The City of WORCESTER

Administration & Finance – Purchasing Division
Christopher J. Gagliastro, MCPPO – Purchasing Director
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purchasing@worcesterma.gov

November 15, 2024

To All Proposers:

Subject: **Bid #: 8319-W5, Lincoln Square Improvements / DPWP**

ADDENDUM NO. 2

To Whom It May Concern:

With reference to our proposal request relative to the above subject, please refer to the changes/modifications/clarifications to the original proposal request.

PLEASE SEE ATTACHED GENERAL BID CLARIFICAITONS

Bidders are requested to acknowledge and/or include this addendum with submission. All other terms, conditions and specifications remain unchanged.

Very truly yours,

Christopher J. Gagliastro
Purchasing Director

ADDENDUM NUMBER TWO

Date: **November 15, 2024**
Project: **Lincoln Square Improvements**
City of Worcester Department of Public Works and Parks
Parks, Recreation and Cemetery Division

General Bid Questions

Question1:

Is there any Geotech information (soil borings, test pits, etc.) for this project? If so, please forward these documents as soon as possible. We need this information for the design of the aggregate piers.

Response 1:

Geotechnical Report attached.

Attachments:

Bid 8319-W5 Lincoln Square Prebid Sign In (one page)

Bid 8319-W5 Lincoln Square LGCI Geotechnical Report 011421 (74 page)

END OF ADDENDUM TWO

Bid 8319-W5 Lincoln Square Improvements

City of Worcester Department of Public Works and Parks

Pre-Bid Meeting @ 1 Lincoln Square November 13, 2024, 10AM

Robert C. Antonelli, Jr., Assistant Commissioner

	Name	Company	Contact Info	G. C. or Sub
1	Mike Dapuis	FW Madigan	mdupuis@fwmadigan.com	GC
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4	Tim Dickerson	RJ LA 617-524-6258	413-568-4381	CC
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LGCI
Lahlaf Geotechnical Consulting, Inc.

January 14, 2021

Mr. Ray Dunetz, PLA
Ray Dunetz Landscape Architecture
179 Green Street
Boston, MA 02130
Phone: (617) 524-6265
Fax: (617) 522-5020
E-mail: rdunetz@gmail.com

Re. Geotechnical Report
Proposed Lincoln St. WWI Monument Renovation
Worcester, Massachusetts
LGCI Project No. 2031

Dear Mr. Dunetz:

Lahlaf Geotechnical Consulting, Inc. (LGCI) has completed a geotechnical study for the proposed Lincoln St. WWI Monument Renovation in Worcester, Massachusetts. This report contains the results of our explorations and our foundation design and construction recommendations.

The soil samples from our explorations are currently stored at LGCI for further analysis, if requested. Unless notified otherwise, we will dispose of the soil samples after three (3) months.

Thank you for choosing LGCI as your geotechnical engineer.

Very truly yours,

Lahlaf Geotechnical Consulting, Inc.

Abdelmadjid M. Lahlaf, Ph.D., P.E.
Principal Engineer

LGCI
Lahlaf Geotechnical Consulting, Inc.

GEOTECHNICAL REPORT
PROPOSED LINCOLN ST. WWI MONUMENT RENOVATION
WORCESTER, MASSACHUSETTS

LGCI Project No. 2031
January 14, 2021

Prepared for:

RAY DUNETZ LANDSCAPE ARCHTECTURE
179 Green Street
Boston, MA 02130
Phone: (617) 524-6265
Fax: (617) 522-5020

GEOTECHNICAL REPORT
PROPOSED LINCOLN ST. WWI MONUMENT RENOVATION
WORCESTER, MASSACHUSETTS
LGCI Project No. 2031
January 14, 2021

Prepared for:

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Prepared by:

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Abdelmadjid M. Lahlaf, Ph.D., P.E.
Principal Engineer

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1. PROJECT INFORMATION

1.1 Project Authorization

This geotechnical report presents the results of the subsurface explorations and a geotechnical evaluation performed by Lahlaf Geotechnical Consulting, Inc. (LGCI) for the proposed Lincoln St. WWI Monument Renovation in Worcester, Massachusetts. Our services were performed in general accordance with our proposal No. 19077-Rev. 1 dated May 29, 2020 and revised on June 12, 2020. Mr. Ray Dunetz of Ray Dunetz Landscape Architecture (RDLA) authorized our services by signing our proposal on August 14, 2020.

1.2 Purpose and Scope of Services

The purpose of our geotechnical services was to perform subsurface explorations at the site and to provide foundation and construction recommendations. LGCI performed the following services:

- Researched the site history and interviewed City personnel familiar with the monument to inquire about the history of the movement experienced by the monument.
- Coordinated our boring and test pit locations with RDLA.
- Marked the boring and test pit locations at the site and notified Dig Safe Systems Inc. (Dig Safe) and the City of Worcester for utility clearance.
- Engaged a drilling subcontractor for one (1) day to advance three (3) soil borings.
- Provided an LGCI geotechnical engineer at the site to coordinate and observe the borings and test pits (3 excavated by City personnel and equipment), describe the soil samples, and prepare field logs.
- Engaged a subcontractor to perform vibration monitoring.
- Submitted four (4) soil samples to a laboratory for grain-size analyses.
- Prepared this geotechnical report containing the results of our subsurface explorations and our foundation design and construction recommendations.

LGCI's scope of services does not include an environmental assessment for the presence or absence of wetlands or analytical testing for hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site, or mold in the soil or in any structure at the site. Any statements regarding odors, colors, or unusual or suspicious items or conditions are strictly for the information of the client.

Our scope does not include attending meetings, reviewing drawings, or performing field services. We will be pleased to perform these services for an additional fee. Recommendations for unsupported slopes, stormwater management, erosion control, pavement design, site specific liquefaction analysis, slope stability analyses, and detailed cost or quantity estimates are not included in our scope of work. Our scope does not include environmental services.

1.3 Site Description

1.3.1 References

Our understanding of the site is based on our field observations, our discussions with RDLA, and on the following drawings:

- Drawing EX-1 titled: "Existing Conditions, Lincoln Square and the World War II Memorial Improvement, Lincoln Square, Worcester, MA" (Existing Conditions Plan) prepared by Nitsch Engineering, Inc., dated June 19, 2020, and provided to LGCI via e-mail by RDLA on September 8, 2020.

- Drawing titled: "Worcester, Lincoln Square Improvement, Relocation of War Memorial, Foundation Plans and Sections," (Monument Foundation Plans) prepared by Singstad & Baillie Consulting Engineers, dated June 7, 1954, and provided to LGCI via e-mail by RDLA on September 8, 2020.

- Drawing titled: "Worcester, Lincoln Square Improvement, Borings," (Previous Boring Plan) prepared by Singstad & Baillie Consulting Engineers, dated June 7, 1954, and provided to LGCI via e-mail by RDLA on September 8, 2020.

- Drawing titled: "Worcester, Lincoln Square Improvement, Typical Sections of Underpass Structure," (Tunnel Sections) prepared by Singstad & Baillie Consulting Engineers, dated June 7, 1954, and provided to LGCI via e-mail by RDLA on September 8, 2020.

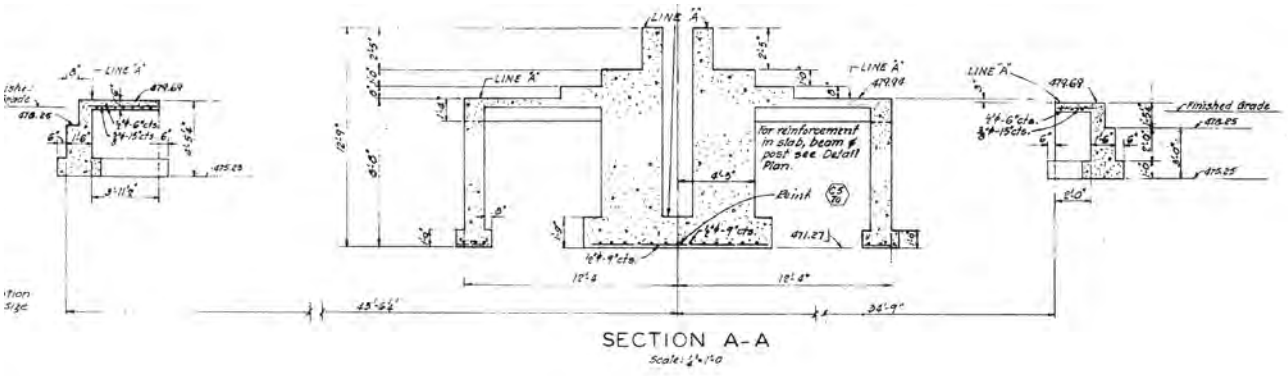
1.3.2 Monument Description

The WWI Monument is located in front of the former Worcester Voke Building (formerly also known as Lincoln Square Boy's Club) located at 16 Salisbury Street in Worcester, Massachusetts as shown in Figure 1. The site is bordered by the former Voke Building on the northern side, by Grove Street on the western side, by Lincoln Street on the eastern side, and by Highland Street (US Route 9) on the southern side. The monument is across the street from Worcester Memorial Auditorium. The Worcester Police Department is located southwest of the monument on the opposite side of US Route 9.

The WWI Monument is set within a landscaped area and is accessible from stairs leading to the Lincoln Street sidewalk on the eastern side and stairs leading to a walkway that crosses the landscaped area on the western side. The monument consists of an obelisk, a curved wall

(Whisper Wall) on the northern side of the monument, and a knee-high wall on the southern side of the monument. The area around the obelisk is covered with brick pavers. Based on the Existing Conditions Plan, the grades in the brick-paver covered area around the obelisk range between El. 482.2 feet and El. 482.6 feet.

Based on the Monument Foundation Plans, the obelisk is supposed to be located within the center of the monument. However, the obelisk is located on the southern side of the monument, close to the knee-high wall. The Monument Foundation Plans indicate that the obelisk is supported on a concrete foundation extending to a depth of about 8.7 feet beneath the ground surface, and that the Whisper Wall and the knee-high wall are supported on concrete footings extending to a depth of about 4 feet beneath the ground surface as shown in the cross section below.

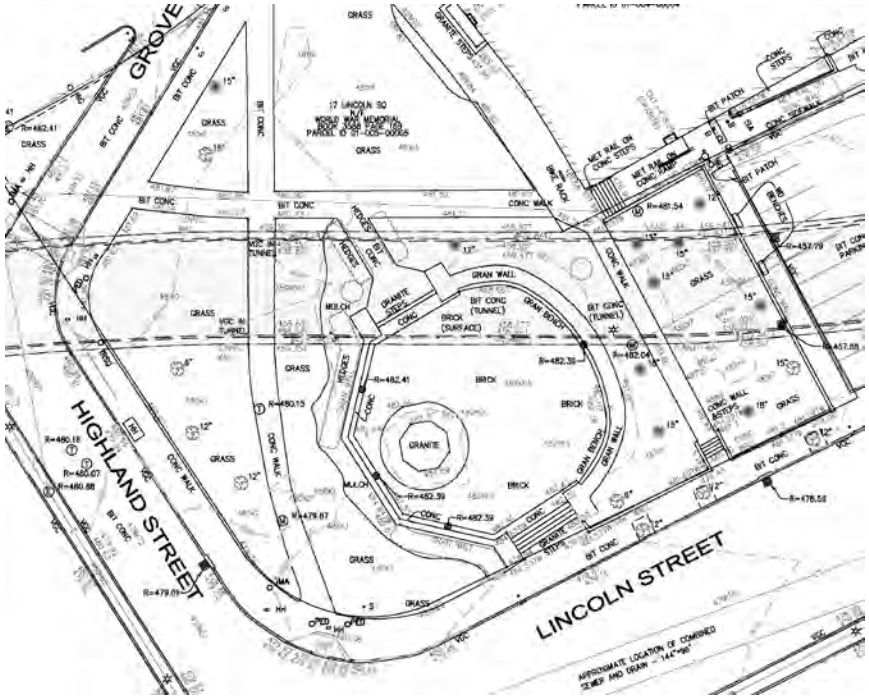


Cropped from the Monument Foundation Plans listed above

Based on the Tunnel Sections, the tunnel is about 37 feet wide and 21 feet high.

The historic topo maps included in Appendix A show the change in configuration of Lincoln Square over time. The historic topo maps do not clearly depict whether fill was placed in the vicinity of the current location of the monument. However, the Previous Boring Plan indicates that the borings closest to the current monument location contained between 6.5 and 11.5 feet of fill and organic soil.

The northwestern portion of the monument overlaps with the alignment of the tunnel connecting Salisbury Street and Main Street as shown in the drawing below.



Cropped from Existing Conditions Plan listed above

1.3.3 Monument History

The WWI Monument was relocated twice from its original location. More details on the relocations are included in Appendix B.

1.4 Monument Condition

The monument is in a state of slight disrepair as evidenced by cracks in the wall, relative movement of stone blocks in the knee-high wall and Whisper Wall, and uneven ground. LGCI documented the condition of the existing monument with photographs included in Appendix C.

1.5 Project Description

We understand the WWI Monument will likely be rebuilt at a new location not far from its current location. The purpose of our services was to assist RDLA explore the possible causes of the current disrepair of the WWI Monument and to provide foundation design and construction recommendations for the rebuilding of the monument.

1.6 Elevation Datum

We understand that the elevations shown in the Existing Conditions Plan are referenced to the National American Vertical Datum of 1988 (NAVD 88).

2. SITE AND SUBSURFACE CONDITIONS

2.1 Surficial Geology

LGCI reviewed the following Surficial Geologic Map: "Surficial Materials Map of the Worcester North Quadrangle, Massachusetts," prepared by Stone, B.D., Stone, J.R., and DiGiacomo-Cohen, M.L., for U.S. Geological Survey, Scientific Investigation Map 3402, Quadrangle 80 – Worcester North.

The Surficial Geologic Map indicated that the soils in the general area of the site consist of coarse deposits. The coarse deposits are described as sand, sand and gravel, and gravel deposits. The sand deposits are comprised mostly of fine to coarse sand. Coarser layers may contain up to 25 percent gravel. Finer layers may contain very fine sand, silt, and clay. The sand and gravel deposits occur as a mixture of gravel and sand within individual layers and as alternating layers of sand and gravel. The sand and gravel layers range between 25 and 50 percent gravel and 50 to 75 percent sand. The gravel deposits are comprised of at least 50 percent gravel, cobbles, and boulders. Sand occurs within gravel beds and as separate layers within the gravel.

The Surficial Geologic Map is shown in Figure 2.

2.2 LGCI's Borings

2.2.1 General

LGCI coordinated our exploration locations with RDLA and marked the exploration locations in the field by taping distances from the physical landmarks. The drilling subcontractor notified Dig Safe and the City of Worcester for utility clearance prior to starting our explorations at the site. The drilling subcontractor cleared utilities using vacuum exploration.

Unless notified otherwise, we will dispose of the soil samples obtained during our explorations after three months.

2.2.2 LGCI Soil Borings

LGCI engaged Technical Drilling Service, Inc. (TDS) of Sterling, Massachusetts to advance three (3) borings (B-1A, B-1B, and B-2) on September 22, 2020. The borings were advanced with a truck-mounted Diedrich D-120 drill rig using a 4-1/4-inch hollow stem auger and drive and wash techniques with a 3-inch casing. The borings extended to depths ranging between 8.1 feet and 19.1 feet beneath the ground surface. Upon completion, the boreholes were backfilled with the soil cuttings and sand.

TDS performed Standard Penetration Tests (SPT) during drilling and obtained split spoon samples in the borings with an automatic hammer at typical depth intervals of 2-feet or 5-feet as noted on the boring logs in general accordance with ASTM D-1586.

An LGCI engineer observed and logged the borings in the field.

2.2.3 Test Pits

LGCI provided a field engineer to observe three (3) test pits (TP-1 to TP-3) excavated by the City of Worcester Department of Public Works (DPW) around the walls of the monument. The purpose of the test pits was to expose the foundations of the existing walls.

The test pits were excavated with a backhoe and extended to depths ranging between 4.4 and 6.3 feet beneath the ground surface. Upon completion, the test pit excavations were backfilled with the excavated material that was placed in lifts and tamped with the excavator bucket.

2.2.4 Boring and Test Pit Logs and Locations

The boring and test pit locations are shown in Figure 3. Appendix D contains LGCI's boring logs. Appendix E contains LGCI's test pit logs, sketches, and photographs. Tables 1 and 2 include summaries of LGCI's borings and test pits, respectively.

2.3 Subsurface Conditions

The subsurface description in this report is based on a limited number of borings and test pits and is intended to highlight the major soil strata encountered during our borings and test pits. The subsurface conditions are known only at the actual boring and test pit locations. Variations may occur and should be expected between boring and test pit locations. The boring and test pit logs represent conditions that we observed at the time of our borings and test pits and were edited, as appropriate, based on the results of the laboratory test data and inspection of the soil samples in the laboratory. The strata boundaries shown in our boring and test pit logs are based on our interpretations and the actual transitions may be gradual. Graphic soil symbols are for illustration only.

The soil strata encountered in the borings and test pits were as follows, starting at the ground surface.

Topsoil – Topsoil was encountered at the ground surface in boring B-1B. The thickness of the topsoil was about 6 inches. All three (3) test pits, TP-1 to TP-3, encountered topsoil at the ground surface. The thickness of the topsoil in the test pits was about 1 foot.

Fill – A layer of fill was encountered at the ground surface or beneath the topsoil in all the borings and test pits. The fill extended to termination depths of borings B-1A and B-1B at

depths of 8.1 and 16.0 feet beneath the ground surface, respectively. The fill extended to a depth of 13.1 beneath the ground surface in boring B-2. The fill extended to termination depths of test pits TP-1 to TP-3 at depths ranging between 4.4 feet and 6.3 feet beneath the ground surface. The samples in the fill were mostly described as silty sand with gravel. One (1) sample was described as well graded gravel with silt and sand, and one (1) sample was described as silty gravel with sand. Two (2) samples in TP-3 and one (1) sample in TP-2 were described as well graded sand with silt and gravel. The fines content in the fill ranged between 5 and 30 percent and the gravel content ranged between 15 and 45 percent. The sand content in the gravel samples ranged between 20 and 45 percent.

The fill contained traces of organic soil, roots, asphalt, and brick. In boring B-1B, a boulder up to 1.5 feet in size was encountered at a depth of 5.7 feet beneath the ground surface. A large void was encountered beneath the boulder that extended to a depth of 10 feet beneath the ground surface.

The standard penetration test (SPT) N-values in this layer ranged between 13 blows per foot (bpf) and refusal. The high SPT N-values may have been caused by obstructions in the fill and may not be representative of the true density of the fill.

Sand – A layer of sand was encountered beneath the fill in boring B-2. The sand extended to the boring termination depth of 19.1 feet beneath the ground surface. The samples in this layer were mostly described as silty sand. The fines content in this layer ranged between 20 and 25 percent and the gravel content ranged between 10 and 20 percent.

The SPT N-values in this layer ranged between 54 bpf and refusal, with most values less than 59 bpf, indicating mostly dense to very dense sand.

2.4 Groundwater

Groundwater was not encountered in the borings or test pits.

The groundwater information reported herein is based on observations made during or shortly after the completion of drilling and excavation. Furthermore, the drilling procedure introduced water into the boreholes. Therefore, the reported groundwater levels may not represent the actual groundwater conditions, as additional time may be required for the groundwater levels to stabilize. The groundwater information presented in this report only represents the conditions encountered at the time and location of the explorations. Seasonal fluctuation should be anticipated.

2.5 Laboratory Test Data

LGCI submitted four (4) soil samples collected from the borings for grain-size analysis. The results of the grain-size analysis are provided in the test data sheets included in Appendix F and are summarized in the table below.

Grain-Size Analysis Test Results

Boring or Test Pit No.	Sample No.	Stratum	Sample depth (ft.)	Percent Gravel	Percent Sand	Percent Fines
B-1B	S2	Fill	2.0 – 4.0	44.4	40.7	14.9
B-1B	S5	Fill	12.0 – 14.0	29.6	53.7	16.7
TP-1	G3	Fill	4.3 – 5.6	37.3	46.9	15.8
TP-3	G3	Fill	5.0 – 5.5	43.1	48.8	8.1

2.6 Vibration Monitoring

To explore whether vibration induced by vehicular traffic in the tunnel contributed to the movements of the obelisk and walls, and settlement of the ground, LGCI engaged a testing agency to perform vibration monitoring near and around the monument. LGCI coordinated with the City of Worcester DPW to drive a large front loader through the tunnel to mimic heavy truck traffic. The sensors of the seismograph were set on the ground near the monument foundation, on the pavers, and on top of the walls. The measured peak particle velocity (ppv) was in all cases significantly less than 0.1 inch per second (ips). Values of ppv lower than 0.1 ips are typically not harmful to foundations.

3. EVALUATION AND RECOMMENDATIONS

3.1 General

Based on our understanding of the proposed construction, our observation of our borings and test pits, and the results of our laboratory testing, there are a few issues that we would like to highlight for consideration and discussion.

3.1.1 Evaluation of Monument Movements

LGCI interviewed City of Worcester DPW staff, reviewed the historical records of the monument, observed the condition of the existing monument, and observed test pits and borings performed at the site. Based on our discussions, reviews, and observations, we believe that the movements, cracks, and settlement observed in the monument, as documented in Appendix C, are caused by two factors: 1) settlement of the soft/loose fill under the weight of the foundations, and 2) frost heave as described below. Based on the results of the vibration monitoring, LGCI has ruled out vibration as the sole cause of or a contribution to the movements of the monument.

Settlement – We believe that the monument foundations were placed on fill that was not placed in compacted lifts. Furthermore, the fill appeared to contain traces of organic soil. Existing fill that was not placed with strict moisture, density, and gradation control presents risks of unpredictable settlement that generally result in poor performance of foundations.

Frost Heave – Our test pits indicated that the walls of the monument were set on what appears to be a concrete "leveling pad" cast on top of a concrete foundation. The "leveling pad" was only a few inches beneath the ground surface. In all three (3) test pits a seam of soil was observed between the "leveling pad" and the underlying concrete foundation. We believe that as water seeps in the soil seam and freezes, it causes an uplift movement of the wall. We believe that this repeated action has caused cracks to open in the walls and in the mortar between stone blocks. The movement was exacerbated by water entering the cracks and the separations between the stone blocks and freezing, causing further movement.

3.1.2 Existing Fill

Based on the results of the borings and the test pits, the subsurface conditions are suitable to support shallow spread and continuous footings bearing on Structural Fill placed directly on top of the natural sand after removing the surficial organic soil and the existing fill.

RDLA indicated to us that the location where the WWI Monument will be relocated to may partially overlap with the tunnel. We anticipate that the major consideration during construction will be to provide a uniform subgrade beneath the foundation of the obelisk and monument wall. To reduce the potential for differential settlement between the portion of the monument overlapping with the tunned, and the remainder of the monument, the existing fill

around the tunned should be entirely removed and replaced with Structural Fill, or the ground outside of the footprint of the tunnel should be improved by means of aggregate piers (APs) or rigid inclusions (RIs).

Removing the existing fill would likely require a temporary support of excavation (SOE) system. The selection of "remove and replace" or ground improvements by means of APs or RIs should be based on a cost benefit analysis.

3.1.3 Silt Content

The existing fill and the natural soil are generally silty. Silty soils are very susceptible to disturbance when exposed to moisture. Care should be exercised during construction to maintain a dry working subgrade and to provide working mats, e.g., crushed stone or concrete mud mats, to reduce the potential for disturbance of the foundation subgrade and to improve working conditions. The existing fill cannot be reused as Structural Fill.

Our recommendations for footing design are presented in Section 3.4.1. Our estimates for settlement are presented in Section 3.4.2. Section 4.1 provides recommendations for preparation of subgrades.

3.2 Aggregate Piers

APs are typically relatively short, stiff elements of compacted aggregate which improve the existing fill. These elements are typically installed by augering holes ranging from 20 inches to 36 inches in diameter. Aggregate (new crushed stone or recycled concrete) is then introduced into the hole and is generally compacted in one-foot lifts by repeated penetrations with the vibrator, which can be mounted to a crane or tracked carrier. The vibratory or ramming energy densifies the aggregate in the element; thus, producing high modulus aggregate piers. The installation of APs also densifies the surrounding soil depending on the type of soil. These high modulus elements reinforce the treatment zone and increase the composite friction angle and stiffness of the reinforced soil mass. The design of APs is typically verified with a modulus load test.

LGCI observed several obstructions in the fill in the borings. The work of the specialty contractor installing the APs should be coordinated with that of the site contractor who should perform pre-trenching for possible boulders, abandoned foundations, metal pipes, or other obstructions before the installation of the APs.

While the AP installation generates far fewer spoils than complete removal and replacement, some spoils are created during the installation process. Where it is not desired to generate spoils during the improvement process, vertical displacement APs could be used. These are installed by driving a mandrel and hammer to the design depth, feeding the backfill material through the hollow mandrel, and compacting the backfill in one-foot lifts using the hammer; thus, generating

no spoils. Vertical displacement APs are installed with diameters ranging between 12 and 16 inches and could be installed to depths of up to 35 feet.

The ground improvement technologies are patented and the design is performed by the specialty contractors. We recommend that the project plans and specifications for ground improvement be performance-based, allowing a variety of ground improvement contractors the opportunity to bid the work. Specifications should indicate the required allowable bearing pressure for footings, and the allowable total and differential settlements for the structure. In addition, we recommend that the specifications require that the supporting design calculations be available for review by the design team. Ground improvement contractors should also be provided with grading plans and subsurface information associated with the proposed structure for use in preparing their bids.

3.3 Rigid Inclusions

Rigid inclusions (RIs) are a ground improvement technique whereby rigid, cylindrical concrete elements are installed through a soil that is not suitable to support shallow foundations, such as the existing fill, organics, and loose sand and silt at the site. The concrete is installed using a bottom feed from a mandrel as the mandrel is extracted from the ground. After the ground is improved using rigid inclusions, the proposed structure may be supported on shallow foundations.

Rigid inclusions generally generate little spoils.

The design of the rigid inclusions, including the size and layout of the inclusions, is performed by a specialty contractor. However, based on our experience with ground improvement techniques, we anticipate that the rigid inclusions at the site will consist of 12- to 16-inch elements extending into the sand layer. The rigid inclusions should be placed under the proposed footings.

The design of the rigid inclusions should be substantiated with a modulus test performed before the start of installation of production rigid inclusions.

Before the footings are constructed, a layer of granular fill should be placed at the top of the rigid inclusions to serve as a load transfer platform (LTP) to distribute the load from the footings onto the rigid inclusions.

3.4 Foundation Recommendations

3.4.1 Footing Design

- We recommend supporting the proposed monument on footings bearing on Structural Fill placed directly on the natural sand or on ground improved with APs or RIs.

- We recommend designing the proposed footings using a net allowable bearing pressure of 3 kips per square foot (ksf) for footings bearing directly on a minimum of 6 inches of Structural Fill overlying the natural sand and gravel.

- Footing subgrades should be prepared in accordance with the recommendations in Section 4.1.

- Foundations should be designed in accordance with The Commonwealth of Massachusetts State Building Code 780 CMR, Ninth Edition (MSBC 9th Edition).

- The footings should be placed at a minimum depth of 4 feet below the final exterior grade to provide adequate frost protection.

- Wall footings should be designed and constructed with continuous, longitudinal steel reinforcement for greater bending strength to span across small areas of loose or soft soils that may go undetected during construction.

- A representative of LGCI should be engaged to observe that the subgrade has been prepared in accordance with our recommendations.

3.4.2 Settlement Estimates

Based on our experience with similar soils and designs using a net allowable bearing pressure of 2 ksf, we anticipate that the total settlement will be approximately 3/4 inch, and that the differential settlement of the footings will be 1/2 inch or less over a distance of 25 feet. We believe that total and differential settlements of this magnitude are tolerable for a similar structure. However, the tolerance of the proposed structure to the predicted total and differential settlements should be assessed by the structural engineer.

3.5 Seismic Design

In accordance with Section 1613 of MSBC 9th Edition, the seismic criteria for the site are as follows:

- Site Class: D
- Spectral Response Acceleration at short period (Ss): 0.180 g
- Spectral Response Acceleration at 1 sec. (S_1): 0.066g
- Site Coefficient Fa (Table 1613.5.3(1)): 1.6
- Site Coefficient Fv (Table 1613.5.3(2): 2.4
- Adjusted spectral response S_{MS}: 0.288 g
- Adjusted spectral responses S_{M1}: 0.158 g

Based on the SPT data from the borings, the site soils are not susceptible to liquefaction.

3.6 Sidewalks

- Sidewalks should be placed on a minimum of 12 inches of Structural Fill with less than 5 percent fines.

- To reduce the potential for heave caused by surface water penetrating under the sidewalk, the joints between sidewalk concrete sections should be sealed with a waterproof compound.

4. CONSTRUCTION CONSIDERATIONS

4.1 Subgrade Preparation

- Existing topsoil organic materials, existing fill, buried topsoil, abandoned utilities, buried foundations, and other below-ground structures should be entirely removed from within the footprint of the monument before the start of foundation work.

- Tree stumps, root balls, and roots larger than ½ inch in diameter should be removed and the cavities filled with suitable material and compacted per Section 4.3 of this report.

- Due to the silty nature of the natural sand, we recommend placing a minimum of 6 inches of Structural Fill or crushed stone below the bottom of the footings to provide a working pad.

- Cobbles and boulders should be removed at least 6 inches from beneath footings. The resulting excavations should be backfilled with compacted Structural Fill under the monument and with Ordinary Fill under the subbase of paved areas.

- The base of the footing excavations in granular soil should be compacted with a dynamic vibratory compactor weighing at least 200 pounds and imparting a minimum of 4 kips of force to the subgrade.

- The subgrade of the proposed slabs in the natural soil should be compacted with a dynamic vibratory compactor imparting a minimum of 20 kips of force to the subgrade.

- Fill placed within the footprint of the proposed monument should meet the gradation and compaction requirements of Structural Fill, shown in Section 4.3.1.

- Fill placed under the subbase of sidewalks should meet the gradation and compaction requirements of Ordinary Fill, shown in Section 4.3.2.

- Fill placed in the top 12 inches beneath sidewalks should consist of Structural Fill with less than 5 percent fines.

- Loose or soft soils identified during the compaction of the footing subgrade should be excavated to a suitable bearing stratum, as determined by the representative of LGCI. Grades should be restored by backfilling with Structural Fill or crushed stone.

- When crushed stone is required in the drawings or is used for the convenience of the contractor, it should be wrapped in a geotextile fabric for separation except where introduction of the geotextile fabric promotes sliding. A geotextile fabric should not be placed between the bottoms of the footings and the crushed stone.

- An LGCI representative should observe the exposed subgrades prior to fill and concrete placement to verify that the exposed bearing materials are suitable for the design soil bearing pressure. If soft or loose pockets are encountered in the footing excavations, the soft or loose materials should be removed and the bottom of the footing should be placed at a lower elevation on firm soil, or the resulting excavation should be backfilled with Structural Fill, or crushed stone wrapped in a filter fabric.

4.2 Subgrade Protection

The onsite fill and natural soils are frost-susceptible. If construction takes place during freezing weather, special measures should be taken to prevent the subgrade from freezing. Such measures should include the use of heat blankets or excavating the final six inches of soil just before pouring the concrete. Footings should be backfilled as soon as possible after footing construction. Soil used as backfill should be free of frozen material, as should the ground on which it is placed. Filling operations should be halted during freezing weather.

Materials with high fines contents are typically difficult to handle when wet, as they are sensitive to moisture content variations. Subgrade support capacities may deteriorate when such soils become wet and/or disturbed. The contractor should keep exposed subgrades properly drained and free of ponded water. Subgrades should be protected from machine and foot traffic to reduce disturbance.

4.3 Fill Materials

Structural Fill and Ordinary Fill should consist of inert, hard, durable sand and gravel free from organic matter, clay, surface coatings, and deleterious materials, and should conform to the gradation requirements shown below.

4.3.1 Structural Fill

The Structural Fill should have a plasticity index of less than 6 and should meet the gradation requirements shown below. Structural Fill should be compacted in maximum 9-inch loose lifts to at least 95 percent of the Modified Proctor maximum dry density (ASTM D1557), with moisture contents within ±2 percentage points of the optimum moisture content.

Sieve Size Percent	Passing by Weight
3 inches	100
1 ½ inch	80-100
½ inch	50-100
No. 4	30-85
No. 20	15-60
No. 60	5-35
No. 200*	0-10

* 0 – 5 for the top 12 inches under sidewalks, exterior slabs, pads, and walkways

4.3.2 Ordinary Fill

Ordinary Fill should have a plasticity index of less than 6 and should meet the gradation requirements shown below. Ordinary Fill should be compacted in maximum 9-inch loose lifts to at least 95 percent of the Modified Proctor maximum dry density (ASTM D1557), with moisture contents within ±2 percentage points of the optimum moisture content.

Sieve Size Percent	Passing by Weight
6 inches	100
1 inch	50-100
No. 4	20-100
No. 20	10-70
No. 60	5-45
No. 200	0-20

4.4 Reuse of Onsite Materials

Based on our field observations and the results of the grain-size analyses, the site soils are not suitable for reuse as Structural Fill. Some of the fill free of organic matter may be used as Ordinary Fill.

Should the contractor encounter materials suitable for reuse during earthwork operations, the contractor should avoid mixing the reusable soils with fine-grained and/or organic soils. The soils to be reused should be excavated and stockpiled separately for compliance testing.

Soils with 20 percent or greater fines contents are generally very sensitive to moisture content variations and are susceptible to frost. Such soils are very difficult to compact at moisture contents that are much higher or much lower than the optimum moisture content determined from the laboratory compaction test. Therefore, strict moisture control should be implemented during the compaction of onsite soils with fines contents of 20 percent or greater. The contractor should be prepared to remove and replace such soils if pumping occurs.

Materials to be used as fill should first be tested for compliance with the applicable gradation specifications.

4.5 Groundwater Control Procedures

Based on the groundwater levels measured in our borings and test pits, we do anticipate that groundwater control procedures will be needed during the removal of the existing fill. We anticipate that filtered sump pumps installed in a series of sump pump pits located at least three feet below the bottom of planned excavations may be sufficient to handle groundwater and surface runoff that may enter the excavation during wet weather. The contractor should be prepared to use multiple sump pumps, including deep stationary and moveable sump pumps, to maintain a dry excavation during the removal of the existing fill.

The contractor should be permitted to employ whatever commonly accepted means and practices are necessary to maintain the groundwater level below the bottom of the excavation and to maintain a dry excavation during wet weather. Groundwater levels should be maintained at a minimum of 1 foot below the bottom of the excavations during construction. The placement of reinforcing steel or concrete in standing water should not be permitted.

To reduce the potential for sinkholes developing over sump pump pits after the sump pumps are removed, the crushed stone placed in the sump pump pits should be wrapped in a geotextile fabric. Alternatively, the crushed stone should be entirely removed after the sump pump is no longer in use, and the sump pump pit should be restored with suitable backfill.

4.6 Pre-Construction Condition Survey

To document the conditions of nearby structures, we recommend that the Owner perform a pre-construction condition survey of structures located within 100 feet of the nearest construction operation to document the existing conditions of the structures. The Owner may also consider using crack monitoring gauges to monitor large cracks identified during the pre-construction surveys.

4.7 Temporary Excavations

All excavations to receive human traffic should be constructed in accordance with OSHA guidelines.

The site soils should generally be considered Type “C” and should have a maximum allowable slope of 1.5 Horizontal to 1 Vertical (1.5H:1V) for excavations less than 20 feet deep. Deeper excavations, if needed, should have shoring designed by a professional engineer.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain the stability of the excavation sides and bottom.

5. RECOMMENDATIONS FOR FUTURE WORK

We recommend engaging LGCI to perform the following services:

- Review the geotechnical aspect of foundation drawings;
- Prepare Earth Moving Specifications;
- Review requests for information (RFIs) and submittals; and
- Perform field services during construction.

6. REPORT LIMITATIONS

Our analyses and recommendations are based on project information provided to us at the time of this report. If changes to the type, size, and location of the proposed structures or to the site grading are made, the recommendations contained in this report shall not be considered valid unless the changes are reviewed, and the conclusions and recommendations modified in writing by LGCI. LGCI cannot accept responsibility for designs based on our recommendations unless we are engaged to review the final plans and specifications to determine whether any changes in the project affect the validity of our recommendations, and whether our recommendations have been properly implemented in the design.

It is not part of our scope to perform a more detailed site history; therefore, we have not explored for or researched the locations of buried utilities or other structures in the area of the proposed construction. Our scope did not include environmental services or services related to moisture, mold, or other biological contaminants in or around the site.

The recommendations in this report are based in part on the data obtained from the subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations from anticipated conditions are encountered, it may be necessary to revise the recommendations in this report. We cannot accept responsibility for designs based on recommendations in this report unless we are engaged to 1) make site visits during construction to check that the subsurface conditions exposed during construction are in general conformance with our design assumptions and 2) ascertain that, in general, the work is being performed in compliance with the contract documents.

Our report has been prepared in accordance with generally accepted engineering practices and in accordance with the terms and conditions set forth in our agreement. No other warranty, expressed or implied, is made. This report has been prepared for the exclusive use of Ray Dunetz Landscape Architecture for the specific application to the proposed WWI Monument Renovation in Worcester, Massachusetts as conceived at this time.

7. REFERENCES

In addition to the references included in the text of the report, we used the following references:

The Commonwealth of Massachusetts (2017), "The Massachusetts State Building Code, Ninth (9^{th}) Edition."

The Department of Labor, Occupational Safety and Health Administration (1989), "Occupational Safety and Health Standards - Excavations; Final Rule," 20 CFR Part 1926, Subpart P.

USGS Worcester, MA topographic map from http://mapserver.mytopo.com.

Table 1 - Summary of LGCI's Borings
Proposed Lincoln St. WWI Monument Renovation
Worcester, Massachusetts
LGCI Project No. 2031

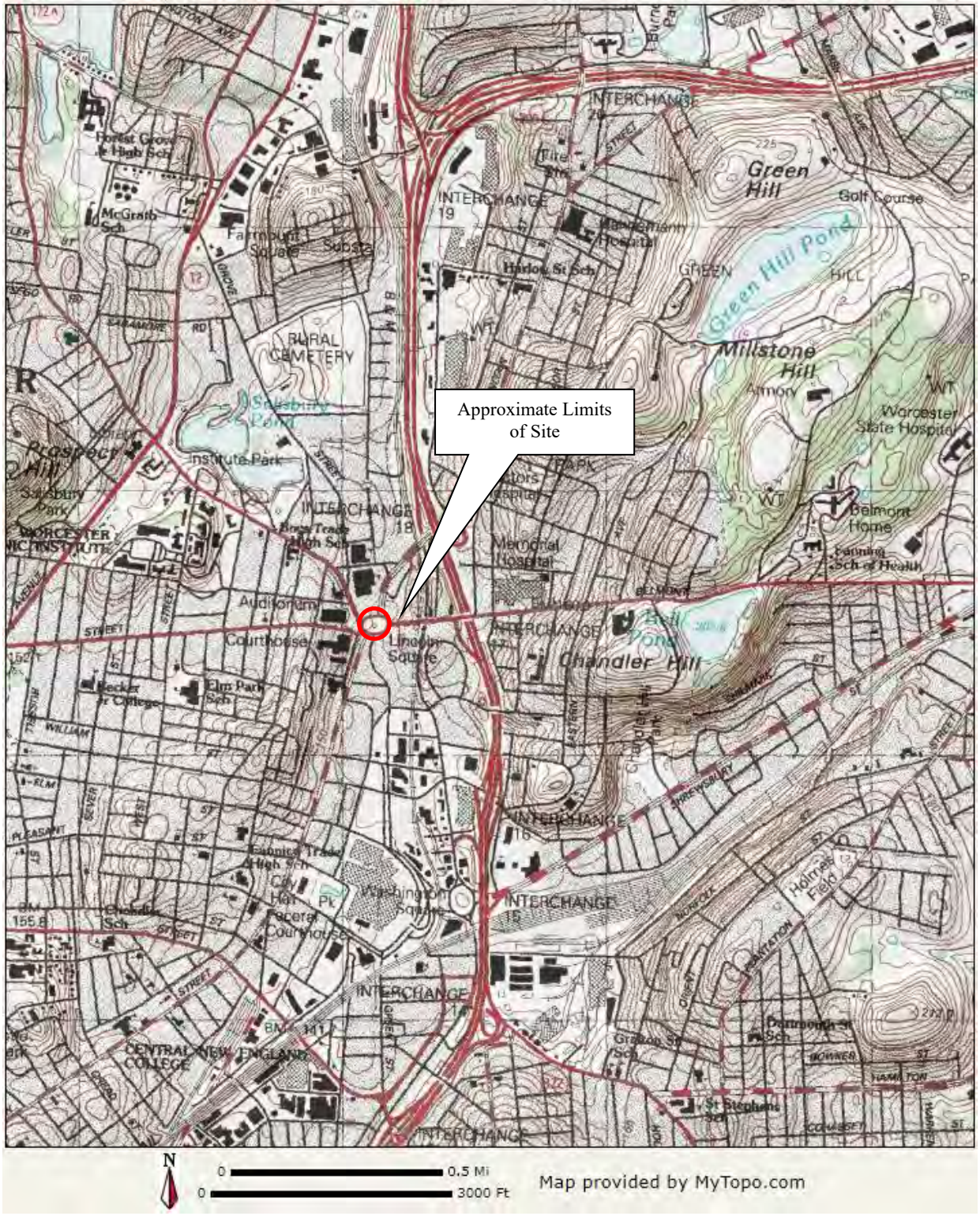
Boring No.	Ground Surface Elevation (ft.)[1]	Groundwater Depth / El. (ft.)	Bottom of Topsoil Depth / El. (ft.)	Bottom of Fill Depth / El. (ft.)	Bottom of Sand Depth / El. (ft.)	Bottom of Boring Depth / El. (ft.)
B-1A	480.0	- / -	- / -	8.1 [3]/ **471.9**	- / -	8.1 / **471.9**
B-1B	480.0	- / -	0.5 / **479.5**	16.0 [3]/ **464.0**	- / -	16.0 / **464.0**
B-2	481.0	- / -	- / -	13.1 / **467.9**	19.1 [4]/ **461.9**	19.1 / **461.9**

1. The ground surface elevation was interpolated to the nearest foot from the drawing titled: "Existing Conditions, Lincoln Square and the World War II Memorial Improvement, Lincoln Square, Worcester, MA," prepared by Nitsch Engineering Inc. (Nitsch), dated June 19, 2020 and provided to LGCI by Nitsch via e-mail on September 8, 2020.
2. Boring terminated in the fill layer.
3. Boring terminated in the sand layer.
4. "-" means groundwater or layer was not encountered.

Table 2 - Summary of LGCI's Test Pits
Proposed Lincoln St. WWI Monument Renovation
Worcester, Massachusetts
LGCI Project No. 2031

Test Pit No.	Ground Surface Elevation (ft.)[1]	Groundwater[2] Depth / El. (ft.)	Bottom of Topsoil Depth / El. (ft.)	Bottom of Fill[3] Depth / El. (ft.)	Bottom of Test Pit Depth / El. (ft.)
TP-1	481.0	- / -	1.0 / **480.0**	6.3 / **474.7**	6.3 / **474.7**
TP-2	482.0	- / -	1.0 / **481.0**	4.4 / **477.6**	4.4 / **477.6**
TP-3	482.0	- / -	1.0 / **481.0**	5.5 / **476.5**	5.5 / **476.5**

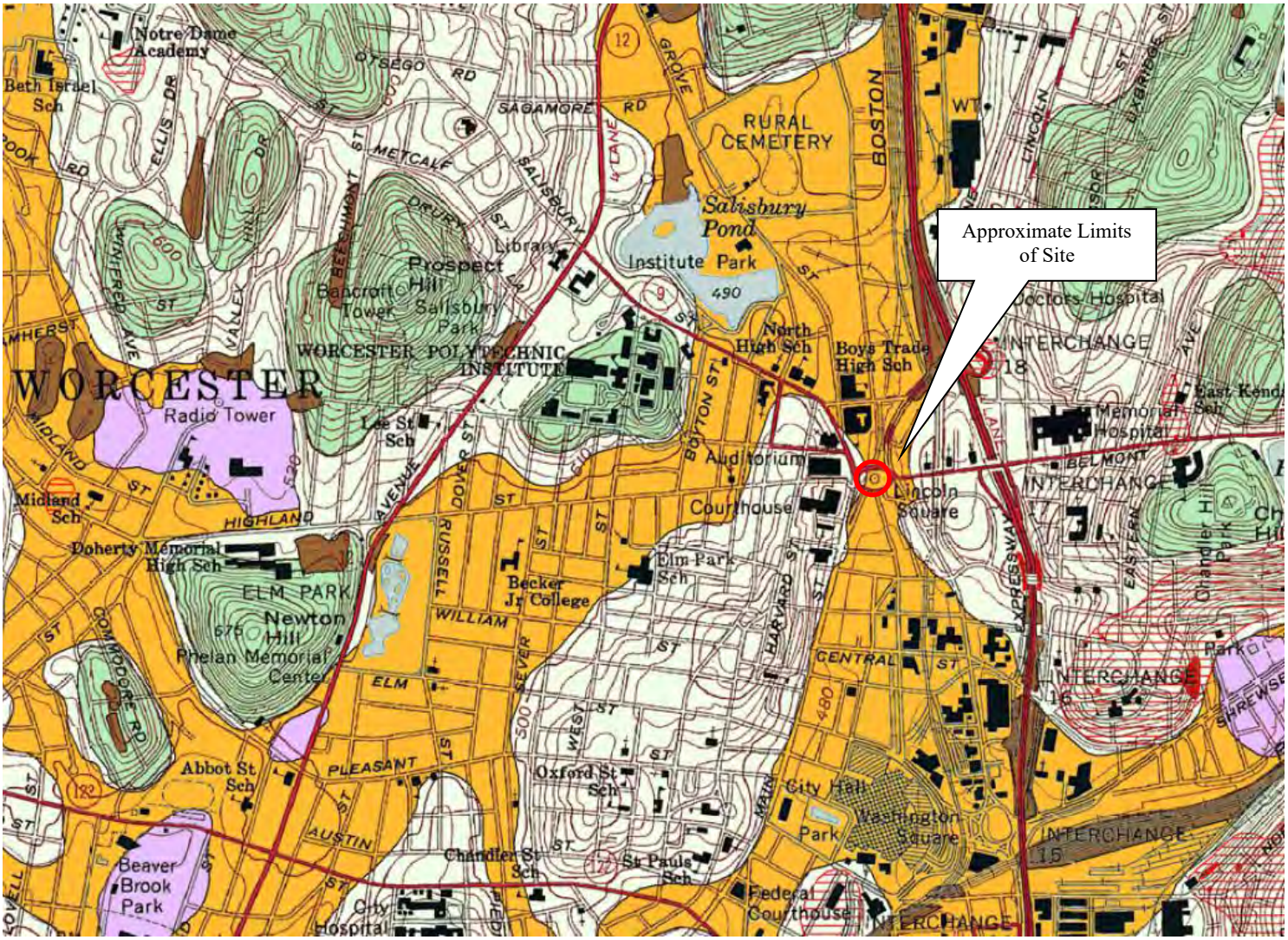
1. The ground surface elevation was interpolated to the nearest foot from the drawing titled: "Existing Conditions, Lincoln Square and the World War II Memorial Improvement, Lincoln Square, Worcester MA," prepared by Nitsch Engineering Inc. (Nitsch), dated June 19, 2020 and provided to LGCI by Nitsch via e-mail on September 8, 2020.
2. "-" means groundwater or layer was not encountered.
3. Test pit terminated in the fill layer.



Contour Intervals: 3 meters

Note: Figure based on USGS topographic map of Worcester, MA obtained from www.mytopo.com/maps

Client:	Project:		
Ray Dunetz Landscape Architecture	Proposed Lincoln St. WWI Monument Renovation	Figure 1 – Site Location Map	
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Worcester, MA	LGCI Project No.: 2031	Date: Jan. 2021



N

Coarse deposits consist of *gravel deposits*, *sand and gravel deposits*, and *sand deposits*, not differentiated in this report. *Gravel deposits* are composed of at least 50 percent gravel-size clasts; cobbles and boulders predominate; minor amounts of sand occur within gravel beds, and sand comprises a few separate layers. Gravel layers generally are poorly sorted, and bedding commonly is distorted and faulted due to postdepositional collapse related to melting of ice. *Sand and gravel deposits* occur as mixtures of gravel and sand within individual layers and as layers of sand alternating with layers of gravel. Sand and gravel layers generally range between 25 and 50 percent gravel particles and between 50 and 75 percent sand particles. Layers are well sorted to poorly sorted; bedding may be distorted and faulted due to postdepositional collapse. *Sand deposits* are composed mainly of very coarse to fine sand, commonly in well-sorted layers. Coarser layers may contain up to 25 percent gravel particles, generally granules and pebbles; finer layers may contain some very fine sand, silt, and clay

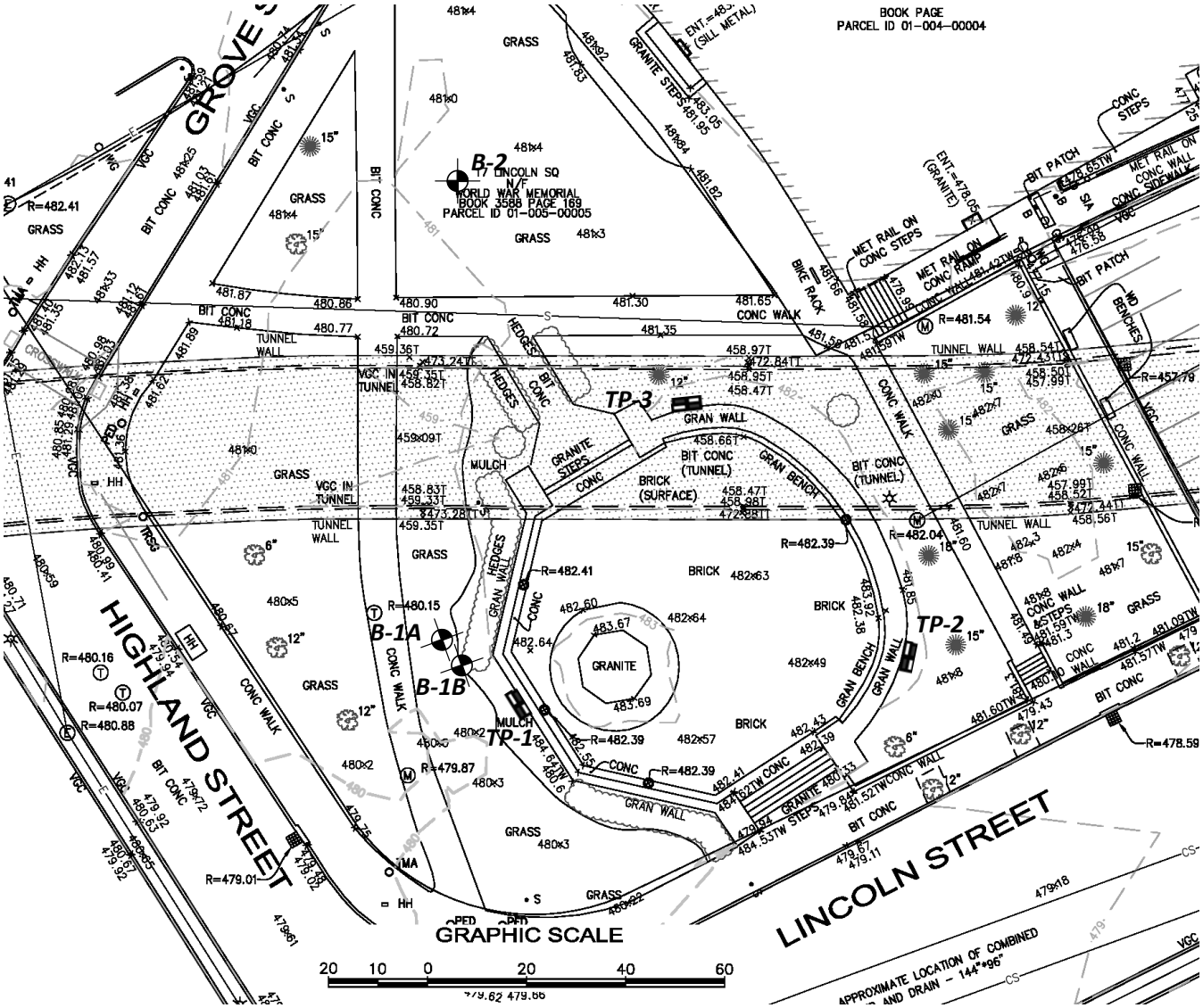
Note: Figure based on map titled: "Surficial Materials Map of the Worcester North Quadrangle, Massachusetts," prepared by Stone, B.D., Stone, J.R., and DiGiacomo-Cohen, M.L., for U.S. Geological Survey, Scientific Investigation Map 3402, Quadrangle 80 – Worcester North.

Client:	Project:	Figure 2 – Surficial Geologic Map	
Ray Dunetz Landscape Architecture	Proposed Lincoln St. WWI Monument Renovation		
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Worcester, MA	LGCI Project No.: 2031	Date: Jan. 2021

Legend

Approximate location of borings advanced by Technical Drilling Services, Inc. (TDS) of Sterling, MA on September 22, 2020, and observed by Lahlaf Geotechnical Consulting, Inc. (LGCI).

Approximate location of test pits excavated by City of Worcester Department of Public Works and Parks (DPW) of Worcester, MA on October 14, 2020 and observed by LGCI.



MASSACHUSETTS STATE PLANE COORDINATE SYSTEM NAD 83

Note

Figure based on drawing titled: "Existing Conditions, Lincoln Square and the World War II Memorial Improvement, Lincoln Square, Worcester, MA," prepared by Nitsch Engineering, Inc. (Nitsch), dated June 19, 2020 and provided to LGCI by Nitsch Engineering, Inc., via e-mail on September 8, 2020.

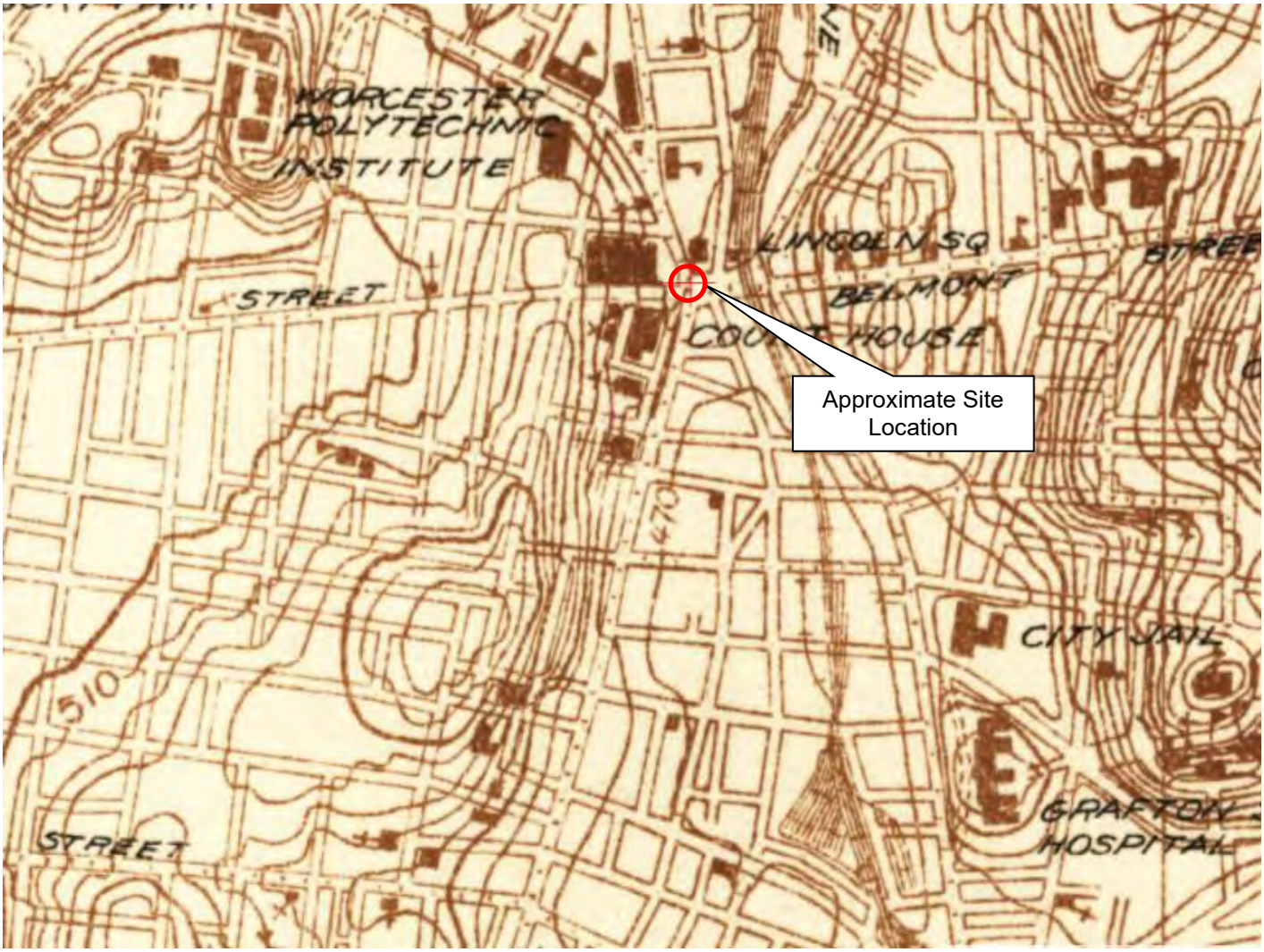
Client: Ray Dunetz Landscape Architecture	Project: Proposed Lincoln St. WWI Monument Renovation	Figure 3 – Boring and Test Pit Location Plan	
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Worcester, MA	LGCI Project No.: 2031	Date: Jan. 2021

Appendix A – Historical Topo Maps

Contour Intervals: 20 feet

Figure based on USGS topographic map of Worcester, MA (1886) obtained from https://livingatlas.arcgis.com/topoexplorer/index.html.

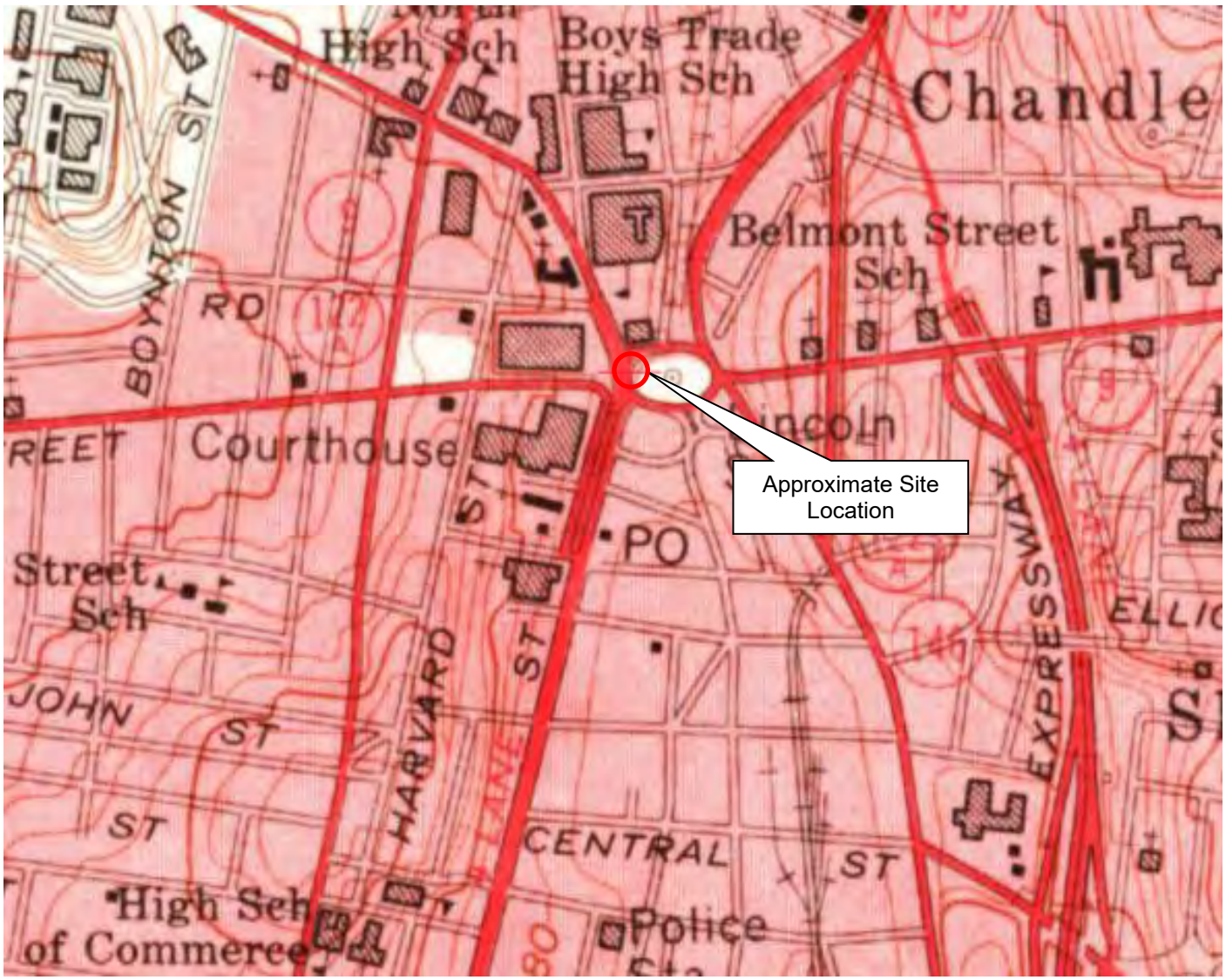
Client:	Project:	Figure A1 – 1886 Historical Topo Map	
Ray Dunetz Landscape Architecture	Proposed Lincoln St. WWI Monument Renovation		
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Worcester, MA	LGCI Project No.: 2031	Date: Jan. 2021



Contour Intervals: 10 feet

Figure based on USGS topographic map of Worcester, MA (1934) obtained from https://livingatlas.arcgis.com/topoexplorer/index.html.

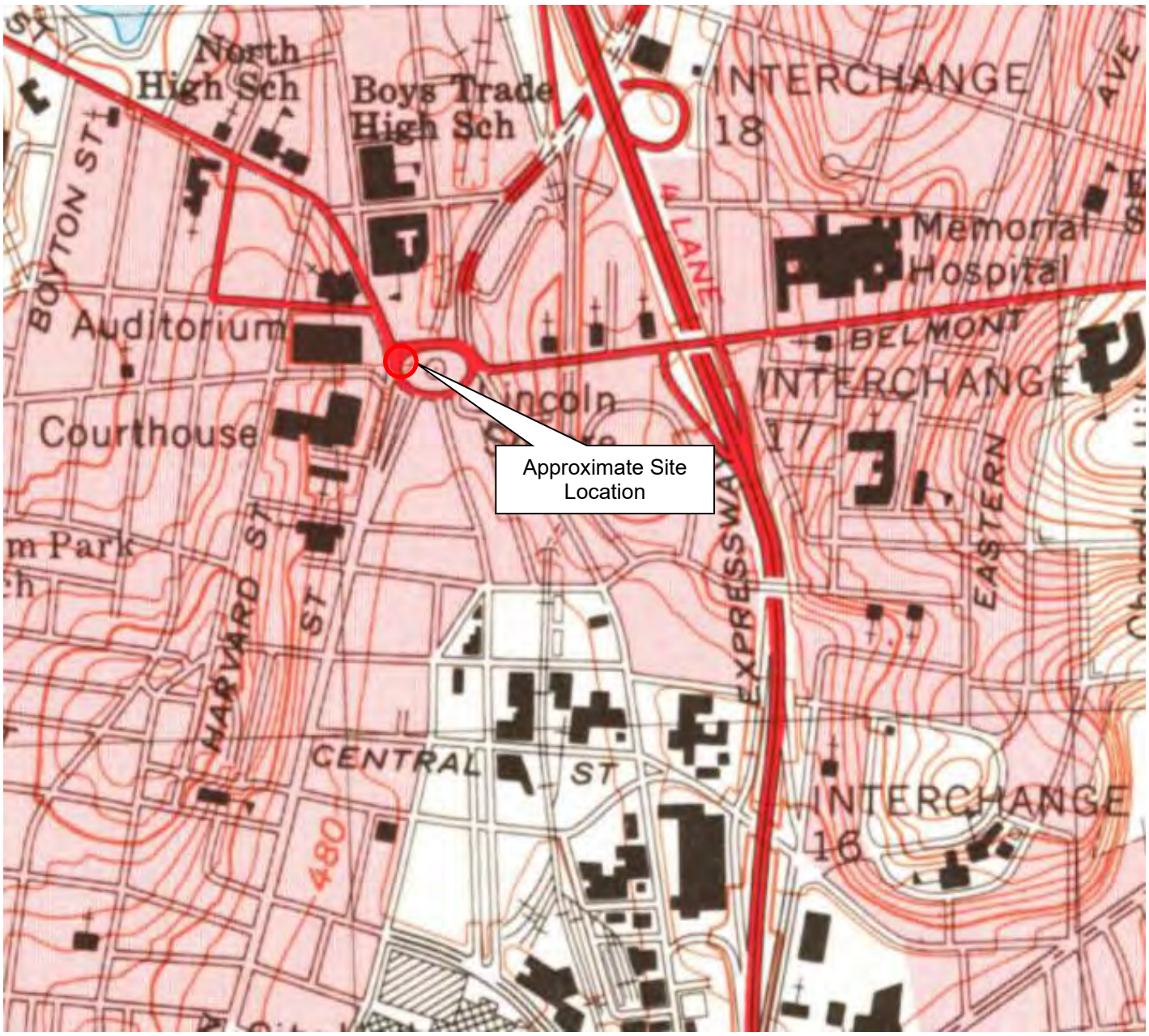
Client:	Project:	Figure A2– 1934 Historical Topo Map	
Ray Dunetz Landscape Architecture	Proposed Lincoln St. WWI Monument Renovation		
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Worcester, MA	LGCI Project No.: 2031	Date: Jan. 2021



Contour Intervals: 10 feet

Figure based on USGS topographic map of Worcester North, MA (1960) obtained from https://livingatlas.arcgis.com/topoexplorer/index.html.

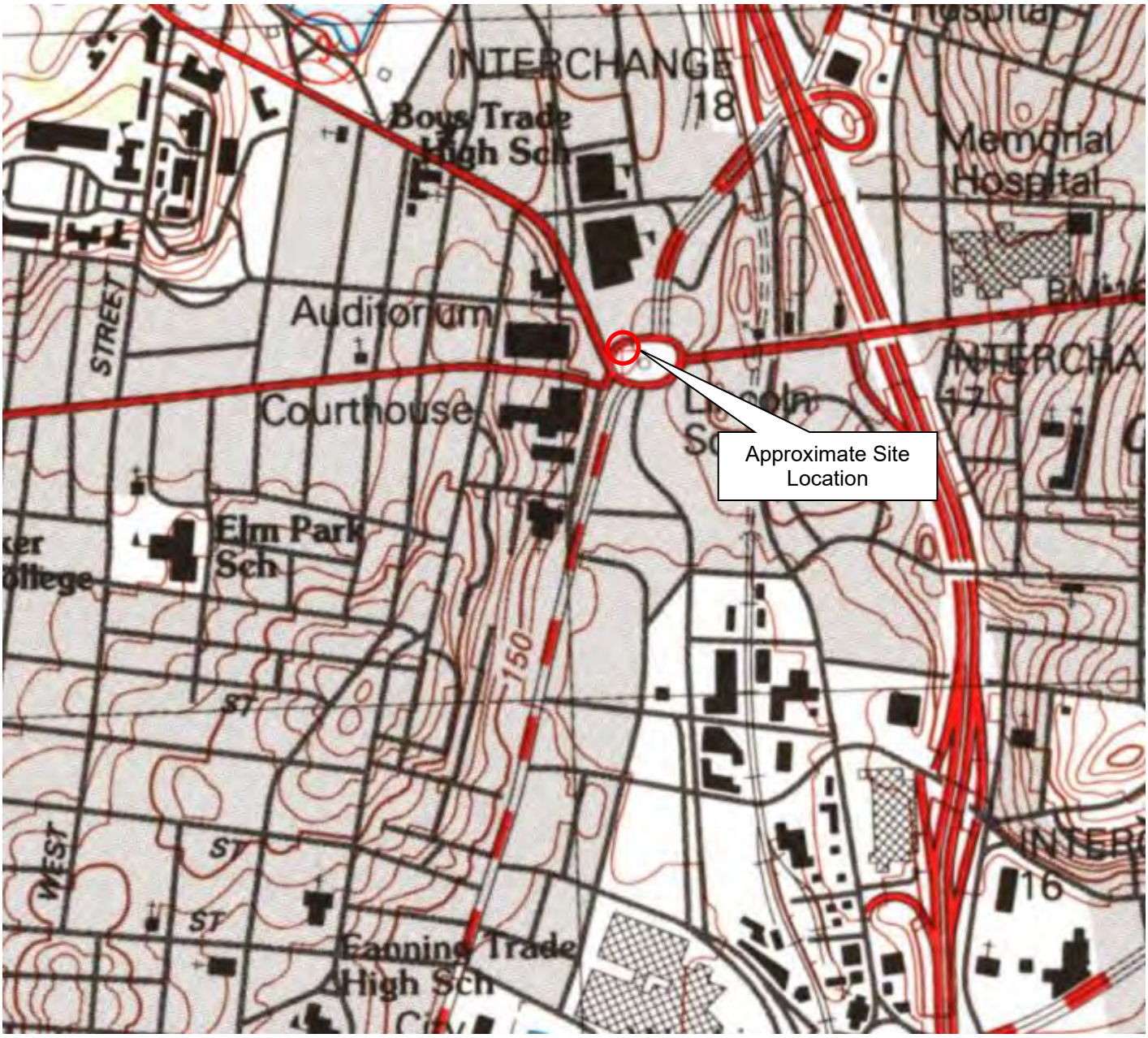
Client:	Project:	Figure A3– 1960 Historical Topo Map	
Ray Dunetz Landscape Architecture	Proposed Lincoln St. WWI Monument Renovation		
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Worcester, MA	LGCI Project No.: 2031	Date: Jan. 2021



Contour Intervals: 10 feet

Figure based on USGS topographic map of Worcester North, MA (1974) obtained from https://livingatlas.arcgis.com/topoexplorer/index.html.

Client:	Project:	Figure A4– 1974 Historical Topo Map	
Ray Dunetz Landscape Architecture	Proposed Lincoln St. WWI Monument Renovation		
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Worcester, MA	LGCI Project No.: 2031	Date: Jan. 2021



Contour Intervals: 3 meter

Figure based on USGS topographic map of Worcester North, MA (1983) obtained from https://livingatlas.arcgis.com/topoexplorer/index.html.

Client:	Project:	Figure A5– 1983 Historical Topo Map	
Ray Dunetz Landscape Architecture	Proposed Lincoln St. WWI Monument Renovation		
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Worcester, MA	LGCI Project No.: 2031	Date: Jan. 2021

Appendix B – WWI Monument History

Monument History

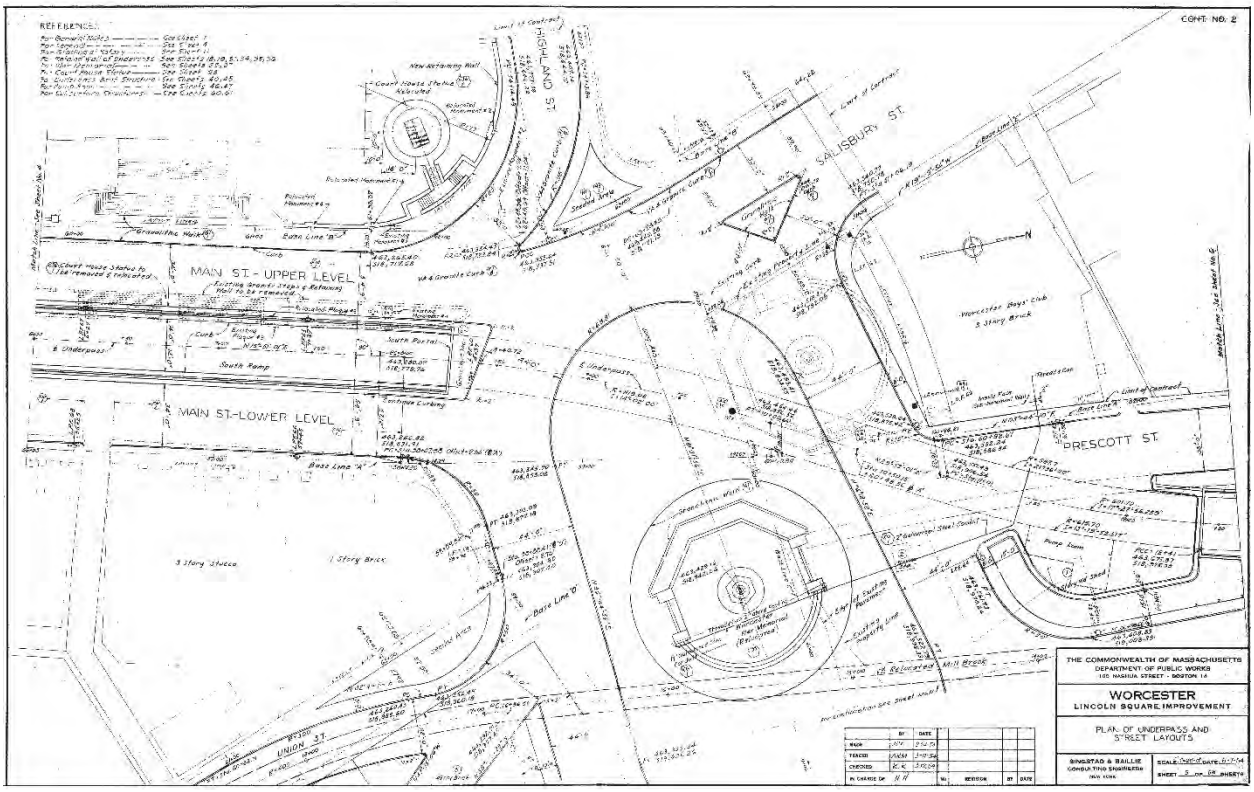
According to an article obtained from telegram.com dated October 1, 2017 and titled: "WWI Memorial in Worcester's Lincoln Square waits for neighbors and some TLC," the Lincoln Square WWI Monument (WWI Monument) was dedicated in 1935. The monument was constructed in front of the existing three-story brick building formerly known as the Lincoln Square Boy's Club[1] as shown in the aerial view from 1939 and the photograph from 1950 shown below.

Aerial view showing WWI Monument at its original location in front of the Lincoln Square Boy's Club in 1939 (obtained from www.historicaerials.com)

Photograph taken in 1950 showing Lincoln Square with WWI Monument at its original location in front of the Lincolns Square Boy's Club[2]

[1] Article titled: "Despite setback, developer vows to renovate Worcester's Boy Club building," obtained from telegram.com and dated May 23, 2019.
[2] Article obtained from www.worcesterthen.com by Don Chamberlayne, dated 2016.

To improve vehicular traffic, Lincoln Square was reconfigured in the mid-1950s. Based on the drawing shown below, the reconfigured Lincoln Square was designed in 1954 and included a new traffic circle and a tunnel connecting Salisbury Street to Main Street to alleviate surface traffic.



Drawing titled: "Plan of Underpass and Street Layouts, Lincoln Square Improvement," prepared by the Commonwealth of Massachusetts Department of Public Works, dated June 7, 1954 and provided to us by RDLA on September 8, 2020.

Aerial view showing WWI Monument in roundabout (traffic circle) in 1960
(obtained from www.historicaerials.com)

Photograph taken in 1969 showing the reconfigured Lincoln Square[2] with the WWI Monument within the traffic circle.

The WWI Monument was relocated again from the traffic circle shown above to its current location which is back near the original location. Based on the aerial views shown herein and the historic topo maps shown in Appendix A, the most recent move occurred between 1983 and 1995 as shown in the aerial view and photograph below.

Aerial view showing WWI Monument at its current location (aerial from 1995 obtained from www.historicaerials.com)

Current location of WWI Monument (obtained from Bing.com/maps)

Appendix C –Photographs of WWI Monument Condition

Photo No. 1: Crack in ground stone and displaced wall stones.

Photo No. 2: Crack in ground stone and displaced wall stones.

Photo No. 3: Crack in ground stone.

Photo No. 4: Displaced wall stone (knee high wall).

Photo No. 5: Displaced wall stone (knee high wall).

Photo No. 6: Displaced wall stone (knee high wall).

Photo No. 7: Crack in ground stone and displaced wall stones (knee high wall).

Photo No. 8: Filled wall stones (knee high wall).

Photo No. 9: Filled and displaced wall stone (knee high wall).

Photo No. 10: Displaced wall stones (knee high wall).

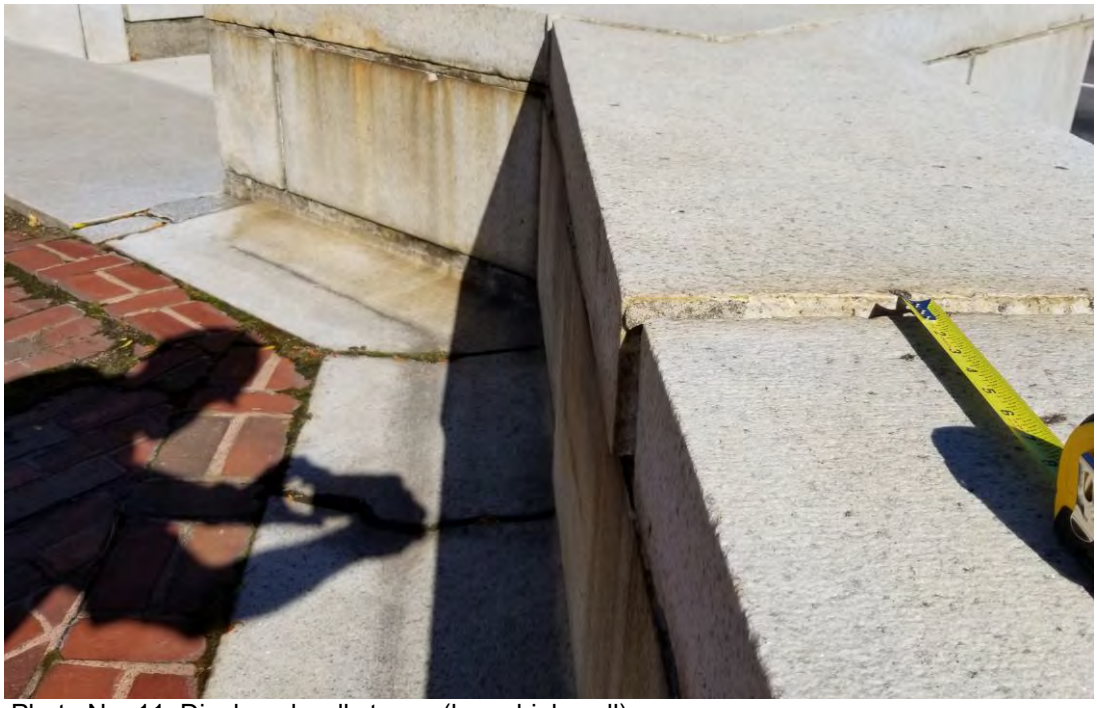


Photo No. 11: Displaced wall stones (knee high wall).

Photo No. 12: Depression in brick pavers at interface with stairs.

Photo No. 13: Uneven stairs.

Photo No. 14: Displaced stone (whisper wall).

Photo No. 15: Displaced stone (whisper wall).

Photo No. 16: Displaced stone (whisper wall).

Photo No. 17: Displaced stone (whisper wall).

Photo No. 18: Displaced stone (whisper wall).

Photo No. 19: Displaced stone (whisper wall).

Photo No. 20: Displaced stone (whisper wall).

Photo No. 21: Displaced stone (whisper wall).

Photo No. 22: Displaced stone (whisper wall).

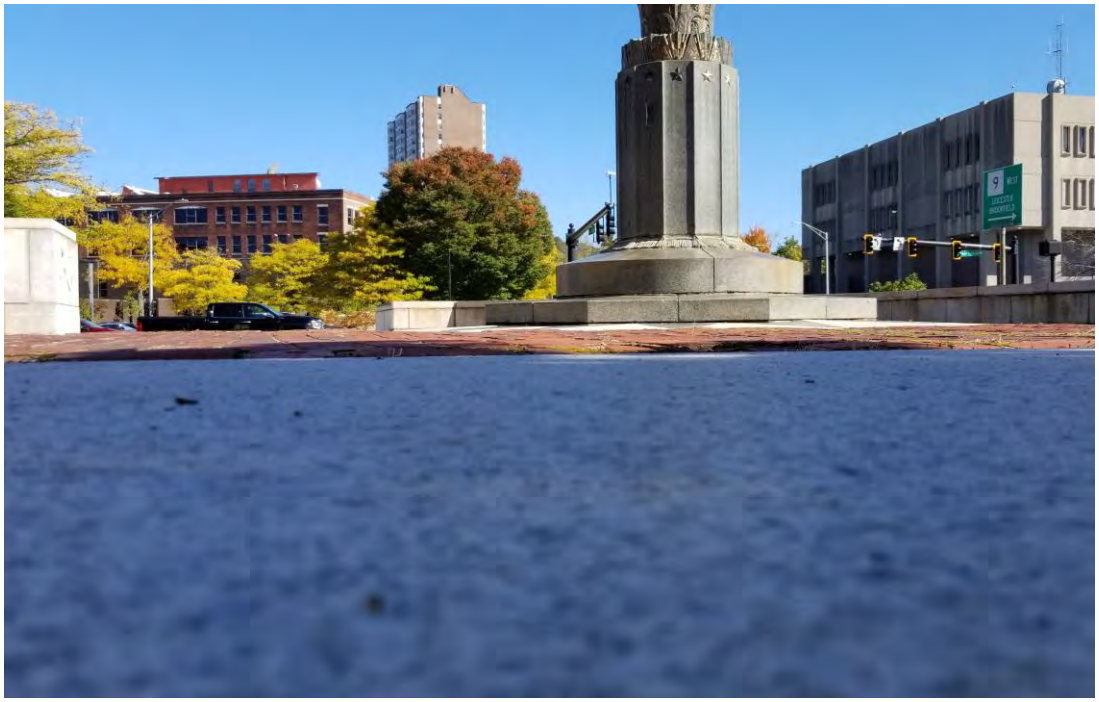


Photo No. 23: Uneven ground surface around monument.

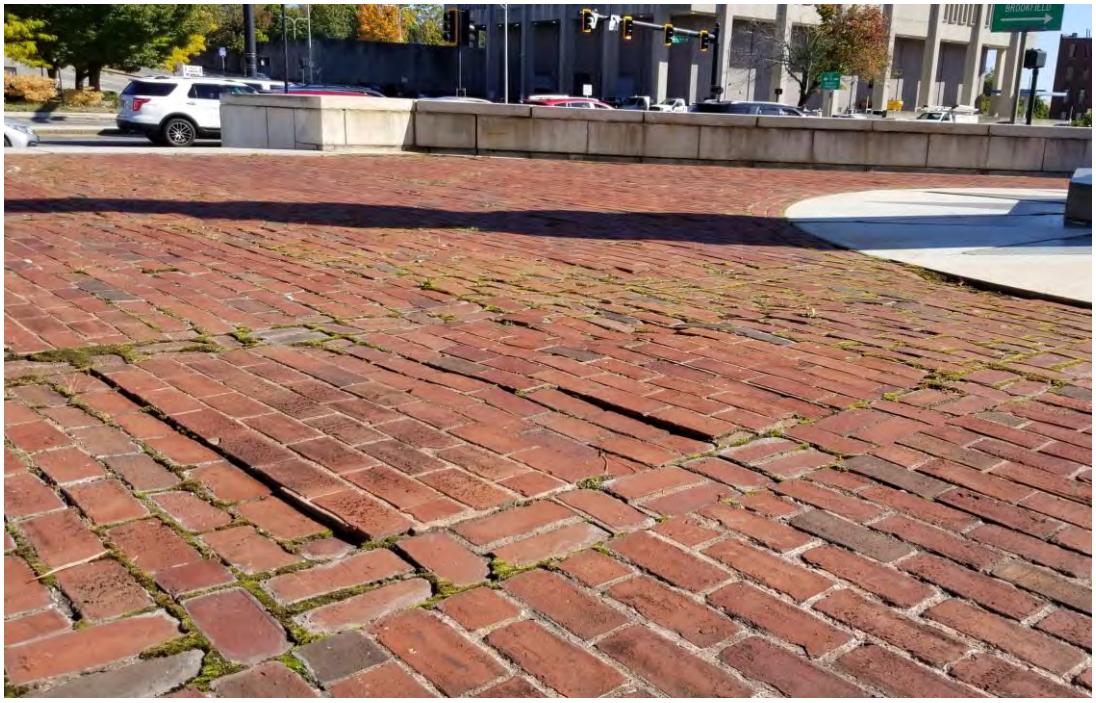


Photo No. 24: Uneven ground surface around monument.

Photo No. 25: Uneven ground surface around monument.

Photo No. 26: Uneven ground surface around monument.

Appendix D – LGCI's Boring Logs

LGCI Lahlaf Geotechnical Consulting, Inc.
100 Chelmsford Road, Suite 2
Billerica, MA 01862
Telephone: (978) 330-5912
Fax: (978) 330-5056

BORING LOG

B-1A
PAGE 1 OF 1

CLIENT: Ray Dunetz Landscape Architecture
PROJECT NAME: Proposed Lincoln St. WWI Monument Renovation
LGCI PROJECT NUMBER: 2031
PROJECT LOCATION: Worcester, MA

DATE STARTED: 9/22/20 **DATE COMPLETED:** 9/22/20
BORING LOCATION: Near southern side of memorial
COORDINATES: NA
SURFACE El.: 480 ft. (see note 1) **TOTAL DEPTH:** 8.1 ft.
WEATHER: 60's Cloudy
GROUNDWATER LEVELS:
DURING DRILLING: Not encountered
AT END OF DRILLING: Not encountered
OTHER: -

DRILLING SUBCONTRACTOR: Technical Drilling Services, Inc.
DRILLING FOREMAN: Darwin Newton
DRILLING METHOD: Hollow Stem Auger (4-1/4" I.D.)
DRILL RIG TYPE/MODEL: Vactron PMD-500/Diedrich D-120 Truck Rig
HAMMER TYPE: Automatic
HAMMER WEIGHT: 140 lb. **HAMMER DROP:** 30 in.
SPLIT SPOON DIA.: 1.375 in. I.D., 2 in. O.D.
CORE BARREL SIZE: NA
LOGGED BY: TG **CHECKED BY:** SD

Depth (ft.)	El. (ft.)	Sample Interval (ft.)	Sample Number	Blow Counts (N Value)	Pen./Rec. (in.)	Remark	Strata	Depth El.(ft.)	Material Description
5	475.0	5	S1	10-12-19-22 (31)	24/7	1 2	Fill		REMARK 1: Vacuum exploration to clear utilities to a depth of 4'. At depth of 4' a utility line was encountered. The borehole was moved 12' west. REMARK 2: Vacuum exploration to clear utilities to a depth of 4.7', no utilities were encountered. S1 - Silty SAND with Gravel (SM), fine to medium, trace coarse, ~15% fines, 30-35% fine to coarse subangular to angular gravel, trace of brick, trace of asphalt, light brown, moist
		7	S2	19-16-120/1"	13/11	3			REMARK 3: Hollow stem auger refusal at depth of 7'. Borehole was moved 7' east, see B-1B. S2 - Similar to S1
10	470.0	8.1						8.1	Bottom of borehole at 8.1 feet. Backfilled borehole with drill cuttings and 1.5 bags of sand.
15	465.0								
20	460.0								
25	455.0								

GENERAL NOTES:

1. The ground surface elevation was interpolated to the nearest foot from the drawing titled: "Existing Conditions, Lincoln Square and the World War II Memorial Improvement, Lincoln Square, Worcester, MA," prepared by Nitsch Engineering Inc. (Nitsch), dated June 19, 2020 and provided to LGCI by Nitsch via e-mail on September 8, 2020.

LGCI Lahlaf Geotechnical Consulting, Inc.
100 Chelmsford Road, Suite 2
Billerica, MA 01862
Telephone: (978) 330-5912
Fax: (978) 330-5056

BORING LOG

B-1B

CLIENT: Ray Dunetz Landscape Architecture
PROJECT NAME: Proposed Lincoln St. WWI Monument Renovation
LGCI PROJECT NUMBER: 2031
PROJECT LOCATION: Worcester, MA

DATE STARTED: 9/22/20 **DATE COMPLETED:** 9/22/20
BORING LOCATION: Near southern side of memorial
COORDINATES: NA
SURFACE El.: 480 ft. (see note 1) **TOTAL DEPTH:** 16 ft.
WEATHER: 60's Cloudy
GROUNDWATER LEVELS:
DURING DRILLING: Not encountered
AT END OF DRILLING: Not encountered
OTHER: -

DRILLING SUBCONTRACTOR: Technical Drilling Services, Inc.
DRILLING FOREMAN: Darwin Newton
DRILLING METHOD: HSA (4-1/4" I.D.) then 3-inch casing
DRILL RIG TYPE/MODEL: Diedrich D-120 Truck Rig
HAMMER TYPE: Automatic
HAMMER WEIGHT: 140 lb. **HAMMER DROP:** 30 in.
SPLIT SPOON DIA.: 1.375 in. I.D., 2 in. O.D.
CORE BARREL SIZE: NA
LOGGED BY: TG **CHECKED BY:** SD

Depth (ft.)	El. (ft.)	Sample Interval (ft.)	Sample Number	Blow Counts (N Value)	Pen./Rec. (in.)	Remark	Strata	Depth El.(ft.)	Material Description
		0	S1	6-9-18-22 (27)	24/12		Topsoil	0.5 479.5	S1 - Top 6": Topsoil Bot. 6": Silty SAND with Gravel (SM), fine to medium, 15-20% fines, 20-25% fine to coarse subrounded to subangular gravel, light brown, moist
		2	S2	34-29-19-12 (48)	24/14				S2 - Well Graded GRAVEL with Silt and Sand (GW-GM), fine to coarse, subrounded to subangular, 10-15% fines, 40-45% fine to coarse sand, trace of organic soil, trace of brick, brown, moist
		4	S3	15-13-31-50/2" (44)	20/11	1			S3 - Silty SAND with Gravel (SM), fine to medium, trace coarse, 15-20% fines, 35-40% fine to coarse subrounded to angular gravel, gray, moist REMARK 1: Drill rig chattering at depth of 5'.
5	475.0	5.7	C1		18/17	2 3			REMARK 2: Hollow stem auger refusal at depth of 5.5', switched to drive and wash with 3" casing. C1 - min/ft: 5.9, 3.5/6" REMARK 3: Rock core sample was taken from depth of 5.7' to 7.2', advanced button bit through 1.5' boulder.
		7.2				4	Fill		REMARK 4: A large void was encountered beneath the rock core sample.
10	470.0	10	S4	4-4-13-35 (17)	24/4	5			REMARK 5: Continuous split spoon sampling from depth of 10' to 16'. S4 - Silty GRAVEL with Sand (GW), fine to coarse, subrounded, 15-20% fines, 20-25% fine to coarse sand, trace of asphalt, trace of organic soil, brown to black, wet
		12	S5	16-9-9-10 (18)	24/7				S5 - Silty SAND with Gravel (SM), fine to coarse, 15-20% fines, 25-30% fine subrounded to subangular gravel, trace of brick, trace of asphalt, brown, moist
		14	S6	5-7-6-6 (13)	24/0				S6 - No recovery
15	465.0	16						16.0	
20	460.0								Bottom of borehole at 16.0 feet. Backfilled borehole with drill cuttings and 0.5 bags of sand.
25	455.0								

GENERAL NOTES:

1. The ground surface elevation was interpolated to the nearest foot from the drawing titled: "Existing Conditions, Lincoln Square and the World War II Memorial Improvement, Lincoln Square, Worcester, MA," prepared by Nitsch Engineering Inc. (Nitsch), dated June 19, 2020 and provided to LGCI by Nitsch via e-mail on September 8, 2020.

LGCI
Lahlaf Geotechnical Consulting, Inc.
100 Chelmsford Road, Suite 2
Billerica, MA 01862
Telephone: (978) 330-5912
Fax: (978) 330-5056

BORING LOG

B-2

CLIENT: Ray Dunetz Landscape Architecture
PROJECT NAME: Proposed Lincoln St. WWI Monument Renovation
LGCI PROJECT NUMBER: 2031
PROJECT LOCATION: Worcester, MA

DATE STARTED: 9/22/20 **DATE COMPLETED:** 9/22/20
BORING LOCATION: Near western side of memorial
COORDINATES: NA
SURFACE El.: 481 ft. (see note 1) **TOTAL DEPTH:** 19.1 ft.
WEATHER: 60's Cloudy
GROUNDWATER LEVELS:
DURING DRILLING: Not encountered
AT END OF DRILLING: Not encountered
OTHER: -

DRILLING SUBCONTRACTOR: Technical Drilling Services, Inc.
DRILLING FOREMAN: Darwin Newton
DRILLING METHOD: Hollow Stem Auger (4-1/4" I.D.)
DRILL RIG TYPE/MODEL: Vactron PMD-500/Diedrich D-120 Truck Rig
HAMMER TYPE: Automatic
HAMMER WEIGHT: 140 lb. **HAMMER DROP:** 30 in.
SPLIT SPOON DIA.: 1.375 in. I.D., 2 in. O.D.
CORE BARREL SIZE: NA
LOGGED BY: TG **CHECKED BY:** SD

Depth (ft.)	El. (ft.)	Sample Interval (ft.)	Sample Number	Blow Counts (N Value)	Pen./Rec. (in.)	Remark	Strata	Depth El.(ft.)	Material Description
0	480.0								
5	475.0	5	S1	14-14-12-10 (26)	24/5	1	Fill		REMARK 1: Vacuum exploration to clear utilities to depth of 5'. S1 - Brick and angular gravel
		7	S2	47/3"	3/0	2			REMARK 2: Drill rig chattering from depth of 7' to 10'. S2 - No recovery
		7.3							
		8	S3	21/2"	2/0				S3 - No recovery
		8.2							
10	470.0	10	S4	20-28-49-26 (77)	24/16				S4 - Silty SAND with Gravel (SM), fine to coarse, 20-25% fines, 30-35% fine to coarse subrounded to angular gravel, trace of bricks, light brown, moist
		12	S5	29-29-25-39 (54)	24/20				S5 - Top 13": Silty SAND with Gravel (SM), fine to coarse, 20-25% fines, 20-25% fine to coarse subrounded to angular gravel, trace of brick, light brown, moist
		13.1						13.1 467.9	Bot. 7": Silty SAND (SM), fine to medium, trace coarse, 20-25% fines, 10-15% fine subrounded to subangular gravel, gray, moist
		14							
15	465.0	15	S6	26-32-27-25 (59)	24/11		Sand		S6 - Silty SAND with Gravel (SM), fine to medium, trace coarse, 20-25% fines, 15-20% fine to coarse subrounded to subangular gravel, gray, moist
		17				3			REMARK 3: Drill rig chattering from depth of 17' to 19'.
		19	S7	50/1"	1/0	4		19.1	REMARK 4: Hollow stem auger refusal at depth of 19'. S7 - No recovery
		19.1							Bottom of borehole at 19.1 feet. Backfilled borehole with drill cuttings.
20	460.0								
25									

GENERAL NOTES:

1. The ground surface elevation was interpolated to the nearest foot from the drawing titled: "Existing Conditions, Lincoln Square and the World War II Memorial Improvement, Lincoln Square, Worcester, MA," prepared by Nitsch Engineering Inc. (Nitsch), dated June 19, 2020 and provided to LGCI by Nitsch via e-mail on September 8, 2020.

Appendix E – LGCI's Test Pit Logs, Sketches, and Photographs

LGCI
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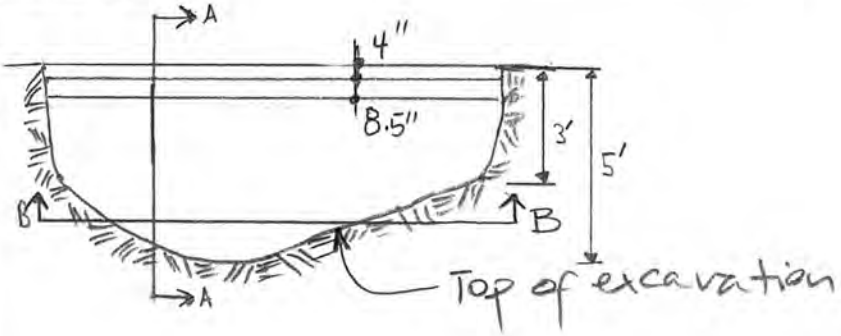
Billerica, MA 01862
Phone: (978) 330-5912
Fax: (978) 330-5056
E-mail: LGCI@lgcinc.net

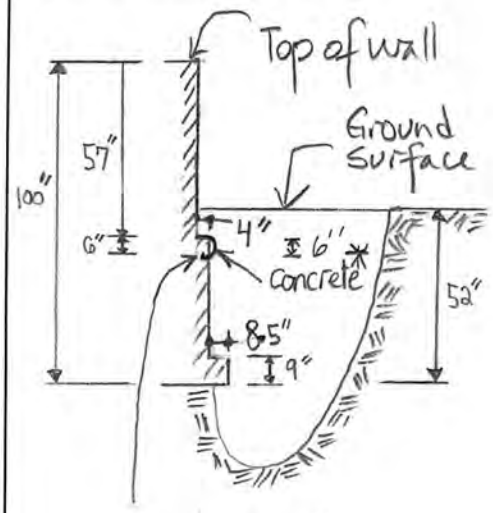
Project Name: Prop. Lincoln St. WWI Monument Reno.
Project Location: Worcester, MA
LGCI Project No.: 2031
Prepared by: Madjid Lahlaf
Date: 10/14/2020
Checked by:
Date:
Purpose: Expose the existing monument foundation

Test Pit TP 1

Plan View

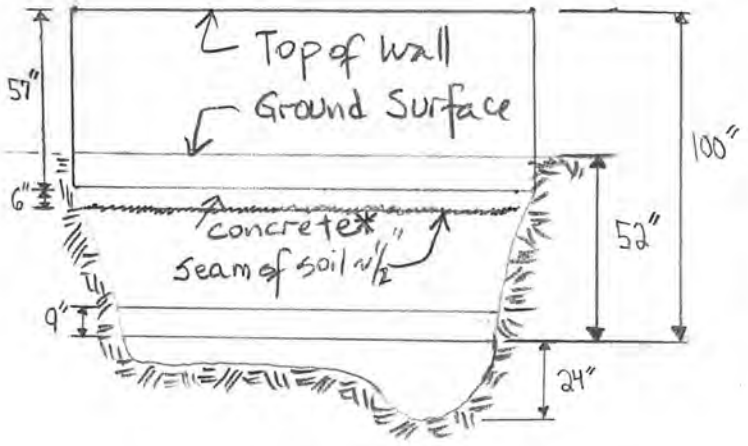


Cross Section A-A



Seam of soil ~ ½"

Cross Section B-B



Scale - 12"

* Concrete over-pour appears to possibly be a leveling pad for wall. The leveling pad appears to have been placed on foundation without thoroughly cleaning top of foundation.

Photo 1 - TP-1 - Overall View

Photo 2 - TP-1 - Depth to bottom of foundation

Photo 3 - TP-1 - Existing Fill under foundation

Photo 4 - TP_1 - Seam of soil between foundation and leveling pad

Photo 5 - TP-1 - View of foundation

Photo 6 - TP-1 - View of foundation

LGCI
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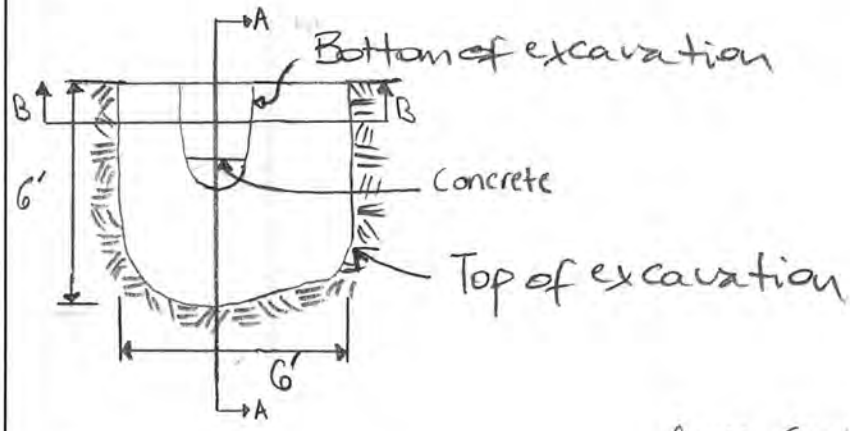
Fax: (978) 330-5056
E-mail: LGCI@lgcinc.net

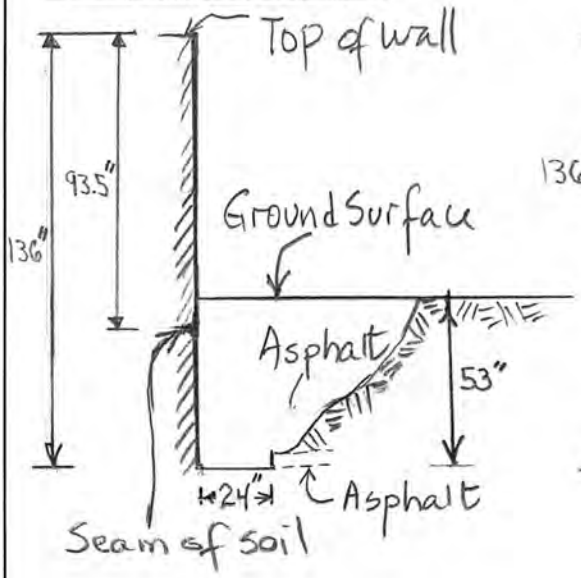
Project Name: Prop. Lincoln St. WWI Monument Reno.
Project Location: Worcester, MA
LGCI Project No.: 2031
Prepared by: Madjid Lahlaf
Date: 10/14/2020
Checked by:
Date:
Purpose: Expose the existing monument foundation

Test Pit TP-2

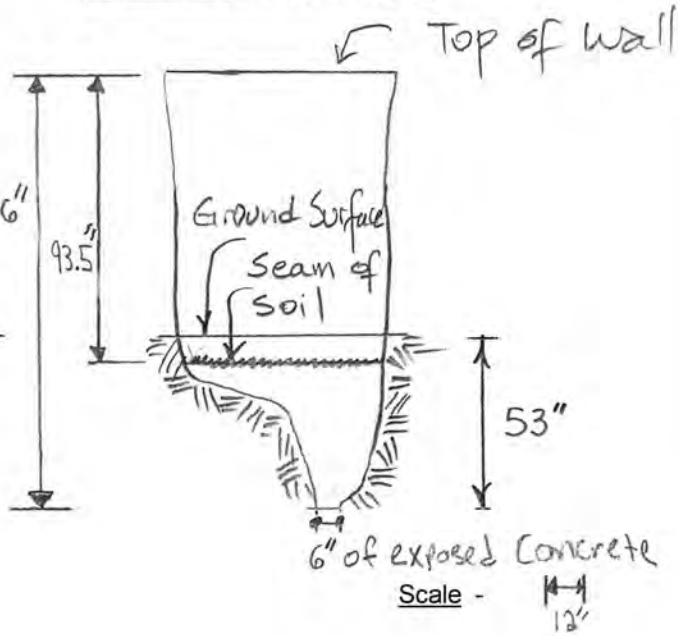
Plan View



Cross Section A-A



Cross Section B-B



Scale - 12"

Photo 7 - TP-2 - Overall View

Photo 8 - TP-2 - View of foundation

Photo 9 - TP-2 - Seam of Soil

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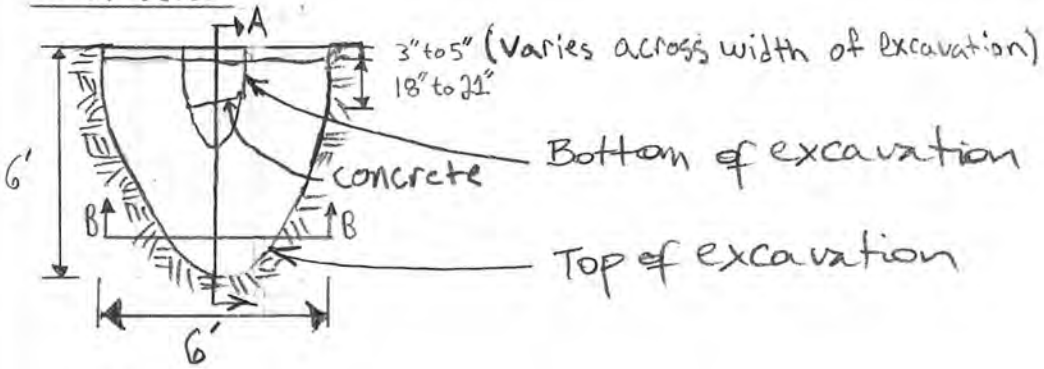
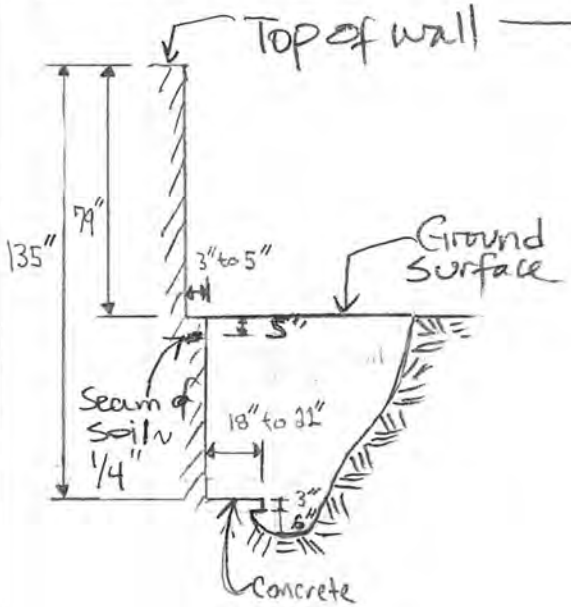
Project Name: Prop. Lincoln St. WWI Monument Reno.
Project Location: Worcester, MA
LGCI Project No.: 2031
Prepared by: Madjid Lahlaf
Date: 10/14/2020
Checked by:
Date:
Purpose: Expose the existing monument foundation

Test Pit TP-3

Plan View



Cross Section A-A



Cross Section B-B

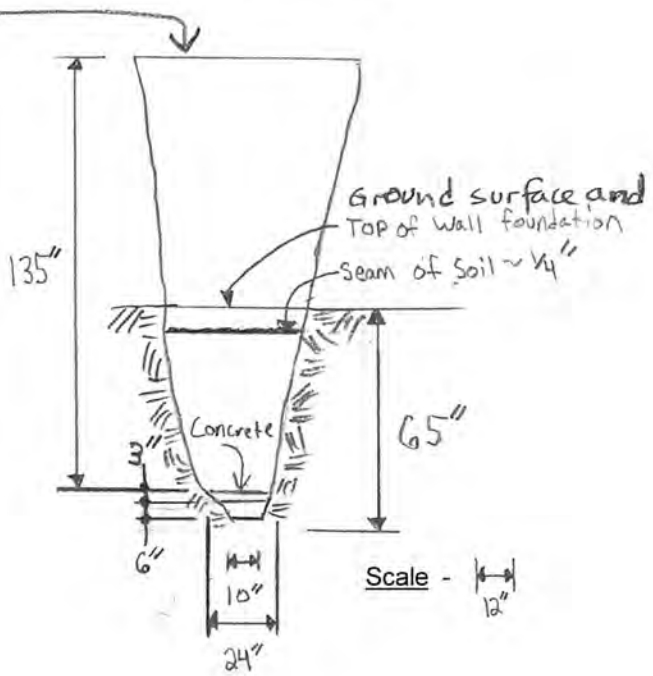
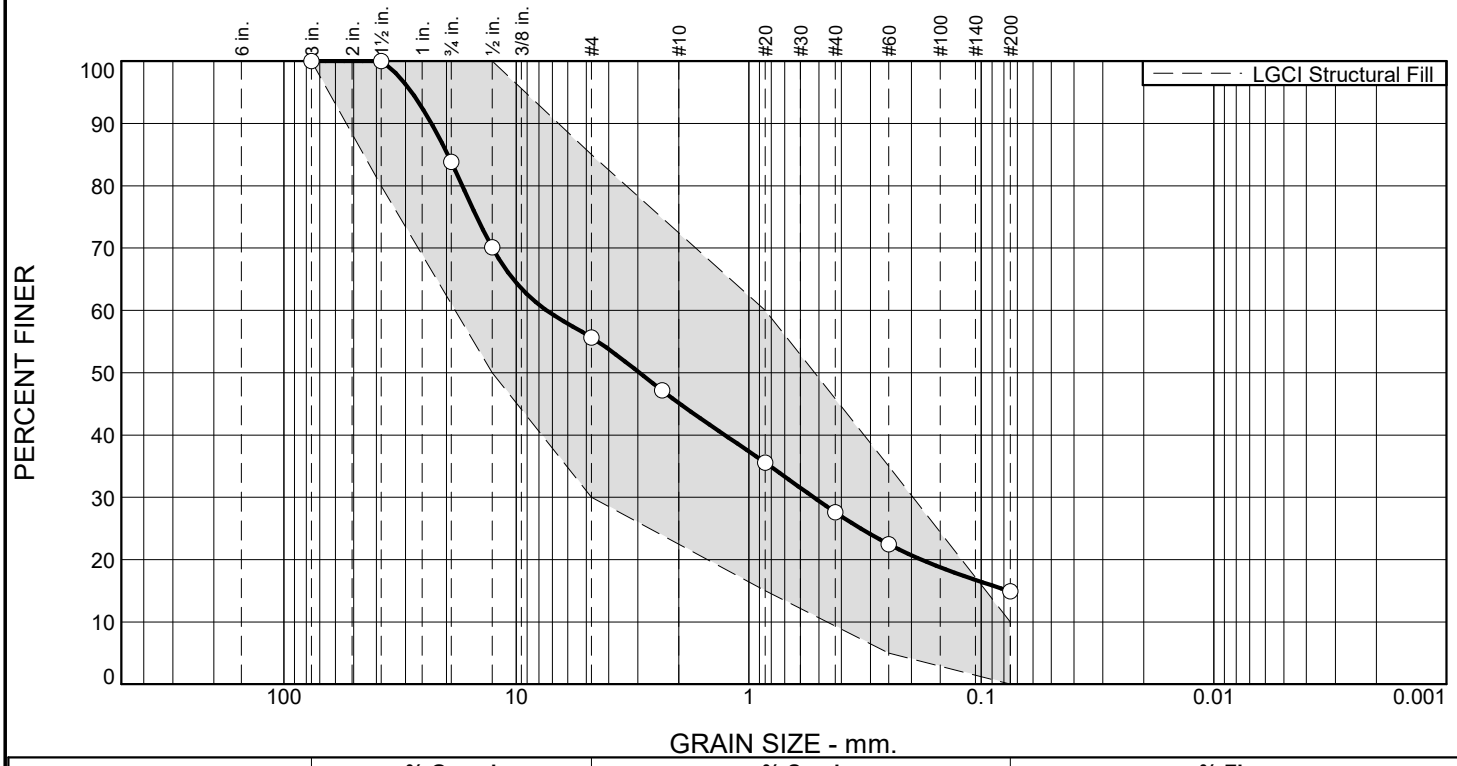


Photo 10 - TP-3 - Overall View

Photo 11 - TP-3 - View of Foundation

Appendix F – Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	16.2	28.2	10.4	17.6	12.7	14.9	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3"	100.0	100.0	
1.5"	100.0	80.0 - 100.0	
0.75"	83.8		
0.5"	70.1	50.0 - 100.0	
#4	55.6	30.0 - 85.0	
#8	47.2		
#20	35.5	15.0 - 60.0	
#40	27.6		
#60	22.5	5.0 - 35.0	
#200	14.9	0.0 - 10.0	X

* LGCI Structural Fill

Material Description

ASTM (D 2488) Classification: Well-Graded GRAVEL with Silt and Sand (GW-GM), fine to coarse, subrounded to subangular, 10-15% fines, 40-45% fine to coarse sand, brown

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 23.1789 D_{85}= 19.7225 D_{60}= 7.3977
D_{50}= 2.9537 D_{30}= 0.5265 D_{15}= 0.0765
D_{10}= C_u= C_c=

Remarks

Fill sample

Date Received: 9/22/2020 **Date Tested:** 9/24/2020

Tested By: RL

Checked By: TG

Location: Boring B-1B
Sample Number: S2 **Depth:** 2' - 4'

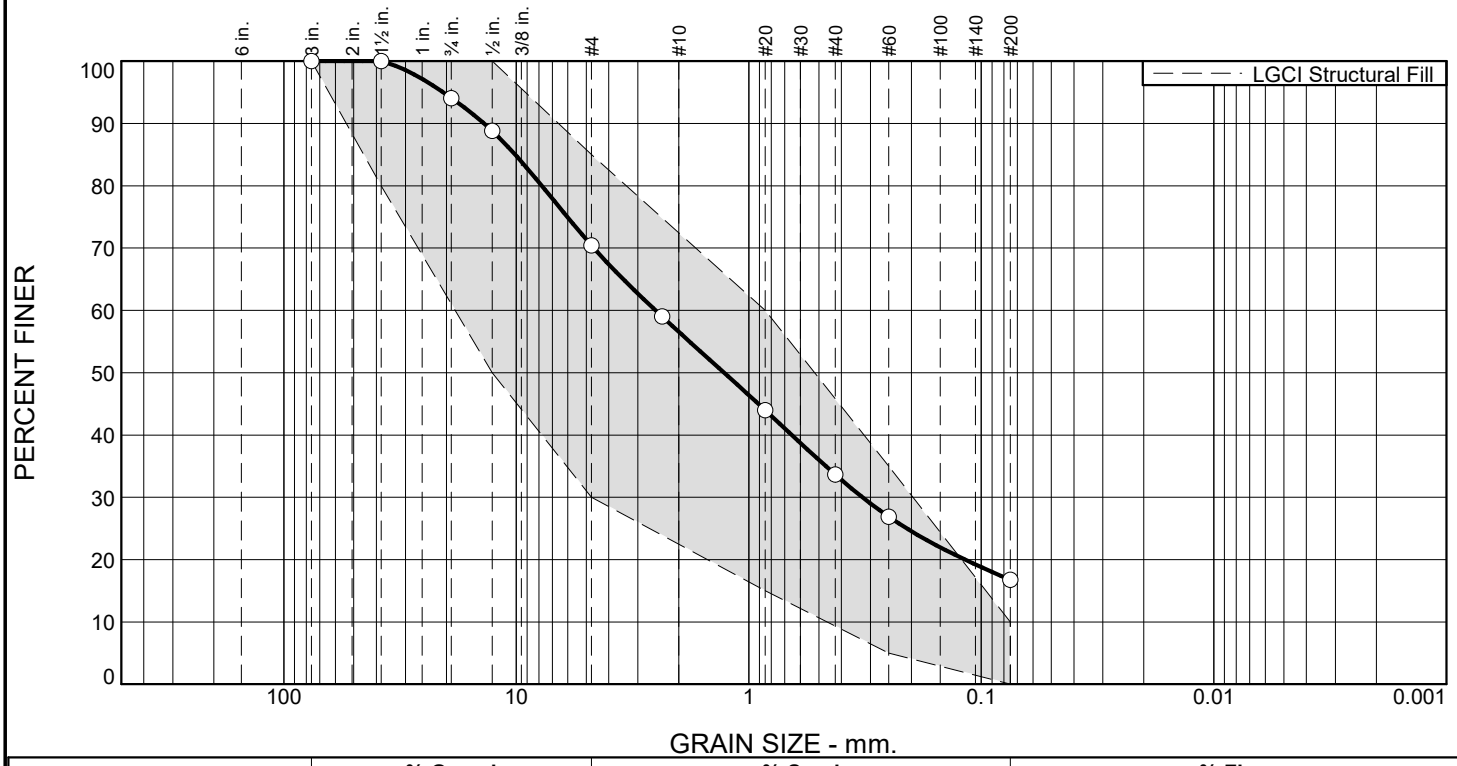
Date Sampled: 9/22/2020

LGCI
Lahlaf Geotechnical Consulting, Inc.

Client: Ray Dunetz Landscape Architecture
Project: Proposed Lincoln St. WWI Monument Renovation, Worcester, MA

Project No: 2031 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	5.9	23.7	13.8	22.9	17.0	16.7	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3"	100.0	100.0	
1.5"	100.0	80.0 - 100.0	
0.75"	94.1		
0.5"	88.8	50.0 - 100.0	
#4	70.4	30.0 - 85.0	
#8	59.0		
#20	44.0	15.0 - 60.0	
#40	33.7		
#60	26.9	5.0 - 35.0	
#200	16.7	0.0 - 10.0	X

* LGCI Structural Fill

Material Description

ASTM (D 2488) Classification: Silty SAND with Gravel (SM), fine to coarse, 15-20% fines, 25-30% fine subrounded to subangular gravel, brown

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 13.7597 D_{85}= 10.1014 D_{60}= 2.5183
D_{50}= 1.2775 D_{30}= 0.3238 D_{15}=
D_{10}= C_u= C_c=

Remarks

Fill sample

Date Received: 9/22/2020 **Date Tested:** 9/24/2020

Tested By: RL

Checked By: TG

Location: Boring B-1B
Sample Number: S5 **Depth:** 12' - 14'

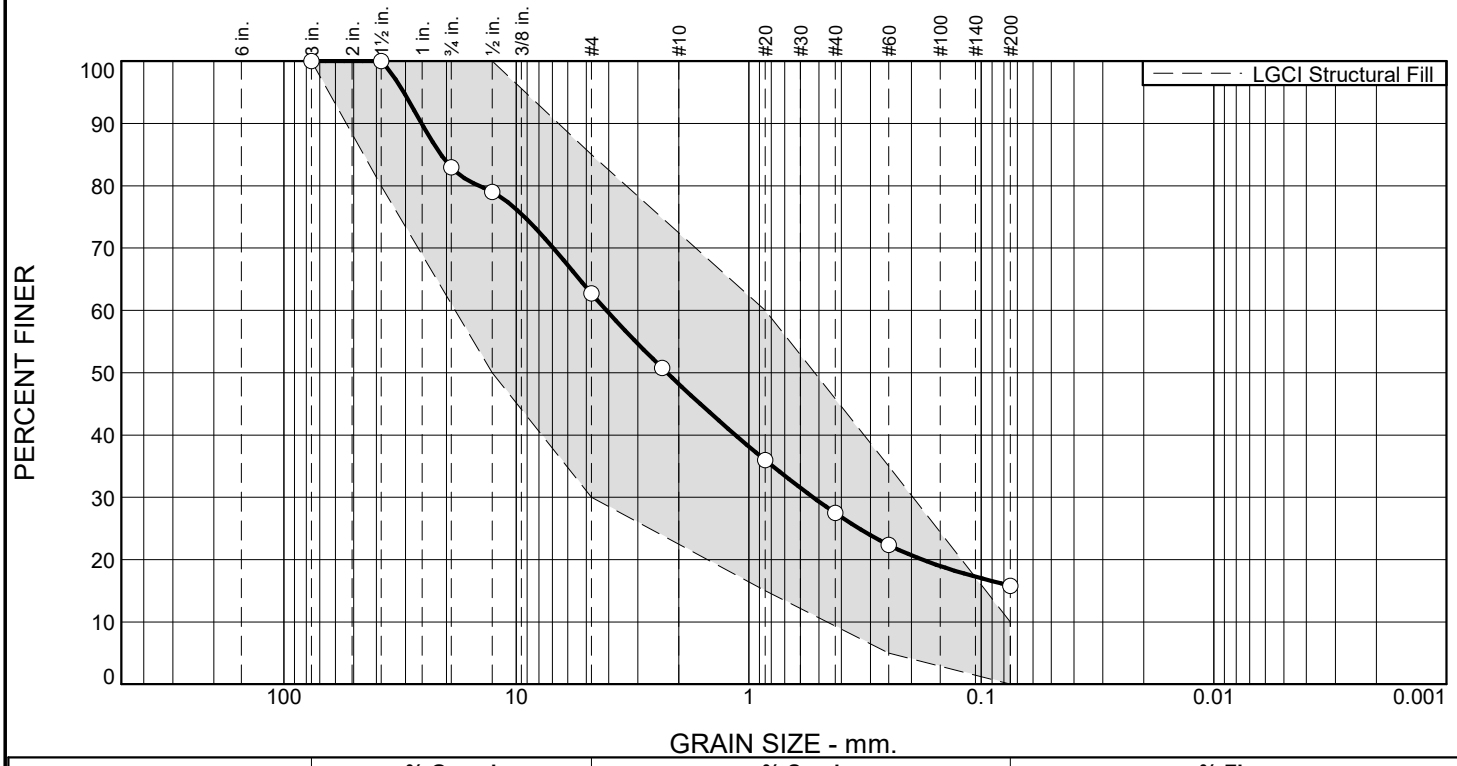
Date Sampled: 9/22/2020

LGCI
Lahlaf Geotechnical Consulting, Inc.

Client: Ray Dunetz Landscape Architecture
Project: Proposed Lincoln St. WWI Monument Renovation, Worcester, MA

Project No: 2031 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	17.1	20.2	14.5	20.7	11.7	15.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3"	100.0	100.0	
1.5"	100.0	80.0 - 100.0	
0.75"	82.9		
0.5"	79.0	50.0 - 100.0	
#4	62.7	30.0 - 85.0	
#8	50.8		
#20	36.0	15.0 - 60.0	
#40	27.5		
#60	22.4	5.0 - 35.0	
#200	15.8	0.0 - 10.0	X

* LGCI Structural Fill

Material Description

ASTM (D 2488) Classification: Silty SAND with Gravel (SM), fine to coarse, 15-20% fines, 35-40% fine to coarse, subrounded to angular gravel, brown

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 25.5255 D_{85}= 21.0976 D_{60}= 4.0975
D_{50}= 2.2467 D_{30}= 0.5295 D_{15}=
D_{10}= C_u= C_c=

Remarks

Fill sample

Date Received: 10/14/2020 **Date Tested:** 10/15/2020

Tested By: RL

Checked By: TG

Location: Test Pit TP-1
Depth: 52" - 68"

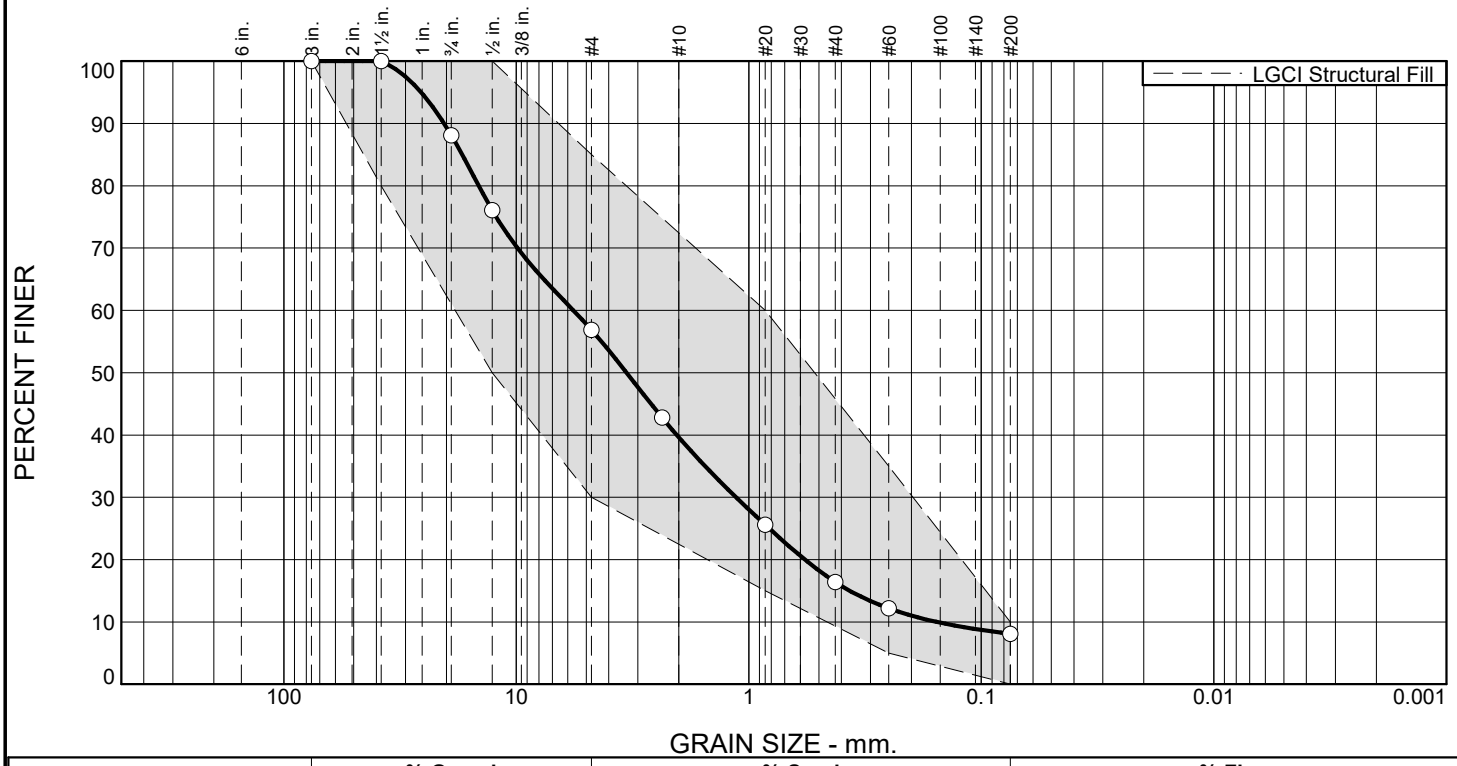
Date Sampled: 10/14/2020

LGCI
Lahlaf Geotechnical Consulting, Inc.

Client: Ray Dunetz Landscape Architecture
Project: Proposed Lincoln St. WWI Monument Renovation, Worcester, MA

Project No: 2031 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	11.9	31.2	17.3	23.2	8.3	8.1	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3"	100.0	100.0	
1.5"	100.0	80.0 - 100.0	
0.75"	88.1		
0.5"	76.1	50.0 - 100.0	
#4	56.9	30.0 - 85.0	
#8	42.8		
#20	25.6	15.0 - 60.0	
#40	16.4		
#60	12.2	5.0 - 35.0	
#200	8.1	0.0 - 10.0	

* LGCI Structural Fill

Material Description

ASTM (D 2488) Classification: Well Graded SAND with Silt and Gravel (SW-SM), fine to coarse, 5-10% fines, 40-45% fine to coarse subrounded to angular gravel, brown

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 20.4426 D_{85}= 17.0986 D_{60}= 5.6803
D_{50}= 3.3565 D_{30}= 1.1334 D_{15}= 0.3680
D_{10}= 0.1559 C_u= 36.44 C_c= 1.45

Remarks

Fill sample

Date Received: 10/14/2020 **Date Tested:** 10/15/2020

Tested By: RL

Checked By: TG

Location: Test Pit TP-3
Depth: 60" - 66"

Date Sampled: 10/14/2020

LGCI
Lahlaf Geotechnical Consulting, Inc.

Client: Ray Dunetz Landscape Architecture
Project: Proposed Lincoln St. WWI Monument Renovation, Worcester, MA

Project No: 2031 **Figure**