



GEOHERMAL SITE FEASIBILITY STUDY

LOWELL HOUSING AUTHORITY

FEBRUARY 19, 2026



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1.0 EXECUTIVE SUMMARY

The Lowell Housing Authority (LHA) has contracted ODIN EPC, Inc., in collaboration with Weston & Sampson Engineers, Inc., to conduct a Feasibility Study to provide a roadmap for network geothermal infrastructure for a new heating and cooling system at both new and existing public housing.

The study was completed in two phases:

- 1.** The first phase of the study included the feasibility of installing a geothermal system to provide heating and cooling for a new public housing development near Decatur, Merrimack and Salem Streets in Lowell, MA known as the Merrimack Corridor Site Development.
- 2.** The second phase includes expanding the geothermal footprint within the community of Lowell. This expansion was selected for Phase II to anticipate replacement needs and/or modernization of key public facilities, deliver modern cooling to underserved residential properties, and create opportunities for shared system efficiencies.

The Phase I site is primed for investment and has its own mechanical plans underway yet studying the geothermal potential beyond a single development is important. Such an effort could allow for a geothermal network with load-sharing abilities to meet needs beyond the Housing Authority campus and provide public benefit by piloting a transition from natural gas in an Environmental Justice community. The selected facilities were studied because they are proximate and diverse in use, creating an “anchor load” that supports resource-efficient deployment. At this stage, no commitments have been made for these buildings to participate in a project, as this remains a study; however, public facilities are generally well aligned with advancing long-term sustainability objectives. A future, more detailed phase, conducted in parallel with community outreach, education, and engagement could also assess opportunities to serve residential and commercial loads. Guidance from the **Lowell EJ Plan** highlights proven engagement strategies and underscores the value of prioritizing Lowell in clean energy planning.

Phase I

The Project's design is grounded architecturally within the neighborhood's context and fills a gap in Lowell's urban fabric along Merrimack Street. The two new buildings will activate the streetscape, filling the current visual void with preserved open space, an improved streetscape, and new residential uses. For residents, the buildings will offer healthy homes with fantastic connectivity into downtown Lowell, and easy access to public transit.



Renditions of Buildings along Merrimac Decatur & Salem Streets, courtesy of RENU

During the development of this feasibility study, the ODIN and Weston & Sampson team cooperated with the project development team led by Trinity Financial and their team members, such as Icon Architecture, Langan (civil engineer) and R.W. Sullivan Engineering (MEP engineer) to flush out specific details regarding the design, operations and costs of geothermal system options for this project.

Phase II

The second phase of the project identifies conceptual plans for a networked geothermal system that could include complimentary uses and improve efficiencies for multiple existing buildings/facilities. These facilities include the North Common Village housing complex, the Raymond Lord Memorial Pool and the Murkland Elementary School.



North Common Village, courtesy of Lowell Housing Authority



Raymond Lord Memorial Swimming Pool, Photo courtesy of Elizabeth Martins NP



Charlotte M. Murkland Elementary School Photo courtesy of Lowell Public Schools

This report details the two phases of the feasibility study which includes an analysis establishing, creating, and expanding the geothermal network into the developing community of Lowell to install a new geothermal infrastructure to provide cooling and retire the need for the existing natural gas distribution network for heating and domestic hot water.

2.0 BACKGROUND

2.1. | Kickstart Program Goals

The Lowell Housing Authority project was initiated and conceived through funding by the Clean Energy Center and funds administered by HEET, a non-Profit Thermal Energy Innovation Hub (<https://www.heet.org>)

The Massachusetts Clean Energy Center (MassCEC) has set ambitious goals for decarbonizing the state's building sector, which remains one of the largest sources of greenhouse gas emissions.

Central to these goals is advancing the transition away from fossil gas infrastructure and toward clean, reliable, and affordable alternatives. Geothermal networks, also called thermal energy networks, are a cornerstone of this strategy. This technology choice has the potential to offer scalable, non-combustion-based heating and cooling that can be deployed equitably across communities.



The Learning from the Ground Up Research Project sponsored by the Massachusetts Clean Energy Center allocated \$450,000 to fund research partnerships that perform geothermal potential studies for communities interested in serving as hosts for geothermal network projects and to engage and educate stakeholders in the host communities of potential sites.

Kickstart Massachusetts frames project potential as an alignment between community priorities, technical parameters, and institutional factors. HEET launched Kickstart Studies to fund 12 early-stage community geothermal potential assessments (spanning diverse geographies and use cases across Massachusetts) to build a pipeline of project sites and learn from their varied contexts, generating insights in line with HEET’s mission of bringing stakeholders together to co-develop and drive a resilient and inclusive thermal energy transition (See Appendix A). Each study is designed to inform both local decision-making and statewide learning, ensuring that technical findings, community feedback, and institutional insights contribute to Massachusetts’ clean energy roadmap.

2.2. | Stakeholders

Geothermal Energy Networks (GENs) are decentralized utilities, and their deployment depends on the participation of buildings with diverse loads and other distributed energy resources (DERs) in the form of available parcels for geothermal borefields or other opportunistic thermal resources. Thus, collaboration is essential across a wide range of stakeholders, from local residents and institutions to state agencies and technical experts. Each stakeholder brings a unique role—whether providing land and anchor loads, shaping policy, ensuring technical rigor, or representing community priorities.

In Lowell, the Kickstart study has drawn on the perspectives of municipal leaders, housing authority staff, academic partners, engineers, and advocates. The following list outlines the core stakeholders engaged in or relevant to this study, highlighting their contributions and areas of alignment.



Massachusetts Clean Energy Center (MassCEC) – program funder, advancing statewide geothermal learning through the Kickstart initiative and aligning with state climate policy goals.



HEET – a Massachusetts-based nonprofit climate-solutions incubator. As the designated implementing partner for the Kickstart Massachusetts program, HEET administers the planning grants, provides technical and community engagement support, and fosters a statewide learning network around networked geothermal potential.



Lowell Housing Authority (LHA) – project owner and anchor partner, providing access to properties, resident engagement, and long-term operational perspective.



City of Lowell – municipal government, planning, and sustainability offices; coordination on permitting, infrastructure, and long-term planning.



University of Massachusetts Lowell (UML) – Rist Institute for Sustainability and Energy (RISE) – academic partner supporting research, student engagement, and applied analysis.



National Grid – prior utility partner in Lowell’s neighborhood geothermal pilot (terminated in June 2024). While not directly involved in this feasibility study, their past work with the City of Lowell and UML provides important context for stakeholder knowledge and utility considerations.



Community-Based Organizations and EJ Advocates – including local tenant leaders, Acre neighborhood groups, and participants in UML’s Environmental Defense Fund Climate Corps fellowship, who bring resident priorities and equity considerations into the project.



Technical and Engineering Partners – Weston & Sampson Engineers, ODIN EPC, RENU, Icon Architecture, and RW Sullivan Engineering, providing subsurface analysis, design options, and cost modeling. Trinity Financial is the developer of the Merrimack Corridor Site, responsible for project-specific design and integration of mechanical systems.



Potential Anchor Institutions – Lowell Public Schools (e.g., Murkland Elementary, Mercier School) and the Massachusetts Department of Conservation and Recreation (DCR, Raymond Lord Memorial Pool) have been highlighted in this study as strong candidates for anchor participation in a future Phase II network.

2.3. | Connection to Municipal Priorities

The City of Lowell’s **Lowell Forward** comprehensive plan sets a twenty-year vision for equitable growth, resilience, and economic vitality. At its core, the plan recognizes that climate action, housing quality, infrastructure modernization, and inclusive economic development must advance together. This geothermal feasibility study contributes to that vision by testing how innovative infrastructure can deliver both environmental and community benefits.

2.3.1. Climate Action and Equity

Lowell Forward commits the City to achieving carbon neutrality by 2050, with an interim goal of reducing building emissions 50% by 2030. It also emphasizes **energy equity**—ensuring decarbonization does not increase energy burdens for vulnerable residents. GENs directly supports these commitments by replacing combustion-based heating with clean, non-emitting systems that provide affordable, reliable comfort. Siting the pilot in the Acre neighborhood, a designated Environmental Justice area, advances the plan’s call to prioritize equitable climate action.

2.3.2. Housing and Quality of Life

The plan’s housing objectives include developing homes for all and increasing quality for households of low and very low income. The LHA project speaks directly to this goal: upgrading aging public housing with modern, non-combustion infrastructure can improve safety, indoor air quality, and year-round comfort for residents. By integrating geothermal at the housing authority

scale, Lowell can demonstrate how climate goals and environmental justice can be advanced in tandem.

2.3.3. Resilience and Infrastructure Modernization

Lowell Forward stresses the importance of modernizing utilities and safeguarding residents during heat waves and cold snaps. Geothermal networks embody this principle: they replace aging gas infrastructure with state-of-the-art thermal systems, providing stable, efficient heating and cooling even under grid stress. Each borehole (well) and distribution pipe represents a long-term investment in resilient infrastructure that supports both climate goals and public safety.

2.3.4. Economic Development and Local Opportunity

The plan calls on Lowell to promote a clean energy economy and expand job opportunities for residents. Geothermal networks can help realize this vision by creating local jobs while attracting partnerships. Public housing upgrades can spark further neighborhood investment. By linking climate action to economic opportunity, geothermal aligns directly with the City's vision of sustainable prosperity.

2.4. | Preceding Efforts Shaping the Current Study

This study builds on earlier pilots and engagement efforts in Lowell, which provided valuable context and lessons for the current study.

2.4.1. Preliminary EJ Engagement Framework (2023)

In 2023, the University of Massachusetts Lowell's Rist Institute for Energy and Sustainability hosted an Environmental Defense Fund Climate Corps Fellow, Dillan Patel, to examine environmental justice considerations related to networked geothermal in Lowell. The fellowship produced a story map and final report documenting the EJ context, identifying potential participants, and suggesting approaches for community engagement.

These materials provide useful background for understanding how equity concerns intersect with technical planning and remain a reference point for ongoing work in Lowell. They also offer a starting framework that the Kickstart feasibility study can draw on when considering stakeholder engagement and alignment with community priorities (see Appendix A).

2.4.2. National Grid Neighborhood Geothermal Pilot (2023–2024)

In 2021, the Massachusetts Department of Public Utilities approved an order authorizing gas utilities to pursue up to five demonstration projects to test geothermal networks as an alternative to costly gas pipe replacement (D.P.U. 21-24 under the framework established in D.P.U. 20-120). This regulatory decision established a precedent for utility-owned and operated GENs in the

Commonwealth, framing geothermal not as an optional add-on but as a potential successor to aging gas infrastructure. The order outlined criteria including siting in gas-constrained or leak-prone areas, serving EJ communities, and prioritizing diverse building loads that could demonstrate system balancing. These parameters directly shaped eligible sites.

In response, the UMass Lowell Rist Institute for Sustainability and Energy (RIST) and the City of Lowell applied for Lowell to be designated a National Grid pilot community. The proposed site consisted largely of tenant-occupied housing. Within the pilot boundaries, 68 of 108 accounts were eligible National Grid customers because both the building residents and property owners needed to be National Grid account holders, even if they lived elsewhere.

From early 2023 through mid-2024, National Grid pursued a proposed neighborhood-scale geothermal pilot in the vicinity of UMass Lowell's South Campus. The project sought to serve 42 properties (with 12 distinct property owners), including a Lowell Housing Authority building at 189 Walker Street, through a shared borehole system designed to test the feasibility of utility-owned thermal networks. UML was identified as a strong anchor institution, with two university buildings considered for inclusion to strengthen the load profile. The primary parcel for geothermal bores was the university's parking lot; a straight-line borefield in the Waugh Street right-of-way was also considered but ultimately set aside due to the regulatory complexity it would present. RIST expressed support for serving not only as an anchor load but also as a primary energy prosumer through the geothermal network, though the exact ownership structure of the borefield was not defined at the time.

The engagement approach during the pilot period combined targeted outreach to property owners. Broader resident engagement was limited. At the time of this report, the National Grid pilot has been formally cancelled. The utility determined that projected costs were higher than feasible for a utility-scale demonstration. Following this decision, participants were presented with three options: (1) remain on natural gas, (2) convert to air-source heat pumps (ASHP), or (3) adopt geothermal or ground-source heat pumps (GSHP) on an individual basis. The Lowell Housing Authority opted to remain on natural gas, citing uncertainties around resident affordability and the absence of sufficient protections to address potential increases in utility costs.

2.4.3. Lowell Housing Authority Geothermal Evaluation Efforts

The Lowell Housing Authority (LHA) has been working to find resolution of the dynamics for geothermal networks and costs reflected in infrastructure modernization. Three separate, but conceptually related, projects confronted LHA. These three projects should be considered together rather than mutually exclusive projects. These dynamics continue to shape LHA decision-making regarding building upgrades and transitions in energy use, which remain primarily dependent on electricity and natural gas.

LHA Project 1 – Networked Geothermal, National Grid

As discussed above, a Networked Geothermal pilot with National Grid, the University of Massachusetts-Lowell (UML) , City of Lowell, and the Lowell Housing Authority’s 189 Walker Street 12-unit apartment building, all in the area of UML’s South Campus. This project was cancelled ostensibly due to overall site electrification and geothermal investment costs. A follow-on non-network project was considered as a new pilot, but utility costs passed on to residents became the primary consideration for ultimately opting for no change in service (i.e., remain on natural gas). As a result of the considerations on July 24, 2025, the LHA selected a “no change” option with National Grid, remaining on natural gas rather than pursuing ASHP or GSHP alternatives and effectively pausing electrification efforts for the near future.

LHA Project 2 – Mass DPU Requirements for Master Meter Operator Regulation

The Massachusetts Department of Public Utilities required several public housing authorities, including Lowell, to comply with the state’s “Master Meter Operator” regulation. State-aided developments received dedicated funds, but HUD-aided sites such as Lowell did not. In response, the Lowell Housing Authority was compelled to either reallocate limited HUD modernization funds or pursue alternative financing, creating tradeoffs that delayed or reduced other planned housing upgrades.

LHA Project 3 – Upper Merrimack Street Development

Lowell Housing Authority’s “Upper Merrimack Street Development.” The LHA and its non-profit corporation “RENU” (per IRC 501©) planned two housing developments for a total of 118 units of low-income housing units at its sites in the Merrimack, Salem, and Decatur Streets in Lowell’s “Acre” Environmental Justice neighborhood. Part of the developer’s planning included an analysis of whether geothermal systems could be used.

Separately, the LHA dedicated grant funds toward a networked geothermal feasibility study for this project and abutting sites, which also included the UML East Campus. The engineering firms retained by the LHA under the feasibility study grant and collecting data from the LHA’s independent development company led to the developer’s conclusion that the site was not conducive financially for a geothermal solution, and the developer, working on its own engineering studies, opted for air sourced heat pump systems for the new 118-unit development. The LHA Project 3 represents the Phase I portion of this study and is more exhaustively described in Section 4 of this report. Phase II of this study includes the conceptualization of a larger networked geothermal system including multiple stakeholders and building/facility types.

3.0 BASIS FOR FURTHER ANALYSIS

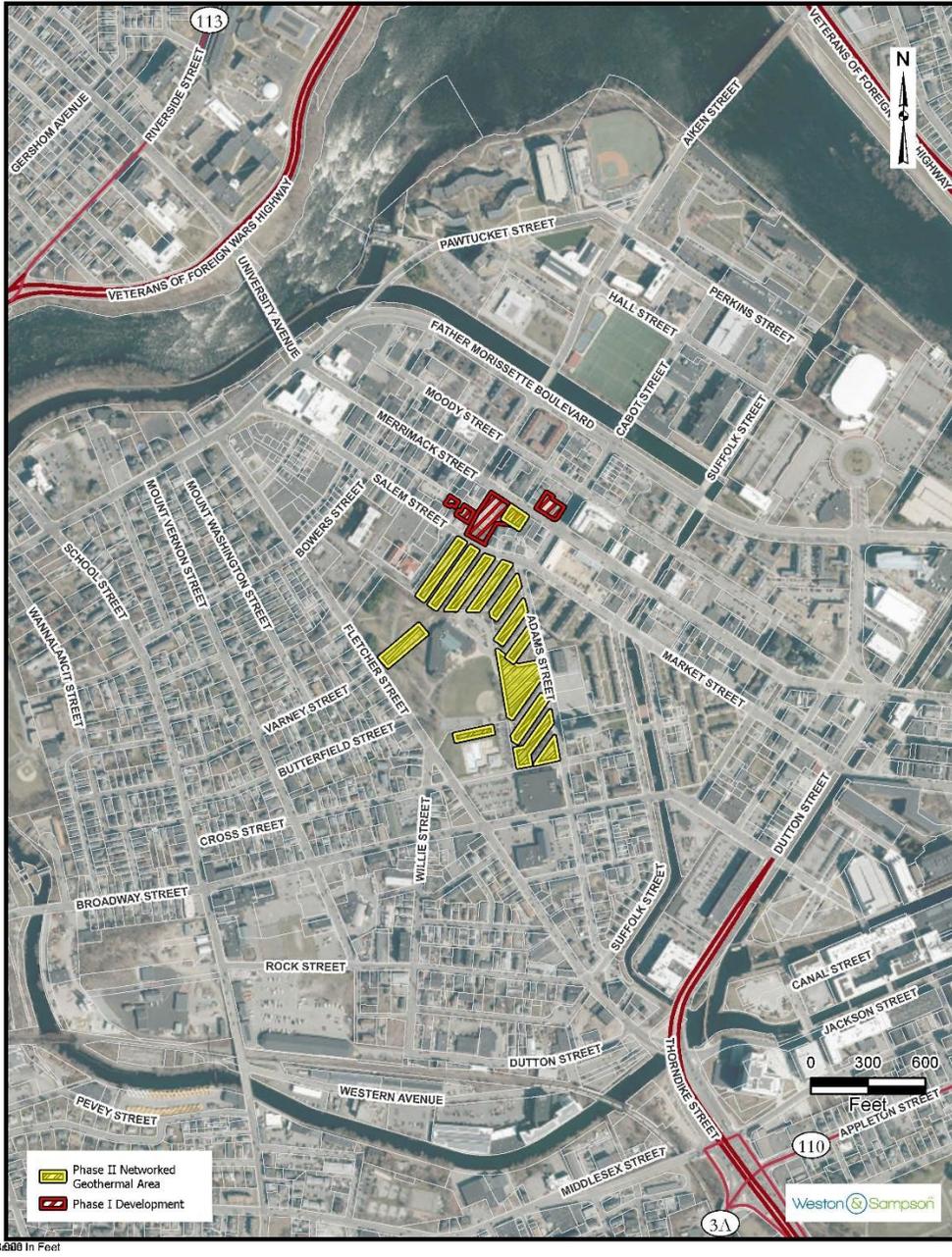
While the City of Lowell and the LHA each have distinct roles, their goals converge on improving housing quality, advancing decarbonization, and modernizing infrastructure.

Those goals do not pause with the conclusion of early pilots; rather, the lessons learned to date underscore the potential benefits of networked geothermal and create momentum to continue exploring adoption. At the same time, targeted electrification goals for housing authorities provide both a mandate and an opportunity for the LHA to leverage state policy in ways that align with resident needs and citywide climate objectives.

The technical details presented in this study matter for several reasons. First, they provide transparency into the conditions, costs, and performance expectations of potential geothermal systems—information that is critical for informed decision-making. Second, they serve as a learning tool for a wide range of stakeholders, from residents to policymakers, to better understand what geothermal networks can and cannot accomplish in Lowell’s context. By documenting site-specific findings in Phases I and II, the study informs the LHA’s planning and contributes to the broader effort of building shared knowledge and confidence in the pathway toward adoption.

Residents in Lowell face high energy burdens, limited access to central cooling, and disproportionate exposure to fossil fuel pollution, all while living in housing stock that has historically been underinvested. Locating the Phase I study portion in the Acre, ensured that evaluation of new infrastructure investments directly address these inequities and position Lowell’s residents as leaders in shaping the transition away from gas.

Figure 1 - Google map of the area (next page).



Geothermal Energy Networks (GENs) provide a pathway for an infrastructure transition by replacing aging gas infrastructure with safe, non-combustion heating and cooling. These systems circulate water through underground pipes, allowing multiple buildings to share thermal loads. This design reduces risk from gas leaks and combustion, lowers dependence on volatile fuel markets, and strengthens resilience during extreme weather. Importantly, the shared-network model can provide stable, predictable costs for households while delivering efficient, pollution-free comfort. Instead of

continuing to invest in expensive gas pipeline replacements, GENs offer long-term, first-class infrastructure that can bring modern cooling and safe heating to EJ households. The Acre's mix of housing, public facilities, and institutional anchors creates the diversity of loads needed to test and expand such a system.

The use of heat pumps has been shown to be an efficient, reliable solution in the transition towards electrification and a reduction in carbon emissions. This is true even when compared to air-source heat pumps. A Maryland Energy Administration (MEA) study found that 1 kw of electricity grid demand reduction can be achieved for each ton of ground source heat pump technology installed compared to electrification with air source heat pumps.

Continued efforts by the LHA to play a leadership role in the equitable transition for clean energy led to this feasibility study. The LHA applied to the Kickstart Massachusetts program in 2024. Through this award, LHA undertook a two-phase study: Phase I evaluated geothermal options for new development along Merrimack, Salem, and Decatur Streets, while Phase II explored the potential to expand to existing housing, schools, and public facilities. Together, these efforts lay the foundation for an equitable transition beyond gas in Lowell. The LHA is collaborating with Lowell municipal, university, utility partners and *HEET.org*.

4.0 SITE ANALYSIS (PHASE I & PHASE II)

4.1. | Introduction

The City of Lowell is nestled within the Merrimack Valley region in the state of Massachusetts, located at the confluence of the Merrimack and Concord Rivers.

Lowell is the fifth largest city within the small state and has a long history as a mill city, where it once specialized in textile factories. While the textile mills are no longer operational, they have been preserved to house local restaurants and shops, school institutions, and provide housing.



This historic city is the home to two institutions of higher education: The University of Massachusetts Lowell (UML) and Middlesex Community College (MCC). Lowell has long been a city of immigrants and has a diverse racial community. There is a small sport presence in the city, hosting collegiate and minor-league professional sports teams.

Large scale geothermal projects are impacted by a variety of factors in an urban setting. Feasible projects depend not only on adequate subsurface conditions but a variety of site infrastructure conditions including conflicting utilities (water, wastewater & stormwater), lot size or open area, site use constraints, and future modifications. Heat transfer in the subsurface is influenced by depth of saturation, geologic formations (and their ability to conduct heat), groundwater flow and other environmental factors. This study seeks to combine infrastructure constraints with an evaluation of subsurface conditions to determine the feasibility of providing heating and cooling loads for both a planned Phase I development and for a conceptual Phase II area using geothermal systems often referred to as thermal energy networks or community geothermal systems.

The Phase II area would use the LHA, North Commons as an anchor customer with ancillary facilities added to a utility scale geothermal network. While the utility model for the supply of heat energy needs continued refinement and definition, this study evaluates the potential building loads and the feasible construction of a network.

4.2. | Phase I

4.2.1. Site Background

The Phase I project location includes open areas on Salem Street and Merrimack Street in Lowell, MA. These areas are proposed to be the location of new housing as well as geothermal energy generation. This geothermal energy infrastructure will be placed underground by excavating a large area to install piping which will act as a heat exchanger providing a stable temperature to equipment above ground. The image below depicts the area of interest where the feasibility study for Phase I

was considered. Planned development of 118 units would be located in Study Area A & B while adjacent parcels C & D represent potential beneficial areas for additional geothermal capacity



Figure 2: Phase I Project area

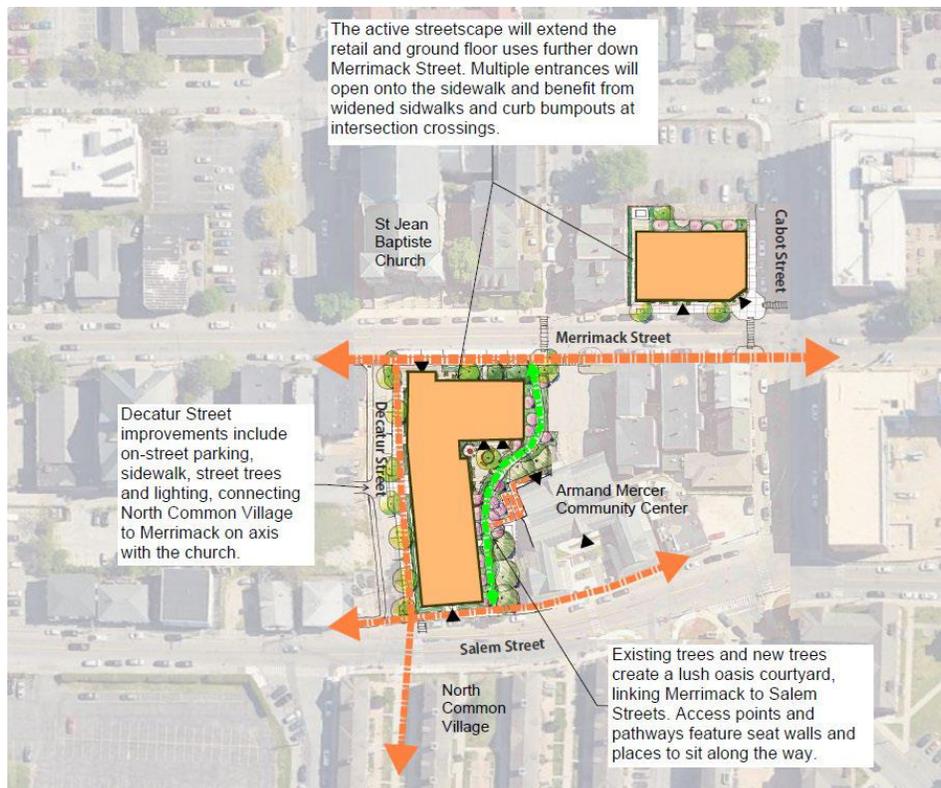


Figure 3: Phase I Proposed Site Plan

4.2.2. Site Conditions

Site conditions were screened at the four (4) site locations. These parcels represent the available land areas for the placement of geothermal wells or borefields for the planned development. In general, these parcels are underlain by crystalline bedrock (granite). The bedrock appears to be moderately fractured based on test boring logs (McPhail, 2009) revealing a fracture capable of producing 30 gpm. This degree of fracturing indicates the possibility for excellent subsurface heat transfer but can also create difficult or more costly drilling conditions. To the southeast, bedrock mapping indicates the presence of a metamorphic schist deposit. While the crystalline bedrock represents a formation capable of moderate to high thermal conductivity values, the schist would have lower heat conductivity characteristics.

Above the bedrock unconsolidated silts and sand deposits are generally observed throughout this area of Lowell. Urban fill is seen in many areas, and its presence is likely dependent on historical construction activities including demolition, redevelopment, or filling activities. These unconsolidated deposits are generally less than 15 to 20 feet. In general, they do not represent a barrier to the installation of deep, bedrock geothermal wells and associated costs. However, care will be needed to manage these soils and to install upper steel casings to protect geothermal well piping. Static ground water levels are relatively shallow (less than 20 feet) indicating excellent saturation and the potential for increased thermal conductance. Additionally, bedrock fractures should increase groundwater flow within subsurface bedrock deposits minimizing heat build-up in a multiple well borefield, **increasing the effectiveness of the thermal resource.**

Due to the presence of existing infrastructure and utilities, urban settings increase the difficulty and cost of circulation piping from remote borefields. In this study, smaller remote parcels to the west of borefield development in Areas D & C would likely require disruption of existing infrastructure to install circulation piping to well fields on these lots. Instead, subsurface heat coupling would be most cost effective if wellfields were considered only on the two largest lots (Decatur Street, Study Area B, and at the corner of Merrimac and Cabot Streets).

4.2.3. Geothermal Capacity

Site specific geothermal capacity can often be evaluated using borehole tests of thermal conductivity. In 2009 a thermal conductivity testing of a 400-foot test boring was conducted. The test consisted of a controlled measurement of heat decay in a grouted borehole containing a 1 ¼ inch u-loop circulation tube. This style test is standard and produced a resultant thermal conductivity value of approximately 1.35 Btu/ft °F. Based on this value, thermal transfer rates for a 500-foot closed loop circulation style well can be calculated. Given expected subsurface temperatures of 50-51°F, a standard 500-foot-deep closed loop well should produce approximately 3.5-5 tons of heat capacity and approximately 4.0 to 4.8 tons of cooling capacity. While this capacity is true for an

individual well, a field of wells, dependent on well spacing, can be impacted due to heat interference between wells. Borefield capacity is discussed below.

The moderate to high thermal conductivity value and the expected moderate to high degree of fracturing indicates that open loop or standing column systems will generate significant thermal capacity and was also considered for Phase I. Expected yield would be approximately 22-26 tons of heating/cooling capacity per 1500-foot standing column or open loop well system.

4.2.4. Load Requirements and Borefield Design

Total load requirements for the planned development in Phase I were estimated as 130 tons of cooling and 120 tons for heat. Due to the lower operating temperature differential, heating is the limiting HVAC mode therefore requiring enough borehole or wellfield capacity to provide sufficient heat in the winter. The 120-ton heat capacity could be satisfied by approximately 44-46 closed loop wells installed to 500 feet. With a suggested separation of 25 feet between boreholes the same number of wells can produce approximately 20% more cooling capacity easily satisfying the 130 tons of cooling required. Outside of the building footprint planned in Study Areas A & B, sufficient area exists to drill and install the necessary borefield. Conceptually, a smaller field of 20 wells can be located in Study Area A allowing up to 60-65 tons of heating capacity for that facility. Similarly, all 44-46 wells could be located at Study Area A along Decatur St. providing approximately 120 tons of heat capacity. Closer borehole spacings of 20 feet could allow for site constraints associated with planned building foundations, however, the well field performance with closer spacings should be modeled to avoid mutual interference between boreholes. Modeling this scenario of borefield performance should be accomplished by conducting an on-site test boring and thermal conductivity test.

Standing column wells would require significantly less space and associated subsurface piping if the site construction constraints impact the closed loop design. Standing column well spacing of 60 to 80 feet on center would easily allow 4-6 standing column wells at each site. This reduction in space requirement allows each site to have the capacity to meet total project loads of up to 120-130 tons. Appendix B provides conceptual diagrams of closed loop systems vs. a standing column well or open loop applications.

4.2.5. Cost Estimate

Although a variety of geothermal well systems have been developed, cost differentials are best developed by comparing closed loop versus open loop systems. Closed loop systems generally consist of sealed piping containing a glycol and water mixture. In the borehole, polyethylene tubing is grouted in place. The most common system is considered to be a U-loop with two 1 ¼" tubes, with a "U" connection at the bottom of the borehole. The fluid is circulated to a group of wells using a circulation pump often housed within the building. Circulation is routed directly to an air to water heat pump.

Standing column wells are a type of open-loop system. These well systems allow the circulation of water in direct contact with the natural borehole wall. Generally, a submersible pump is emplaced in each standing column well. Groundwater is pumped from the well to a plate and frame heat exchanger, and the return water is directed back to the well. A return line or shroud over the well pump, returns water to the bottom of the borehole forcing its contact with the surrounding geologic formation. This direct contact provides a more efficient heat coupling with the subsurface. Within the buildings mechanical systems, an additional internal loop is required to transfer heat from the plate and frame heat exchanger to the air to water heat pumps. These systems, although more efficient, can be subject to water quality and fouling concerns due to the direct water contact with natural formations. Annual inspection and maintenance of the well, submersible pumps and the plate and frame heat exchanger should be considered.

For Phase I, cost estimates for each type of geothermal system are provided in Appendix B. Capital costs for well installation represent a major difference in the two types of systems. Mechanical system costs or operational costs for the standing column option increase due to the addition of circulation pumps, controls and plate and frame heat exchangers. Anticipated annual operation and maintenance costs would increase by approximately \$30-50,000/yr for system service requirements for an 8-well standing column well system.

Final selection of the appropriate space conditioning system for any development can be an iterative process. Phase I development plans consisted of 2 mixed use residential buildings. Study Area Maps are provided in Appendix C.

Based on architectural plans, design stakeholders held a series of technical and financial meetings to discuss an expanded geothermal network for the project. Extensive efforts were undertaken to layout and position both a closed loop wellfield of 44-46 closed loop wells, and an open or standing column design of 6-10 wells. Reduced maintenance requirements of a "closed loop" system dictated its selection for more detailed analysis of costs and site constraints. Lead by Trinity Financial, LHA design engineers and representatives from ODIN held numerous meetings to compare geothermal costs against Air Source Heat Pump systems (ASHP) for the buildings. The final decision to specify ASHP systems for each building was influenced by several factors. Site constraints for utilities including water, sewer, and stormwater along with the large building footprint on each parcel limited the simplicity and symmetry of the borefield for a closed loop installation. Overall capital costs for the borefield were in excess of 4 million dollars. These costs would be offset by lower operating costs (electric consumption) and lower anticipated maintenance for water to air geothermal heat pumps. However, operational efficiencies were estimated to be only 6-16% better than an ASHP system which would create a payback period in excess of 20 years. With anticipated electric costs for LHA of \$0.134/kwh based on negotiated contracts and ongoing subsidies, the payback period increased well beyond 20 years. Both systems, GSHP or an ASHP system achieve the goal of reducing carbon emissions when compared against fossil fuel fired heating equipment.

4.3. | Phase II

The Phase II assessment focused on a more varied suite of building types or heating and cooling applications. These were selected in order to evaluate the impacts to networked geothermal system costs, constructability issues, and operational efficiencies. The building types included residential housing, a school, and a large public pool. The North Common Village represented an excellent example of an extensive residential complex with both heating and cooling needs. In addition, nearby opportunistic thermal resources or buildings loads were mapped as part of the study. It should be noted that inclusion in the study does not indicate a commitment by the facility owners to participate in a project. Adding this hypothetical residential building type to two other hypothetical uses is discussed below with Study Area Maps provided in Appendix C.

Theoretically, the Mercier School provided both additional potential land area for borefield development and an alternate heating and cooling profile. Concurrent connection of the LHA multiuse center also provides complementary heating and cooling demands. The last consideration was given to the inclusion of the DCR Raymond Lord Memorial swimming pool, which represents a unique facility where excess building heat might be transferred through a network system allowing efficient operational modifications that could extend the useful operating season of the pool. While detailed information regarding energy use could not be gathered for these three facilities, available utility consumption data provides reasonable understanding of the heating and cooling needs.

Other residential loads are proximate but were not included as part of the study due to data constraints and the need for a participatory community-led data collection process, for which foundational planning is now underway.

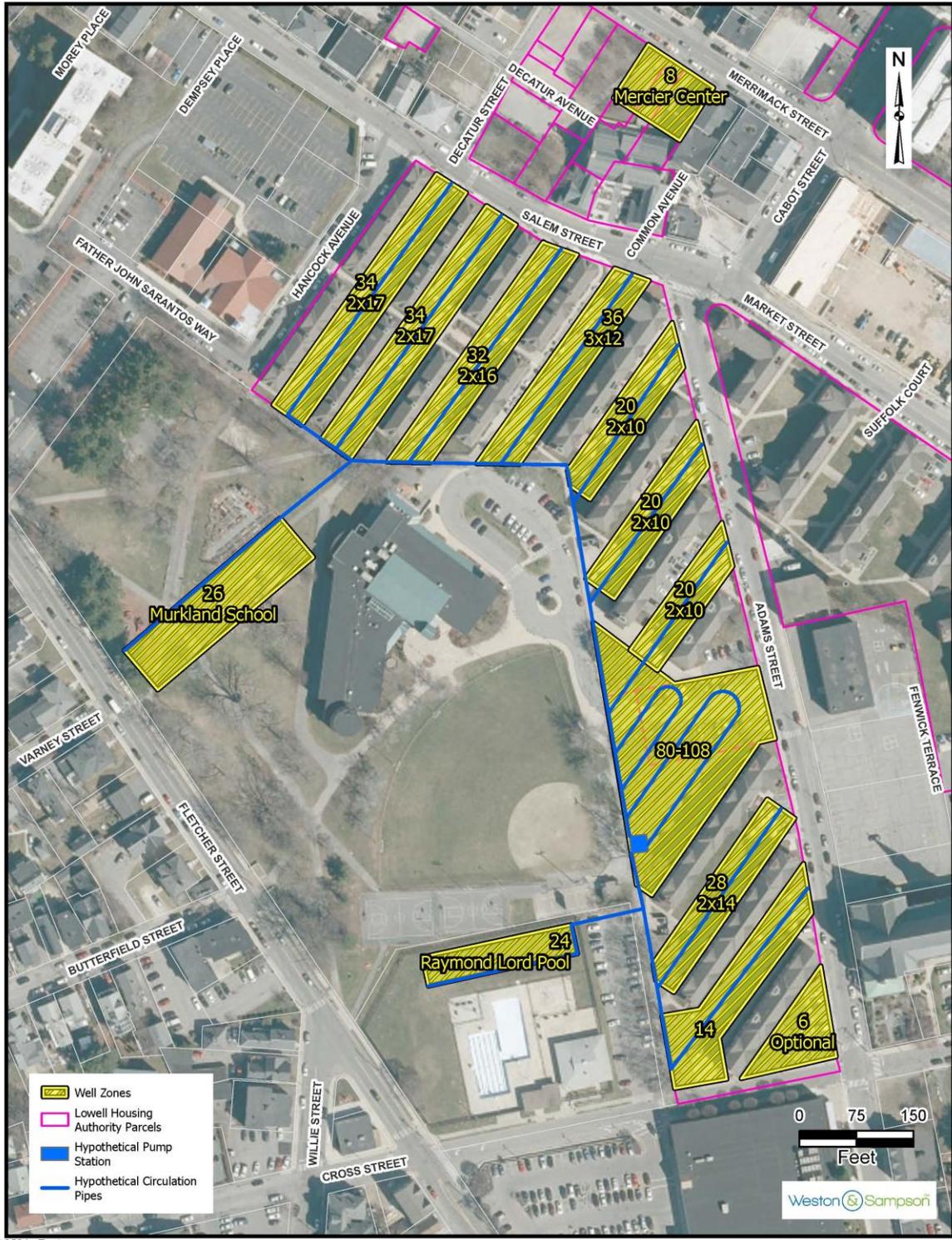


Figure 3: Phase II Project Area

4.3.1. Site Background

The North Common Village consists of 524 residential units, 2-3 bedrooms and 1,000-1,300 square feet of living space. The brick buildings represent one of the first affordable housing complexes in the Commonwealth of Massachusetts, originally constructed in 1939, the Village has been maintained, upgraded, and managed by the LHA. The units currently have numerous gas fired boilers satisfying heating demands. These replacement boilers, installed between 2007 and 2009 under a capital improvement plan, indicate a total design capacity of 2,265 tons with an estimated operational heating demand of 1,100-1,400 tons. The system retrofit/upgrades cost approximately 3.9 million dollars at that time – equivalent to approximately 6.03 million in 2025. With the assumption of 20-to-25-year operational life for heating systems, planning the North Common Village upgrades is prudent. The residential buildings were not constructed with cooling systems leaving heat management up to individual residential window air conditioners. The number and cost of these units could not be reliably estimated as part of this study. Replacement of these units represents potential electrical capacity available through reuse of more efficient geothermal systems. In sum, upgrades to provide both heating and cooling with one system represents an ideal opportunity to meet previously stated community and efficiency goals.

4.3.2. Site Conditions

The North Common Village consists of numerous linear buildings interlaced with greenways, sidewalks, roadways, and minor parking areas. Placement of linear borefields parallel to the buildings represents an ideal situation. The age of construction for the housing complex indicates careful location of conflicting utility and drainage corridors would be necessary prior to final borefield layout or construction. Subsurface conditions likely contain some amount of fill material but bedrock depths and depths to saturation are estimated to be less than 30-40 feet and would not create excessive costs for well construction. While open loop or standing column wells could be considered, the available linear layout and the general need for system simplicity and low maintenance as a management criteria warrants an analysis of closed loop systems.

4.3.3. Geothermal Capacity

Assuming a similar capacity for a networked geothermal system, maximum borefield heat transfers of up to 1,400 tons can be used for conceptual purposes. Based on a ratio of heating to cooling loads common for urban settings in New England, we would apply a maximum cooling load of 1,600 tons for the same buildings. Further evaluations, including the development of an energy model for these facilities, would be beneficial to refine these conceptual heating and cooling loads. A facility audit, review of insulation upgrades and building envelopes would be necessary for an accurate assessment and model.

Assuming a 20-year lifecycle for the existing boilers, imminent replacement suggests this is an optimal situation for planning and design of a replacement HVAC system.

4.4. | Conceptual Borefield and Geothermal Capacity

Previous work in Phase I identified the Lowell area to be underlain by crystalline and metamorphic bedrock deposits. A range in borehole thermal conductance is useful in bracketing borehole heat exchange capacity. Given assumed depths to saturated bedrock deposits with a moderate degree of fracturing, a conservative range of 1 ton of heat transfer can be used per 150 foot of closed-loop borehole length. With an anticipated maximum heat load of 1,400 tons, approximately 280-320 closed loop wells would be required totaling 200,000 linear feet of borings. Borehole spacing and layout (position) will influence the performance of an entire borefield. Borefield performance should be modeled once a final layout / well configuration is developed. Capital costs for just the well installation would likely range between \$10 to \$13 million at an average installation cost of \$38,000 dollars per well. In addition to the borefield, connecting piping, circulation pumps, and controls would be necessary. Internal building modifications would also be necessary including removal of the boilers and the addition of heat pumps and ductwork. Fortunately, the building structures generally have unoccupied crawl spaces within the attics or basements of most buildings. This ductwork could be used to transfer warm or cold air from individual heat pumps. The heat pumps could be connected to internal building circulation loops. Distribution or circulation pumps provide flow to the subsurface well system on the ground loop side of the networked geothermal well fields. Detailed studies and design work would be the next steps in developing a successful retrofit project and accurate costs for internal building systems including mechanical equipment and ductwork.

The LHA Multi Service Center located on Salem Street near Decatur could also be added to an overall community geothermal system. This building is estimated to require approximately 40-60 tons of heating / cooling load, Networked geothermal wells could be placed in parking lot to the rear of the building.

A third building/facility added to the Phase II concept was the Mercier School Facility at approximately 150,000 square feet heating loads are estimated at 70-80 tons. Cooling for the school is currently handled by a chiller system. This rooftop system is rated for approximately 100 tons and was apparently replaced in 2018. While the age of the system indicates replacement may not be necessary, the complimentary heating and cooling loads of a school facility could benefit the circulation network. This is particularly true if the last facility, the Raymond Lord Memorial Pool, is added. Extended seasonal use of the pool could be realized by rejecting building heat in early and late summer to heat exchangers at the pool. This means of heat transfer is ideal since an energy source to generate heat for the pool would not be needed. Instead, rejected heat from the school or other buildings could be transferred through the networked circulation piping minimizing costs and energy consumption. Heating requirements for the pool are assumed to be 150 tons but could vary based on seasonal temperatures and range of operation. However, no additional wells would be required.

4.5. | Phase II Summary

The conceptual designs of the second phase for the project have significantly different criteria and characteristics. The presence of an anchor project, retrofit of the existing LHA housing (boiler replacements and the addition of efficient large scale cooling systems), provides a significant benefit to the EJ community. Use of rejected heat from the building systems to extend seasonal pool use is also a considerable community amenity. In addition, daytime use for commercial or community buildings may offer a different load or timing of the heating and cooling loads.

Adoption will take significant education and community buy-in. The MVCEC represents a possible implementation and education partner who could apply resources and funding to both garner political support but obtain funding to offset design and potentially capital costs. Advocacy and education of the benefits of a community scale project will be imperative for future success. While the Phase II conceptual project has merit, further work and education on key concepts is necessary.

The following benefits identified by HEET hold true for the Phase II concepts:



Efficiency: *Geothermal networks are the most efficient form of building heating and cooling.* One case study demonstrated a near-600% annual efficiency, with a winter efficiency of 890%.



Affordability and accessibility: A planned, utility-scale gas-to-geo transition means that the utilities shoulder up-front costs, making geothermal networks affordable and accessible for everyone.



Safety: Thermal energy is non-combusting, meaning no harmful byproducts of combustion or risk of explosions.



No fuel: This means no price volatility, no reliance on leak-prone fossil fuel pipelines, and no harm to the environment from oil and gas drilling as system adoption grows.



Lower cost of electricity and electric grid impact: Because they are ultra-efficient, geothermal networks have the potential to shave over \$1 trillion off projected electric grid build-out—and cut the cost of electricity for consumers.



Good-paying jobs: Geothermal networks projects provide jobs for drillers, pipe layers, laborers, and HVAC technicians. When installed by gas utilities, geothermal networks allow gas utilities to continue providing good jobs with minimal retraining to their existing workforce, which can work on both gas system integrity and geothermal networks.



Energy security: Although in recent years the U.S. has become a net exporter of natural gas, we continue to depend on foreign energy. Geothermal networks break this dependence through entirely local generation. In addition, because geothermal networks are highly segmented and locally controlled, they are less susceptible to deliberate system breaches.



Non-intermittent energy: Geothermal energy is always available and does not require external storage through batteries or other systems. In fact, the circulating water is its own form of thermal storage; even if electric power goes out, the system can continue delivering heat or cooling for several hours.



Minimal above-ground footprint: The geothermal subsurface systems can be installed within existing open areas, parking lots or by using the existing right of way. Boreholes can be drilled with a minimal footprint in parking lots or similar areas.

5.0 CONCLUSIONS

Both Phase I and Phase II have provided valuable lessons regarding the adoption of geothermal systems, for smaller projects like Phase I, a central bore-field location is generally necessary. Pre-

planning requires borefield considerations to be part of the site development in order to identify utility and construction constraints. Adequate time is necessary during these planning efforts to determine both long-term benefits and the economic arguments based on real values for the return on investment.

Phase II concepts reveal a viable area within an urbanized setting that can provide sufficient space and a beneficial combination of heating/cooling loads from a variety of uses (e.g., pools, community center, schools, and housing). Adoption issues are discussed below while technical analysis, engineering design and modeling of building systems would be required to provide foundational costs for any retrofit system. These analyses would be necessary prior to the development of an economic model for utility adoption.

6.0 RECOMMENDATIONS AND FUTURE WORK

6.1. | Considerations and Challenges

6.1.1. Clarity on Participation Thresholds

To ensure that the minimum participation threshold for technical and economic viability can be achieved at any project site, it is essential to invest significant effort in engaging the broader community and/or municipality. Listening to community perspectives and building trust early helps identify where participation barriers are low or where targeted support can address them. It also creates opportunities to align resources with the unique challenges of each community.

Equally important is being transparent about where the project stands, what stage it is in, and what it can realistically accomplish. At the same time, fostering strong interest, even if it exceeds early capacity, is far better than struggling to secure participation. A demand-driven approach opens the door to additional opportunities for growth and replication.

Early engagement across a broad set of stakeholders is a worthy investment as it helps clarify the goals of a project, whether the focus is on:



Demonstrating the technology to **maximize learnings** for public benefit



Serving the **thermal needs** of customers as economically as possible, or



Pursuing full **gas decommissioning** of street segments or community blocks

In the example goals given, each pathway carries different participation implications. For instance, full decommissioning requires near-universal adoption and possible additional appliance upgrades (such as converting domestic hot water), which must be factored into investment costs, retrofit complexity and resident readiness.

In all cases, clear communication and expectation management are best practices that build trust and credibility over the long term. Establishing these distinctions through dialogue ensures that participation thresholds are realistic and that project strategies align with community priorities. This approach not only adds value and maximizes potential benefits but also ensures transparency in decision-making.

6.1.2. Unlocking Large-scale Thermal Potential

At the policy level, Massachusetts is beginning to confront issues facing geothermal system adoption through emerging “thermal commons” legislation that seeks to define ambient heat and cold as public resources. If enacted, such a framework could simplify access to shared sources like large borefields or surface water such as Lowell’s canals while embedding safeguards for ecological health and public accountability. Until then, projects like Lowell’s must navigate fragmented regulatory pathways, balancing innovation against caution. The lesson is that large, shared thermal sources offer some of the greatest opportunities for cost savings and resilience, but only if project teams are prepared to tackle the economic regulatory, governance, and policy challenges head-on.

The Commonwealth has taken important steps to encourage electrification in public housing, yet without explicit affordability protections these mandates risk raising costs for residents who are already energy burdened. For Lowell, this challenge is particularly acute: units are smaller than the “break-even” threshold for cost-effective electrification, residents pay their own utility bills, and full conversion may extend beyond heating to include domestic hot water, cooking, and laundry—compounding seasonal bill impacts.

To safeguard equity, electrification mandates should be paired with comprehensive affordability protections. This includes requiring economic impact studies before conversion, piloting bill-stabilization or percentage-of-income tariffs, and ensuring subsidies apply not only to residents but

also to PHAs for common-area and master-metered costs. Appliance and panel upgrades should be bundled with envelope improvements to limit kWh demand, while clear consumer protections (such as bill caps) are essential to prevent financial strain. Demonstration projects in Lowell, like the project provided in Appendix E and F, could pioneer these protections, generating evidence for statewide application and ensuring that the clean thermal transition reduces, rather than deepens, energy burdens for low-income households.

6.1.3. Explore Utility Incentives and Regulatory Frameworks to Manage Costs

For geothermal networks to scale equitably, investor-owned utilities and regulators must treat thermal networks as core infrastructure rather than optional add-ons. Current utility business models still reward reinvestment in gas infrastructure, while electrification costs often fall directly on customers. By reframing geothermal as a **non-pipeline alternative (NPA)** and aligning it with grid modernization goals, Lowell can help chart a regulatory path that reduces costs and unlocks utility investment.

Key opportunities include:



Non-pipeline alternatives framework: Ensure geothermal is considered alongside or instead of gas main replacements, with cost savings counted toward utility performance metrics.



Tariff and rate design: Pilot low-income geothermal rates that extend beyond heating to cover summer cooling and year-round electrification, while offering stability for master-metered PHAs.



Incentives and on-bill mechanisms: Expand state and utility programs to cover borefield capital costs, appliance conversions, and panel upgrades through on-bill repayment or direct subsidies.



Planning integration: Require utilities to evaluate geothermal in both gas decommissioning and electric grid planning processes, with transparent data-sharing to community partners. This should include quantification of long-term grid impacts—such as reduced peak demand, deferred infrastructure upgrades, and avoided gas pipeline costs—and mechanisms to ensure those

benefits are redirected appropriately, whether as direct savings to developers, cost relief for housing authorities, or affordability protections for residents.

By aligning utility incentives with community benefits, regulatory frameworks can transform geothermal from a niche demonstration into a cost-effective replacement strategy. For Lowell, advancing these reforms would not only reduce project costs but also ensure that housing authorities, residents, and the city itself share in the long-term value of thermal networks.

Utilities are indispensable partners in both individual geothermal projects and the broader gas-to-geo transition. Their role extends well beyond service delivery. Because they manage both gas and electric infrastructure, utilities are uniquely positioned to evaluate where geothermal can serve as a **non-pipeline alternative**, avoiding costly gas main replacements while aligning with electric grid modernization. They are also able to provide shared thermal service across municipal boundaries, a capability that is critical for scaling networks beyond a single district.

Utilities bring technical and financial clarity to difficult questions of feasibility. They can define the participation thresholds required to fully decommission gas pipe on a given street segment, quantify long-term system benefits such as avoided infrastructure costs, deferred grid upgrades, and reduced peak demand, and help ensure that those savings are redirected appropriately to residents, developers, or housing authorities. Their authority over rate design is equally important: utilities could potentially implement specialized geothermal or electrification tariffs, such as seasonal heat pump rates, low-income protections, or bill-stabilization mechanisms that shield residents from cost spikes.

Finally, utilities connect this work to both workforce and regulatory systems. Their existing underground workforce can be retrained to support loop installation and maintenance, preserving good-paying jobs, while their role in regulatory proceedings ensures that pilot projects like Lowell's feed directly into state policy frameworks. For all these reasons, utility collaboration is not simply helpful but foundational: without their capacity, mechanisms, and authority, geothermal cannot scale equitably or sustainably.

If networked geothermal can work in Lowell, with its dense housing, Environmental Justice neighborhoods, and complex regulatory environment, it can work in many other places. Navigating these challenges will generate lessons that are critical for the broader "gas-to-geo" transition, including how to redirect fossil fuel investments, safeguard the electric grid, and build projects that are both equitable and resilient. Lowell already has much in place: strong institutional partnerships, political will, and clear community need.

Engagement remains the cornerstone of progress and would be particularly helpful in furthering efforts for LHA or other agencies that have "anchor" projects. HEET is partnering with the University of Massachusetts Lowell's (UML) RIST Institute for Sustainability and Energy to integrate geothermal

networks into a broader suite of climate resilience strategies being shared with the local community. On August 30, 2025, HEET, UML, and the City of Lowell co-hosted a workshop with the Cambodian Mutual Assistance Association to share this work in a fully Khmer-language program, with written resources provided in both Khmer and English. The workshop showcased how social diffusion, the process of spreading new ideas through a community, can boost awareness and adoption of sustainability efforts in language-isolated communities, an area of research UML is actively leading. Engagement and resourcing funding such as Mass CEC's Empower funding are key elements that allow education and co-design to continue at the pace required for networked geothermal adoption.



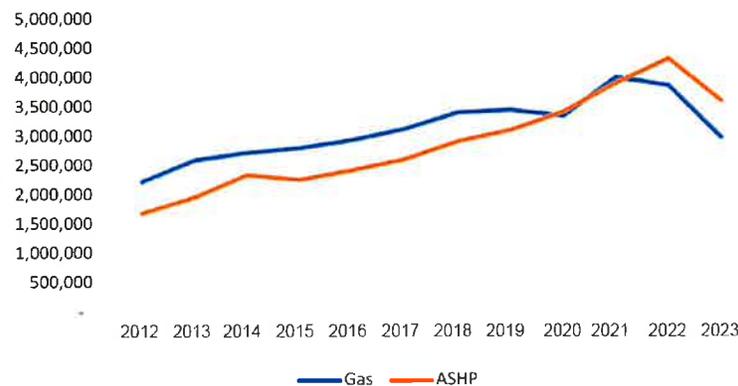
APPENDIX A: HEET – GAS-TO- GEO TRANSITION: THE BIG PICTURE

Gas-to-Geo Transition: The Big Picture

Electrification is happening

Driven largely by pressures to address climate change, the way we heat and cool our buildings is moving away from fossil fuels and towards electrification. In recent years, for example, sales of electric heat pumps have outpaced those of gas furnaces¹

Heat pump sales in U.S. compared to gas furnaces, 2012-2023



Source: Air-Conditioning, Heating, and Refrigeration Institute

We need a utility-scale solution

Although the conversion of individual homes to air-source heat pumps is an important part of the clean energy transition, it cannot happen fast enough to get us to net zero. In addition, many households cannot afford the upfront cost of upgrading their heating system. States are increasingly recognizing that we need an equitable, utility-scale solution to building decarbonization. One promising approach gaining national traction is geothermal networks, also known as thermal energy networks (TENs).²

In such systems, ground source heat pumps are networked together to serve a collection of connected buildings on the scale of a street segment or neighborhood. Individual networks can interconnect with others over time, growing to serve an entire community, municipality, or region.

¹ [International Energy Association](#)

² *A note about terminology:* As interest in these systems grows exponentially, consensus on terminology has yet to emerge. The following terms (not an exhaustive list) are generally accepted as synonyms or close relations: networked geothermal, thermal energy networks (TENs), community heat pumps, geoexchange, district energy systems, and ambient temperature loops.

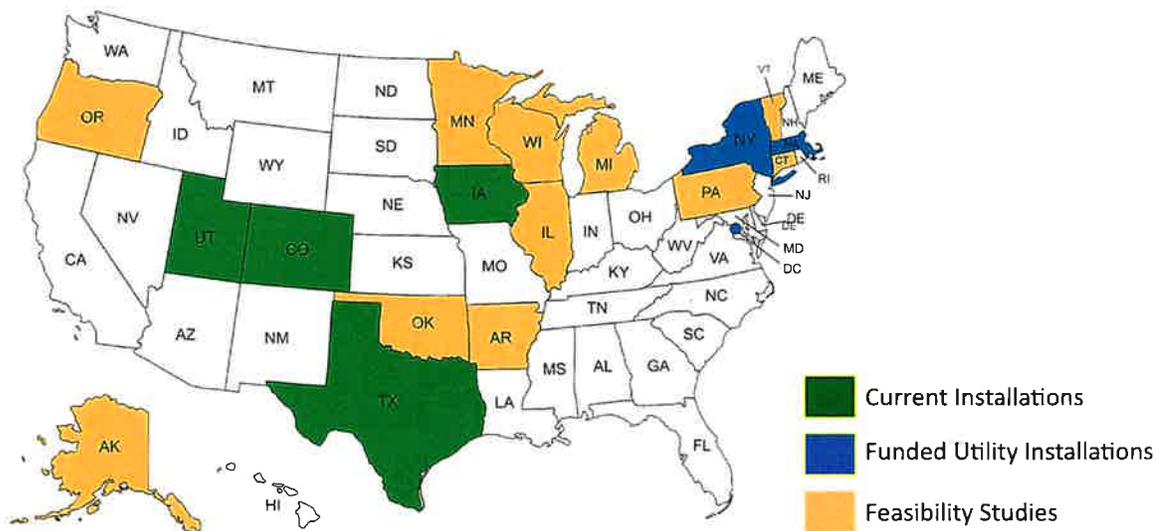
Examples include [Whisper Valley](#), a planned community in Austin, Texas; the [Springwater development](#) in Markham, Ontario; and the [Mt. Holyoke College campus](#)—to name just a few. Colorado Mesa University’s highly successful and innovative system, which began in 2008, one of the largest and longest-running geothermal networks in the country.

In 2017, HEET proposed that gas utilities could install and maintain these systems, delivering thermal energy rather than natural gas. Systems would be installed neighborhood by neighborhood, strategically replacing gas infrastructure.

Interest in such systems is growing rapidly. As of January 2024, fourteen states have passed, filed, or are considering legislation to advance—in some cases require—the transition from natural gas to geothermal networks.³ Installations and feasibility studies are progressing in twelve states, including three in Massachusetts and 14 in New York. A number of gas utilities, currently 23 and growing, have formed a coalition and are meeting regularly to explore the approach.

As this map shows, the approach is being considered and adopted not just on the coasts but across the country, showing that it has the power to transcend political differences.

Geothermal Network Sites/Feasibility Studies Nationwide



³ New York’s Utility Thermal Network and Jobs Act (UTENJA) was passed nearly unanimously in just three months, driven by an unlikely coalition of utilities, environmentalists, and labor unions. Colorado has recently passed a similar law.

To stay in business, utilities need a new plan

Utilities are uniquely suited to build geothermal networks for a number of reasons. To start with, they can leverage their capital financing power—which amortizes large up-front costs over decades and across the entire customer base, making the system affordable for end users. Utilities also have the needed right-of-way in the street, an existing customer base, and a skilled workforce. Finally, the regulatory framework is already in place to determine pricing and other parameters, including the potential to mandate an equitable transition that supports low- to moderate-income communities.

At scale, this approach provides gas utilities with a much needed, viable new business model and allows them to continue providing an essential public service as the use of natural gas declines.

A proven technology comes of age

Heating and cooling buildings with geothermal energy is not new; the ground source heat pump was first patented in 1912, and modern versions have been in use for decades. The technology is proven, safe, highly efficient, and cuts carbon emissions by an estimated 70% with the current electric grid in Massachusetts. As electricity generation moves to renewables nationwide, emissions will fall to zero. Utility-scale geothermal networks will also deliver economic benefits through growth in domestic manufacturing, supply chain development, and job creation.

System Benefits

Efficiency: *Geothermal networks are the most efficient form of building heating and cooling.*

Because customers on the system use heating and cooling at different times (load canceling), waste heat is reused. This means the overall energy use is lower than the sum of individual building needs.

Affordability and equity: An unmanaged transition to building electrification risks leaving renters, low- to moderate-income populations, and environmental justice communities out in the cold, unable to afford the high cost of new equipment and building retrofits and left paying higher and higher gas prices as fewer customers are forced to pay for the entire gas system. A planned, utility-scale gas-to-geo transition alleviates this risk by having the utilities shoulder up-front costs and prioritize the inclusion of otherwise marginalized populations.

Safety: Thermal energy is non-combusting. This means no explosions, and no harmful byproducts of combustion emitted into homes.

No fuel: This means no reliance on leak-prone fossil fuel pipelines, as well as the avoidance of spikes in fossil fuel prices driven by geopolitical and market forces. In addition, the environmental degradation from fracking and drilling for gas and oil is reduced as system adoption grows.

Reduced cost and electric grid impact: As greater diversity of energy use results in increased system efficiency, less backup heating and cooling and fewer linear feet of boreholes are needed, thus decreasing the cost of installed infrastructure. Load canceling also significantly reduces the electric grid peaks that would result from conventional building electrification.

Essential public service and jobs: Utilities are uniquely suited to build geothermal networks because they can leverage their capital financing model, which amortizes up-front costs over decades and across the entire customer base. The approach allows gas utilities to continue delivering an essential public service as the use of natural gas declines, as well as continue providing good jobs to their existing workforce with minimal retraining.

Energy security: Although in recent years the U.S. has become a net exporter of natural gas, we continue to depend on foreign energy. Geothermal networks break this dependence through entirely local generation. In addition, because geothermal networks are highly segmented and locally controlled, they are less susceptible to deliberate system breaches.

Non-intermittent energy: Geothermal energy is always available and does not require external storage through batteries or other systems. In fact, the circulating water is its own form of thermal storage; even if electric power goes out, the system can continue delivering heat or cooling for several hours.

Minimal above-ground footprint: The horizontal loop is installed in the street, using the existing right of way. Boreholes can be drilled with a minimal footprint in parking lots or similar areas.



APPENDIX B: PHASE I BUDGETARY COST ESTIMATES

Table 1 – Closed Loop System

Lowell Housing Authority
Geothermal Budget Cost Estimate

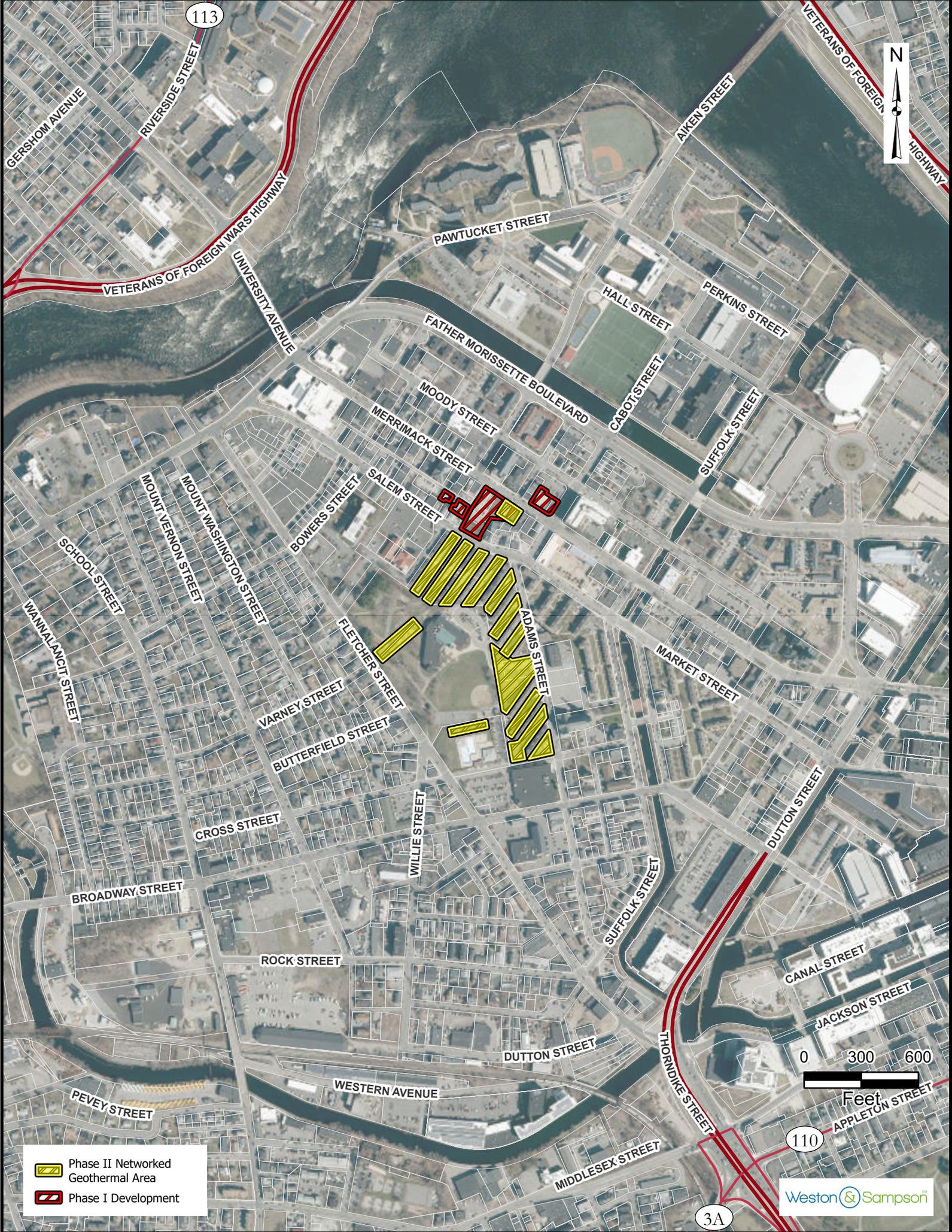
Construction/Capital Cost Closed Loop System	Unit	Unit Cost	Extension	
Mobilitation	1	\$ 80,000.00	\$ 80,000.00	
Drilling and loop installation (500')	44	\$ 49,000.00	\$ 2,156,000.00	
Water Handling Environmental Controls	1	\$ 260,000.00	\$ 260,000.00	
Sound attenuation	1	\$ 100,000.00	\$ 100,000.00	
Labor surcharge for wage rate			\$ 90,000.00	
Trench Connections and Headers			\$ 230,000.00	
Piping (Circulation)			\$ 300,000.00	
Circulation Pumps and VFD's			\$ 210,000.00	
Controls			\$ 140,000.00	
Heat Pumps			\$ 290,000.00	
Misc			\$ 150,000.00	
Subtotal			\$ 4,006,000.00	
Contingency @10%			\$ 400,600.00	
Total Construction/Capital Cost			\$ 4,406,600.00	
Engineering (Design, Permitting, Construction Oversight)				
2 additional test borings			\$ 68,000.00	
Testing & modeling bore hole field			\$ 48,000.00	
Piping layout circulation design			\$ 64,000.00	
Mechanical systems and specifications			\$ 98,000.00	
Permitting; Construction oversight			\$ 120,000.00	
Startup			\$ 26,000.00	
O&M documentation training			\$ 18,000.00	
Total Engineering			\$ 442,000.00	
Total Project Cost			\$ 4,848,600.00	

Table 2 – Standing Column System

Construction/Capital Cost Standing Column System	Unit	Unit Cost	Extension
Mobilization	1	\$ 60,000.00	\$ 60,000.00
Drilling and loop installation (800')	7	\$ 105,000.00	\$ 735,000.00
Water Handling Environmental Controls	1	\$ 190,000.00	\$ 190,000.00
Sound attenuation		\$ 80,000.00	\$ -
Labor surcharge for wage rate			\$ 70,000.00
Trench Connections and Headers			\$ 230,000.00
Piping (Circulation)			\$ 300,000.00
Circulation Pumps and VFD's			\$ 340,000.00
Controls			\$ 160,000.00
Heat Pumps and plate exchangers			\$ 410,000.00
Misc			\$ 17,000.00
Subtotal			\$ 2,512,000.00
Contingency @10%			\$ 251,200.00
Total Construction/Capital Cost			\$ 2,763,200.00
Engineering (Design, Permitting, Construction Oversight)			
1 additional test boring to 1500'			\$ 110,000.00
Testing & modeling bore hole field			\$ 24,000.00
Piping layout circulation design			\$ 35,000.00
Mechanical systems and specifications			\$ 112,000.00
Permitting; Construction oversight			\$ 120,000.00
Startup			\$ 26,000.00
O&M documentation training			\$ 18,000.00
Subtotal Engineering			\$ 445,000.00
Total Project Cost			\$ 3,208,200.00



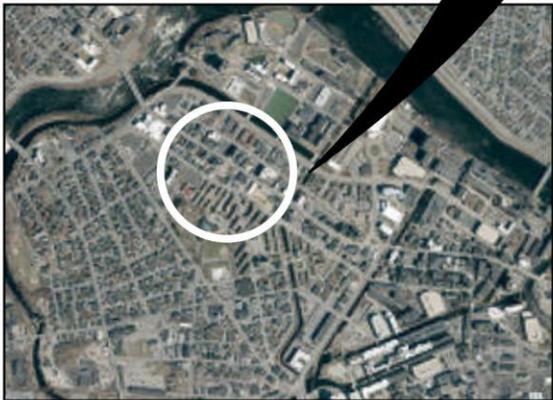
APPENDIX C: Study Area Maps



-  Phase II Networked Geothermal Area
-  Phase I Development

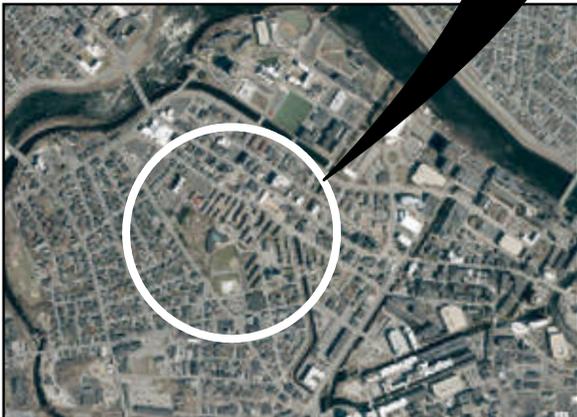
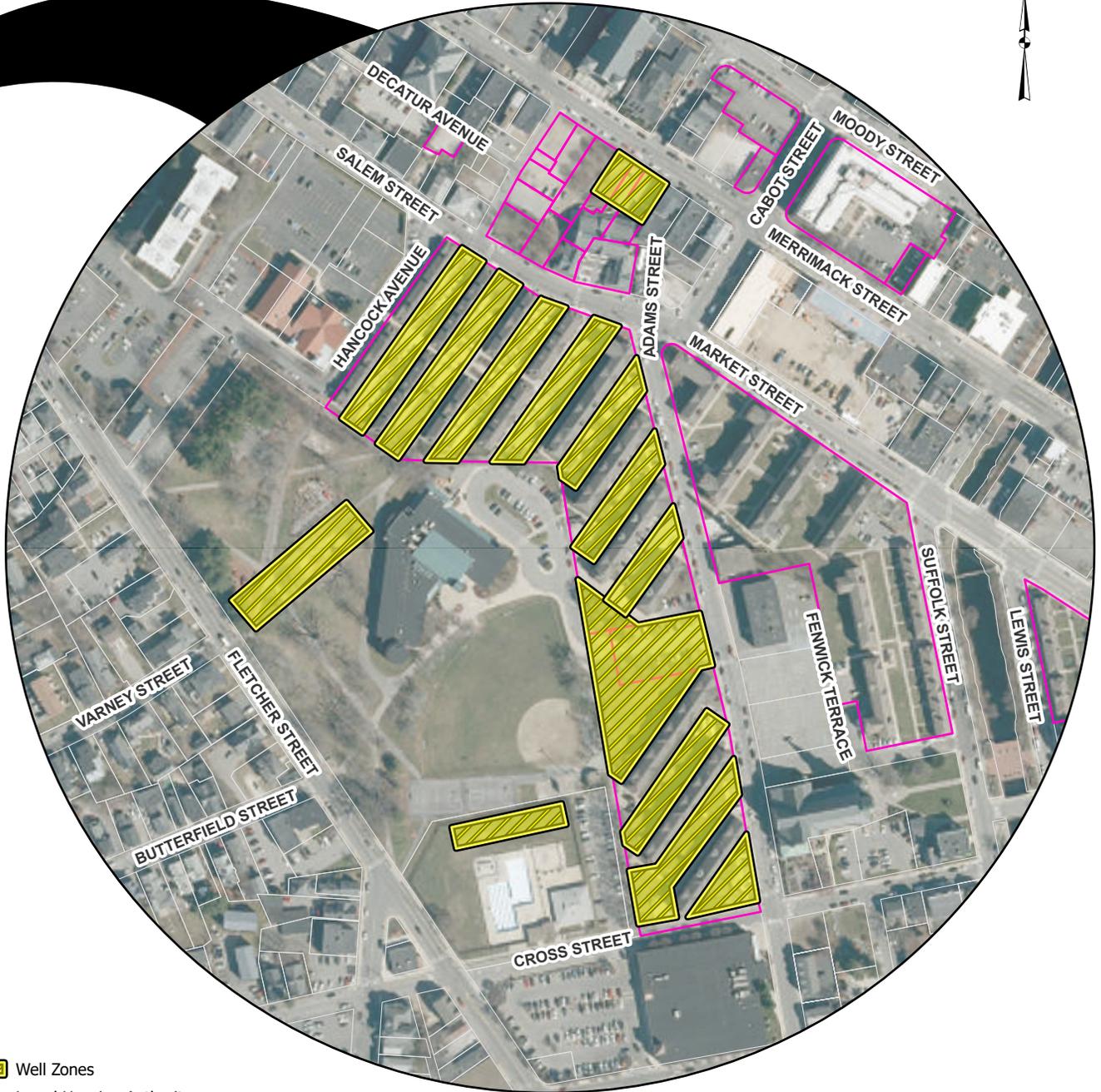
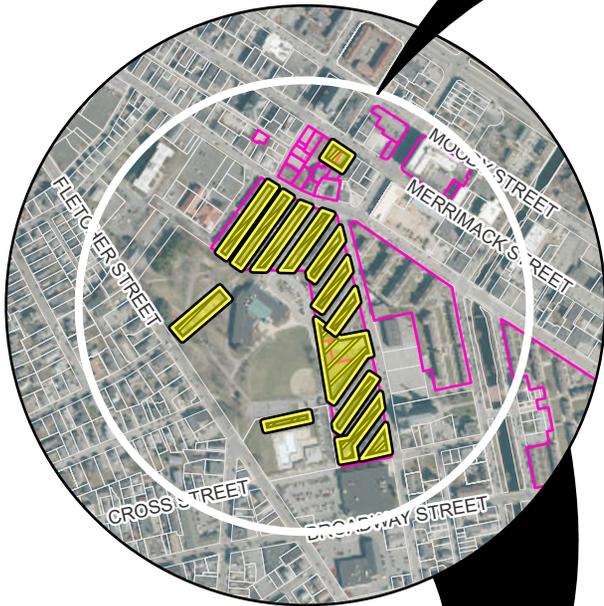
Map labels include: GERSHOM AVENUE, RIVERSIDE STREET, VETERANS OF FOREIGN WARS HIGHWAY, UNIVERSITY AVENUE, PAWTUCKET STREET, AKEN STREET, VETERANS OF FOREIGN WARS HIGHWAY, FATHER MORISSETTE BOULEVARD, HALL STREET, PERKINS STREET, MOODY STREET, CABOT STREET, SUFFOLK STREET, MERRIMACK STREET, SALEM STREET, BOWERS STREET, MOUNT WASHINGTON STREET, MOUNT VERNON STREET, SCHOOL STREET, WANNALANCIT STREET, FLETCHER STREET, ADAMS STREET, MARKET STREET, VARNEY STREET, BUTTERFIELD STREET, WILLIE STREET, CROSS STREET, DUTTON STREET, BROADWAY STREET, ROCK STREET, SUFFOLK STREET, THORNDIKE STREET, PEVEY STREET, WESTERN AVENUE, DUTTON STREET, CANAL STREET, JACKSON STREET, APPLETON STREET, MIDDLESEX STREET, and 110.

PHASE 1



-  Phase 1
-  Lowell Housing Authority Parcels

PHASE 2



-  Well Zones
-  Lowel Housing Authority Parcels



APPENDIX D: EJ SCREEN COMMUNITY REPORT

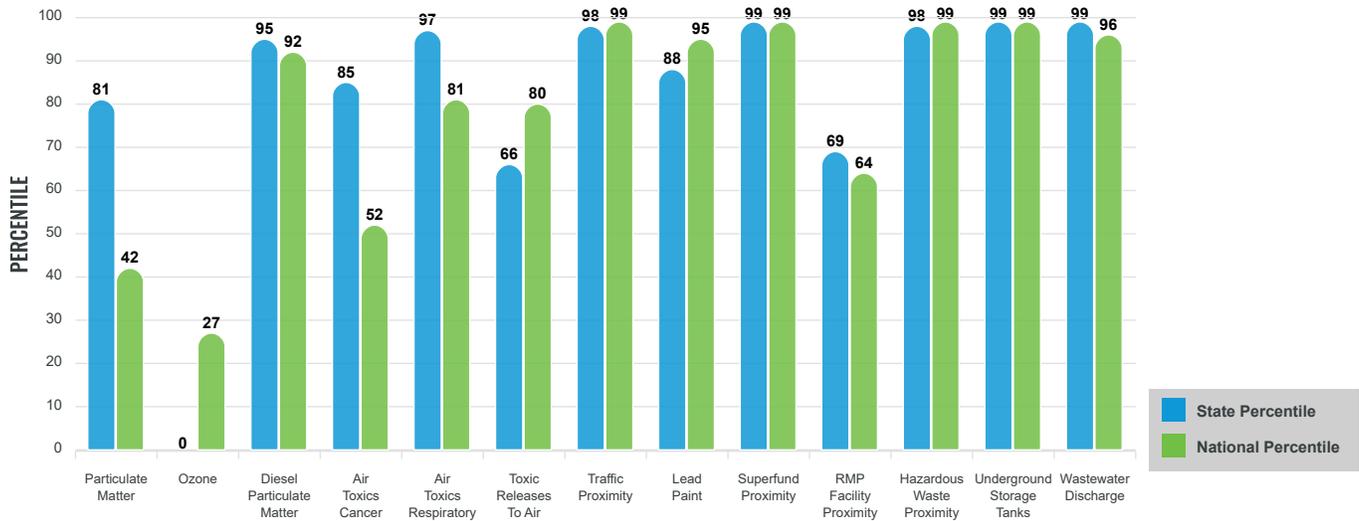
Environmental Justice & Supplemental Indexes

The environmental justice and supplemental indexes are a combination of environmental and socioeconomic information. There are thirteen EJ indexes and supplemental indexes in EJScreen reflecting the 13 environmental indicators. The indexes for a selected area are compared to those for all other locations in the state or nation. For more information and calculation details on the EJ and supplemental indexes, please visit the [EJScreen website](#).

EJ INDEXES

The EJ indexes help users screen for potential EJ concerns. To do this, the EJ index combines data on low income and people of color populations with a single environmental indicator.

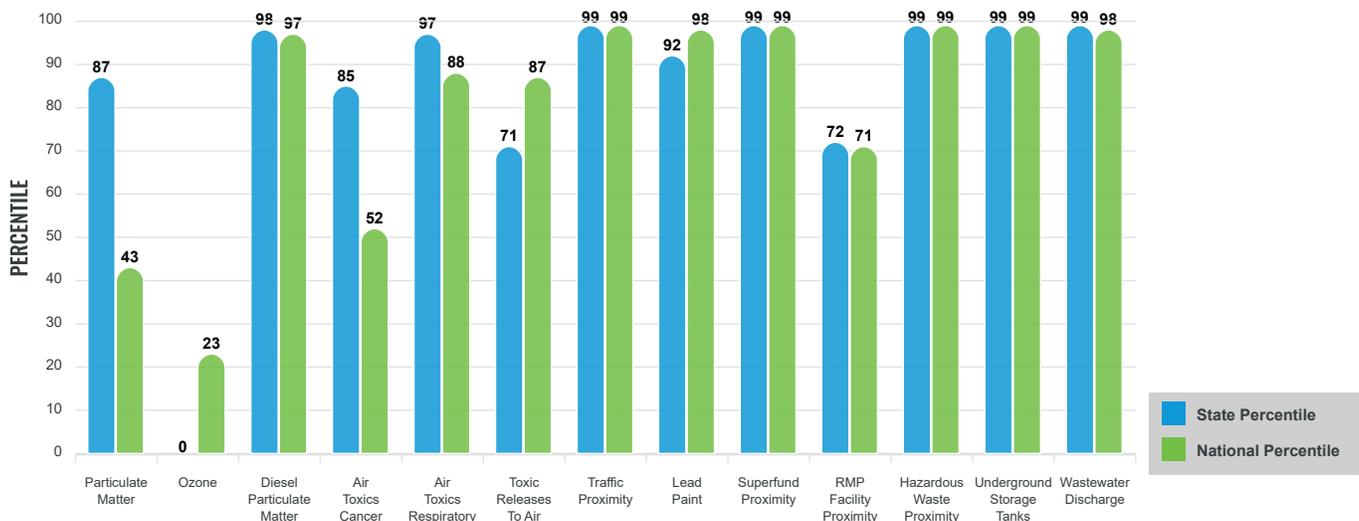
EJ INDEXES FOR THE SELECTED LOCATION



SUPPLEMENTAL INDEXES

The supplemental indexes offer a different perspective on community-level vulnerability. They combine data on percent low-income, percent linguistically isolated, percent less than high school education, percent unemployed, and low life expectancy with a single environmental indicator.

SUPPLEMENTAL INDEXES FOR THE SELECTED LOCATION



These percentiles provide perspective on how the selected block group or buffer area compares to the entire state or nation.

Report for Blockgroup: 250173883001

EJScreen Environmental and Socioeconomic Indicators Data

SELECTED VARIABLES	VALUE	STATE AVERAGE	PERCENTILE IN STATE	USA AVERAGE	PERCENTILE IN USA
POLLUTION AND SOURCES					
Particulate Matter (µg/m ³)	6.36	6.62	30	8.08	11
Ozone (ppb)	54	58.3	0	61.6	6
Diesel Particulate Matter (µg/m ³)	0.28	0.253	66	0.261	64
Air Toxics Cancer Risk* (lifetime risk per million)	20	21	3	25	5
Air Toxics Respiratory HI*	0.3	0.26	49	0.31	31
Toxic Releases to Air	240	2,800	17	4,600	35
Traffic Proximity (daily traffic count/distance to road)	1,000	630	82	210	96
Lead Paint (% Pre-1960 Housing)	0.46	0.51	42	0.3	71
Superfund Proximity (site count/km distance)	0.5	0.18	92	0.13	94
RMP Facility Proximity (facility count/km distance)	0.083	0.36	20	0.43	23
Hazardous Waste Proximity (facility count/km distance)	8.9	6.7	82	1.9	95
Underground Storage Tanks (count/km ²)	21	3.4	98	3.9	96
Wastewater Discharge (toxicity-weighted concentration/m distance)	0.016	0.2	84	22	71
SOCIOECONOMIC INDICATORS					
Demographic Index	84%	26%	99	35%	97
Supplemental Demographic Index	41%	12%	99	14%	98
People of Color	80%	30%	92	39%	83
Low Income	88%	22%	99	31%	98
Unemployment Rate	17%	5%	95	6%	93
Limited English Speaking Households	27%	6%	95	5%	95
Less Than High School Education	53%	9%	99	12%	99
Under Age 5	5%	5%	60	6%	54
Over Age 64	14%	17%	40	17%	41
Low Life Expectancy	21%	17%	84	20%	62

*Diesel particulate matter, air toxics cancer risk, and air toxics respiratory hazard index are from the EPA's Air Toxics Data Update, which is the Agency's ongoing, comprehensive evaluation of air toxics in the United States. This effort aims to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that the air toxics data presented here provide broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. Cancer risks and hazard indices from the Air Toxics Data Update are reported to one significant figure and any additional significant figures here are due to rounding. More information on the Air Toxics Data Update can be found at: <https://www.epa.gov/haps/air-toxics-data-update>.

Sites reporting to EPA within defined area:

Superfund	0
Hazardous Waste, Treatment, Storage, and Disposal Facilities	0
Water Dischargers	0
Air Pollution	0
Brownfields	0
Toxic Release Inventory	0

Other community features within defined area:

Schools	1
Hospitals	0
Places of Worship	5

Other environmental data:

Air Non-attainment	Yes
Impaired Waters	Yes

Selected location contains American Indian Reservation Lands*	No
Selected location contains a "Justice40 (CEJST)" disadvantaged community	Yes
Selected location contains an EPA IRA disadvantaged community	Yes

Report for Blockgroup: 250173883001

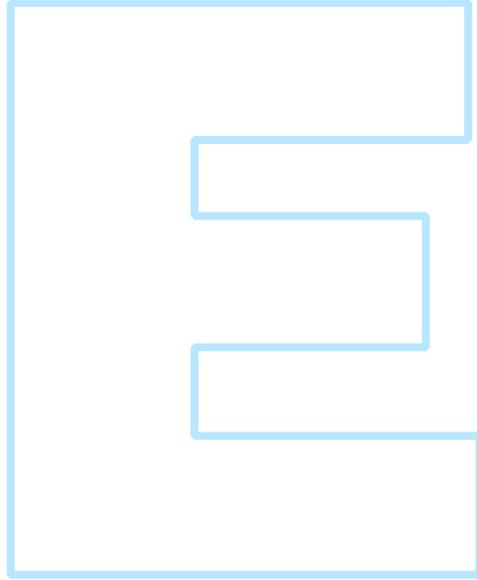
EJScreen Environmental and Socioeconomic Indicators Data

HEALTH INDICATORS					
INDICATOR	VALUE	STATE AVERAGE	STATE PERCENTILE	US AVERAGE	US PERCENTILE
Low Life Expectancy	21%	17%	84	20%	62
Heart Disease	5.5	5.4	55	6.1	39
Asthma	12.6	10.8	91	10	94
Cancer	3.6	6.6	4	6.1	7
Persons with Disabilities	16.9%	11.9%	85	13.4%	75

CLIMATE INDICATORS					
INDICATOR	VALUE	STATE AVERAGE	STATE PERCENTILE	US AVERAGE	US PERCENTILE
Flood Risk	0%	12%	0	12%	0
Wildfire Risk	0%	0%	0	14%	0

CRITICAL SERVICE GAPS					
INDICATOR	VALUE	STATE AVERAGE	STATE PERCENTILE	US AVERAGE	US PERCENTILE
Broadband Internet	43%	10%	98	14%	96
Lack of Health Insurance	3%	3%	61	9%	19
Housing Burden	Yes	N/A	N/A	N/A	N/A
Transportation Access	Yes	N/A	N/A	N/A	N/A
Food Desert	No	N/A	N/A	N/A	N/A

Report for Blockgroup: 250173883001



APPENDIX E: UML DRAFT REPORT PHASE I



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Effective Community Engagement Strategies for Siting Energy Facilities

A partnership between the University of Massachusetts at Lowell and Environmental Defense Fund

Report to The Barr Foundation

June 2023

Introduction

The University of Massachusetts Lowell (UML) is a national research university with over 18,000 students located in Lowell, Massachusetts. UML is home to the Rist Institute for Sustainability and Energy, the University's center for hands-on research on sustainability, climate change, and renewable energy. The City of Lowell has a population of approximately 114,000 and falls within the Massachusetts criteria of an environmental justice population.¹ Environmental Defense Fund (EDF) is a membership organization whose mission is to build a vital Earth. For everyone. EDF supports and advances justice and equity in its work around the world.

UML and EDF entered a partnership to develop sound community engagement practices regarding the siting and construction of a possible networked geothermal pilot project in the vicinity of UML (geothermal project). At the outset, we determined that the engagement practices would be informed by community input, insight from past successful community outreach efforts by UML, and by community engagement practices successfully utilized by clean energy advocates across the country and advocated by EDF in various regulatory utility proceedings.² Soon after the partnership was formed, plans for the geothermal project stalled and it was unclear if the project would be developed. EDF and UML decided to continue the partnership with a slightly different focus; namely, to obtain community input and direction regarding effective community engagement practices in siting energy facilities in general and to get a better understanding from the community regarding what is important to them relative to the clean energy transition. Throughout 2022, UML and EDF gathered community input on these issues.

On December 13, 2022, Boston Gas Company d/b/a National Grid (National Grid) informed the Massachusetts Department of Public Utilities that they selected a site in Lowell for the National Grid's geothermal project. This report develops community engagement principles that are appropriate for this juncture of the process. UML and EDF will continue working together during Phase II of the partnership, which will consist of implementing and expanding and/or modifying these engagement practices, as necessary. It is the goal of UML and EDF that these community engagement practices will be replicable and scalable for use by similar cities in Massachusetts and across the country as they grapple with the issues and opportunities associated with the clean energy transition.



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UML Chancellor Julie Chen Announces the Networked Geothermal Project on April 19, 2023. Left to right: Melissa Lavinson, National Grid; Paul Ratha Yem, Lowell City Councilor; Tom Golden, Lowell City Manager; Mike Judge, MA Undersecretary Energy & Environmental Affairs, MA State Senator Mike Barrett, Chairperson, Joint Committee on Telecommunications, Utilities and Energy; MA Representative Jeffrey Roy, Chairperson, Joint Committee on Telecommunications, Utilities and Energy; MA Representative Rodney M. Elliott.

Why the City of Lowell is an Optimum Location for the Geothermal Project

The City of Lowell is a diverse, multicultural “gateway city”³ with a population of 114,000 and a median household income and educational attainment level below the state average. All census tracts within the city are classified as environmental justice communities with sociodemographic traits that are strong predictors of low engagement and participation with incentivized energy programs, including low- to moderate income status, English language isolation, and ethnic or racial minority status.⁴

Twenty-two percent of Lowell’s population were born in other countries, with immigrants primarily from Cambodia (Lowell’s largest immigrant community), Portugal, Latin America, and other Southeast Asian countries. About 30% of Lowell’s population speaks languages other than English. While its poverty rate is almost twice the Massachusetts state average, it is typical of mid-sized American cities.⁵ It therefore shares many features with other mid-sized American cities that are critical to local, state, regional, national, and international climate commitments and goals.



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The UML/EDF partnership builds on the existing strong ties UML has with its civic partners in Lowell as well as with the environmental justice communities in which UML is geographically embedded. UML is a Minority Serving Institution, with 35% of undergraduates identifying as under-represented minorities and 13% identifying as Asian American.⁶ Many of UML's students are from or currently live in the environmental justice neighborhoods that will be served by the geothermal project. UML takes a community-based approach to sustainability that has made it the top-ranked higher education institution for sustainability in Massachusetts and among the top in the United States by AASHE-STARs, Princeton Review's 2021 Guide to Green Colleges, and Sierra Club's "Cool Schools" list. UML's student body is actively involved in research and implementation of sustainability projects on its campus and in the community and is already engaged in projects with community partners such as Mill City Grows and the Cambodian Mutual Assistance Association. UML's physical, cultural, and social ties to these communities create unique opportunities to deliver on environmental justice goals through a meaningful and robust partnership-focused approach.

UML will leverage the existing organizational infrastructure provided by the Lowell Green Community Partnership to facilitate cross-sector project work. The Lowell Green Community Partnership brings together more than two dozen leaders from business, community, and environmental organizations focused on supporting sustainability innovation in Lowell. These established relationships will enable UML to meet its responsibilities regarding the geothermal project on a fast-paced timeline, which is not typical in academia.

Background and Description of the Geothermal Project

Recognizing that the geothermal project would be critical in advancing UML's energy and carbon goals in a manner that directly benefits residents in Lowell, in late 2022, UML applied to serve as the site for a geothermal project in Massachusetts. The application outlined an innovative approach that brings together UML's climate, energy, and sustainability leadership along with community-engaged research expertise in a compact project area that can be readily developed in the heart of Lowell's environmental justice populations.

The geothermal project location is in the block bounded by Wilder Street, Broadway Street, Walker Street, and West Adams Street, as well as a small number of adjacent properties in the Acre neighborhood of Lowell. Project maps on the following page show the neighborhood location, current land uses, and environmental justice neighborhood characteristics as defined by the Massachusetts Executive Office of Energy and Environmental Affairs. The geothermal well locations that will support the entire geothermal networked system will be constructed on UML property.

Project Size

National Grid's initial survey of the proposed project area identified the following characteristics:

- More than 60 properties that typically contain one building, although at least five properties contain two or more buildings.
- More than 300,000 gross square feet of residential space.

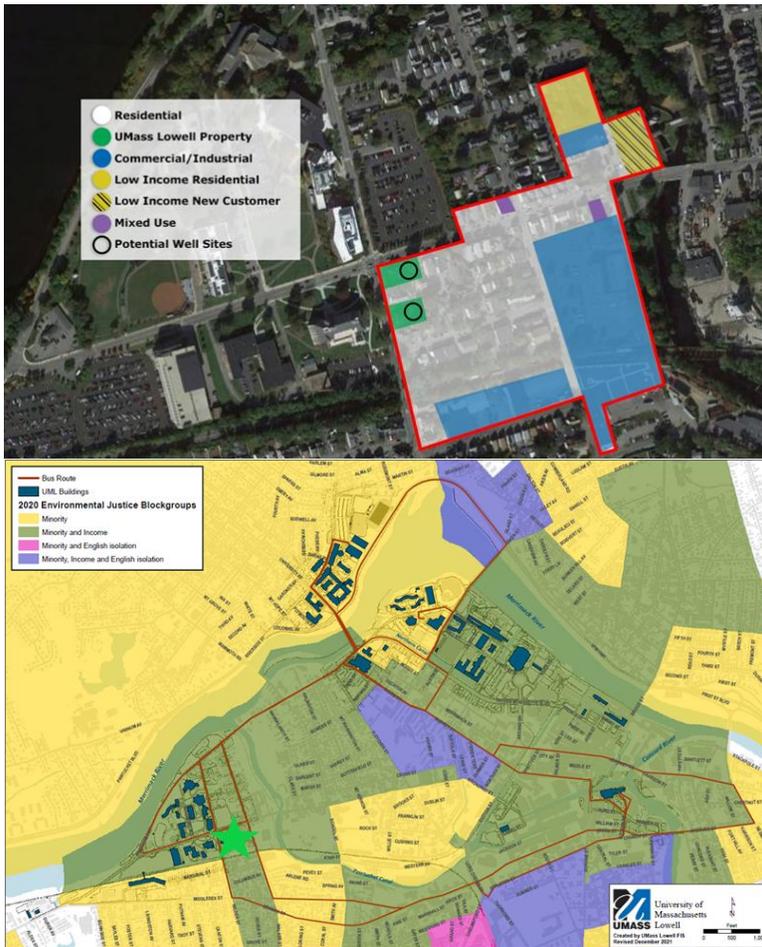


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- More than 140,000 gross square feet of light industrial space.
- Two institutional buildings that utilize converted residential properties for UML office uses.

Description of Building Types

The neighborhood block proposed includes residential buildings in single- and multi-family configurations that model most housing types and ages in the National Grid service territory. In addition, the proposed area contains multiple other land uses including small mixed-use (retail/residential), small industrial, large industrial, a warehouse, affordable housing operated by Lowell Housing Authority, and a proposed new building by a local community development corporation. We believe that the pilot program outreach to owners and the ensuing partnerships developed with small, medium, and large property owners will serve as a model for neighborhood engagement for future networked systems.





Why Community Engagement Strategies Must Be Revisited

The energy landscape in Massachusetts as well as across the country is rapidly changing. Nationwide, it is projected that by 2050, renewables will account for 42% of the electric generation market.⁷ Further, the U.S. has pledged to reduce its greenhouse gas (GHG) emissions by 20-25% from 2005 levels by 2030.⁸ Individual states are also taking proactive measures to reduce GHG emissions.⁹ To achieve these reduction goals, significant amounts of clean energy infrastructure will need to be sited and constructed. Historically, community advocates have experienced barriers in being effective in energy siting cases (traditionally, siting of fossil fuel-supported infrastructure) due to the financial costs of obtaining lawyers and expert witnesses, the significant time commitment involved, and the technical complexity. For example, the Massachusetts Energy Facilities Siting Board (Siting Board) examines various issues including route selection and environmental impacts relative to land use and historic resources, water and wetlands, noise, visual, air, hazardous waste, safety, traffic, and electromagnetic fields. In addition, the Siting Board determines whether the proposed project is consistent with the policies of Massachusetts. With respect to National Grid's geothermal project in Lowell, even though it does not fall under Siting Board jurisdiction, it is no less technically complicated. In making its decision to approve the project, the Department of Public Utilities evaluated the consistency of the proposed project with applicable laws, policies and precedent, the size and scope of the project in relation to the likely benefits, the adequacy of the evaluation plan, and bill impacts to customers.

With respect to fossil gas transition, pathways for using cleaner technologies are being explored, including: the use of renewable resources such as geothermal, expansion of wind and solar energy, and the possibility of replacing fossil gas with different fuel sources. Although some of these pathways may be beneficial from the perspective of reducing GHG emissions, there remains the issue of where infrastructure should be sited, what environmental and health impacts may result from the construction and operation of such facilities, and whether infrastructure disproportionately burdens or benefits certain populations. Clean energy must be pursued hand-in-hand with equitable and responsible siting. Otherwise, we will continue to perpetuate past systematic inequities.

Commented [CH1]: This paragraph is particularly important, maybe worthy of a call-out bubble or something?

Recent Policy and Legislative Changes in Massachusetts

In Massachusetts, there are clear signals that inclusivity and equity must be a part of the public engagement process as we transition to clean energy. For example the Massachusetts 2050 Decarbonization Roadmap, which lays out pathways for Massachusetts to achieve net-zero GHG emissions by 2050, states that "broad and sustained public engagement during policy and program development, particularly with environmental justice populations, communities of color, and low-income residents, will not only be necessary to avoid inequitable outcomes, it will be a key step in achieving a Net Zero future."¹⁰ Thereafter, An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy was passed stating that the regulations promulgated in order to achieve GHG limits and sub-limits shall achieve emission reductions "equitably and in a manner that protects low-and moderate-income persons and environmental justice populations."¹¹ Even the highest state court in Massachusetts has stated that the



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environmental justice policy of the Massachusetts Executive Office of Environmental Affairs is a policy of Massachusetts and therefore must be taken into consideration by the Siting Board.¹²

We must take these foundations and develop specific, concrete ways to ensure that these important equity goals are achieved. It is the intent that the principles discussed in this report will be applied as the geothermal project moves forward in Lowell and will result in an in-depth understanding by the community relative to what is a geothermal project, how it fits into the clean energy landscape, what benefits are expected, what community impacts may be experienced, and what, if any, impact there will be on utility bills. As stated above, this geothermal project has already received regulatory approval. However, UML and EDF will incorporate the successful engagement strategies that we use in this segment of the project into a larger framework that will discuss sound engagement practices that should be implemented from the beginning of a regulatory siting process. This larger framework will be the focus of our next report. It is our goal that what we learn from collaborating with an environmental justice population in developing meaningful community engagement practices will be valuable for the siting of energy facilities of all types, both within Massachusetts and elsewhere throughout the country.

Objectives of a Meaningful Community Engagement Framework

A primary objective of an equitable community engagement framework is inclusivity. This requires easily accessible, easily understood, and accurate information as well as holding meetings at various points throughout a siting process to answer community questions and receive feedback. Further, there must be transparency on how such community feedback is used in the decision-making process. **In the past, many of the meetings between project developers and communities consisted of one-way conversations. These types of engagements will no longer suffice, and a distinction must be made between talking “to” a community and talking “with” a community. Without authentic two-way dialogue, transparency, and a willingness to make decisions that align with community priorities, community engagement practices will not be meaningful.**

Steps Taken in Lowell

In trying to understand the challenges, opportunities, and barriers to community engagement, talking openly with the community in Lowell was imperative. We looked at the community holistically to include UML, a trusted community partner, those living in the community, and community leaders. EDF did not want to superimpose on the community what EDF viewed as important but rather wanted to hear what is important to the community and develop ways to be supportive.

We began our partnership with UML by learning about UML, its goals in the energy space, programs at the University that pertain to energy and sustainability, and the UML's connections to the community and to city leaders. This was accomplished by a series of meetings and visits to the campus. Seeing firsthand some of the sustainability programs at UML, and how those programs intersect and benefit the Lowell community, gave us an important perspective



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regarding the close connection between UML and the community. At our first community meeting there were representatives from a number of key community partners in Lowell that have equal investment in ensuring a just and equitable clean energy transition. Attendees included:

- **The Cambodian Mutual Assistance Association (CMAA):** a well-established hub for Lowell's Cambodian community with a mission to improve the quality of life for Cambodian Americans and other minorities and economically disadvantaged populations in Lowell.
- **Municipal government partners:** UML's close working relationships with Lowell City Manager Tom Golden and City Energy Manager Katherine Moses (both UML alumni), and Energy Advocate Victor Vargas, who is bilingual in Spanish and English, is essential to understanding and enhancing our engagement with the community.
- **The Lowell Plan, Inc.:** a private non-profit that ensures the City of Lowell is a successful thriving place for all to live, learn, work, play, and grow a business in a rapidly changing global economy.
- **E4L:** a local stakeholder group including members of the non-profit, educational, and governmental sectors looking to ensure an equitable energy transformation in Lowell. E4L builds on the city's history of environmental leadership and innovation to help serve the most vulnerable members of the Lowell community.
- **Mill City Grows:** an organization that fosters food justice by improving physical health, economic independence, and environmental sustainability in Lowell through increased access to land, locally grown food, and education.

Our main objective was to better understand what community leaders are doing in the energy space and what they are envisioning long-term. After that meeting, key takeaways included: that community leaders are trying to fill a clean energy educational void in Lowell; that city leaders recognize the complexity for anyone to navigate the available energy programs and opportunities; that decarbonization is an important issue to the community; and that there are likely many energy efficiency opportunities not being used by Lowell residents.

We also received community input at the 5th Annual Sustainability Summit hosted by the Lowell Sustainability Council.¹³ At the Summit, EDF provided an opportunity for people to write down their thoughts regarding the barriers and opportunities for Lowell residents in the clean energy transition. Based on the feedback, we grouped the barriers into five areas: money, engagement, workforce, infrastructure, and hearts and minds. Comments concerning the money category included: the prevailing wage is unsustainable; landlords do not have an incentive to install energy efficiency since they do not pay the energy bill; there is a lack of education regarding the long-term investment of sustainable infrastructure; and the mill buildings that were converted to condominiums have not been able to get energy savings. Under the heading of engagement, the comments included: language challenges for non-English speakers; finding community members, especially younger people, to get involved; and that Mass Save®¹⁴ is a "minefield" for non-English speakers and those who cannot call between 9:00 to 5:00.



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Comments stating that it is difficult to contact Mass Save® highlight the need for more investment and resources in this area to ensure that environmental justice populations have an equal opportunity to take advantage of energy efficiency programs. Improving residential building energy efficiency has the potential to significantly benefit low-income and under-served urban communities. For example, reducing the leakiness of “building envelopes” lowers energy costs while improving resilience to climate extremes and energy supply disruptions.¹⁵ Low-income and marginalized urban communities carry higher energy burdens and are more vulnerable to climate impacts than their wealthier counterparts^{16,17} and could therefore gain more from improved energy efficiency. These communities are also especially vulnerable to climate change: urban heat islands exacerbate heatwaves, impervious surfaces worsen flood risk, and urban infrastructure is often damaged by extreme climate events.¹⁸

Communities that may have the most to gain from energy efficiency face barriers to participation even in states with policies that incentivize residential energy efficiency projects. In Massachusetts, a top-ranked state in energy efficiency policy,¹⁹ free or highly discounted energy efficiency upgrades are available to all residents. The benefits of these programs outweigh their costs by a factor of more than 2.5.²⁰ The programs cover a wide range of upgrades, including home energy assessments, insulation and weatherization, heat pumps, rooftop solar, energy efficient appliances, and more. But participation rates in the programs lag far behind program goals and vary by more than twenty-fold between municipalities. The highest municipal participation rates (~36%) are in wealthy, suburban communities. In contrast, diverse, low-income communities in urban cores have substantially lower participation rates, with as few as 11% of eligible households benefiting from energy efficiency programs. Households that are underserved by energy efficiency programs tend to be renters who have low- to moderate-income, high-energy burdens, and limited English proficiency.^{21,22}

Under the category of infrastructure, concern was expressed that the bike lanes in Lowell are “terrible” and therefore commuters cannot use their bikes in lieu of driving. With respect to workforce, concern was expressed that electrician ratios prevent new workers from entering the trade. In terms of hearts and minds, comments included a resistance/fear of change, “a bit” of apathy, not knowing how an individual can make a change, and a low level of advertisement and dissemination of information about the clean energy transition.

In terms of opportunities for Lowell in the clean energy transition, feedback included: hiring a sustainable manager for the City of Lowell to focus on all sustainability issues, not just energy management; increasing recycling opportunities, including finding ways to recycle plastics that are currently being thrown away; providing recycling units at large apartment complexes; adding more jobs and community amenities such as pools and other community recreation; and breaking down ethnic barriers.

EDF’s engagement in Lowell on clean energy transition issues is supported by work that EDF is doing in other forums. For example, EDF is actively advocating for increased inclusivity in proceedings before state regulators. **Since these regulators make decisions that affect environmental justice populations, it is vital that communities know what is transpiring and, equally as important, how they can be part of the process to effectuate the energy**



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changes that are important for their community. Further, EDF is a part of a stakeholder working group (SWG) convened by the Massachusetts Attorney General's Office. The SWG is comprised of community-based organizations that have experience in environmental justice work, consumer and environmental advocates, and those who have experience with state regulatory processes. In its capacity as a SWG member, EDF presented at a roundtable held by the Department of Public Utilities and Siting Board to discuss how to increase access and participation in regulatory proceedings and subsequently submitted written comments. Key points discussed at the roundtable included more effective ways to notify communities of proceedings, how to make documents more available, increased transparency by decision-makers and developers, and better ways of incorporating community input into decisions. The SWG recently finalized a comprehensive report entitled "Overly Impacted & Rarely Heard" that makes over 30 short- and long-term recommendations regarding how the Siting Board and Department of Public Utilities can better embed equity into their regulatory processes.²³ EDF is also engaging with other advocates regarding potentially drafting a clean energy equity bill in Massachusetts.

Further, a research team from UML is currently engaged in a National Science Foundation funded CIVIC Planning Grant titled "Accelerating diffusion of energy efficiency programs in under-represented communities through social networks." This project can be complementary to our community outreach approach for this networked geothermal project. As the NSF CIVIC program develops along with additional outcomes from the research team, it will lead to new, science-based approaches to enhancing outreach to underserved communities for energy related projects.

Suggested Community Engagement Framework for Geothermal Project

As stated above, National Grid has selected a site in Lowell for their geothermal pilot. One reason cited by National Grid for this location is that the Lowell site will give National Grid an opportunity to connect low-income customers to the project.²⁴ Assuming that the geothermal project goes forward, UML and EDF will be well positioned to advocate for engagement strategies that will address the concerns that we have heard in our meetings. The below strategies will first be discussed at a meeting with the Lowell community and amended as necessary based on community input.

- I. To ensure that cultural values are respected, we will request that National Grid meet with leaders from the Cambodian as well as other communities in Lowell to understand any cultural protocols used to make decisions. Timing related to such protocols must then be incorporated into the timeframes associated with development of the geothermal project.
- II. To address the community input, we heard regarding the necessity for education about the clean energy transition and challenges for non-English speakers:
 - a. We will request that a state energy agency (possibly the Department of Energy Resources) provide information at a virtual or in-person meeting in Lowell regarding Massachusetts' decarbonization goals and how geothermal technology, a non-pipe alternative for leak prone pipelines on the fossil fuel system, may fit into those goals.



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Sources

¹ In Massachusetts, an [environmental justice population](#) is a neighborhood where one or more of the following criteria are true:

1. The annual median household income is 65 percent or less of the statewide annual median household income
2. Minorities make up 40 percent or more of the population
3. 25 percent or more of households identify as speaking English less than “very well”
4. Minorities make up 25 percent or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150 percent of the statewide annual median household income.

² See e.g. https://ssir.org/articles/entry/legislating_for_climate_justice_starts_with_listening; see also EDF comments in MA Department of Public Utilities and EFSB 21-01; OPP development comments.

³ Lowell is one of 26 gateway cities in Massachusetts and was founded in the 1820s as a planned manufacturing center for textiles. Lowell has the second largest Cambodian population in the country. About the Gateway Cities, <https://massinc.org/our-work/policy-center/gateway-cities/about-the-gateway-cities/#:~:text=The%20Legislature%20defines%2026%20Gateway,%2C%20Springfield%2C%20Taunton%2C%20Westfield%2>.

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⁶ <https://www.uml.edu/equity-inclusion/about/msi.aspx>.

⁷ EIA Projects Renewables Share of U.S. Electricity Generation Mix Will Double by 2050, <https://www.eia.gov/todayinenergy/detail.php?id=46676>.

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⁹ An Act Driving Clean Energy and Offshore Wind, <https://malegislature.gov/Bills/192/H5060>; An Act Concerning Climate Change Mitigation, Public Act 22-5 <https://www.cga.ct.gov/2022/ACT/PA/PDF/2022PA-00005-R00SB-00010-PA.PDF>.

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¹¹ An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy p. 10
<https://malegislature.gov/Laws/SessionLaws/Acts/2021/Chapter8>.

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¹³ <https://lowelllandtrust.org/5th-annual-sustainability-summit/> Oct. 15, 2022.

¹⁴ Mass Save® is a collaboration of electric and gas utilities and energy efficiency providers designed to assist businesses and residences to make energy efficiency upgrades.
<https://www.masssave.com/en/about-us>.

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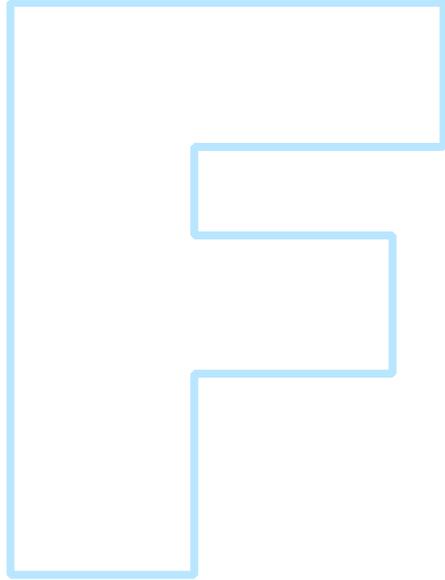
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²³ <https://www.mass.gov/overly-impacted-and-rarely-heard-incorporating-community-voices-into-massachusetts-energy-regulatory-processes>.

²⁴ Department of Public Utilities Docket 22-62 letter from Bess Gorman, Assistant General Counsel, National Grid.



APPENDIX F: UML EDF REPORT APRIL 2025

Models for Enhanced Engagement and Community Partnerships to Support Future Networked Geothermal Projects in Massachusetts



**Rist Institute for Sustainability and Energy & The Environmental
Defense Fund**

June 2025

Report Outline

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Abbreviations

ARPA	American Rescue Plan Act
CARES	Coronavirus Aid, Relief, and Economic Security Act
CBA	Community Benefits Agreement / Coalition for a Better Acre
CECP	Clean Energy and Climate Plan
CMAA	Cambodian Mutual Assistance Association
CWA	Community Workforce Agreement
DOE	[United States] Department of Energy
DOER	[Massachusetts] Department of Energy Resources
DPU	[Massachusetts] Department of Public Utilities
EDF	Environmental Defense Fund
EEAC	Energy Efficiency Advisory Council
EFSB	Energy Facilities Siting Board
EIA	Energy Information Administration
EJ	Environmental Justice
EM&V	Evaluation, Monitoring, and Verification
ESA	Energy Service Agreement
ESRI	Environmental Systems Research Institute
GHG	Greenhouse Gas
GLICA	Greater Lowell Indian Cultural Association
GRRP	Green and Resilient Retrofit Program
HEET	Home Energy Efficiency Team
HVAC	Heating, Ventilation, and Air Conditioning
HUD	[United States Department of] Housing and Urban Development
IJJA	Infrastructure Investment and Jobs Act
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
LEED	Leadership in Energy and Environmental Design
LEGUP	Learning from the Ground Up
LIHEAP	Low-Income Home Energy Assistance Program
LLAMA	Lifting Lowellians: Assistance and Mutual Aid
Mass CEC	Massachusetts Clean Energy Center
MVP	Municipal Vulnerability Preparedness [Program]
PA	Program Administrator
PACE	Property-Assessed Clean Energy
PLA	Project Labor Agreement
RECS	Residential Energy Consumption Survey
UML	University of Massachusetts Lowell

Executive Summary

This report is the third phase of an outreach and engagement strategy resulting from a collaborative effort by the Rist Institute for Sustainability and Energy at the University of Massachusetts at Lowell (“UML”) and the Environmental Defense Fund (“EDF”). This effort was initially undertaken to provide support for the community engagement strategies undertaken regarding a proposed networked geothermal pilot project in Lowell Massachusetts (“Pilot Project”). Since the Pilot Project is no longer being developed, this report aims to highlight the significant opportunities to learn from the initial approach taken with the Pilot Project. At the same time, it provides a series of recommendations related to enhanced community engagement and partnerships that can be deployed for future networked geothermal energy projects in the Commonwealth of Massachusetts, and beyond.

The initial Pilot Project was a partnership between Boston Gas Company d/b/a/ National Grid (“National Grid” or “Company”), the City of Lowell (“City” or “Lowell”) and UML.

The first phase of the outreach and engagement strategy focused on engagement to increase community awareness and participation in energy transitions projects (include link to report here). In the second phase UML provided an engagement toolkit, namely the **Lowell Geothermal District Heating and Cooling Pilot Project Plan (link to Plan) for inclusive outreach and achieving environmental justice** as a resource to expand participation of the local community (include link to report here). Specific phase two recommendations focused on:

1. Increasing public education and awareness;
2. Creating community ownership and maximizing involvement;
3. Maximizing energy efficiency and GHG reduction;
4. Creating a pipeline for well-paid, secure jobs;
5. Ensuring-e tenant security;
6. Fostering citizen science and increasing data transparency;
7. Increasing corporate giving; and
8. Increasing tree coverage.

The Pilot Project aimed to utilize networked geothermal technology, which involves underground pipes and electric heat pumps to exchange heat with the earth. In winter, the system would extract heat stored underground to warm buildings, and in summer, it would dissipate heat back into the ground to cool indoor spaces. This approach is considered one of the most energy-efficient methods for heating and cooling.¹

¹ cite

The Pilot Project was part of a broader five-year demonstration program approved by the Massachusetts Department of Public Utilities (“MADPU”) in 2021, aiming to reduce greenhouse gas emissions and provide clean energy solutions to communities, including those in Gateway cities like Lowell.² In April 2023, construction crews began drilling test boreholes on the UML campus to study the sub-surface conditions, a crucial step for designing the geothermal system.

In December 2024, National Grid informed **select project** stakeholders that they would not be proceeding with construction of the Lowell geothermal project primarily due to the fact that the . cost per customer was too high.³ Various factors contributed to these higher than anticipated costs including inflation, rising supply costs, an underdeveloped market for geothermal construction, and increased cost driven by the infrastructure conditions of the existing building stock in Lowell.

As stated above, this report provides suggestions for effective community engagement processes based on lessons learned. We note that since every community has distinct characteristics that make it unique, recognition of such characteristics must be taken into account when developing effective community engagement strategies.

² [About the Gateway Cities - MassINC](#)

³ [National Grid pulls plug on a geothermal pilot program in Lowell - Commonwealth Beacon](#)

1. Context and introduction

On February 18, 2021, National Grid filed with the MADPU a geothermal implementation plan that would allow the Company to construct up to four networked geothermal pilot projects within its service territory at a total cost of \$15.6M. Thereafter, on December 15, 2021, the (MADPU) approved the filing and required that the Company's geothermal shared-loop systems serve 20-40 customers residential and/or commercial customers. Additionally, National Grid was to prioritize installation of each project to evaluate one of the four following criteria:

- (1) customers with a more diverse load profile than the Company's geothermal project in N.Y.⁴;
- (2) located in an environmental justice⁵ and/or low-income community;
- (3) installing loops to manage existing gas system constraints and peaks;
- or (4) as an alternative to leak prone pipe (LPP) replacement.

Site Selection

National Grid provides both gas and electricity to the City of Lowell as well as electricity to the UMass Lowell campus.⁶ In late 2022, the Energy Team⁷ from the City of Lowell worked in partnership with the Rist Institute for Sustainability and Energy and the Facilities Management team at UMass Lowell and submitted an application to use a portion of the UMass Lowell campus for the Pilot Project. Given that UMass Lowell campus is located within the heart of the City of Lowell's environmental justice neighborhoods, the partnership between them was designed not only to advance equity but also to advance sustainability and energy goals in Lowell. This approach brought together UML's sustainability leadership and community-engagement expertise to advance the development of the Pilot Project. UML was identified as the primary customer of the energy generated from the Pilot Project with a view towards leveraging the University's capital and academic assets which have been intrinsic to its successful track record of energy innovation and practical applications of new technologies.⁸

The application submitted to the MADPU by the University and the City of Lowell not only addressed the four criteria listed in section 1 above, but also provided :

- i) Customer diversity (residential and commercial/industrial ("C&I") mix);

⁴ The KEDLI project in New York included a geothermal shared loop serving ten single-family homes that were using delivered oil or kerosene fuels for primary heating. See DPU 21-24 at ftnt 5.

⁵ EJ statute in MA

⁶ UMass Lowell operates its own steam plants (maybe another sentence about that here)

⁷ The Energy Team consisted of

⁸ Cite a few examples of these technologies

- ii) A location including more than one EJ criteria such as low-income and minority;
- iii) A location involving a network that is not part of a single facility;
- iv) Availability of space for geothermal equipment such as the bore field and pumphouse;
- v) Ease of permitting;
- vi) Community stakeholder acceptance and support;
- vii) Geologic conditions,
- viii) Construction challenges that are intrinsic to Gateway Cities across the Commonwealth and offer significant learning opportunity for the future of networked geothermal projects in Massachusetts;
- ix) Area system constraints; and
- x) Flexible options for routing and installation of the bore field/vertical loop.

On December 15, 2022, National Grid notified the DPU that they had chosen The Lowell Networked Geothermal Project to be the site of their first demonstration project.⁹

Location of Project

The selected project location is critical in understanding the development of the Pilot Project. As proposed by the City of Lowell, and UML, the neighborhood block bounded by Wilder Street, Broadway Street, Walker Street, and West Adams Street and a small number of adjacent properties in the Acre neighborhood of Lowell would comprise the project area. (we need to attach a map of the site location) It's important to note that several UML properties on Wilder Street and Broadway Street were identified as available with no long-term redevelopment plans or potential. The well locations needed for the Pilot Project were proposed for UML-owned property at locations to be determined in consultation with National Grid. The neighborhood block selected includes residential building types in single- and multi-family configurations that model most housing types and ages in the National Grid service territory. In addition, the selected area contains multiple other land uses including small mixed-use (retail/residential), small industrial, large industrial, warehouse, and affordable housing operated by Lowell Housing Authority and a proposed new building by a local Community Development Corporation. The City and UML viewed this location as a diverse, and fundamentally important, example of the type of partnerships necessary to accelerate the Commonwealth's energy transition. The potential to collaborate and coordinate with small, medium, and large property owners and multiple stakeholders is critical for neighborhood engagement for future networked systems.

Figure 1: Proposed Lowell Network Geothermal Area from Application

⁹ cite



Source: University of Massachusetts Lowell

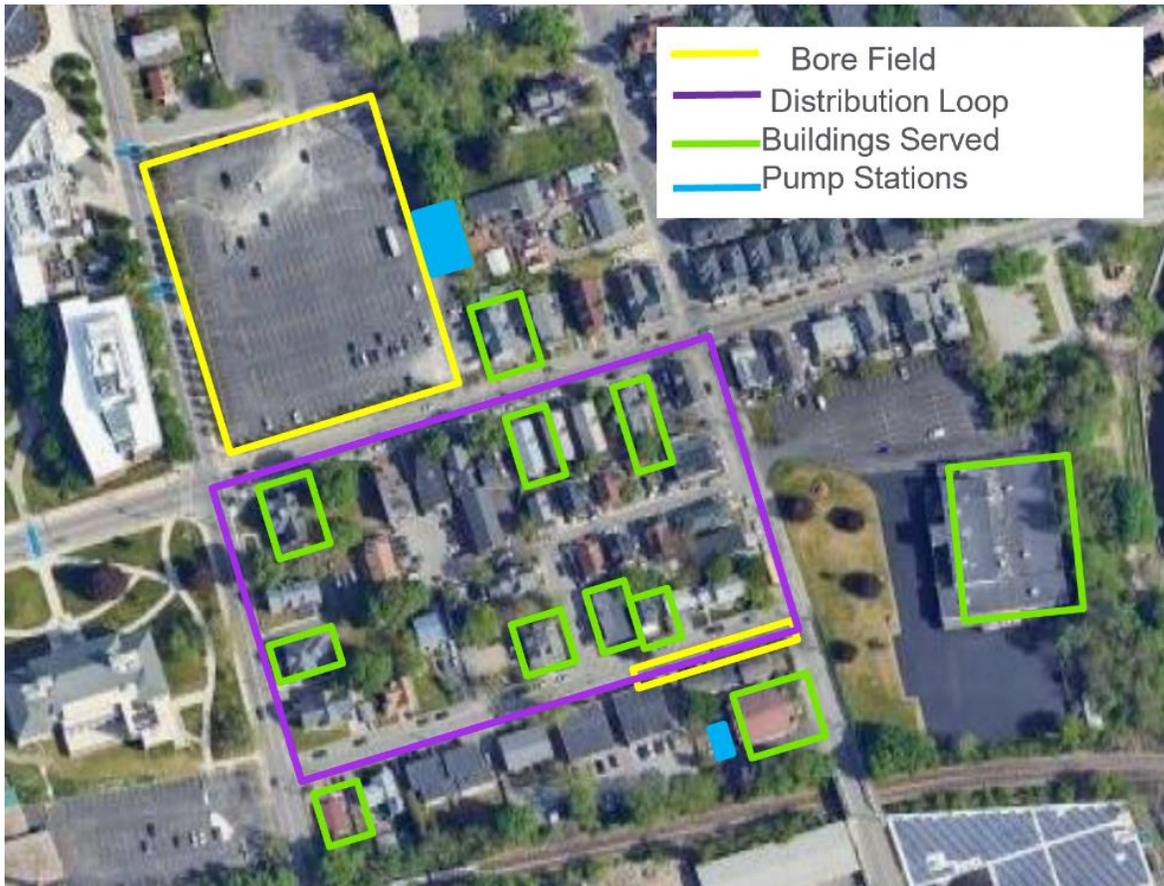
The selected project area contained the following characteristics:

- More than sixty (60) properties that typically contain one building, although at least five (5) properties contain two or more buildings.
- More than 300,000 gross square feet of residential space.
- More than 140,000 gross square feet of light industrial space.
- Two institutional buildings that utilize converted residential properties for office use by UML.

Finally, the Pilot Project was selected at a time when UMass Lowell's Rist Institute for Sustainability and Energy was leading a number of ongoing research and engagement projects focused on effective outreach for energy initiatives in Lowell, funded by various partners such as the United States Department of Energy, The National Science Foundation, the Massachusetts Clean Energy Center, and the Massachusetts Department of Energy Resources.

As designed, operation of the Pilot Project would have provided heating and cooling for 31 customers, including single and multifamily homes, a Lowell Housing Authority property, and two UML buildings.

Figure 2: Aerial View of Designed Lowell Networked Geothermal Pilot Project



Source: National Grid

2. Community Engagement for the Pilot Project

The Pilot Project is in many ways a precursor for the type of energy projects that will be critical in meeting the Commonwealth’s energy transition goals i.e. new technology, requiring upskilling and development of a new workforce, and a siting and permitting process that is focused on community benefit in addition to utility and infrastructural requirements.¹⁰

Effective community engagement is a necessity for these types of projects, particularly in environmental justice communities like the Acre neighborhood in Lowell where the pilot project was scheduled to take place. As the Commonwealth looks to deploy more renewable energy projects in cities and towns across the state, enhanced community engagement that prioritizes and incentivizes the following

¹⁰ See An Act Promoting a Clean Energy Grid, Advancing Equity, and Protecting Ratepayers

areas should be the norm for all parties engaged in these projects versus the exception. These engagement strategies include:

1. **Public Support and Acceptance:** Energy projects, especially those located in close proximity to population centers, will become long term fixtures in a community. Effective engagement with residents early in the process is an essential step to help address concerns, answer questions, and foster public support. If the community is involved and supportive, projects are more likely to success and face fewer delays or legal challenges.
2. **Building Trust:** Effective community engagement creates transparency and helps build trust between project developers, project partners, local government, and residents. Building community trust is vital for reducing skepticism and promoting positive collaboration from project design to implementation, and throughout the life of the project.
3. **Understanding Local Needs and Concerns:** Context sensitive solutions are a key component of energy project siting and development. Every community across the Commonwealth, and across the country, has unique needs, unique environmental conditions, and unique concerns. By engaging with the local community, in a manner that promotes the needs of that community and its residents, project developers can understand these specific factors – whether they are focused on land use, economic and workforce development opportunities, or environmental impact – and adapt the project to better serve the community’s interests.
4. **Maximizing Benefits to Local Communities:** Effective community engagement can ensure that energy projects have an exponential benefit on a community. In the case of renewable energy projects like the Pilot Project, these could include environmental improvements, local job creation, community wide economic development opportunities, and a sense of local ownership and pride in the project. Effective community engagement can enhance opportunities to maximize these benefits, such as creating local partnerships with community organizations and advocacy groups, partnership focused job training opportunities, and mitigation and resiliency options that can be deployed in partnership with the local community such as urban-heat island mitigation approaches in conjunction with the core project development.
5. **Long Term Success and Sustainability:** The Pilot Project as designed had a long lifespan with significant opportunity for future expansion¹¹. Community

¹¹ What was the lifespan?

engagement is essential to ensure community wide investment in the success of a project and its long-term sustainability.

For the Pilot Project, National Grid completed a significant amount of community outreach and engagement including customer targeted recruitment, presentations to the Lowell City Council, and a community meeting held at UML. However, feedback from the local community in Lowell outlined a number of improvements that could be made by the Company that point to the need to prioritize more effective community centric engagement. This is not intended to be a criticism of National Grid, more so an indication of how, as a whole, a new approach is needed to engage communities in energy projects.

Utilities often focus on meeting regulatory requirements and may not always have the flexibility or incentives to go beyond what's legally required in terms of engagement, leaving communities feeling underserved or neglected.

For energy utilities to improve community engagement, an enhanced focus on building trust, providing clear and accessible information, being responsive to feedback, and understanding and addressing the diverse needs of different communities needs to be a key requirement for energy projects in the Commonwealth. Additionally, the following areas should be addressed to ensure the communities that are impacted by energy permitting and siting are adequately engaged throughout:

1. **Lack of Trust and Transparency:** Many communities view energy utilities as distant, profit-driven organizations. Past experience in Lowell with service disruptions, the high cost of gas and electric bills, and opaque decision-making processes have created a lack of trust. When utilities don't provide clear, timely, or relevant information about their actions, residents may feel left in the dark, leading to frustration.
2. **One-way Communication:** Energy utilities often focus on informing customers rather than engaging in a meaningful, two-way dialogue. This results in community members feeling as if their concerns and input aren't truly valued or heard.
3. **Limited Outreach:** Utilities might engage with only a narrow segment of the population, often focusing on customers who are already vocal or organized (e.g., business leaders, political officials). This leaves out underrepresented groups or those who are less able to navigate formal channels of communication, such as lower-income communities, seniors, or renters.

4. **Cultural and Regional Insensitivity:** Utilities may fail to tailor their engagement efforts to the cultural, social, or economic specifics of each community. This can result in messages that don't resonate or outreach efforts that feel impersonal.

For the duration of the Lowell Pilot Project, there was a significant focus on the technical components of the networked geothermal system. This contrasted with the approach that Eversource took with the Framingham Networked Geothermal Pilot Project which had a far more robust community outreach process including community partnership events such as Introduce a Girl to Engineering and Science in partnership with Framingham Public Schools.¹²

The Lowell Geothermal District Heating and Cooling Pilot Project Plan for inclusive outreach and achieving environmental justice was developed early in the project and included best practice examples from the Framingham project that were applicable to Lowell. However, it appears that many of the recommendations provided in this report were not followed. From a utility perspective, National Grid was in full compliance with the DPU as it hit the requirement for “20 – 40 commercial and residential customers on the shared loop system”. In retrospect, this approach led to significant challenges with the cost per customer on the loop. Additional customer recruitment and engagement during the outreach process could have driven down the cost per customer even allowing for a particularly challenging bidding environment. The City of Lowell, particularly through its Sustainability Department felt underutilized throughout the project. Through its Sustainability Director and Energy Advocate, the City of Lowell’s Sustainability Department has an impressive track record in successfully delivering energy and sustainability projects in partnership with the City’s residents.

Additionally, elected officials, notably Councilor Paul Ratha Yem, from District 7 that includes the Acre, had limited opportunity to engage in the community outreach components of the project. Councilor Yem is a noted sustainability champion in the City and would have offered a significant boost to community outreach and engagement approaches to support the project.

For future projects in the Commonwealth it is essential that the approach shifts to a heavy focus on community outreach and engagement as one of the most critical components of a project. While a relatively new technology, networked geothermal still consists of pipes and pumps and is an area that utilities have significant experience and expertise in.

Effective community engagement, however, is an area that has to be refined. The responsibility for this work cannot be solely left to the utilities. Rather, it should be

¹² [Introduce a Girl to Engineering & Science](#)

a requirement of future projects that a robust community outreach and engagement plan be developed as a partnership between the utilities and host communities. This approach should be an essential tool to ensure that future networked geothermal projects contribute positively to communities across the Commonwealth. By establishing clear and defined collaboration between utilities, local governments, and community members, projects can be delivered in an inclusive, equitable, predictable, and repeatable manner that address the needs of all stakeholders involved.

In addition to networked geothermal, the community outreach and engagement lessons learned, are directly applicable to additional energy transformation initiatives in the Commonwealth such as targeted electrification and similar energy affordability initiatives.

3. Technical Lessons Learned with the Lowell Pilot Project

Project Cost

The Lowell Pilot Project was cancelled by National Grid primarily as a result of the overall cost of the project. For the purposes of this report, it is useful to examine decisions made in the context of how, and why, these decisions led to the higher than anticipated costs that ultimately terminated the project.

As a reminder, the original MADPU order approved up to four networked geothermal pilot projects in National Grid territory, along with a budget of \$15.6M. Each project was required to have 20-40 customers and 100-200 tons of load.

In retrospect, the fiscal amount originally authorized was significantly lower than the likely cost of up to four networked geothermal projects in Massachusetts. The cost estimates developed as part of the initial DPU filing (DPU 21-24) were based on the KEDLI project in New York which included a geothermal shared loop serving ten single-family homes that were using delivered oil or kerosene fuels for primary heating. The on the ground infrastructure requirements in the City of Lowell, and in particular in the Acre neighborhood, represented a significant difference, and as such led to higher than anticipated costs per customer that impacted the viability of the project.

Throughout the design process numerous delays were encountered which ultimately led to a less-than-ideal timeframe for National Grid to solicit bids for the project. Bid documents were issued in during the 2023 holiday season which in and of itself was problematic. When construction specific inflation, and a severe shortage of drilling equipment and workers available to work in Massachusetts, were factored into the mix it resulted in a far higher overall cost than anticipated.

For a burgeoning industry like networked geothermal energy, the cost of delivering projects is an area of concern, not just for Massachusetts – which has plans to build up a workforce and grow the supply chain for more networked geothermal projects, but across the industry.

However, as the use of networked geothermal technology grows, and the scale of projects increases costs should go down. More drilling companies are choosing to secure a Massachusetts drilling license and establish operations in the Commonwealth e.g. Rototec which provides surveying, design, drilling and installation as well as consulting for geoenergy projects. Rototec group currently operates in Finland, Sweden and Norway.

There are a number of projects of note where this approach has been proven out. At [Colorado Mesa University](#), an early pioneer in networked geothermal energy systems, a second networked geothermal loop was installed in the summer of 2023 that doubled the size of its initial loop. This second loop was installed at half the cost of the first. Closer to home with the [Framingham Networked Geothermal system](#) we see similar results: twice as big, half as expensive.

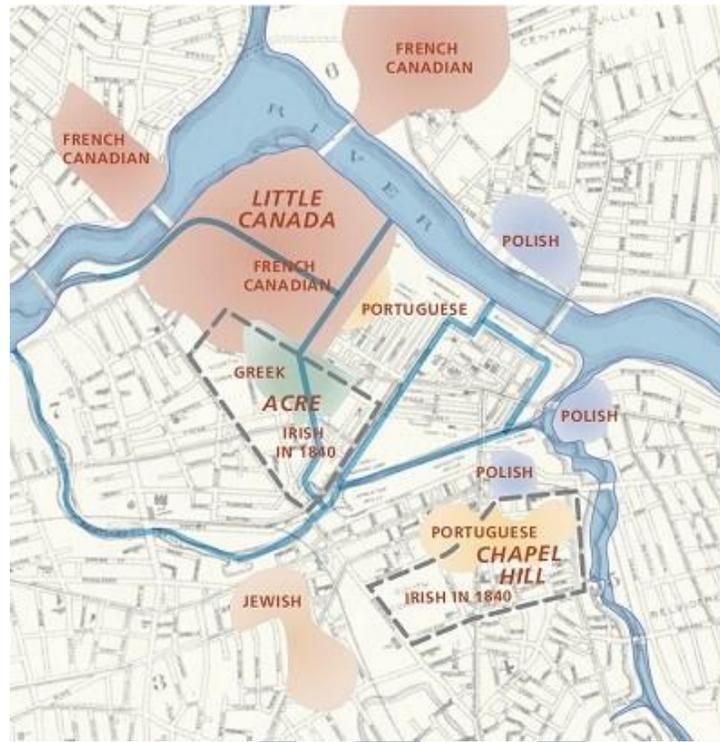
Reduction in cost also applies to the design of networked geothermal systems in Massachusetts. As utilities and design firms become more familiar with design and implementation, lower costs will be recognized. In Framingham the design for the second loop was significantly cheaper than the first. Locating supporting infrastructure underground such as system pump houses are far cheaper than the above ground costs that were included in the first loop and recommended for the Lowell Pilot Project. In National Grid territory, design work for the company's second pilot project at Franklin Field Apartments in Boston has been considerably more streamlined and cost contained.

Building Stock

The Acre neighborhood in Lowell boasts over 200 years of history. Originally settled in 1822, the Acre has consistently served as a landing spot for newly arrived immigrants in Lowell. From its first Irish residents in the early 1800's to today's significant Southeast Asian population, each wave of new immigrants in Lowell passed through the Acre. Each generation, and each wave of immigrants brought its culture, language, and contributions to Lowell. Each new immigrant also needed somewhere to live.

The housing stock in the Acre, and specifically in the Lowell Pilot Project location, is old with core sections of the neighborhood having structures that have been in situ since the late 1800s and early 1900s. This results in the types of issues that accompany old, and specifically in Gateway Cities like Lowell, multi-unit buildings.

Figure 3: A Map of Ethnic Neighborhoods in Lowell 1912



Source: Lowell National Historical Park

For any retrofit energy project, the most logical first step is to focus on energy efficiency, building weatherization, and insulation upgrades. In the older building stock in the project area, this was never going to be a straightforward process. Code violations, mold, asbestos, and faulty wiring were prevalent throughout the project resulting in each home presenting unique challenges requiring its own prescriptive upgrades.

Figure 4: Older Housing Stock in the Lowell Pilot Project



Source: National Grid

This resulted in higher than anticipated costs. However, these issues will be prevalent in a significant amount of environmental justice and gateway cities across the Commonwealth. As such, they should not be a surprise for vendors, particularly in light of the fact that participation rates in the Mass Save program are significantly lower in Massachusetts' Gateway communities and therefore, a lot of "low hanging" energy efficiency and building weatherization projects remain uncompleted in communities like Lowell.

Engaging energy efficiency vendors through the Mass Save program as early as possible for future projects will result in more accurate building loads while ensuring the incorporation of verified equipment that can help create cost and operational efficiencies in future networked geothermal systems. Similarly, with the diversity of building stock in networked geothermal systems in urban environments, different vendors are required for different buildings and customer types e.g. affordable housing, market rate housing, commercial, and industrial properties were all present, by design, in the Lowell Pilot Project.

The issues with older building stock delaying energy transformation projects will increase across the Commonwealth's Gateway Cities if a new approach to community outreach and engagement does not accompany key energy infrastructure projects. While these issues represent a significant hurdle, they also present an opportunity for significant workforce and economic development activities that will engage the residents of communities like Lowell as the state prioritizes energy security, independence, and affordability for the Commonwealth and its residents.

System Design and Project Size

The final project design included eleven buildings in total with three commercial, and eight residential. Of these eight, five were multi-family buildings, two were single, and one was a Lowell Housing Authority Unit. National Grid did an admirable job in recruiting customers for the pilot and were in full compliance with its regulatory requirements i.e. 20-40 customers, and 100-200 tons of load. During the bid review process, and subsequent discussions amongst project partners, it was clear that the size of the project was too small, and unfortunately the customers along the loop were too spread out to make the cost per customer financially viable. More densely packed distribution with a higher number of customers off taking heating and cooling from the system would have resulted in a significantly lower cost per customer.

The standard gas utility project design and implementation is rightly risk adverse which can create issues when dealing with a newer technology and associated innovations in project design and delivery.

Designing networked geothermal systems to peak demand can significantly increase the size of the system and the heat exchanger as was the case in Lowell. In a heating dominant climate like the north-east, designing the system to supply between 75-85% of annual heating needs and utilize supplemental heat for remaining peak needs can be more efficient and result in a lower upfront install cost. Additionally, inclusion of Domestic hot water for the Lowell site increased the ground source heat exchanger by nearly 20%.

The project was designed to include heat exchangers at each building to isolate distribution fluid from the heat pumps. This added an additional layer of protection against single point of failure to whole system, but at significant additional cost.

Construction estimates for 8" distribution loop was significantly higher than typical installation of a gas main, due to the additional burial depth, at 4 feet minimum. As this was the first project of its type in National Grid territory it is reasonable to assume that this extra cost was not anticipated and contributed to the increased costs of the Lowell Pilot Project.

Opportunity for further investment in Lowell

As outlined throughout, the Lowell Pilot Project has resulted in essential learning outcomes for the future of geothermal energy networks in Massachusetts. As part of the Healey-Driscoll Administration Clean Energy and Environment Legacy Transition (CELT) Project UMass Lowell, Boston University, and HEET are currently working on the development of a

Geothermal Energy Network Roadmap for Massachusetts. High-level focus areas for this roadmap will include:

1. **Regional Assessment:** A summary of regional characteristics and assessments (social, technical, and economic) influencing the thermal transition. This includes identifying stakeholders in the state, the characteristics of the gas and electric grid infrastructures, the buildings, as well as relevant policy. Covers human factors, Workforce, Financing, R&D, and policy.
2. **Market Potential:** Estimation of the market potential for geothermal in the state
3. **The Road Forward:** Each section has recommended policy and actions.
 - **Human Factors:** Recommendations based on community characteristics, barriers and opportunities that can influence interest, buy-in and affordability.
 - **Workforce Development:** Recommendations for workforce development
 - **Financial Models:** Identify multiple financial models that could be used to scale thermal networks in an equitable and affordable manner and make recommendations to enable or accelerate them.
 - **Research and Development:** Identify areas for research and development opportunities and make recommendations for funding and/or partnerships.
 - **Policy:** Assessment of state's current geothermal policy and identification of policies needed for a thermal transition for the commonwealth.

Experience with the Lowell and Framingham pilot projects will be a critical component of this roadmap as it is developed over the next six months.

While ultimately not successful in its current form, the Lowell Pilot Project still represents a significant investment of time, energy, and funding to establish the geothermal energy transition in Massachusetts. We currently have a fully designed and permitted networked geothermal energy system in Lowell that represents a significant opportunity to benefit the City of Lowell and its residents while at the same time further establishing Massachusetts as a national leader in geothermal energy networks.

Both the City of Lowell and UMass Lowell remain committed to the project. National Grid have been extremely collaborative and supportive in providing design documents and staff time to explore lessons learned and what options exist to revive the Lowell project.

Additionally, geothermal energy has received clear cut support from the current federal administration at a time when additional energy transformation technologies do not have the same level of support or access to funding.

UMass Lowell, the City of Lowell, and HEET hosted a community engagement workshop in Lowell in May, 2025. There is significant interest from community members and community benefit organizations in reviving the Lowell project supported by a more robust community outreach and customer recruitment process.

The future for geothermal energy networks in Massachusetts is bright. The Lowell Pilot Project will continue to be a central component in establishing Massachusetts as global leader in this critical energy transformation technology.

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