\]

Increasing moisture and clay content, along with the presence of metal, will all decrease the resistance. Increasing sand content and air-filled pore space, along with massive stones or bricks, will all increase the resistance. Resistance meters, therefore, can be very useful in mapping shallow walls, ditches, pits, roads, and pathways. However, due to natural heterogeneities in the near surface, it can often be difficult to distinguish between anthropogenic features and natural features such as tree roots, animal burrows, boulders, changing clay content, sand lenses, etc.

For the resistance meter used in this program, the mobile current and voltage electrodes are spaced 0.5 m apart, providing a depth of investigation of about 0.75 m. Resistance measurements were recorded every metre on lines spaced one metre apart.

2.8 Bartington 601-2 Magnetic Gradiometer Mapping

The Bartington 601-2 Magnetic Gradiometer, an instrument designed specifically for archaeological prospection, is sensitive to both thermoremanent magnetization and changes in magnetic susceptibility.
Thermoremnant magnetism is created when iron bearing earth materials, including clays, are heated above the Curie Point (565°C for magnetite, 675°C for hematite), and then re-magnetized upon cooling (Gaffney and Gater 2003). Clay hearths, large pieces of fired pottery, kilns, and soils baked by burning may all be detectable as thermoremnant magnetic anomalies.

Magnetic susceptibility is the magnetism induced in a sample when placed in a magnetic field. Although magnetic gradiometers are passive instruments (i.e. they do not induce a magnetic field), all earth materials are subject to the earth’s magnetic field. As topsoil and subsoil usually have different magnetic susceptibilities due to processes of oxidation and reduction, localized areas of disturbed soil such as pits, post holes, or trenches, may be mapped by a magnetic gradiometer.

As a "gradiometer", the Bartington 601-2 sensors each have two fluxgate sensors mounted vertically, one above the other, spaced one metre apart. The instrument therefore measures the vertical component of the Earth’s magnetic field. In fact, the Bartington 601-2 consists of two gradiometers (i.e., four fluxgate sensors), allowing for the simultaneous measurement of two lines. For archaeological investigations, gradiometers are greatly preferred to total field measurements as the vertical gradient measurement is very sensitive to small objects in the near surface, and largely insensitive to features buried at depth. The gradient measurement is also insensitive to diurnal variations in the Earth’s magnetic field.

A magnetic gradiometer will have a different response to the same object, depending where in the Earth’s magnetic field the survey is undertaken. Toward the Earth’s magnetic north pole (as, for example, is the case of Warsaw or Kaunas), anomalies will be positive and larger. As a survey moves toward the Earth’s magnetic equator (British Geological Survey 2018), the same feature will have a smaller response and show a positive and negative anomaly (i.e. a dipolar response), centred above the feature (Gaffney and Gater 2003, p. 40). Of note is that archaeological features will generally appear as small, discrete anomalies. Geological features will typically be broad, diffuse anomalies.

The magnetic gradient is recorded in units of nanoTeslas per metre (nT/m). The noise level of the Bartington is about 0.1 nT/m, providing outstanding sensitivity. All lines for any one grid were collected parallel, and in the same direction, therefore eliminating “heading errors” which are often a major source of noise in magnetic surveys. Gradiometer measurements were recorded every 0.125 m on lines spaced 0.5 m apart.

2.9 Geonics EM38 Terrain Conductivity and Magnetic Susceptibility Mapping

The Geonics EM38 MK2 Terrain Conductivity and Magnetic Susceptibility Meter is a portable electromagnetic survey instrument that can be used to collect terrain conductivity data over relatively large areas in a short period of time. Terrain conductivity is defined as the bulk electrical conductivity of the subsurface. It is a measure of the combined electrical conductivity of the soil matrix and pore fluids. Typically, electrical conductivity is greater for finer matrix grain sizes (i.e., clays are generally more conductive than sands). Increasing water and salt content will also increase conductivity. Conductivity is recorded in units of mS/m. Similar to the TR/CIA resistance meter, the EM38 conductivity meter can map walls, ditches, pits, etc., but may also have difficulty distinguishing such anthropogenic features from natural subsurface variations in clay and water content.
Terrain conductivity instruments use the principles of electromagnetic induction to measure the conductivity of the soil. A transmitter coil induces an alternating electrical current to flow in subsurface conductors. A receiver coil measures the strength of the magnetic field caused by the induced alternating current (secondary field), as well as the magnetic field from the transmitter (primary field). Of the combined fields measured by the receiver, the component that is 90 degrees out-of-phase (quadrature) with the primary field is recorded by the EM38. The quadrature component is directly proportional to the conductivity of the soil.

The EM38 also maps "terrain magnetic susceptibility", which is defined as the magnetic response of the ground when subjected to an inducing magnetic field (McNeill 2013). Unlike a magnetometer, the EM38 induces its own magnetic field from its transmitter coil. Soil magnetic susceptibility may be enhanced by metal, burning of soils, baking of clay (e.g. bricks), bacterial activity associated with human waste, and the addition of magnetic materials such as iron and steel construction debris, or fire baked bricks.

Generally, the depth of investigation of an electromagnetic (EM) device is a function of the transmitter/receiver inter-coil spacing and the dipole (or coil) orientation. The EM38, with inter-coil spacings of 0.5 m and 1 m, has maximum depths of investigation of approximately 0.75 m and 1.5 m, respectively. The EM38 in the vertical dipole mode has a peak response at a depth of 40% of the inter-coil spacing, that is, at 0.2 m depth and 0.4 m depth for the 0.5 m and 1.0 m coil spacings, respectively. With the coil dipoles positioned in the vertical position, the instrument has essentially no response to the first few centimetres of depth and is therefore largely insensitive to irregularities in the micro-relief of the surveyed area.

At the Great Synagogue site in Vilnius and at Mila 18 in Warsaw, EM38 data were collected every metre as referenced to the local rope grids established for the Bartington 601-2 gradiometer and the TR/CIA resistance meter. At all other sites, EM38 data were collected every metre on lines spaced approximately 5 m apart. In each measure point, two conductivity and two susceptibility measurements were recorded. All data were recorded in the field onto an Archer palmtop computer. As current is induced into the subsurface rather than by using direct current and probes as with the TR/CIA resistance meter, EM38 surveys proceed significantly more quickly than resistance meter surveys. Data collection was done with the instrument coupled to a GPS for georeferencing. Only the data from the deeper looking one metre intercoil spacing are presented as the very shallow looking 0.5 m intercoil spacing data provided no discernible information of value.

2.10 Unmanned Aerial Vehicle (UAV) Photogrammetry and Multispectral Aerial Photography

Multispectral imagery and visible light photogrammetry (also called RGB or red, green, blue colour model) were collected from a MicaSense Sequoia camera mounted on to a DJI Matrice 100 (Photograph 1) quadcopter UAV (also called a “drone”). The Sequoia records four discrete spectral bands of light (MicaSense 2016) including green, red, Red Edge, and near infrared (NIR). Conventional photographs are also captured with the RGB visible light imager. A higher quality visible light camera (a 12.0-megapixel DJI Zenmeuse X3) was also mounted on the Matrice 100 to improve the quality of the photogrammetry.
Reflected energy in the green spectral band (wavelengths of 530 nanometres [nm] to 570 nm) is closely correlated to leaf chlorophyll content. As such, the green band may provide information where vegetation is stressed due to, for instance, buried pavement or a shallowly buried wall limiting root growth. Or, the green band may indicate areas of unusually healthy vegetation due to, for instance, an old garden plot or trench which may be capturing more moisture and nutrients.

The red spectral band (wavelengths of 640 to 680 nm) is strongly absorbed by vegetation. As such, red band energy is used in the vegetation indices (such as Normalized Difference Vegetation Index [NDVI]) to calculate vegetation stress, or to contrast vegetation with exposed soil.

The Red Edge band (narrow band of wavelengths of 730 nm to 740 nm) bridges the spectrum for red to near infrared reflectance and is particularly sensitive to plant nutrient stress.

Near Infrared wavelengths (770 nm to 810 nm) are sensitive to vegetation type and vegetation stress. NIR, along with red, is used in the commonly mapped vegetation health indicator NDVI. This index is simply calculated as:

$$\text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{Red})}$$

All multispectral information was managed through the photogrammetry software Pix4D.

Photogrammetry is the science of creating maps from photographs. The visible light imagery was used to create a georeferenced orthophoto (i.e., a photographic base map) using Pix4D and Agisoft Photo Scan software platforms. The Matrice 100 was flown at an altitude of approximately 40 m. Orthophotos were created with a resolution of about 5 cm/pixel or less. Georeferencing was accomplished with drone mounted GPS as well as GPS locating of discrete features on the ground (e.g. the corner of a paved walkway) that appear in the drone image and georeferenced intentionally placed aerial targets. All imagery is referenced to the datum of WGS84, UTM Zone 35N is Lithuania, and WGS84, UTM Zone 34N in Warsaw.
3 Investigated Sites

3.1 Rumšiškės (Rumsheshok)

3.1.1 Background and Overview

Before World War II, there were more than 1500 shtetls (small Jewish towns) in Eastern Europe; all were destroyed in the war. Rumšiškės (Rumsheshok in Yiddish) is a small town (Figure 4-1) located 20 kilometres (km) from Kaunas (Kaunas had been the provisional interwar capital of Lithuania from 1918 until 1939). In 1941, the Jewish population included 50 families, or about 300 persons (Figure 4-1).

On June 24, 1941, the German army entered Rumšiškės and immediately began detaining Jews (Gustaitis 2010). On June 26, a platoon of Lithuanian collaborators was created, ostensibly to pursue the retreating Red Army. Immediately, this platoon began looting Jewish belongings, enslaving the Jewish population as laborers and farm workers, terrorizing the population, and randomly shooting a few Jews every day.

Between June 24 and August 29, most of the surviving Jewish population were deported to either the Kaunas Ghetto or the nearby Pravieniškės labour camp. At noon on August 29, a group of collaborators forced the remaining 80 Jews to dig a pit 22 metres (m) long and 4 m wide within an area that is now part of the Open-Air Museum of Lithuania. Ten to 15 drunken soldiers shot the Jews from 10 paces distance. By
September 20, 1941, the remaining Jewish property had been auctioned off for 30,123 rubles, with the proceeds going to the Kaunas district government.

In 1959, the Soviets built a dam and hydroelectric station, and submerged Rumšiškės in creating the Kaunas Reservoir. The town of Rumšiškės, now underwater and empty of Jews, was moved two kilometres away to a new location (Figure 4-1). A Jewish mass grave of 50 Jewish murder victims from July and early 1941 that was to be flooded by the reservoir was disinterred, with the remains being moved to the Aleksotas cemetery in Kaunas. The 80 person mass burial of August 29, 1941 is thought to have remained on high ground, though previous disinterment is a possibility. A stone monument memorializes the August 29, 1941 mass murder, though the exact location of the burial trench is not known.

In 1966, Europe’s largest historical village, the Rumšiškės Open-Air Museum of Lithuania (aka the National Living Museum), was created on the shores of the reservoir from non-Jewish buildings salvaged before flooding. In our current (i.e., 2020) post-Soviet era, the Museum would like to recognize and incorporate pre-Holocaust Jewish life into the museum. As part of this effort, the Museum wants to map what remains of the Rumšiškės shtetl and locate the mass burial of August 29, 1941. The Jewish community is committed to memorializing the shtetl and mass grave or graves.

There were two objectives of the geophysical portion of the Rumšiškės investigation. First, we used sidescan sonar to explore for remains of the Jewish shtetl, Rumsheshok in Yiddish, on the floor of the reservoir. Secondly, we used geophysical surveys and UAV photography to explore for the mass burial of August 29, 1941.

The French government and the French Institute of Lithuania are also very interested in the Rumšiškės mapping project as the famous French Jewish philosopher Emmanuel Levinas was born in Rumšiškės and was naturalized as a French citizen only in 1939. Largely because of Levinas’s connection to Rumšiškės, Loïc Salfati, a photographer and film maker from the French Institute of Lithuania, documented the various geophysical and historical investigations related to this project. Independent Lithuanian documentary film makers Rytis Titas and Rūta Vyžintaitė–Lajienė documented the field work and associated historical studies for Lithuanian television. University of Hartford student film makers (Kyle Conti, Becca Chien and Travis Girouard under the direction of faculty Susan Cardillo, Assistant Professor of Communication at the University of Hartford) also filmed and interviewed for a documentary with a working title of “The Lost Shtetl.”

3.1.2 Field Work

In 2018, we georeferenced pre-flooding aerial photographs of Rumšiškės (Figure 1) and overlaid them onto the present photographic footprint of the Kaunas Reservoir (Figure 2). In January of 2019, Harry Jol of the University of Wisconsin and Richard Freund of the University of Hartford (currently at CNU) ran a few GPR lines on the ice of the reservoir (Figure 3). They determined the location of the main channel of the submerged Nemunas river and identified some topographic features that served as landmarks for orienting the July 2019 sidescan sonar survey.

Sidescan sonar data (SSS) and single-beam echosounder (SBES) data (for bathymetry) were collected on July 8, 2019, from on board a small sport fishing boat. Data were collected over an area of about 750 m
east/west, and 900 m north/south, so as to be confident of fully covering the footprint of the central portion of Rumšiškės.

Vessel positioning was provided by a Trimble 6000 GeoExplorer GPS receiver. The GPS was configured to output two standard NMEA GGA strings at a 20Hz rate that were used as positioning to provide navigation input to both the echosounder and sidescan sonar. As with the terrestrial surveys, georeferenced coordinates for the survey were determined using a Trimble handheld Geo7X GPS unit, and all positions were referenced to WGS84; UTM Zone 35N. SBES bathymetry data were collected using a Garmin system.

Geophysical surveys on land, in search of the August 29, 1941 mass burial, were carried out on July 8 and 9, 2019. Surveys included ground penetrating radar (500 MHz antennae), Geonics EM61 metal detection, Geonics EM38 terrain conductivity mapping, Geonics EM38 magnetic susceptibility mapping, and ERT.

An orthophoto base map was created from UAV RGB photography acquired from a DJI Matrice 100. Four aerial targets were distributed over the photographed area and surveyed with a total station.

The GPR survey was carried out over a low area close to, but not encompassing the stone monument. Data collection was done within a gridded area of 25 m X 34 m. Traces were collected every 0.02 m on 100 GPR lines spaced 0.25 m apart. A single, large diameter odometer wheel was used with the 500 MHz GPR system due to the very uneven forest floor.

EM38 terrain conductivity and magnetic susceptibility, and EM61 metal detection data were collected in proximity to the stone monument established near the assumed site of the mass grave. An 80 metre (m) long, west/east trending ERT profile (Line 1) was centered at the stone monument. A shorter, south/north trending, higher resolution 40 m long line was located over a depression hypothesized to be a grave. This 40 m long ERT line intersected the longer west/east trending ERT line at 90°. The ERT line positions and elevations were surveyed using a handheld Trimble GPS and a total station.

Ten soil samples for total phosphorus analysis were collected from depths of about between 0.20 mbgs and 0.30 mbgs. Soil sampling positions were measured with the GeoExplorer 6000 GPS.

3.1.3 Results and Interpretation

The bathymetric data are presented in Figure 4. The sidescan sonar data are presented in Figure 5. Targets in the sidescan data, as defined by prominent features protruding from the lake floor, are noted in Figure 5.

Approximately 50 features were identified as likely being associated with the site of the former Jewish shtetl of Rumšiškės. However, all these features were point features, most being isolated, while a few were in a linear, evenly spaced row of as many as four (Figure 6). These point features are interpreted as being fence posts, tree stumps, truncated poles, large stones, possible bridge piers (Figure 6), or building debris. No structural features such as building foundations or enclosures were identified. It is now assumed that given the shallow nature of the reservoir, that 1. All buildings were levelled before flooding of the reservoir, 2. Other structures and features may have collapsed since flooding of the reservoir, and 3. Many or most low-lying features may have been buried in silt and clay since flooding. A photograph (Figure 7) later identified from the Kaišiadorių Muzeum, near Rumsiskes, and photographed in 1959, immediately
prior to filling of the reservoir, would indicate that few structures remained standing at the time of flooding of the reservoir.

In searching for the mass burial trench of August 29, 1941, the 500 MHz GPR data, as collected, processed, and interpreted by students from UWEC, identified an anomalous area with muted GPR reflections to a depth of about 1.5 metres below ground surface (Figure 8, Figure 9). The UWEC students interpret this area as a pit and possible mass burial site. No anomalous features were identified in the EM38 or ERT results (Appendix B). No clear patterns or distinctly anomalous sample points were identified in the total phosphorus sampling. The EM61 results clearly showed that the entire site, and well beyond the specific area of interest, was littered with metal debris buried at a shallow depth. Five randomly chosen metal anomalies were exposed. None of these features were distinctly contemporaneous to World War II. All exposed pieces of metal were discarded trash, being either metal pie plates or containers for placing memorial candles. As related to the mass burial trench of August 29, 1941, our overall conclusion is that its location and delineation remain uncertain. Furthermore, the large amount of buried metal indicates that the area has been heavily disturbed since World War II.

If the UWEC GPR delineation of the burial trench is not correct, and if in fact the other geophysical surveys are correctly determining that the stone monument is not sited on the burial trench, the explanation is likely one of the following: 1. The stone monument is not in the correct location. Perhaps it was randomly placed by the Soviets in 1959 before the flooding of the reservoir. 2. The human remains were removed, and the trench was refilled and packed with sand. 3. The incorrect location is memorialized due to incorrect remembrances. 4. The existing mass grave, or the empty trench of the exhumed mass grave, may not be providing a diagnostic response to any of the applied surveys.

3.1.4 Scuba Diving on the Submerged Shtetl of Rumsheshok

Paul Bauman and Ross Hill carried out a very short dive in what was determined to be the centre of the shtetl of Rumšiškės. Unfortunately, a complete lack of underwater visibility prevented the identification of any submerged features. The poor visibility was due to summer algae growth in the Reservoir.

3.2 The “Battlefield”, Fort IX

3.2.1 Background and Overview

In the late 19th century, Lithuania was part of Tsarist Russia. To protect the Russian Empire's western borders against an expected Prussian invasion, a network of nine fortresses or forts (Forts I-IX) were constructed around the city of Kaunas (Kovno in Yiddish), Lithuania. The complex of forts was constructed and renovated between 1882 and 1915 and was designated a “first-class” fortress in 1887. During World War I, this fortress system was the largest defensive structure in the entire state, occupying 65 sq. km (25 sq mi). Between wars, Lithuania enjoyed 22 years of independence before the Soviets annexed the country again in 1940.

During the Nazi occupation, starting in June 1941, Fort IX (Figure 4-2) became a place of torture and mass executions. Of the nine forts surrounding Kaunas, Fort IX was chosen as the largest execution site due to its proximity to the Kovno Ghetto in Slobodka. In his final report on the extermination of Lithuanian Jews,
Karl Jäger, the commander of Einsatzkommando 3 and the Security Police and SD (Sicherheitsdienst des Reichsführers or Security Service of the Reichsführer) in Lithuania, provides a chillingly premeditated account (Ben-Naftali 2004) of the factors that informed his choice of killing sites (Exekutionsplätze):

“...The carrying out of such Aktionen is first of all an organizational problem. The decision to clear each sub-district systematically of Jews called for a thorough preparation for each Aktion and the study of local conditions. The Jews had to be concentrated in one or more localities and, in accordance with their numbers, a site had to be selected and pits dug. The marching distance from the concentration points to the pits averaged 4 to 5 kms. The Jews were brought to the place of execution in groups of 500, with at least 2 kilometres distance between groups.”

To the Jewish community, Fort IX was known as the “Death Fort”. In secret, the Nazi Gestapo called it “Vernichtungsstelle Nr 2” – Extermination place number 2, or “Kaunas Vernichtungsstelle” (Ehrenburg and Grossman 2009). Here were murdered some 25,000 of Kovno’s Jews, as well as 15,000 Jews deported from the Greater Reich, thousands of Jewish POWs who had served in the Red Army, and many other Jews. In total, it is estimated that more than 50,000 persons were killed at Fort IX.

Between June of 1941 and 1943, the killings went on at Fort IX. Most of the dead were buried in linear trenches in an open field outside the western wall of Fort IX, known euphemistically as “The Battlefield”. The testimony of survivors (including from those survivors of the escape of Christmas Day, 1943) of Fort IX describe 14 burial trenches with 3,000 to 4,000 murdered victims in each trench (Feitelson 2006). According to the Soviet Government Statements on Nazi Atrocities (1946), within a few days of occupying Kaunas, the Nazis forced Soviet POWs to begin digging these trenches, each of which was 200 metres
long, three metres wide, and two metres deep. “By October of 1943 all the ditches west of Fort IX were full of corpses.”

In August 1943, the Kaunas Gestapo received orders from Berlin to eliminate the mass graves created in the previous years, including the widely issued Sonderaktion (special action) 1005– to exhume the corpses and to burn them. These operations were to be complete by the end of January 1944, when the German retreat from the Baltic States was foreseen. The carrying out of this order was imposed upon 75 Jews in Kovno who were already imprisoned at the Fort. Included among the 75 Jews were Ghetto inmates who had been seized in the Ghetto and brought to the Fort, Red Army POWs, and youngsters from the Ghetto who had been caught on their way to join partisans in the forest. Of the original 75, only 64, including 60 men and four women (Tory 1990), became the “Burning Brigade” of Fort IX.

According to the testimony of Mikhail Geltrunk given to the Soviet Extraordinary State Commission (Soviet Government Statements on Nazi Atrocities 1946):

“We exhumed and burned 600 bodies a day. That was the quota fixed by the Germans. Two huge pyres with 300 bodies in each were burned every day. After the bodies had been burned the bones were crushed with metal tools and buried.”

“In six weeks, we excavated three and a half ditches, from which we exhumed and burned 12,000 corpses; nine and a half ditches and many smaller pits, containing no fewer than 40,000 bodies, still remained unopened.”

The above testimony is echoed by other very similar testimonies. After the exhumations and the burning of corpses was completed, “the Hitlerites filled in the ditches, plowed up and sowed the field.”

Limited archaeological excavations of The Battlefield were performed by Soviet archaeologists between 1958 and 1971. A map of the archaeological excavations (Appendix C) was produced showing the hypothesized arrangement of the linear trenches within the approximately 1.7 hectare (Ha) area of The Battlefield. Notebooks describing the excavations are currently in storage at the present-day Ninth Fort Museum. At the time of an abbreviated geophysical investigation by this same group of geoscientists and historians at Fort IX in 2017, the excavation notes had not been translated from the original Lithuanian text, only a small portion of the notes had been located, the excavation map had not been georeferenced, and the excavation notes were not used as part of the field investigation.

3.2.2 Excavation Journals of 1960 to 1971, Museum Artifacts

In Appendix D is the burial trench map that resulted from the excavations, though it should be noted that there is no scale nor any kind of local or georeferencing.

The excavation journal pages were photographed by Josie Bauman and Maddje (Madeline) Fuerstenberg, a journalism student from UWEC. Organization, translation, and compilation of the translated journals and associated photographs were carried out by a summer student from Olds College in Alberta, Carissa Samoila. The translation of the journals from Lithuanian to English was carried out by Dalia Grobovaite with the Faculty of Arts at the University of Calgary. The full English Translation of the Excavation Journals can be found in Appendix E. The compiled Lithuanian text of the Excavation Journals has not been included in this report but is available upon request.
In Appendix F are found photographs from the excavation journals, as they were located in storage at the Ninth Fort Museum during our field investigations of July 2019.

The journals are extensive but often lacking in detail, span 12 years, tend toward the descriptive rather than the objective, are very difficult to spatially reference, and represent only a very small percentage of the entire killing area. Much of the area that was excavated has now been disturbed or destroyed by the gargantuan, 32 metre high 1984 “Monument to the Victims of Fascism” (note that as was typical of the Soviet period of occupation, there is no mention of Jews). In addition, despite the translation being carried out by a native and highly educated Lithuanian speaker, the Lithuanian language of the 1960s used significant amounts of vocabulary not regularly familiar to Lithuanian speakers of today. This is certainly partially due to the specific jargon of archaeology as well as the evolution of the language over the last 50 years. However, it is likely that Lithuanian of the 1960's as used in the scientific but politicized arena of mass grave investigations was influenced, to some degree, by Soviet politics and Russian language.

Despite various limitations and shortcomings of the excavation journal descriptions, the information within the journals is extremely helpful in both guiding the geophysical interpretations and providing detail which is beyond the ability of any geophysical technique. As it is unlikely that excavations will ever again occur in the trenches of Fort IX, the excavations act as a proxy for limited “ground-truthing” of the geophysical interpretations of the trench locations.

Regarding depths of the trenches, the journals describe trench bottoms ranging from 1 to 2.5 mbgs, with 1.5 to 1.8 mbgs being typical. During the construction of the 1984 Monument, though, considerable earth moving and earth spreading occurred, and trench bottoms may now be significantly deeper, or even shallower, than recorded in the excavation journals.

Regarding victims' remains, though survivors' testimonies document the burning of tens of thousands of corpses, significant numbers of human remains were nevertheless identified in the excavations of the trenches. Also, clear evidence of outdoor crematoriums, burnt bones, ashes, and burnt artefacts were identified and described. Included among the artefacts noted in the excavation diaries are passports and photographs, examples of “ground-truthing” that no geophysical plot can match for intimacy, descriptiveness, time sensitivity, and emotive quality.

Though testimonies from survivors of the Burning Brigade describe the separation of metal artefacts from the corpses before burning, the excavation notes (Appendix D), as well as artefacts stored in the Ninth Fort Museum (Appendix F), clearly show that large numbers of artefacts, including many that could be detected by the Bartington 601-2 Magnetic Gradiometer, the Geonics EM38, or the Geonics EM61, remain in the trenches. Such artefacts include ammunition shell casings, eye glasses, clothing and shoe buckles, jewellery, metal buttons, spoons and knives, bullets, keys, female hairpins, empty food tins, military pots, and lids from food cans.

Interestingly, photographs from the excavations and signatures in the excavation journals indicate that much, and perhaps most of the excavation work was carried out by women.
3.2.3 Field Survey

Geophysical and drone (aka UAV) surveys were carried out at Fort IX on July 10 through 13, 2019. This is in addition to the drone photogrammetry survey carried out by Paul Bauman and Alastair McClymont in 2017. A 30 m X 30 m GPR grid was surveyed in the northeast quadrant of the burial area with 500 MHz antennae. Individual profiles with 200 MHz GPR antennae were also collected. Six ERT sections were surveyed, including two from a 2017 program (Line 1 and Line 2) carried out by Paul Bauman and Alastair McClymont. ERT Line 1 used a minimum electrode spacing of 0.5 m. All other lines used a minimum electrode spacing of 1 m. As with the GPR surveys, all ERT sections were collected in a slightly offset north/south trend oriented perpendicular to the likely trench orientations.

Two 40 m X 40 m magnetic gradiometer grids were mapped. Geonics EM38 terrain conductivity and magnetic susceptibility, and EM61 metal detection surveys were carried out. A UAV spectral imaging survey was carried out with the DJI Matrice 100. A lower elevation, higher resolution photogrammetry survey was carried out with the DJI Mavic Pro.

56 soil samples were collected for Total Phosphorus analysis. Samples were collected from a depth of between 0.15 and 0.20 m below ground surface (mbgs). Samples were collected in a NE/SW trend, midway in the burial area, beginning near the fortress moat and heading toward the western retaining wall. The intention was to intersect as many burial trenches as possible. Samples 1 to 51 were collected every 2.5 m along a tape measured line. Each sample location was georeferenced with the GeoExplorer 6000 GPS. Samples 52 and 53 (i.e., the two westernmost samples on the profile) were taken beyond the retaining wall and may be considered background samples as compared to those located in immediate proximity to the interpreted locations of the burial trenches. Samples 54 and 55 were collected south of the interpreted burial area and are also considered to be background samples.

3.2.4 Results and Interpretation

Figure 10 summarizes our best interpretation, at present, of the locations of the burial trenches. The trenches are slightly skewed from a north/south trend. The trench alignments are approximately parallel. If one adds the 12 mapped longer trench sections to the two short, more southerly sections that fall between the delineated longer sections, a total of 14 trenches are identified. If one counts each individually delineated trench section, 16 are identified.

No trenches are mapped into the far southwest quadrant of the killing area as the construction of the Monument, completed in 1984, heavily displaced and disturbed the subsurface. Geophysical evidence for the massive disturbance in this area is seen in the large amounts of metal mapped by both the EM38 and the EM61 (Appendix G).

Together, the 2017 and 2019 UAV acquired orthophotos provide the broadest outlines of the trenches, with the 2017 orthophoto providing significantly better detail, perhaps because of drier conditions and vegetation stress at that period. The multispectral imagery (Appendix G) also highlighted a number of trenches as the various spectral bands tend to amplify the effects of differential vegetation health that is likely due to variations in soil conditions immediately above the trenches and between the trenches.
The magnetic gradiometer clearly identified a few of the trenches (Appendix G), while others were invisible. The variable success with the gradiometer may be due to the depth of burial, the depth of cover (i.e., fill later applied on surface), to what degree victims were stripped of their belongings, and the efficiency of corpse removal and burning. The gradiometer also identified two pipes or utilities that were previously unknown to the investigators.

GPR surfaces provided some support for the conclusions from the above combined data sets, though the GPR results were surprisingly quite ambiguous when viewed alone. Resistivity imaging provided no detailed information regarding the precise trench locations or depths (Appendix G).

Despite the failure to clearly define any trenches, all six ERT sections show a shallow (top three metres), high resistivity (pink, >90 Ohm-m) layer which may be indicative of the post exhumation infilling with sand during the Nazi occupation or, more likely, the spreading of sand (or other fill) and recontouring of the site during the Soviet occupation. Similarly, on each of the six ERT sections is a low resistivity layer (blue horizon, <20 Ohm-m, top two metres) which may be indicative of the undisturbed or perhaps only partially disturbed burial layer of the trenches. Specifically (Appendix G), on Line 1, from positions two meters to 40 m may be undisturbed, while 40 m to 68 m is disturbed. On ERT Line 2, 10 m to 70 m may be undisturbed, with 70 m to 137 m being disturbed. On ERT Line 3, 25 m to 68 m may be undisturbed, and 68 m to 108 m may be disturbed or infilled. On ERT Line 4, 20 m to 70 m may be undisturbed, and 70 m to 115 m may be disturbed, infilled, and/or recontoured. On ERT Line 5, the most northerly of the ERT lines, the uphill portion of the ERT line appears to be disturbed or infilled from 4 m to 70 m, with a clear blue, conductive horizon in the upper three meters of the subsurface, extending from 70 m to 100 m, possibly indicating the area of relatively undisturbed burials. On ERT Line 6, the high resistivity layer extends across much of the “Battlefield”, with the shallow, clear, blue, low conductivity horizon extending only from 55 to 77 m.

Four equal elevation slices were created across the six ERT sections (Appendix G, F9-10). No linear trends indicative of the trenches are observed. Given the cross-sectional and high resolution imaging of both GPR and ERT data, the results from these two survey techniques, in terms of precisely identifying the edges and depths of at least a few of the trenches, are surprisingly disappointing.

The results of the profile of Total Phosphorus analyses are plotted across 11 of the delineated trenches (Figure 11). Loosely interpreted, elevated phosphorus concentrations can be correlated with nine of the trenches (i.e., as compared to Total Phosphorus concentrations in the background samples and in locations between the interpreted trenches). Highly elevated phosphorus concentrations also correlate very well with the north/south trending pipe. However, as the pipe runs in close proximity, parallel, and likely at a similar depth to an adjacent burial trench to the east, construction trenching for the pipe may have brought soils with very high phosphorus concentrations (sample Fort 9 17.5 m, 631 mg/kg) to surface. Samples Fort 9 135 m (386 mg/kg), Fort 9 143 m (352 mg/kg, two westernmost samples on profile), Fort 9 BKD1 (351 mg/kg), and Fort 9 BKD2 (451 mg/kg) (two southernmost samples about 50 m and 100 m, respectively, from killing area) do fall in the lower range of concentrations and may be representative of background values and variability. The phosphorus value of background sample Fort 9 BKD3 will be ignored as this soil sample was taken from a very different area of the Fort about 200 m from the mass grave area.
The soil total phosphorus analyses at Fort IX are certainly intriguing, suggestive, and encouraging, but not completely convincing. Although 56 samples are a large number of Total Phosphorus analyses for any study, the site is large, and there is no spatial distribution beyond the single sampled profile. While one could state with some confidence that there are no “false positive” indicators in the data set, there are certainly many false negatives.

There are many possible reasons why soil samples from some trenches do not show high Total Phosphorus concentrations. Generally, at least a century is required for significant concentrations of phosphorus to translocate to the near surface. Sandy soils are far less amenable to capturing phosphorus than are clayey soils. The exhumation and burning of the majority of the corpses has removed a large percentage of the source of phosphorus. Modifications to the landscape, including adding fill, has likely altered the translocation of phosphorus or perhaps simply placed the layer of higher concentration phosphorus at depths greater than the sampling depth of 0.20 mbgs. On the other hand, burning, crushing bone, the scattering of ashes, and the shockingly large number of victims would all tend to favour the presence of higher total phosphorus concentrations in the soil. As such and at this time, our conclusion is that the measurement of total soil phosphorus concentrations continues to hold promise for Holocaust and other mass grave mapping and as a potential proxy for excavating but is still not proven nor fully understood.

### 3.2.5 Leapfrog 3-D Modelling and Imaging

All the Fort IX data sets described above, along with the 1960-1971 excavation map and the 2017 UAV orthophoto, have been brought into the interactive 3-D modelling and viewing platform of Leapfrog Works, developed by Seequent. Links to the 3-D visualization have been sent to all participating parties in this program, as well as to the Ninth Fort Museum. Additional links can be delivered upon request to Paul Bauman (paul.bauman@advisian.com, paul.bauman58@gmail.com) and/or Dr. Alastair McClymont (alastair.mcclymont@advisian.com). A few snapshots from the 3-D views of Fort IX are provided in Appendix H.

The 3-D visualization provides a powerful means of identifying spatial correlations. For example, lineaments clearly visible in the spectral imagery can be quickly correlated with the 2017 RGB photography, the excavation map, and the various geophysical data sets. Anomalous features in the ERT and GPR depth sections can be readily correlated with surface features. Also, the 3-D visualization shows where there are large gaps in the surface and subsurface imagery, and where further work may be beneficial.

### 3.3 Pravieniškės

#### 3.3.1 Background and Overview

Pravieniškės is located (Figure 4-3) about seven km northeast of Rumšiškės, in an area of forests and peatland. The Pravieniškės prison was established by Tsarist Russia in 1863 to imprison Lithuanian nationalists. The prison was used by the Soviets from 1940 to 1941 as a labour camp for criminals and political prisoners; from here, the prisoners mined peat. In June 1941, the Nazis released the surviving...
criminals and political prisoners, and transformed Pravieniškės into a concentration camp for Jews, Roma, and Soviet prisoners of war (POWs).

Figure 3-3  Location map of Pravieniskes

Three sites were investigated in Pravieniškės. These included the current Pravieniškės prison and two nearby mass burials. At all three sites, the objectives were to identify and delineate the exact locations of the mass burials.

The Pravieniškės maximum security prison, also known as the “Alcatraz of Lithuania”, was itself the site of a mass murder of an estimated 230 Lithuanians on June 26, 1941, unrelated to the Holocaust. The Lithuanian political prisoners, along with their families and servants, are believed to have been murdered by the People’s Commissariat for Internal Affairs (NKVD) or the Red Army as they were in retreat from the invading Nazis. They were likely shot as the prisoners and their families would have been witnesses to Soviet atrocities. On June 29, 1941, on the last day of the World War II first Soviet occupation of Lithuania, 182 of the 230 remains were buried within or in close proximity to the prison, while approximately 50 human remains were taken by relatives. 50 survivors escaped to give testimonies, but no trial or investigation occurred as the Soviets retook the area in 1944 with the retreat of the Nazis. As such, the identification of these particular mass graves is a matter of national pride and historical importance and would provide evidence of the atrocities that occurred during the Soviet retreat.

The search for this mass grave was also intended to broaden our work beyond that of locating and delineating only Holocaust mass graves. Possible grave locations were determined through historical aerial photography analysis by Dr. Phil Reeder of Duquesne University. Today, the prison population is largely gangsters and murderers.
There are two memorialized Holocaust mass burials near Pravieniškės. According to the Holocaust Atlas of Lithuania (2020), the 1941 massacre site memorializes 253 Jews imprisoned at the camp (247 men and 6 women) that were killed on September 4, 1941, in the forest near the camp. The stated reason for the mass murder was dissent at the labour camp. Lithuanian soldiers from a German led unit carried out the killings. The monument was erected in 1991. Conflicting anecdotal information suggested that Roma and Russian POWs were also buried at this site, and that the remains of all the victims except for the Roma had been exhumed and reburied elsewhere. No documentation has been identified to support or suggest this.

The second massacre site of 1944, as described by the Holocaust Atlas of Lithuania (2020), is one km from the Pravieniškės Prison. The victims were from the infamous “Convoy 73”, one of the last of the 79 train convoys carrying Jewish deportees from the Drancy (a northeast suburb of Paris) “Transit” Camp to their deaths, and the only train convoy that terminated in the Baltics (essentially Drancy was a concentration camp where Jews were brutally confined until they were deported to death camps). Convoy 73 departed Drancy on May 15, 1944. There were 878 men, women, and children on Convoy 73; 17 survived until liberation.

Most of the 878 victims died in the burial trenches of Fort IX, though 250 were sent to Pravieniškės which functioned as a satellite and overflow camp for Fort IX. How these 250 victims died is described by the Holocaust Atlas of Lithuania (2020): “In 1944 commander of Pravieniškės forced labor camp O. Anderson received about 250 Jewish prisoners from France. On July 10, 1944, according to witness L. Artamonov, when most prisoners were at work, Anderson ordered all Jews to be assembled, lined up and guarded. There were about 35 guards. Then he ordered them to march all Jews into the forest. The commander got into a motor vehicle and accompanied them. ‘We marched the Jews about a kilometre from the camp and saw a large trench about 12 m long, 4 m wide and 2 m deep. Anderson and a few Germans stood by the ditch. Anderson ordered the Jews to come closer to the ditch and lie down on the ground. People understood they were going to shoot them. Chaos and screaming arose. But they didn’t resist and didn’t try to flee. But they couldn’t do that, either, because they were so weakened by hunger that they looked like bones. They were weak and tortured so that even without shooting they had come to look as if they were dead’. They didn’t undress them before the shooting because they were wearing prisoner clothing. They were shot in groups of 40 to 50 people. The others awaiting their own deaths watched the shootings from 30 metres away. The shooting lasted for about 30 minutes.”

The monument at the Convoy 73 site was erected in 1991. There is conflicting and confusing information surrounding the site. A plaque at the site attributes the mass murder to 1941, though this is likely a generic plaque similar or identical to other plaques seen elsewhere at Holocaust sites in Lithuania, and identical to the plaque at the nearby 1941 Jewish, Roma, and Soviet POW mass burial. Anecdotal information from younger (i.e., not contemporaries to the events), local inhabitants stated that the victims remains had been exhumed in 1945 or 1946 by family members. This is highly unlikely as the fate of Convoy 73 was not known to the victims’ families until the early 1990’s. Nevertheless, exhumation and reinterment, as has been carried out by the French government elsewhere, may have occurred at some point, though we were not able to locate any documentation supporting this action. We have attempted to contact the descendants of the families of Convoy 73. We have recently contacted Dr. Jean-Marc Dreyfus (Dreyfus 2019, pers. comm.) whom we have worked with in the past, and who is the former Director of the European Research Council’s Corpses of Mass Genocide and Violence Program, and an authority on the repatriation of French Genocide victims’ remains from World War II.
### 3.3.2 Field Surveys

Field work was carried out inside of the Pravieniškės maximum security prison on July 12, 2019. Field work included collection of 13 soil samples for total phosphorus analysis at locations determined to be possible mass grave locations. Samples were taken from a depth of 0.20 mbgs. “Background” samples were also collected, though decades of industrial activity as a labour camp made the identification of true background locations impossible. Within the prison walls and in immediate proximity to the possible mass burial locations there also existed an abandoned rail track, woodworking shop, loading yard, disposal area of wood waste, prisoner living quarters, overhead storage tanks, and other areas of industrial activity. RGB and multispectral imagery were also collected over the area of interest within, and in immediate proximity of the prison.

At the 1941 mass grave of Jews, Soviet POWs, and Roma, a single 40 m long ERT line was collected (Figure 12) along the long axis of the demarcated mass grave. A relatively tight electrode spacing of 0.5 m was used to maximize spatial and depth resolution. Both resistivity and IP data were collected. As the mass grave site was demarcated by steel posts, plan view mapping with the EM38, EM61, and magnetic gradiometer were not considered. Though the site is well cared for, it is thickly vegetated with junipers and other ground hugging vegetation, making the collection of resistance or GPR data also difficult. Five soil samples from the site were also collected from a depth of 0.20 mbgs. Three samples were from the demarcated mass burial, and two samples were considered to be background.

Similarly, at the Convoy 73 mass grave, a single 50 m long ERT line was collected (Figure 13) along the long axis of the demarcated mass grave, again using a relatively tight electrode spacing of 0.5 m to maximize spatial and depth resolution. Both resistivity and IP data were collected. As this mass grave site was also demarcated by steel posts, plan view mapping with the EM38, EM61, and magnetic gradiometer were not considered. The site was slightly elevated and thickly vegetated with junipers and other ground hugging vegetation, making the collection of resistance or GPR data also difficult. As with the 1941 mass grave, five soil samples from the Convoy 73 site were also collected from a depth of 0.20 mbgs. Three samples were from the demarcated mass burial, and two samples were considered to be background.

### 3.3.3 Results and Interpretations

Somewhat as one might expect, given the long history of disturbance and industrial activities, the various activities that have occurred at the site, and the broad footprint of disturbance and infrastructure, no useful information or tentative conclusions regarding burial locations were gained from the total phosphorus analyses or aerial RGB and multispectral imagery acquired at the Pravieniškės maximum security prison.

At both Jewish mass grave sites near the Pravieniškės prison, no significantly large anomalous features were observed in either the resistivity or IP sections. At both sites, we interpret a very high resistivity (>20,000 Ohm-m) layer of dry sand to be overlying a much lower resistivity layer (between 500 and 2000 Ohm-m) that is likely saturated or partially saturated sand. The dry layer is from one to three metres in thickness.
Five samples for total soil phosphorus analyses were taken at each of the Holocaust burial sites (Appendix B). At both sites, the background total soil phosphorus concentrations were significantly greater than the concentrations measured from the samples taken over the demarcated burials. Background samples were taken several tens of metres from the demarcated burial sites. None of the phosphorus sample locations are plotted on base maps as, although GPS data were collected for more than one minute at each sample location, GPS accuracy was very poor within the dense pine forest.

Regarding the Jewish mass burials, our tentative conclusions raise three possibilities: 1. The burials, demarcated about 50 years after the murders, are not correctly or precisely located. 2. Whatever remains may be present in the burials, and the burial trenches themselves, are not creating measurable geophysical or geochemical anomalies. 3. The burial remains have been exhumed and reinterred elsewhere, with the trenches being refilled with native sand.

Given the nature and sensitivity of this project, the authors would like to explicitly state that given the documentary evidence and testimonies regarding this site, we are accepting as fact that the murderous events at Pravieniškės, as described, did occur. Blurring of details and events may have occurred since the mass murders of 1941 and 1944. The Soviet occupation may also have created misinformation given the reported Soviet atrocities in the area. Soviet exhumations may have taken place associated with Soviet POWs or the investigation of war crimes.

If further work were to be undertaken at the two Jewish mass burial sites, despite the significant ground cover, we would suggest the use of GPR given the presence of the highly resistive sands that appear to blanket the area.

### 3.4 The Great Synagogue, Vilnius

#### 3.4.1 Background and Overview

For at least three centuries, the Great Synagogue stood in the centre of Vilnius. The broad span of the history of the site, as well as much of the recent archaeological and geophysical work, is described on the website “The Great Synagogue & Shulhof of Vilna (Vilnius)” maintained by Dr. Jon Seligman (2020).

In World War II, the Synagogue was ransacked by both the Nazis and the Soviets. In 1957, the Soviets tumbled the walls, levelled the site, and built a school and playground on the Great Synagogue Site. In 2015, ground penetrating radar surveys carried out by Dr. Harry Jol of the University of Wisconsin, Eau Claire, indicated that some intact structures may remain underneath the playground area. Archaeologists Dr. Richard Freund and Dr. Jon Seligman indicated that this area may be associated with the mikveh or ritual bath. GPR surveys continued under the direction of Dr. Harry Jol through 2016, 2017, 2018, and into 2019 as part of this GWB program. Paul Bauman and Dr. Alastair McClymont carried out ERT and UAV surveys in 2016 and 2017.
3.4.2 Field Surveys

On July 15, 2019, UAV, resistance meter, terrain conductivity, and magnetic gradiometry surveys were carried out over the southern portion of the footprint of the former Great Synagogue (i.e., over the main portion of the Synagogue in proximity to the Bimah). The available area for field work was very limited as archaeological excavations were being carried out in the same area, much of the area had been previously excavated, and iron fences and reinforced concrete pavement limited the utility of most survey methods. The entire surveyed area fell within a footprint of 11 m x 30 m.

500 MHz antennae GPR surveys were also completed in the southern portion of the former Great Synagogue. The footprint of the GPR survey fell within an 18.5 m x 30.0 m area. A line spacing of 0.25 m and a trace spacing of 0.02 m were used.

500 MHz antennae GPR data were also collected over a nearby open area and basketball court within a footprint of 29.5 m x 26.3 m. This site was located about 50 m south of the Great Synagogue site. A line spacing of 0.25 m and a trace spacing of 0.02 m were also used here. The site is believed to contain the footprint of the former Ramayles Yeshiva (i.e., an Orthodox Jewish School) that operated from the 1820s until World War II.
3.4.3 Results, Interpretations, and Media Coverage

Selected geophysical data sets and UAV images are presented in Appendix J. The GPR slice over a depth interval of 0.85 to 0.90 mbgs is likely imaging at least one corner, and perhaps two corners of the Ramayles Yeshiva (Figure 14). Resistance meter (i.e., the TR/CIA) mapping on the grass lawn area south of the Soviet school building (Figure 15) and over the footprint of the Great Synagogue appears to have identified one corner of the Great Synagogue, several other building or room corners, and the former location of the alley between the Great Synagogue and the Beit Midrash (a Jewish study hall). Building corners are of particular interest to archaeologists as they provide significant spatial context in return for a relatively small excavation footprint.

Another important aspect of the July 15, 2019 field day at the Great Synagogue site was observing some of the newly opened archaeological “squares” (i.e., 5 m X 5 m excavation areas), and discussing with the historians and archaeologists the results from excavations of previous years. The most significant interpretation realization gained was regarding large, resistive (i.e., >700 Ohm-m), ERT anomalies at depth. Previously, we had interpreted these features as brick rubble, brick or stone foundations, or brick or stone floors. It is now our clear understanding that the massive, resistive anomalies are void spaces as, for example, the cellar area (Figure 16) under the bimah (the platform in a synagogue from which the Torah is read). Numerous important artefacts were discovered while excavating this cellar, including about 200 coins dating from the 16th to the 20th centuries, buttons from Napoleon's army, and a large stone inscription that was part of the Torah reading table. Though the cellar was targeted based on the floor plan of the Great Synagogue and not the resistive anomaly in the ERT section, we now can confidently direct the archaeologists to other high resistivity anomalies that are similarly interpreted as void spaces.

A few of the links to 2019 media coverage of the Great Synagogue excavations and the discovery of the cellar beneath the bimah are below. The first article, from the Daily Mail, is one of the unfortunately few articles to give well deserved credit to the role of geophysics in the Great Synagogue investigations and excavations. The second article, from the Lithuanian Jewish Community, describes a public presentation made by the geophysical investigation team. The third, fourth, and fifth articles below are from the initial phases of geophysical and archaeological investigations at the Great Synagogue in 2015 and 2016.

[Links to articles]

https://www.timesofisrael.com/radar-reveals-buried-grand-synagogue-of-vilnius/
Šeduva Synagogues

3.5.1 Background and Overview

Šeduva (Yiddish Shadova) is a small (2005 population of 3,270) town in Lithuania (Wikipedia 2020) located about 100 km north of Kaunas (Figure 4-5). As was common in Lithuania, Jewish and Catholic populations were present in the town since the 15th century. The town had at least four synagogues and a yeshiva (an Orthodox Jewish school). In 1815, a large green painted, wood synagogue with a zinc sheet roof was consecrated in the central market square of Šeduva (Seligman 2020). Only a single photograph of the main façade exists. Aerial photographs indicate that this wood synagogue stood until 1941 but was likely soon destroyed as determined from a Nazi area plan of 1943.
Somewhere between the end of the 19th century and the beginning of the 20th century, a large, red brick synagogue was built also in the central market area. Several photographs of this synagogue exist. The only surviving plot plan was created by the Nazis in 1941 (Lithuanian Central State Archive, as found in Seligman 2020), following the extermination of the town’s Jewish population. The synagogue is described in some detail by Seligman (2020) and on the webpage “Šeduva-Shadova” (2019) which is maintained by Dr. Jon Seligman.

The economic depression of the 1930s spurred anti-Semitism and consequent immigration of the Jewish population of Šeduva. By 1939, the Jewish population was 200 families and about 800 persons. The Nazis occupied Šeduva around June 24, 1941. Between the end of June and August 25, 1941, many Jews were summarily executed or placed into forced labour. On August 25 and 26, the remaining 664 members of the Jewish community were shot and buried in two previously dug mass graves. The interior of the brick synagogue was emptied; the building was used as a work camp.

The red brick synagogue was destroyed in the 1960s. What had previously been an expansive area of Jewish community structures (i.e., shul hoyf in Yiddish, perhaps best described as a Jewish “campus”) was transformed into a market area hosting agricultural fairs and harvest festivals (Seligman 2020). The building debris was used to pave paths over the site of the previous wood synagogue.

In 2018, Dr. Harry Jol and UWEC students used 500 MHz GPR to locate and map much of the foundation of the red brick synagogue within a grid of 18 m X 32 m. In the 2019 program, Dr. Jol and UWEC students continued 500 MHz GPR mapping over four additional grids (Figure 17) in trying to fully map the
foundations of the 20th century brick synagogue (Grid B), to map the structure of the wood synagogue (Grid A), and to map other Jewish structures associated with the brick synagogue (Grids C and D).

3.5.2 Field Surveys

Field work was carried out on July 19 and 20, 2019. All data were collected with 500 MHz shielded antennae. Traces were collected every 0.02 m on lines spaced 0.25 m apart. The area and location of the five radar grids at the market area are indicated in Figure 17.

3.5.3 Results and Interpretations

The northern edge of 2019 Grid B (Figure 17) is clearly mapping the extension of walls or the foundation from the 2018 GPR mapping of the brick Synagogue. Figure 18 merges a GPR plan view slice from the 2018 data (1.10 to 1.15 mbgs) and a plan view slice from Grid B from 2019 (1.00 to 1.05 mbgs). Figure 19 shows the interpretation of the foundation architecture based on the GPR results and the 1943 Nazi floor plan, as provided by Dr. Jon Seligman (2020).

Although linear features are recognized in grids A, C, and D (Appendix K), it is not clear whether these are related to structures, paths, landscaped boundaries, etc.

3.6 Royal Łazienki Park, Warsaw

3.6.1 Background and Overview

In 1939, before the surrender of Warsaw on September 30, 2019, Polish soldiers buried weapons in Łazienki Park (Figure 20) to prevent their falling into the hands of the Nazis, and for potential use by the Polish resistance at a later date. Other objects of military or historical value may have also been buried in Łazienki Park at this time. However, during the occupation, the Nazis made Łazienki Park inaccessible to Poles. After the Nazi occupation, the communist government made no effort to search for buried weapons or artefacts that may have engendered feelings of Polish nationalism. Excavations in 2007 and 2014 in Łazienki Park did uncover weapons and military equipment from 1939 (Warsaw Ghetto Museum and Łazienki Krolewskie Museum 2019).
In June 2018, a contractor carried out metal detection surveys in Łazienki Park in areas Bc23, Bc25, Be26, and Be27. It is believed that data were collected on a local coordinate system (Appendix L).

In this program, on July 18, 2019, Colin Miazga carried out an EM61 high resolution metal detection survey over a portion of the Romantic Garden in the Royal Łazienki Park. Areas Bc25 and Be27 were surveyed. A large number of buried metal objects are identified over approximately 70% of the surveyed area (Figure 20). Many of these targets are large in both their footprint and likely in the mass of metal.

### 3.6.2 Field Survey

Data were collected on the morning of July 18, 2019. Data were collected approximately every 0.1 m on lines spaced approximately two to four metres apart. While this is not 100% coverage, it is in fact very dense coverage of the field area, and likely sufficient coverage to identify most or all large arms caches that may be present in the surveyed area.

All data were georeferenced with a Trimble GeoX7 GPS. Data are referenced to Datum WGS 84, UTM Zone 34N.

Due to the large number of people using Łazienki Park, no drone imagery was collected. The results have been overlain onto the most recently available Google Earth Image.
3.6.3 Results and Interpretation

The results of the EM61 high resolution metal detection survey are presented in Figure 18. Generally, only anomalies of more than 200 mV are presented, with numerous large area anomalies exceeding 1000 mV being mapped. Surface metal and debris, manhole covers, construction debris, memorial plaques, utilities, and other metal objects that may interfere with the data collection and interpretation are identified and located on the plot. Clearly, numerous targets for excavation exist.

3.7 Bersohn and Bauman Children’s Hospital

3.7.1 Background and Overview

The Bersohn and Bauman Children’s Hospital (Figure 21) was a Jewish Children’s hospital that operated from 1878 to 1942 (Wikipedia 2019). The building’s address is Sienna 60 in Warsaw. In November 1940, the hospital was incorporated within the walls of the Warsaw Ghetto. Due to the extermination of the occupants of the “Little Ghetto,” the hospital facilities were moved in August 1942. On 13 August 1942, the patients and staff of the Bersohn Bauman hospital were deported to the Treblinka Extermination Camp (Warsaw Ghetto Museum).

The Bersohn and Bauman Children’s Hospital was one of the few buildings to survive the destruction of the Warsaw Ghetto. It has been renovated and largely reconstructed since the end of World War II. It is understood, though, that the footprint of the small gardens has remained largely unchanged (Warsaw Ghetto Museum 2019). Currently, the former hospital is being renovated to become the new Warsaw Ghetto Museum.

It is suspected that weapons, various artefacts, and the bodies of deceased patients may be buried in the small gardens. Only a few hours were available for geophysical surveys. EM61 high resolution metal detection and EM38 terrain conductivity and magnetic susceptibility surveys were carried out. Due to buried and overhead utilities, and the close proximity to various metal objects such as concrete curbs and slabs with rebar, the EM38 data sets were of no value. The EM61 metal detector has a much narrower swath of investigation as compared to the EM38. As such, only the EM61 survey is discussed, and only the EM61 results are presented.

3.7.2 Field Survey

EM61 data were collected every 0.1 m on lines spaced approximately 1 m apart, providing essentially 100% area coverage. As the hospital grounds are located in a dense urban area with significant tree cover, no drone imagery was collected.

All data were georeferenced with a Trimble GeoX7 GPS. Data are referenced to UTM Zone 34N, Datum WGS 84.
3.7.3 Results

The results of the EM61 survey, plotted as decay response in milliVolts (mV), are presented in Figure 21. All features shaded in colours of light blue (i.e. 300 mV) to all warmer (i.e. green, yellow, red, and pink) colours are indicative of buried metal. As such, one can conclude that there are large amounts of buried metal buried under most of the open area. The very hot (i.e. pink, >2900 mV) anomalies (i.e. features) are massive buried objects. It should be noted, though, that simply because a certain feature may be larger and contain much more metal, it may not necessarily be of greater interest. Some or all the massive pink targets may be related to reinforced concrete slabs or steel plates, for instance. Smaller features may be related to construction debris, weapons, ordnance, bullets, miscellaneous artefacts, etc. It is likely that only excavations will provide more detailed information regarding the various buried anomalies.

3.8 Mila 18

3.8.1 Background and Overview

Mila 18 is the World War II street address (The Post-War and pre-War numbering on Mila Street do not correspond. The address is now Mila 2.) of the command bunker of the ZOB (Jewish Fighting Organization, i.e. the Warsaw Ghetto resistance fighters). The bunker was originally constructed and used by Jewish Ghetto smugglers (Figure 22). The bunker was later occupied by the ZOB after their own bunker headquarters at Mila 29 had been discovered (Warsaw Ghetto Museum and Łazienki Krolewskie Museum 2019).

There were several hundred bunkers in the Warsaw Ghetto. The ZOB command bunker was discovered by the Nazis on May 8, 1943, three weeks after the start of the Warsaw Ghetto uprising. The Mila 18 bunker was likely the largest bunker in the Ghetto. On May 8, there were about 300 people inside the bunker. The Nazi SS injected poisonous gas through the ventilation ports into the bunker (Rotem 1994); the smugglers surrendered. The leader of the Ghetto uprising, Mordechai Anielewicz, and other members of the ZOB, committed suicide. A few of the resistance fighters escaped the bunker and the Ghetto through the sewer system.

Under the command of the German SS Commander, Jurgen Stroop, the Nazis destroyed the bunker at Mila 18. None of the bodies were ever exhumed, leaving the site as a mass grave, and now as a largely vacant memorial park in the middle of a modern city.

3.8.2 Field Survey

Multiple survey methods were applied at the Mila 18 site over the dates of July 18 and 19 (Figure 22). Four sections of ERT and IP were collected (Figures 23, 24, 25, and 26). Resistance mapping was carried out with the TR/CIA (Appendix M). Magnetic gradiometry data were collected with the Bartington Grad 601-2 (Appendix M). Terrain conductivity (Appendix M) and magnetic susceptibility (Appendix M) mapping were carried out with the Geonics EM38 terrain conductivity and magnetic susceptibility meter. Aerial images for photogrammetry and multispectral imagery were gathered from a drone carrying both RGB and multispectral cameras (Appendix M).
All ERT sections were collected in a southwest to northeast trend. ERT lines 1 and 4 used a one-metre minimum electrode separation and had a maximum depth of investigation of about 10 mbgs. ERT lines 2 and 3 used a 0.75 m minimum electrode separation and had a maximum depth of investigation of about 9 mbgs. For all four lines, IP data were collected simultaneously with the resistivity data.

Resistance meter and magnetic gradiometer data were collected only in the northeast third of the memorial site. EM38 terrain conductivity and magnetic susceptibility data were collected over the southwestern third of the memorial site as well as almost the entirety of the adjacent vacant lot to the northwest. Multispectral imagery and RGB photography were collected over the memorial site, the adjacent vacant lot, and the surrounding streets.

### 3.8.3 Results and Interpretation

All four ERT lines identified a continuous or nearly continuous, high resistivity surficial layer (red to pink, >800 Ohm-m) between 0.5 and 2 m in thickness. This layer is interpreted to consist of destruction rubble from the Nazi occupation. Generally decreasing resistivities (cooler colours ranging from green to blue) with depth are interpreted as partially to fully saturated sediments. Discrete, high resistivity features (red to pink) at depth, as annotated in the figures, are likely voids or partial voids, possibly associated with tunnels, the bunker, or void space within collapsed rubble. Possible void spaces are located on all four ERT lines. Of note, interpretation of these voids is supported by the excavation of similar resistivity anomalies at the Great Synagogue site in Vilnius.

IP measurements were collected only for identifying discrete metal objects in the subsurface. While such features may be associated with construction rubble, they could also be indicative of stoves, munition or gun caches, metal framing associated with tunnels or tunnel entrances, etc. Metal features, as indicated by IP anomalies, are identified at depth in each of the four IP sections. A particularly large IP anomaly is identified in ERT Line 1 (Figure 23). The IP anomaly of Line 2 (Figure 24) is notable in that it spatially correlates with the possible void identified in the resistivity section of Line 2. The tops of both IP anomalies on lines 2 and 3 (Figure 24 and Figure 25) are at similar depths of about 4 mbgs. On adjacent IP lines 1 and 3, IP anomalies are present on both sections at about 35 m along each line, and at a depth to the top of each anomaly of about 2 mbgs.

The resistance meter (TR/CIA) data are largely responding to the area that has been reworked for the monument. The higher resistance areas are likely where the building rubble is thicker.

The magnetic gradiometer results are likely of little value as the area is too “noisy” with nearby metal on the street and metal fragments likely interspersed in the debris buried underneath.

The EM38 terrain conductivity results, like the TR/CIA resistance data, are also likely largely responding to the thickness of the destruction debris. Lower conductivities (i.e. higher resistances and resistivities) are likely indicative of thicker debris. Of note is the 25 m x 25 m, low conductivity (<10 mS/m), approximately square area in the northeastern half of the empty lot located to the north of the memorial park.

The EM38 magnetic susceptibility results are likely largely responding to buried metal and utilities. Long, linear features (either blue or pink) are likely buried utilities or long runs of rebar. Large magnitude (pink)
anomalies, as well as dipolar anomalies (pink adjacent to blue) are likely associated with large pieces of metal, including manhole covers, construction debris, pipe, etc.

An RGB (visible light) orthophoto was constructed from the drone imagery. This orthophoto serves as the base map for all the various geophysical mapping results described above. Besides being of high resolution, this orthophoto has the advantage of being shot concurrently with the dates of the geophysical surveys.

Georeferenced photographs from the various light bands photographed by the multispectral camera are presented in Appendix M. The green band appears to be particularly useful in highlighting subsurface features that may be associated with the pre-War street plans. It should be noted, though, that the various light bands will also respond to modern features including footpaths, dog excrement, modern city infrastructure, pavement, different types of vegetation, irrigation and water sprinkler patterns, etc.

Figure 27 shows the NDVI plot which is constructed from a formulation of the red and near infrared band data. Figure 28 shows a possible interpretation of features identified in the NDVI plot.

3.8.4 Leapfrog 3-D Modelling and Imaging

All the Mila 18 data sets described above, along with the pre-War street plan of the Mila Street block, have been brought into the interactive 3-D modelling and viewing platform of Leapfrog Works, developed by Seequent. Links to the 3-D visualization have been sent to staff at the Warsaw Ghetto Museum and Dr. Richard Freund at Christopher Newport University. Additional links can be delivered upon request to Paul Bauman (paul.bauman@advisian.com, paul.bauman58@gmail.com) and/or Dr. Alastair McClymont (alastair.mcclymont@advisian.com). A few snapshots from the 3-D views of Mila 18 are provided in Appendix N.

The 3-D visualization provides a powerful means of identifying spatial correlations. For example, anomalous ERT features can be readily correlated with surface features. Experts on the pre-War urban planning of Warsaw may be able to interpret correlating ERT features as possible old utilities, sewer lines, tunnels, etc. Also, of note, the correlations of pre-War urban features with the lineaments in the multispectral drone imagery of the Muranowska side of the block and sewer access are very compelling. Finally, the 3-D visualization shows where there are clearly large gaps in the subsurface imagery, and where further work may be very beneficial.

3.8.5 Recommendations for Future Work at Mila 18

Of the mapping techniques executed at Mila 18, somewhat surprisingly, the multispectral imagery provided the most detailed information. It was not expected that vegetation would be responsive to the pre-War architecture due to the significant thickness of destruction rubble blanketing the site. It would be very helpful if someone intimately familiar with the pre-War urban planning were to review the various multispectral images to provide a more knowledgeable interpretation.

The ERT and IP surveys provided, by far, the most significant subsurface information of any of the geophysical surveys completed at Mila 18. Collection of additional ERT and IP data would certainly be helpful in filling in areas with little information. Collecting lines in a spatial trend perpendicular (southeast
to northwest) to the trend of the completed four ERT lines would likely identify linear features trending parallel to the present orientation of the existing four ERT lines.

Given the high resistivity of the overlying rubble and the sediment, ground penetrating radar may provide more highly resolved imaging of the subsurface. However, it is not known what effect the buried rubble will have on radar wave propagation; large blocks of construction rubble at surface may simply scatter the radar waves in various directions.

Given the presence of numerous geophysical targets of interest including possible voids, metal objects, pre-War street boundaries, etc., intrusive investigations would be of great value. Drilling or excavation investigations could potentially be coupled with downhole camera surveys.

3.8.6 Media Coverage of Mila 18 Geophysical Investigations

The geophysical programs at the Bersohn and Bauman Children’s Hospital and Mila 18 received a great deal of public interest and Polish media attention due to the roles of these sites in the Warsaw Ghetto Uprising. Links to some of the Polish media coverage are below. In addition, the geophysics team was filmed and interviewed by Radio Zet, the Polish news agency PAP, and the Warsaw Ghetto Museum.


3.9 Aerial Photographs, CNU Visit

A research visit was made to the National Archives and Records Administration (NARA) in College Park, Maryland, near Washington D.C., on February 19, 20, and 21. Toward the end of World War II, the United States military confiscated 1.2 million Luftwaffe aerial photographs. These photographs were captured in a race before the Wehrmacht could destroy them and before the Soviet Red army could obtain them. The photographs are stored in Building II at NARA and are available there for viewing and scanning.

The Luftwaffe aerial photography archive is difficult to search. As it turned out, all photographs were taken at a scale and at an altitude that was not useful for identifying mass graves. Cloud cover, misplaced photographs, misplaced photograph boxes, improper geographic cataloguing, and other factors together
create an element of serendipity in such an archive search. Nevertheless, 1944 photographs from Fort IX, Rumsiskes, Vilnius (Vilna), Warsaw, and the Sobibór Extermination Camp in Poland were scanned at high resolution (some at 600 dpi, most at 720 dpi or greater). A 1941 aerial photograph from Šeduva was also scanned. Eight cropped images from the photographs are presented in Appendix O.

Although field work at Sobibór was not part of this program, the Camp was investigated by many of the same researchers of this GWB program in 2008. There are no known existing aerial photographs of the Camp during its operation, and very few aerial photographs over the Camp following the Nazi razing of the Camp in 1943. Advantage was therefore taken of the research opportunity at the National Archives and Records Administration.

In coordination with the NARA research visit, a visit was made to Christopher Newport University in Newport News, Virginia. A two hour meeting took place with 12 students and two faculty planning on carrying out a summer program, including geophysical field work, at Holocaust sites in Lithuania and Poland. An evening lecture was given at the Department of Philosophy and Religion regarding this project. The lecture was attended by students, faculty, and members of the public in Newport News.
4 Conclusions

This project successfully brought together a broad suite of geophysical tools and other non-destructive site assessment approaches for the goal of better systematizing Holocaust period mass burial mapping. In the process of carrying out this project, a large number of geophysicists, University faculty, historians, archaeologists, University students, filmmakers, staff from various museums, and the general public in Lithuania and Poland were exposed to, and very likely influenced by the complex historical questions raised by this geoscience exploration program.

Although far more sites than originally planned were investigated in this program, some of the burial location and delineation objectives were not met. In fact, at several sites, our understanding of the histories of the sites and even the mass grave locations were much less clear after completion of our field work than before. We contend, though, that this apparent confusion is simply part of the process of investigating Holocaust sites in the Baltics. Though 1941 is not in the distant past as compared to sites that archaeologists would typically investigate, the politicization of mass burial mapping, the attempts of the Nazis to hide the evidence of their atrocities, the limited access to information and the redefining of many events during the Soviet occupation, the destructive attempts at memorialization by the Soviets, the physical disturbance of burial sites, the complicity of Lithuanians in the mass murder events at many of the visited sites, and simply the passage of time and memory have together blurred the chronicle of exactly what occurred, and where.

Conclusions as related to project and site-specific objectives are described below:

1. At Rumšiškės, a sidescan sonar survey over the submerged site of the Jewish shtetl (village) verified the location of the village as previously determined from aerial photography. The sidescan sonar survey identified approximately 50 features as likely being associated with the site of the former Jewish shtetl of Rumsheshok. However, all these features were point features, most being isolated, while others were in a linear, evenly spaced row of as many as four. These features are interpreted as being fence posts, tree stumps, truncated poles, large stones, possible bridge piers, or building debris. No complex features such as building foundations or enclosures were identified. It is now assumed that given the shallow nature of the reservoir, that a. all buildings were levelled before flooding of the reservoir, b. other structures and features may have collapsed since flooding of the reservoir, and c. many or most low-lying features may have been buried in silt and clay since flooding.

2. At Rumšiškės, UWEC students have identified an anomalous area with muted GPR reflections to a depth of about 1.5 metres below ground surface as being the possible location of the August 29, 1941, Jewish mass murder and burial. However, terrain conductivity mapping, resistivity imaging, and phosphate sampling failed to provide supporting evidence of either a mass burial or a trench. EM61 metal detection mapping and limited exposing of metal trash showed that the area had been significantly disturbed since World War II. No useful total phosphorus correlations were identified at the mass burial sites of Rumšiškės. As such, our overall conclusion is that while the UWEC students have presented a possible trench location, the location and delineation of the Jewish mass grave at Rumšiškės remains uncertain.
3. At Fort IX in Kaunas, in the “Battlefield” area (i.e., mass burial trenches), archived information, UAV imagery, and geophysics together created a map of the burial trenches as well as improved the overall understanding of the site. Multispectral imagery, 2017 RGB imagery photographed during drier conditions, and magnetic gradiometry were all particularly useful in trench mapping. GPR provided some supporting information. ERT surprisingly failed to precisely delineate trench edges or bottoms. However, in each of the six ERT sections running perpendicular to the burial trenches, the ERT sections showed a shallow (<3 m depth), high resistivity (>90 Ohm-m) layer that may be indicative of disturbance, infilling with sand or other fill, or recontouring of the landscape during the Nazi occupation and/or the Soviet period. Similarly, each of the ERT sections showed a shallow (pink, <2 mbgs), continuous, low conductivity (blue, <20 Ohm-m) that may be indicative of the burial layer and trenches.

4. At Fort IX in Kaunas, EM38 terrain conductivity and EM61 metal detection mapping clearly showed that the southwest quadrant of the mass burial area has been heavily disturbed, very likely during the construction of the Soviet era 32 m high Monument to the Victims of Fascism. The EM38 and EM61 also showed a number of coincident buried metal anomalies in the “Battlefield”, well away from the Monument. These anomalies may be indicative of concentrations of metal within the trenches.

5. At Fort IX in Kaunas, the gathering from archives, compilation, translation, and geographical referencing of the 1960 to 1971 Excavation Journals is itself significant as a documented testimony to the events of 1941 through 1944 at the “Battlefield”. The information within the journals was extremely helpful in both guiding the geophysical interpretations and providing detail which is far beyond the ability of any geophysical technique. As it is unlikely that excavations will ever again occur in the burial trenches of Fort IX, the 1960 to 1971 excavations act as a proxy for “ground-truthing” of the geophysical interpretations of the trench locations.

6. At Fort IX in Kaunas, elevated phosphorus concentrations can be loosely correlated with nine of the 11 trenches intersected by the 56 sample total phosphorus soil sampling profile. While this is interesting, and perhaps even encouraging, the significant number of false negatives (i.e., background phosphorus concentrations over mapped burial trenches) limit our confidence in the utility of total phosphorus as a mass grave mapping tool. No false positives (i.e., high total soil phosphorus concentrations over a background area) were identified.

7. For Fort IX, all the data sets, including the 1960-1971 excavation map and the 2017 UAV orthophoto, have been brought into the interactive 3-D modelling and viewing platform of Leapfrog. Links to the 3-D visualization have been sent to all participating parties in this program, as well as to the Ninth Fort Museum. Additional links can be delivered to whomever requests. The 3-D visualization provides a powerful means of identifying spatial correlations.

8. At the Pravieniškės maximum security prison, no useful information or tentative conclusions regarding burial locations were gained from the total phosphorus analyses or from aerial RGB and multispectral imagery. This is not surprising given the long history of the prison, and the large areas dedicated to industrial activity including a rail yard, a wood fabrication shop, and a waste disposal area.

9. At both Jewish mass grave sites near the Pravieniškės prison, no anomalous features were observed in either the resistivity or IP sections. At both sites, the background total soil phosphorus concentrations
were significantly greater than the concentrations measured from the samples taken over the demarcated burials. Our tentative conclusions raise three possibilities at each of these two sites: a. The burials, demarcated about 50 years after the murders, are not correctly or precisely located. b. Whatever remains may be present in the burials, and the burial trenches themselves, are not creating measurable geophysical or geochemical anomalies. c. The burial remains have been exhumed and reinterred elsewhere, with the trenches being refilled with native sand.

10. At Šeduva, over the site of the pre-War (but levelled in the 1960s) brick synagogue, a GPR survey has mapped the extension of walls or foundations from the clearly delineated architecture as mapped by a 2018 GPR survey, also carried out by UWEC. Linear features were mapped by GPR in three other nearby grids in the central market area, though it is presently not clear whether these are related to structures, paths, landscaped boundaries, etc.

11. At the Great Synagogue site in Vilnius, additional geophysical and UAV surveys were carried out in an ongoing program that continues from surveys done in 2015, 2016, 2017, and 2018. GPR has been particularly useful in establishing the plan view architecture of the Synagogue before its razing in 1957. A GPR slice under the footprint of the Ramayles Yeshiva, destroyed in World War II, may be imaging a corner of the structure. Resistance meter (i.e., the TR/CIA) mapping of the only accessible, yet unexcavated, and unpaved area in immediate proximity to the Great Synagogue appears to have identified one corner of the Great Synagogue, several other building or room corners, and the former location of the alley between the Great Synagogue and the Beit Midrash (a Jewish study hall). While the significance of most features geophysically mapped in the 2019 surveys is yet unclear, excavations in July 2019 have exposed very important architectural elements that were initially identified in previous geophysical surveys. Of particular note is a large resistive anomaly under the bimah (the platform in a synagogue from which the Torah is read) that excavations showed to be a cellar. Numerous important artefacts were discovered while excavating the cellar, including about 200 coins dating from the 16th to the 20th centuries, buttons from Napoleon’s army, and a large stone inscription in Hebrew that was part of the Torah reading table.

12. At the Great Synagogue site in Vilnius, and over the life of the project, geophysical and UAV surveys have played a small but significant role not only as mapping tools, but in creating interest among students and academics from various disciplines and countries. To date, of all the sites addressed in this program, continual and ongoing investigations at this site in the very centre of Vilnius have had profound political and social ramifications in Lithuania as a whole, and in the Jewish community worldwide. Presently, the municipal government is planning to demolish the Soviet era school building and to work toward a commemoration of the Synagogue site as part of Vilnius’s 700th jubilee year in 2023.

13. Regarding the utility of total phosphorus mapping as a tool for the mapping of mass grave sites of the World War II period in Lithuania, the conclusions remain uncertain. Besides complicated site histories that may have mechanically disturbed the soil column as well as the mass graves themselves, significant technical challenges remain including: a. Most of the soils were relatively to extremely sandy; phosphorus will tend to bond with metals on clay surfaces b. None of the mass graves preceded 1941; phosphorus mineralization is understood to require 200 to 500 years c. Sources of other phosphorus inputs were unknown; for instance, perhaps the burial area near Fort IX has been
fertilized in the past, and the possible mass burial area at the Pravieniškės Prison was also used as a dumping area for wood waste.

14. At the Royal Łazienki Park in Warsaw, hundreds of buried metal features were mapped with the EM61 metal detector, comprising about 70% of the surveyed area. Many of these features are certainly large enough to represent buried arms caches, the objective in this survey. It is likely that only excavations will now provide more detailed information regarding the various buried metal anomalies.

15. At the Bersohn and Bauman Children’s Hospital, EM61 metal mapping identified large amounts of buried metal buried under most of the open areas, including the gardens. Some or all the larger targets may be related to reinforced concrete slabs or steel plates, for instance. Smaller features may be related to construction debris, weapons, ordnance, bullets, miscellaneous artefacts, etc. It is likely that only excavations will provide more detailed information regarding the various buried anomalies.

16. At Mila 18 in Warsaw, resistivity imaged likely void spaces which could be related to tunnels or the command bunker from the Jewish resistance during the Warsaw Ghetto uprising. IP imaged large pieces of metal at depth that could be stoves, pipes, or arms caches. UAV spectral imagery delineated pre-War architecture and street plans. Future investigations at Mila 18 may occur in 2020.

17. For the Mila 18 site in Warsaw, all data sets, along with the pre-War street plan of the Mila Street block, have been brought into the interactive 3-D modelling and viewing platform of Leapfrog. Links to the 3-D visualization have been sent to staff at the Warsaw Ghetto Museum and to all participating parties in this program. Additional links can be delivered to whomever requests. The 3-D visualization provides a powerful means of identifying spatial correlations. Strong correlation of some pre-War urban features with lineaments in the multispectral drone imagery of the Muranowska side of the block are very distinct. These correlations were not expected given the thick blanket of post-War building debris that covers the entire footprint of the former Warsaw Ghetto. Correlations of some discrete resistive features in the ERT sections and chargeability anomalies in the IP sections are also quite compelling.
5 Closure

We trust that this report satisfies your current requirements and provides suitable documentation for your records. If you have any questions or require further details, please contact the undersigned at any time.

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References


Holocaust Atlas of Lithuania. Website: http://www.holocaustatlas.lt/EN/#a_atlas/search/bendri=pravienes_vietove=aukos=from_year=0 from_month=0.from_day=to_year=0.to_month=0.to_day=killers=/ Accessed January 2020.

Lithuanian Central State Archive (Lietuvos Centrinis Valstybės Archyvas) file LCVA R-729_1_78.


The Great Synagogue & Shulhof of Vilna (Vilnius), 2020. Website: [http://www.seligman.org.il/vilna_synagogue_history.html](http://www.seligman.org.il/vilna_synagogue_history.html)


Figures
Note: Green labels identify one or more point features that may be tree trunks, utility poles, stones, bridge piers, etc.
SC-0001

54.8570267425 24.1951392584 (WGS84)
(X) 319983.97 (Y) 6082486.37 (Projected Coordinates)
Potential Trench Feature

GPR SLICE (0.60 TO 0.65 MBGS) SHOWING POSSIBLE
RUMSISKES MASS BURIAL

GEOSCIENTISTS WITHOUT BORDERS
2019 GEOPHYSICAL INVESTIGATION
RUMSISKES, LITHUANIA
GEOSCIENTISTS WITHOUT BORDERS
2019 GEOPHYSICAL INVESTIGATION
FORMER GREAT SYNAGOGUE OF VILNA, LITHUANIA
GPR SLICE (0.85 TO 0.90 MBGS) SHOWING POSSIBLE
BUILDING FOUNDATION FROM RAMAYLES YESHIVA

FILE: C:\CATALOG\GBS107074-015B6900 - Lithsam 10.0_Techinical_Specialist
18.1 Geophysics\GBS10.1.2_Geophysics

Interpreted Building Foundation

GPR Survey Grid
Seduva Marketplace GPR Survey
Dates Collected: July 19-20, 2019

All Grids Collected With
500 MHz Antennae
.25 Meter Line Spacing
1941 Plan from Lithuanian Central State Archive (Lietuvos Centrinis Valstybės Archyvas) file LCVA R-729_1_78, as taken from Seligman (2020)

Plan 1941

Study Hall, Office, or classroom, stairway access to Women's Gallery

Prayer Hall

Bimah

Aron Kodesh

2019 GPR

Bimah pillars (marked with black circles on scan)
A-Bimah
B-Prayer Hall
C-corridor
D-Room (Beth Midrash or Rabbi's office)

E-Room (Beth Midrash?) steps to women's gallery (Ezrat Nashim) in corner.
F-Aron Kodesh

GEOSCIENTISTS WITHOUT BORDERS
2019 GEOPHYSICAL INVESTIGATION
SEDUVAS, LITHUANIA

INTERPRETATION OF GPR DEPTH SLICES

Date: 17-JAN-2020

Advisian
Interpreted Rubble Layer
Interpreted Voids or Collapsed Yields
Small Metal Object
Large Metal Object (see notes)

Notes:
Metal Object causing high chargeability anomaly (pink colour) likely does not extend as deep as shown.
Photographs
Photo 1  Rumšiškės: Monument to the August 29, 1941 mass murder of the remaining 80 Jews of the Rumseshok shtetl. The burial trench was reportedly 22 m long x 4 m wide.

Photo 2  Rumšiškės: Dr. Richard Freund (with cap) discussing the Rumšiškės sidescan and geophysical investigations with staff from the United States Embassy in Vilnius, Lithuania.
Photo 3  Rumšiškės: Paul Bauman (foreground), Chris Slater (yellow pants), and Colin Miazga setting up the sidescan sonar, bathymetry, and positioning systems.

Photo 4  Rumšiškės: From left to right, Alastair McClymont, Paul Bauman, and Chris Slater depart dock with sidescan sonar sonde ready on rear deck. The sonde was raised and lowered on a rope by hand. The GPS antenna and bathymetry sonde were mounted on the vertical wood board.
Photo 5  Rumšiškės: Paul Bauman (foreground) and Ross Hill prepare to dive on the submerged shtetl of Rumsheshok.

Photo 6  Rumšiškės: Loic Salfati,(center) from the French Institute of Lithuania, filming the sidescan sonar acquisition for a movie documentary.
Photo 7  Rumšiškės: Paul Bauman describing the results of the sidescan sonar survey for Lithuanian television.

Photo 8  Rumšiškės: Dr. Richard Freund (with back to photo) being interviewed and filmed both by Loïc Salfati (second from left) of the French Institute in Lithuania, and by Rūta Vyžintaitė (woman) and Rytis Titas (on far right) for a documentary for Lithuanian television.
Photo 9  Rumšiškės: Colin Miazga of Advisian (far right) with Dr. Harry Jol (second from the right) explaining the UAV photogrammetric and multispectral mapping.

Photo 10  Rumšiškės: GPR mapping at Rumsiskes. Note the broad depression over which the survey was carried out.
Photo 11  Rumšiškės: 500 MHz GPR antennae being employed in search of the August 29, 1941 mass burial.

Photo 12  Rumšiškės: UWEC Environmental Geography student Logan Bergevin collecting 500 MHz GPR data.
Photo 13  Rumšiškės: Dr. Harry Jol taping out lines for his students carrying out the GPR survey.

Photo 14  Rumšiškės: Tape measured GPR lines bordering the stone plaque memorializing the August 29, 1941 mass burial.
Photo 15  Rumšiškės: Dr. Phil Reeder from Duquesne University surveying in the GPR local grid.

Photo 16  Rumšiškės: UWEC Environmental students Kelly Jerviss (left) and Hailee Jefferies surveying relief along the GPR lines using a laser level.
Photo 17  Rumšiškės: UWEC Environmental Geography student Kelly Jerviss reading the laser level determined relief change.

Photo 18  Rumšiškės: Dr. Alastair McClymont georeferencing an aerial target with a Trimble Geo GPS.
Photo 19  Rumšiškės: Paul Bauman collecting a soil sample for Total Phosphorus analysis.

Photo 20  Rumšiškės: Chris Slater collecting EM38 terrain conductivity and magnetic susceptibility data.
Photo 21  Rumšiškės: Dr. Alastair McClymont collecting EM61 high resolution metal detector data.

Photo 22  Rumšiškės: The memorial candle holder and a piece of metal were typical of the excavated EM61 metal detector anomalies.
Photo 23  Rumšiškės: Dr. Alastair McClymont collecting an electrical resistivity tomography (ERT) and an induced polarization (IP) section.

Photo 24  Rumšiškės: Portions of the non-Jewish structures of the flooded town were moved to higher ground to create The Open-Air Museum of Lithuania, one of the largest outdoor historical and ethnographic museums in Europe. The site is 195 hectares and was opened in 1966.
Photo 25  Fort IX: Southwest corner of brick walled courtyard from where two of the guard posts can be seen, approximately where the outdoor crematoriums were located, and along the escape route of the 1943 Christmas Day escape of the 64 prisoners in the “Burning Brigade”.

Photo 26  Fort IX: The gargantuan 32 metre high 1984 Monument to the Victims of Fascism disturbed much of the “Battlefield” mass burial area, as did the Nazi plowing over the burial trenches, the construction of the museum, and the 1960 to 1971 Soviet excavations.
Photo 27  Fort IX: A rope ladder was used to climb out of the outer moat and over the outer wall on the December 25, 1941 escape. The survivors provided testimonies of the atrocities that occurred at the “Death Fort”.

Photo 28  Fort IX: On May 15, 1944, 878 French Jewish men, women, and children were deported by train on Convoy 73 from Paris to Fort IX. 250 of these people were later murdered in Pravieniškės. 17 survived liberation. This etching is on the wall of a concrete cell in Fort IX.
Photo 29  Fort IX: Purpose built rope grids were constructed for use with the TR/CIA Resistance Meter and with the Bartington 601–2 Gradiometer.

Photo 30  Fort IX: Colin Miazga calibrating the compass on the DJI M100 drone, equipped here with both a high resolution RGB camera and a multispectral camera (a Sequoia).
Photo 31   Fort IX: Colin Miazga distributing aerial targets across the mass burial trench area.

Photo 32   Fort IX: Chris Slater collecting magnetic gradiometer data with the Bartington 601-2. Chris is walking in an easterly direction, with the photograph looking south.
Photo 33  Fort IX: Chris Slater collecting magnetic gradiometer data with the Bartington 601-2. Chris is walking in an easterly direction, with the photograph looking west toward what would have been the Kovno Ghetto.

Photo 34  Chris Slater collecting EM38 terrain conductivity and magnetic susceptibility data across “The Battlefield” with the Monument to the Victims of Fascism in the background.
Photo 35   Fort IX: Paul Bauman collecting ERT and IP data across “The Battlefield”.

Photo 36   Fort IX: Paul Bauman collecting and georeferencing the location of a soil sample for Total Phosphorus analysis.
Photo 37  Plastic bagged soil samples waiting to be retrieved along this profile trending approximately east to west. The photograph is looking east. 53 samples were collected along this transect. The fence and horizon in the distance mark the moat and outer wall of Fort IX.

Photo 38  Fort IX: Dr. Harry Jol and UWEC Geospatial student Cameron Wingren collecting 200 MHz GPR data across “The Battlefield”.

Photo 39  Fort IX: UWEC Environmental Geography students Hailee Jefferies (left) and Joe Beck collecting 500 MHz GPR data across the mass burial trench area.

Photo 40  Fort IX: Dr. Alastair McClymont using Leapfrog and the 3D visualization of the geophysical and UAV data to discuss the interpreted burial trench locations with the Ninth Fort Museum Director Marius Pečiulis.
Photo 41  Pravieniškės Maximum Security Prison: Colin Miazga flying RGB and multispectral cameras over the prison and in immediate proximity to the prison.

Photo 42  Pravieniškės Maximum Security Prison: Lithuanian archaeologist Mantas Daubaras augering a soil sample for Total Phosphorus analysis in the former train loading area within the prison.
Photo 43  1941 Holocaust Mass Burial in Pravieniškės: Road sign marking both the 1941 and 1944 memorialized Holocaust mass burials in Pravieniškės.

Photo 44  1941 Holocaust Mass Burial in Pravieniškės: Paul Bauman discussing the history of the 1941 and 1944 Holocaust mass burials in Pravieniškės with Ernėsta (woman on the left) who is the supervisor of the town and a translator (woman on right).
Photo 45  1941 Holocaust Mass Burial in Pravieniškės: The setting of the 1941 Holocaust mass burial. The black stone obelisk Holocaust burial marker and the nearby memorial stone can be seen in the distance in the center of the photograph.

Photo 46  1941 Holocaust Mass Burial in Pravieniškės: Memorial stone and plaque at the site of the 1941 Holocaust mass burial of 253 Jews. Anecdotal information suggests Roma and Soviet POWs were also killed and buried here.
Photo 47 1941 Holocaust Mass Burial in Pravieniškės: ERT section being collected within demarcated mass burial site, between memorial stone and black obelisk that marks recognized Holocaust mass burial sites in Lithuania.

Photo 48 1941 Holocaust Mass Burial in Pravieniškės: ERT line in low area near memorial stone.
Photo 49  1944 Convoy 73 Holocaust Mass Burial in Pravieniškės: Black obelisk memorializing site.

Photo 50  1944 Convoy 73 Holocaust Mass Burial in Pravieniškės: Stone plaque stating that “on the 15th of May 1944, the Nazis deported from France 878 Jews to destinations in Lithuania and Estonia. Half of this convoy was annihilated in Kaunas (Fort IX) and in Pravieniškės. Never forget these victims of racial hatred”. The plaque was put in place by “The sons and daughters of the deported Jews of France”, likely in the 1990s.
Photo 51  1944 Convoy 73 Holocaust Mass Burial in Pravieniškės: The upright stone plaque above the Convoy 73 plaque states that “In this place the Hitlerite killers and their local helpers in the year 1941 destroyed the Jews of Western Europe”. It is likely that this was a “standardized” memorial stone as the murders of the Convoy 73 deportees clearly took place in 1944.

Photo 52  1944 Convoy 73 Holocaust Mass Burial in Pravieniškės: Dr. Alastair McClymont placing electrodes for the ERT and IP line.
Photo 53 1944 Convoy 73 Holocaust Mass Burial in Pravieniškės: ERT and IP data collection in progress.

Photo 54 The Great Synagogue Site, Vilnius: Chris Slater (right) and Dr. Alastair McClymont shoveling dirt to open up the area over the Synagogue sanctuary for surveying.
Photo 55 The Great Synagogue Site, Vilnius: Paul Bauman carrying out a TR/CIA resistance meter survey on the southern side of the Synagogue site. The bimah is in the excavated area behind him, adjacent to the Soviet school building. We are trying to map walls with the resistance meter.

Photo 56 The Great Synagogue Site, Vilnius: Chris Slater carrying out a Bartington 601-2 survey over the southern portion of the Great Synagogue site. We are trying to map walls with the gradiometer.
Photo 57  The Great Synagogue Site, Vilnius: The upright young man is standing on the bimah (the platform from which the Torah is read) of the Great Synagogue. Behind him is the exposed foundation of the present school. To his right is a column base of one of the four nine-metre columns that surrounded the bimah. Below him is the cellar, which was imaged by ERT in 2017 as a very high magnitude resistive anomaly. Excavations in the cellar discovered about 200 coins dating from the 16th to the 20th centuries, buttons from Napoleon’s army, and a large stone inscription that was part of the Torah reading table.

Photo 58  The Great Synagogue Site, Vilnius: Excavations on the north side (what had become the elementary school playground) of the Great Synagogue site revealed that large, high magnitude resistivity anomalies imaged in 2016 and 2017 ERT programs carried out by Paul Bauman and Alastair McClymont were partially filled in void spaces under the bricked cellars and foundation spaces.
The Great Synagogue Site, Vilnius: UWEC students carrying out 500 MHz GPR surveys on the stairs leading to the north entrance of the Great Synagogue. Note that the stairs descend to the south, under the ground surface. This is a result of height restrictions imposed on the construction of the Synagogue by the Christian community. The fact that much of the structure of the Synagogue was built underground is what has saved the remnants for the current discovery.
Photo 60  The Great Synagogue Site, Vilnius: UWEC Environmental Geography students Joe Beck (left) and Logan Bergevin carrying out a GPR survey over the site of the previous Ramayles Yeshiva. The photo is looking north toward the fence surrounding the Great Synagogue site.

Photo 61  The Great Synagogue Site, Vilnius: UWEC students carrying out the 500 MHz GPR survey over the site of the previous Ramayles Yeshiva. The photo is looking south, away from the Great Synagogue site.
Photo 62  The Great Synagogue Site, Vilnius: Dr. Jon Seligman (with the blue shirt) showing artifacts caught in the sifter to a few of the many faculty and volunteers working at the site. Dr. Seligman, Director of External Relations and Archaeological Licensing for the Israel Antiquities Authority, is the lead archaeologist and head of the Great Synagogue project.

Photo 63  The Great Synagogue Site, Vilnius: Students and volunteers of all ages and from many different countries are working on the excavations and investigations at the Great Synagogue site.
Photo 64  The Great Synagogue Site, Vilnius: Lithuanian archaeologists and archaeology students (woman on the left) are participating in the investigations at the Great Synagogue site. There are also a number of Israeli volunteers (man on the right) with ancestral connections (i.e. Litvaks) to Vilna and Lithuania.

Photo 65  Vilnius: Paul Bauman delivering a public lecture on July 16, 2019, entitled “Lost and Found... Archaeogeophysical Investigations at Holocaust Sites”. The presentation was given at the Jewish Community Center in Vilnius, and was well attended by students, academics, the Jewish community and the public.
Photo 66  Šeduva,(Shadova in Yiddish) Brick Synagogue: UWEC students use 500 MHz GPR to map the walls of the brick Synagogue in Market Square. GPR mapping of the buried architecture of the brick Synagogue was completed in the 2019 program by UWEC students.

Photo 67 Royal Łazienki Park, Warsaw: The Advisian geophysics crew confer with Piotr Aaron Lenartowicz (with backpack) from the Digital Collections Departament of the Warsaw Ghetto Museum and Andrew Nowicki, Director of Royal Łazienki the Museum (kneeling to the right of Piotr), before beginning our EM61 survey in the Romantic Garden.
Photo 68  Royal Łazienki Park, Warsaw: Colin Miazga carrying out the EM61 metal detection survey in the Romantic Garden.

Photo 69  Bersohn and Bauman Children’s Hospital, Warsaw: Paul Bauman (left) and Colin Miazga (center) being briefed by Albert Stankowski, Director of the Warsaw Ghetto Museum. The Museum will be make use of the buildings of the former Bersohn and Bauman Children’s Hospital.
Photo 70  Bersohn and Bauman Children’s Hospital, Warsaw: Paul Bauman (left) collecting EM61 metal detection data.

Photo 71  Mila 18, Warsaw: From left to right, Adam Wolniewicz and Piotr Lenartowicz of the Warsaw Ghetto Museum, and Paul Bauman, Chris Slater, and Alastair McClymont of Advisian approach the monument of Mila 18.
Photo 72  Mila 18, Warsaw: Although the monument of Mila 18 is very modest, the iconic site is frequently visited by tour groups, especially from various Jewish communities including from Israel. The groups are often guided by Holocaust survivors.

Photo 73  Mila 18, Warsaw: Chris Slater surveying with the Bartington 601-2 magnetic gradiometer.
Photo 74  Mila 18, Warsaw: Alastair McClymont surveying with the EM38 terrain conductivity and magnetic susceptibility meter.

Photo 75  Mila 18, Warsaw: Geonics EM38 and Bartington 601-2 magnetic gradiometry surveying over the locally gridded site. A rope grid with ropes spaced 2 m apart, and flagging sewn every metre on the ropes, has been laid over the site.
Photo 76  Mila 18, Warsaw: Chris Slater collecting ERT and IP Line 1 along Mila Street. This line would likely intersect any tunnels or utility corridors connecting the command bunker (on the left) to the main sewer line running down the middle of Mila Street.

Photo 77  Mila 18, Warsaw: Chris Slater laying out ERT and IP Line 3 along the base of the rubble mound and monument.
Photo 78  Mila 18, Warsaw: Paul Bauman collecting resistance meter data with the TR/CIA on a local grid.

Photo 79  Mila 18, Warsaw: Dr. Alastair McClymont (left) and Chris Slater plotting data on site, near the entrance of the memorial on Dubois Street.
Photo 80  Mila 18, Warsaw: Adam Wolniewicz (blue hat) from the Warsaw Ghetto Museum identifying and differentiating pre-World War II utility covers from modern utility covers.

Photo 81  Mila 18, Warsaw: A videographer from the Warsaw Ghetto Museum filming Colin Miazga preparing the UAV multispectral imaging camera.
Photo 82  Mila 18, Warsaw: Looking across the Mila 18 monument to the northwest and the empty field that is situated were Muranowska Street ran. The command bunker at Mila 18 likely continued to Muranowska Street.

Photo 83  Mila 18, Warsaw: In 2006, a stone monument to the Ghetto resistance was unveiled at the base of the mound. The inscription says: “Grave of the fighters of the Warsaw ghetto uprising, built from the rubble of the Mila street, one of the most lively streets of pre-war Jewish Warsaw. These ruins of the bunker at 18 Mila street are the place of rest of the commanders and fighters of the Jewish Combat Organization, as well as some civilians. Among them lies Mordechaj Anielewicz, the commander in chief. On May 8, 1943, surrounded by Nazis, after three weeks of struggle, many perished or took their own lives, refusing to perish at the hands of their enemies. There were several hundred bunkers built in the ghetto. Found and destroyed by the Nazis, they became graves. They could not save those, who sought refuge inside them, yet they remain everlasting symbols of the Warsaw Jews’ will to live. The bunker at Mila street was the largest in the ghetto. It is the place of rest of over one hundred fighters, only some of them are known by name. Here they rest, buried where they fell, to remind us that the whole Earth is their grave.”
Photo 84  Mila 18, Warsaw: The Canadian Warsaw Ghetto geophysical investigation team of (from left) Chris Slater, Colin Miazga, Dr. Alastair McClymont, Paul Bauman, and Josie Bauman. The team is standing outside of the Holiday Inn, and just inside the footprint of the Warsaw Ghetto wall.