Preserving Brick Streets with Data

A Mt. Lebanon, PA Case Study

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Executive Summary

How can members of a community assign value to an asset that has been under their feet for more than a century? Mt. Lebanon, a municipality just south of Pittsburgh, Pennsylvania, and notable for its early influence among automobile-based suburbs, has 76 brick streets. Over the past decade, the deconstruction of several brick streets has sparked a community-wide conversation about historic charm, inherent value, and cost.

Currently, Mt. Lebanon evaluates brick streets with two static tools: a document called the Overall Condition Index (the "OCI"), and guidelines offered by a 2016 PennDOT Brick Streets Plan commissioned by the Pennsylvania Department of Transportation. These methods do not appropriately measure brick streets, make predictive assumptions about deterioration over time, and assert that some brick streets are worth transitioning to a paved material.

Making the case for preserving brick streets required a multi-dimensional analysis considering:

1. Public opinion
2. Finance and data analysis
3. Sustainability and environmental benefits
4. Existing models for brick street preservation
5. Current municipal decision-making strategies

To capture **public opinion** and resident input, the first Mt. Lebanon Brick Street Preference Survey was distributed. See Appendix C. The survey received approximately 1,600 unique responses, the majority of which indicated overwhelming support for brick street preservation.

Highlights include:

- 96% of respondents said that brick streets contributed to the character and historic charm of the neighborhood,
- 70% believed that brick streets enhance property values,
- 82% were willing to pay to support brick streets, and
- Over 50% of respondents believed in the traffic-calming and safety benefits of brick streets, either by slowing driving or creating noise that alerts pedestrians to oncoming traffic.

Six hundred and eighty (680) respondents left comments in the survey's open field, with "charm" appearing most often in a word cloud analysis.

Figure 1: Mt. Lebanon residents associate brick streets with charm, character, and community. Source: Author.

For the **financial analysis**, life cycle costs were evaluated for two scenarios:

1) Preserving a brick street, and
2) Reconstructing a brick street with asphalt

While brick streets may higher initial or upfront costs than asphalt, they have a longer lifespans and do not require curb-to-curb maintenance in all cases. Given this, maintaining an average length (700 feet) brick street costs approximately $200,000 less than reconstructing that street with asphalt over a 50-year period.

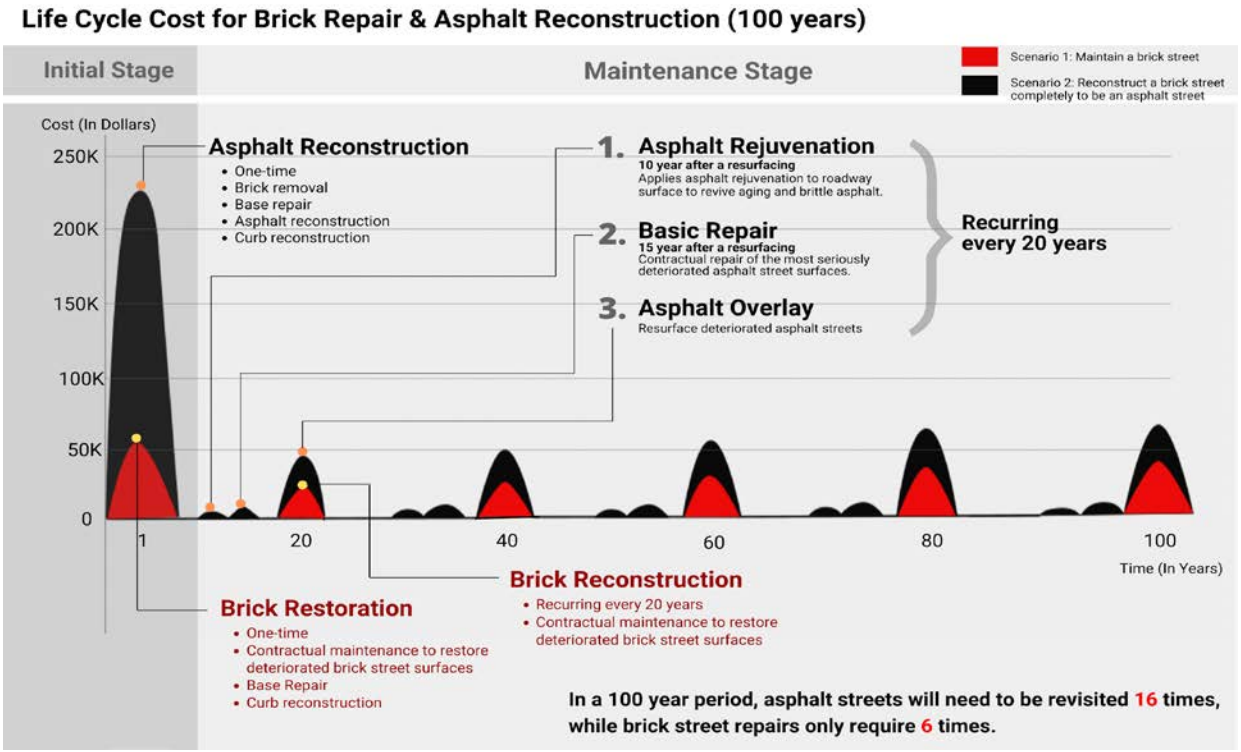

Figure 2: Maintaining a brick street costs $200,000 less over 50 years than reconstructing it with asphalt. Source: Author.

The **financial analysis** also considered the municipal budget, real estate impacts, brick storage, and potential funding sources. It was determined that various financial sources exist to cover upfront costs including grant opportunities relevant to community development, transportation, and historic preservation, public-private partnerships, crowd-funding, or new municipal special projects funds.

Related to real estate specifically, and based on a limited analysis of median home sale values on brick streets versus home sales across all of Mt. Lebanon, findings indicate that homes on brick streets tend to sell at higher prices, which adds to the local tax base while providing benefit to residents.

In terms of the **sustainability** aspects of brick streets, three areas of focus emerged: stormwater mitigation, reusability of materials, and urban heat island effect.

The analysis found that:

- Brick streets aid in stormwater management by slowing down water and easing strain on stormwater infrastructure. The study found examples, including in the City of Pittsburgh, which retained an historic block stone street for this reason.
- Bricks can be stored locally and reused with relative ease, while asphalt must be processed at a plant and then transported to a construction site, creating waste and emissions.
- Brick streets can help to mitigate urban heat island effect.

This study identified multiple cities and municipalities with active brick street programs to analyze and use to develop a working model. In fact, many cities around the United States have developed detailed municipal strategies to preserve brick streets. To understand these, case studies were conducted on the following cities:

- Lafayette, Indiana
- Buffalo, New York
- Canton, Ohio
- Pittsburgh, Pennsylvania
- Oakmont, Pennsylvania
- Philadelphia, Pennsylvania

Each of these cities offered policy, maintenance, and bidding strategies relevant to brick street preservation.

Of note, Mt. Lebanon has a nationally-recognized historic designation. The historic district, which was awarded to the municipality in 2014 with strong reference to its automobile-oriented street plan, relies on the historic charm of its brick street infrastructure. Preserving brick streets maintains the character promised in the historic district. However, the 2016 Brick Streets Plan inadvertently penalizes brick streets that are located outside of the nationally-designated historic district boundary (Murcko et al 2016).[1] This report actively decouples the existence of a brick street within the historic district as contributing to brick protection. Appropriate alternatives are suggested.

Based on this multidimensional analysis, the suggested recommendation to the municipality of Mt. Lebanon is to preserve all brick streets. Brick streets are financially manageable,

[1] Murcko, T. et al. 2016. *Brick Streets Plan*. McCormick Taylor; Pennsylvania Department of Transportation Mt-Lebanon-Brick-Streets-Plan_8-9-2016

ecologically responsible, and important to the community. Therefore, there is no financial or public opinion basis for reconstructing any of the 76 brick roads with asphalt.

To preserve the brick streets, this report suggests three high-level recommendations:

1. Fund brick projects with a multi-year planning strategy and coordination with nearby municipalities to reduce costs and leverage workforce resources
2. Protect the streets with the Historic Preservation Board's brick streets policy.
3. Evaluate the streets with data-driven, state-of-the-art tools.

See "Recommendations" for the complete preservation plan details.

Introduction

Without a preservation plan for existing brick roads, streets in historic towns are at risk. Take, for example, Duquesne Drive in Mt. Lebanon, PA. Duquesne Drive places two options to the community of Mt. Lebanon side-by-side. Half of the street remains paved with brick, and half of the street is paved with asphalt. In July 2019, a flood damaged the base of a portion of Duquesne Drive. Upon inspection, the street had no stormwater infrastructure. Without a preservation plan for bricks in place, the bricks were removed and discarded, and a portion of the street was paved with asphalt. The street today is an interface of asphalt and brick, standing in for the larger conversation of upfront versus long-term costs, sustainability, drivability, maintenance, traffic behavior, historic charm, aesthetics, and what exactly a street can mean to a community.

The deconstruction of Duquesne Drive invigorated a community-wide conversation around Mt. Lebanon's 76 brick streets, with passionate residents lamenting the loss of an asset at Commission meetings, municipal staff voicing concerns over relative costs, and leadership unsure of how to quantify the value of these assets.

The Commission charged this team with creating a data-driven cost-benefit analysis of brick streets. This white paper presents this analysis categorically by quantifying public opinion via Mt. Lebanon's first brick street preference survey, by comparing the life cycle of brick and asphalt streets, by understanding the impact of traffic behaviors, sustainability metrics, and real estate values, and by noting how other cities have dealt with the question of brick street preservations. These analyses were informed by interviews with 40 relevant stakeholders including municipal staff, sustainability experts, civil engineers, real estate appraisers, brick industry experts, historic preservationists, transportation network directors, and brick street preservation leaders from around the country. To begin, however, the team had an unexpected interview at Duquesne Drive.

In the beginning stages of this project, the team drove on the brick streets in Mt. Lebanon. While discussing the paving at the interface of asphalt and brick on Duquesne Drive, a resident on the street approached the team. She told the team how much she loved the aesthetics of bricks and, more importantly to her, how much she valued being able to hear cars coming when she let her kids play in her front yard. Unprompted, she touched on many of the dimensions addressed in this white paper: relative costs, stormwater, drivability, history. She compared the noise of when a car drives from the bricks to the asphalt interface to "a bomb going off." Between her description and the near 1,600 responses on the brick streets survey, one thing is certain: Mt. Lebanon is a passionate, engaged community ready to discuss these assets.

Image 1: The partial paving of Duquesne Drive, pictured above, sparked calls for a brick street preservation policy. Source: Author.

Project Goals

The mission of this white paper is to assist in forming systematic, data-based decision-making for brick street preservation. The paper assesses preconceived notions and anecdotal evidence with input-based cost analyses, expert assessments, and statistically significant quantifications of public opinion. Ultimately, this analysis seeks to assign value to an elusive, aesthetic asset: historic brick streets.

Methodology

This case for brick street preservation featured quantitative and qualitative analyses.

For quantitative strategies, the first ever Mt. Lebanon Brick Street Preferences survey was distributed in October 2020. The survey received nearly 1,600 responses in approximately four

weeks. In addition, a life cycle cost analysis used real-cost inputs from Mt. Lebanon's budget, Mt. Lebanon's brick and asphalt street repair contracts and bid estimates, and expert assessments to determine the true financial comparison between maintaining a brick street and paving it with asphalt over a 50- and a 100-year timespan.

For qualitative research, there were 40 interviews conducted with relevant experts on topics like sustainability, the brick industry, and municipal decision-making. Qualitative strategies also included the analysis of 60 municipal documents and 6 case studies on brick street preservation in various cities.

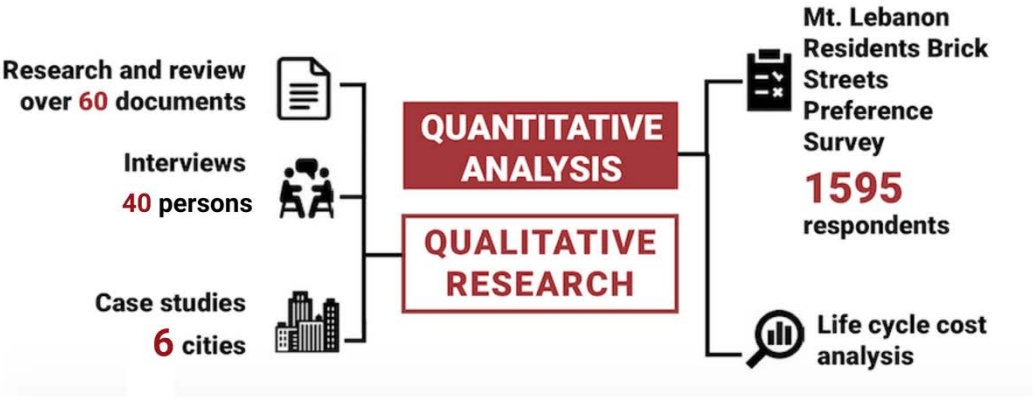

Figure 3: The multidimensional analysis utilized quantitative and qualitative strategies. Source: Author.

The project culminated with a presentation to the Mt. Lebanon Commission at their December 8th, 2020 meeting.

Background on Mt. Lebanon and its Brick Streets

Mt. Lebanon is a municipality located in Allegheny County south of Pittsburgh, Pennsylvania. The township has approximately 35,000 residents and 76 brick streets. These streets, which were first constructed roughly 100 years ago, contribute to the overall historic significance of the neighborhood (Brown 2007).[2] In the 1920s, and 1930s, Mt. Lebanon was one of the first suburbs

[2] Brown, E. 2007. *Mt. Lebanon Cultural Resource Survey Final Report*. Eliza Brown Consulting. Mt (mtlebanon.org)

in the country to be designed for automobiles, with its layout and streets designed for car travel (*National Register of Historic Places* 2014).[3]

Efforts for preserving these brick streets started in the mid-2010s. In 2014, Castle Shannon Boulevard, a prominently-located brick street, was deconstructed. Mt. Lebanon's Historic Preservation Board (HPB) opened the question of designating these streets as historic and assigning value to their charm.

Below is a map of the municipality and its brick streets, highlighted in red, yellow, and blue based on slope. Additionally, an image below shows Mt. Lebanon's nationally registered historic district which features over 4,000 properties (*National Register of Historic Places* 2014).[4] Some of the brick streets are located within the historic district, while others are located outside of it.

Figure 4: Mt. Lebanon's brick streets, categorized by slope. Source: Mt. Lebanon Municipality.

[3] National Register of Historic Places. 2014. *Mt. Lebanon Historic District*. U.S. Department of the Interior, National Park Service https://www.nps.gov/nr/feature/places/pdfs/14000813.pdf
[4] Ibid.

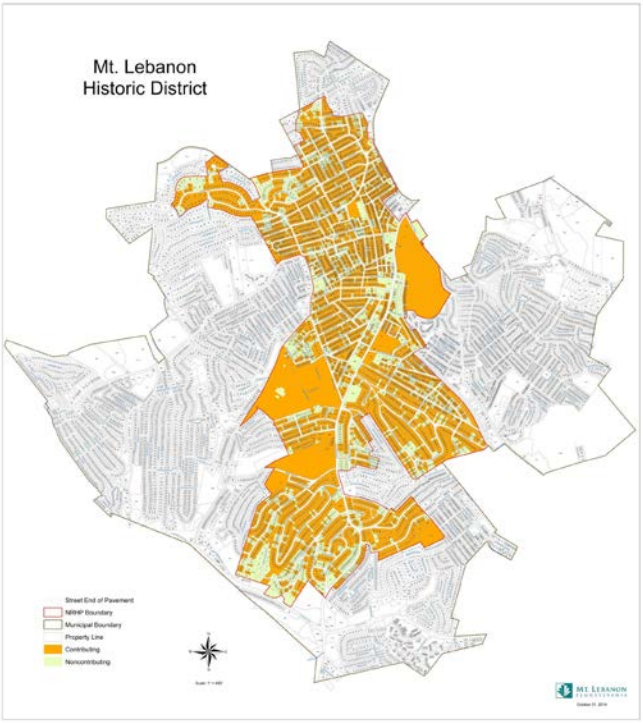

Figure 5: Mt. Lebanon's historic district features more than 4,000 properties. Source: Mt. Lebanon Municipality.

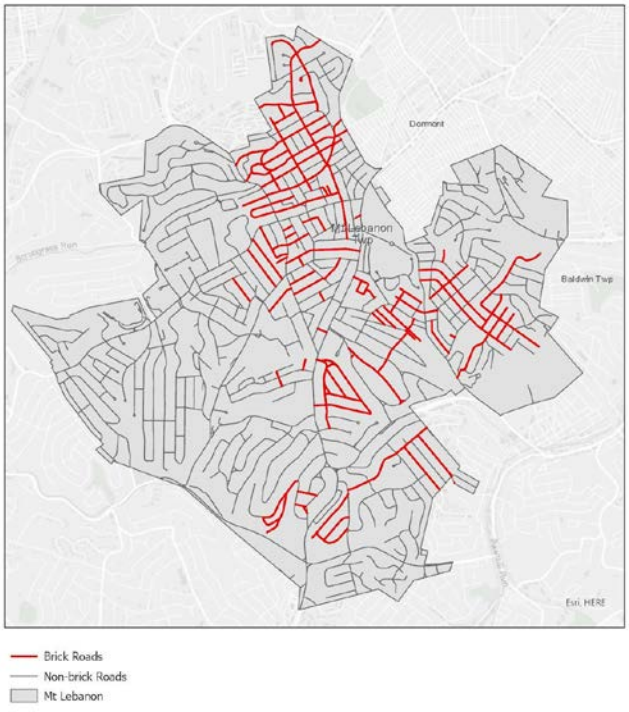

Figure 6: Many brick streets are located within the historic district. However some are adjacent to the district and some are well-removed. Under the 2016 PennDOT Brick Streets Plan[5], this designation penalizes brick streets located outside of the historic district. Source: Author.

After the establishment of the historic district, the HPB tried to create a brick streets policy, as the streets are historic assets to the community. HPB worked in partnership with the Commission and municipal leadership.

In 2016, Mt. Lebanon commissioned a Brick Streets Plan from PennDOT (Pennsylvania Department of Transportation, who hired a consulting firm, McCormick Taylor, to categorize Mt. Lebanon's brick streets. The resulting categorization broke the brick streets into four groups: restore, preserve, questionable, and repave with other materials (Murcko et al 2016).[6] Without a preservation policy, this categorization designates nearly half of the historic brick streets in Mt. Lebanon to be repaved with asphalt. A draft brick street preservation policy was discussed in 2016 but was never finalized.

The brick street preservation process stalled until the deconstruction of Duquesne Drive in July 2019 due to flood damage. A portion of Duquesne Drive was paved with asphalt, which led to an outcry from residents. Residents criticized the lack of transparency in the decision-making process behind deconstructing the street, and expressed frustration that they were not given enough time to advocate for street repair instead of deconstruction. After the street's deconstruction, there was a renewed emphasis and focus on developing a plan to preserve Mt. Lebanon's brick streets (*Mt. Lebanon Magazine* 2019).[7]

Current Municipal Decision Making in Mt. Lebanon

Below is an assessment of the current tools used by Mt. Lebanon staff to aid in their decision-making process regarding brick streets, concerning evaluation, bidding, and budgeting.

Street Assessment - Overall Condition Index (OCI)

Mt. Lebanon's municipal staff evaluates street conditions using an Overall Condition Index (OCI). The OCI was developed from a program called Cartegraph, which is a pavement management platform built on US Army Corps of Engineers and American Society Testing

[5] Murcko, T. et al. 2016. *Brick Streets Plan*. McCormick Taylor; Pennsylvania Department of Transportation Mt-Lebanon-Brick-Streets-Plan_8-9-2016
[6] Ibid.
[7] Mt. Lebanon Magazine. 2019. *Around Town*. https://lebomag.com/around-town-13/

Materials standards (*Cartegraph* n.d.).[8] The OCI provides a measure of the present conditions of the streets based on observations of the pavement and estimated progressive degradation calculated in Cartegraph. The algorithm used in Cartegraph remains non-transparent. Consequently, this team was unable to assess the assumptions embedded in the degradation curves, and furthermore unable to assess the accuracy of the calculations that determine a street's OCI rating.

The physical street observations that accompany the progressive degradation estimates are conducted on five-year intervals. Engineers and municipal staff including interns inspect the streets in Mt. Lebanon based on criteria such as drivability, safety, presence of utility patches, and presence of defects including longitudinal or alligator cracking, ruts, or potholes observed. The street inspections are conducted in segments that are determined in various ways, including changes in a street's pavement surface type, changes relating to the curbs or guardrails, adjustments in a street's usage or width, or changes in the slope of a street (Sukal 2020).[9] Streets with slopes over a 10% grade are penalized. Under this system, a whole street risks receiving a lower rating even if only one segment of the street has defects.

The overall street rating is quantified on a 0-100 scale, with a score of 100 indicating that a street is in the best possible condition. The municipality decides whether to repair or replace streets based on the OCI scores, aiming for its streets to maintain a score of at least 60. The streets with the lowest scores each year are paved.

This process determines which streets will be part of the municipality's annual program which starts in March, due to the fact that winter could impact OCI rating significantly. The Municipal Manager, engineers, and the Director of Public Works review the OCI and recommend a list of streets for maintenance and reconstruction to commissioners.

Bidding Process

Mt. Lebanon currently has two separate programs for bidding: a brick repair program that involves no asphalt work, and a street reconstruction program, which is a joint bid that goes out to both asphalt and brick contractors (Sukal 2020).[10]

For the full street reconstruction program, the municipality bundles brick and asphalt streets of the worst condition (as determined by the OCI ratings) together into one bid package. In theory,

[8] Cartegraph. n.d. *Cartegraph Pavement Asset Management System*. https://www.cartegraph.com/pavement-management-app
[9] Sukal, R., Mt. Lebanon Public Works Director, in conversation with the authors, November 2020.
[10] Ibid.

bundling streets into one bid package instead of bidding each street separately drives down the cost. Contractors submit bids on the entire package, which includes the amount they will charge for their services. In this set of circumstances, brick street prices tend to appear elevated in relation to asphalt. The Commission reviews bids and chooses a winner, often selecting the bid that is most cost-effective. Due to the change of material costs and other market changes over time, street repair contracts in Mt. Lebanon are awarded for a maximum of three years.

Budgeting

Mt. Lebanon sets its budget on an annual basis. The budgeting cycle starts in the summer. The Commission forms the first draft of the budget in October. It reviews the budget in November and approves it in December. Therefore, decisions are made on the single budgetary cycle. Funds that are unused for a specific project will be carried as undesignated funds into another budget year. For an in-depth budget analysis, see Financial Analysis.

The 2016 PennDOT Brick Streets Plan and Brick Street Categorization

Brick streets in Mt. Lebanon are susceptible to unnecessary paving in part because of the 2016 PennDOT Brick Streets Plan. In 2016, PennDOT commissioned a consultant to develop a Brick Streets Prioritization List (on "Page Five" of the 2016 PennDOT Brick Streets Plan). This plan was informed by a different brick streets plan, as noted in the sources. Many of the assumptions from the 2016 PennDOT Brick Streets Plan and its sources have been carefully evaluated and are flawed.

The streets are categorized based on three main dimensions: their relationship to the Mt. Lebanon Historic District, their structural condition, and their architectural integrity. The list puts streets into four categories: Restore (1), Reserve (2), Questionable (3), and Repair with Other Materials (4). Streets with a higher aggregate score were deemed better candidates for restoration (1) or preservation (2).

Page Five of the 2016 PennDOT document penalizes streets outside the historic district, see Appendix A. According to the scoring method, streets residing within the Mt. Lebanon Historic District received 2 points while those residing outside the Historic District received 0 points (Murcko et al 2016).[11] This rule places those streets located outside the Historic District,

[11] Murcko, T. et al. 2016. *Brick Streets Plan*. McCormick Taylor; Pennsylvania Department of Transportation Mt-Lebanon-Brick-Streets-Plan_8-9-2016

especially those adjacent to the Historic District, at a disadvantage. For example, streets like Duquesne Drive and Hilf Street are adjacent to the Historic District and were given a lower score, designating them into the Category 3 'Questionable' (not prioritized). This difference might have significantly impacted the decision-making of Duquesne Drive's deconstruction in 2019.

Additionally, the PennDOT plan gives unclear explanations in its analysis of brick street conditions. Under four criteria including 'Brick Condition', 'Drainage Problems', 'Base Condition', and 'Rideability', streets were rated as 'Good', 'Fair', Average', and 'Poor' without explicit standards of measurement.

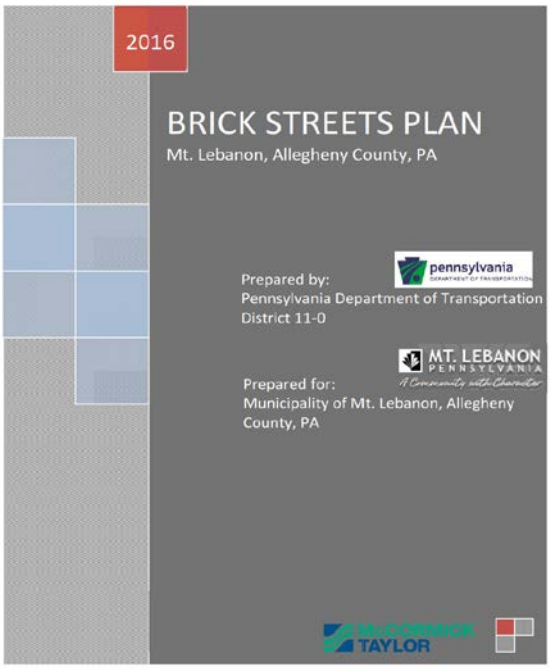

Figure 7: The 2016 PennDOT Brick Streets Plan makes nearly half of Mt. Lebanon's brick streets susceptible to paving.

For other assumptions, this document states that the worst streets, Category 4, should be touched last. According to this project research, the opposite should be true; problem areas should be prioritized to not defer larger problems and costs until later. In short, brick roads should be repaired proactively. The recommendation of this study is not only to prioritize streets that have not been touched in recent years (in some cases, records indicate since 1930) or are in need of repair but also to create a multi-year plan to address issues that have been identified before smaller issues grow.

The PennDOT Brick Streets Plan and the OCI are both inadequate measures assessing brick streets. Both evaluation tools fail to treat brick streets as assets, even though Mt. Lebanon residents identify them as such. Furthermore, both tools fail to capture the ability to maintain brick streets by segment. The evaluations are made under the assumption that brick streets should be judged curb-to-curb. The PennDOT Plan also evaluates whole streets based on their location.

Critically, Page Five of the 2016 PennDOT Brick Streets Plan also designates nearly half of Mt. Lebanon's brick streets as "questionable" or appropriate to "repave with other materials." The life cycle assessment and the budget analysis confirm that there is no long-term financial necessity to repave any of these streets, see Financial Analysis.

A more appropriate brick street categorization is shown in Appendix A. This new categorization does not consider the proximity to the historic district as a metric for preservation. It categorizes the conditions of each street with the assumption that it will be restored, given that a repaving is a more costly and less popular long-term decision. Therefore, the quality categories are renamed "best," "better," "good," and "prioritize." The new categorization also replaces "structural condition" and "architectural integrity" with "surface brick condition" and "non-surface brick condition." "Surface brick conditions" refers to any issues visible in the bricks themselves, including dips, ice patches, and potholes. "Non-surface brick conditions" refer to less visible condition metrics like whether stormwater infrastructure exists, the condition of the street's base, and the age of the street. Older streets are more historic and should therefore be given a higher preservation value.

Follow-up work must be conducted to model the optimal metrics for street categorization.

A new Page Five replacement removes the assumptions that there are brick streets that should be paved. This is an incorrect assumption as proven by the Financial Analysis and public opinion sections in this white paper. It also offers a more comprehensive way to categorize the street, introduces new metrics, and eliminates penalization based on historic district proximity.

Background on Brick Streets

Throughout the 40 interviews conducted, individuals pointed to several commonly held beliefs and misconceptions about brick streets. The following outlines broad benefits, challenges, and misconceptions associated with brick streets.

Benefits and Challenges of Brick Streets

This list of benefits and challenges of brick streets is not exhaustive, and these topics are expanded upon throughout the paper.

Benefits	**Challenges**
Brick streets have a life expectancy of 100 years or more. This is four times as long as a typical, residential asphalt street (*City of*	Brick street labor and materials require higher upfront costs than asphalt, making long-term decision-making and modular repair efforts important. See Financial Analysis.

Columbia Brick Streets Policy Resolution FAQs 2015).[12]	
Brick streets can be repaired in module-like portions; they do not to be repaired end-to-end and curb-to-curb construction. See Financial Analysis.	Brick streets can be slippery in wet weather or icy conditions. 40% of survey respondents agreed with this. See Appendix C.
Brick streets can calm traffic by 10-15 mph (Fodi 2020).[13] Drivers slow down on a brick street regardless of its width (Loukas 2020).[14] Noise generated by brick streets can alert residents and their children to oncoming traffic. 60% of Mt. Lebanon survey respondents noted this as a positive experience. See Survey Analysis.	If not properly maintained, brick streets can cause wear and tear on vehicles.
Brick streets have environmental benefits. They contribute to stormwater management by slowing water runoff that can overwhelm combined sewer systems, they reduce urban heat island effects, and their preservation reduces material inputs. See Sustainability Analysis.	Brick streets can pose difficulties for bicycling, motorcycling, and overall personal mobility. 11% of survey respondents agreed with this. See Appendix C.
Brick streets contribute to the character and historic charm of a neighborhood. 96% of survey respondents agreed with this. See Survey Analysis.	

[12] City of Columbia. 2014. *Brick Streets Policy Resolution FAQs*. https://www.como.gov/community-development/wp content/uploads/sites/14/2015/09/brickstreetsFAQ.pdf.
[13] Fodi, S., Borough Manager of Oakmont, PA, in conversation with the authors, September 2020.
[14] Loukas, N., Assistant City/Traffic Engineer in Canton, OH, in conversation with the authors, November 2020.

Image 2: While 40% of survey respondents noted that brick roads can be slippery when wet or icy, 60% appreciated their traffic calming properties.

Misconceptions About Brick Streets

Often, municipal decisions on brick streets are made with anecdotal evidence. After interviews with 40 experts in the brick industry, sustainability fields, municipal engineering, and more, the answers below were provided for many of the most common questions concerning brick streets.

Misconception 1: Brick producers do not make historic clay pavers anymore.

The Belden Brick Company in Canton, Ohio, located within 100 miles of Mt. Lebanon, produces bricks that meet Mt. Lebanon's brick specifications. Mt. Lebanon's specific brick qualifications are: A.) Pavers must be chamfered and lugged, B.) Paving brick for heavy vehicular traffic, C.) True 4x8x3 as per ASTM C 1272-95, Type F, Application PX, D.) 10,000 PSI minimum, E.) average compressive strength, and F.) 6% maximum absorption.

Specifically, Belden Brick uses the same firing technology that it used 130 years ago to create bricks and owns its mines (Piteo 2020).[15] Therefore, it creates the same kind of bricks that were made when Mt. Lebanon's brick streets were first laid. Brick producers have certifications that can guarantee that their bricks comply with the requirements of the American Society for Testing and Materials (ASTM) standards for heavy vehicular paving brick and meet historic performance metrics. In addition to Belden Brick, three other brick manufacturers vetted by the Brick Industry Association are located within a 500-mile radius of Mt. Lebanon (*Brick Industry Association* n.d.).[16]

See Appendix F for a complete list of brick vendors and brick layers near Mt. Lebanon.

Misconception 2: Bricks do not last for 100 years anymore.

This misconception stems from confusion in distinguishing between historic, clay brick pavers and more recently-created permeable brick pavers. Likely, historic clay pavers last longer by virtue of not being permeable. In addition, traffic patterns contribute significantly to bricks' lifespans. The range of an asphalt street's life span is between 7 and 25 years, typically (Setzler 2020).[17] Whether there are heavy traffic patterns like buses and freight trucks regularly on the street impacts this lifespan. Residential brick streets likely last 100 years or more (Ricks 2020).[18] See Financial Analysis and Case Studies.

Misconception 3: Clay bricks are not permeable therefore they do not contribute to stormwater management.

Historic bricks do contribute to stormwater management; they slow water down with their many rivets and cracks. New brick pavers have built in designs to increase permeability for absorbing water. See Sustainability Analysis.

Misconception 4: Brick streets cost more because they have higher materials costs.

In the long term, brick streets do not cost more than asphalt streets. Upfront materials and labor costs more for brick than asphalt. However, because of the possibility of modular planning and

[15] Piteo, J., Sales Manager Paving Products of the Belden Brick Company, in conversation with the authors, November 2020.
[16] Brick Industry Association. (n.d.). BIA Manufacturer Members. https://www.gobrick.com/find-brick-professionals/manufacturers
[17] Setzler, E., Chief Engineer of the City of Pittsburgh's Department of Mobility and Infrastructure, in conversation with the authors, September 2020.
[18] Ricks K., Director of the City of Pittsburgh's Department of Mobility and Infrastructure, in conversation with the authors, September 2020.

brick streets' life expectancy, brick streets cost significantly less in the long term. See Financial Analysis.

Misconception 5: Bricks quickly chip, meaning they do not last a long time.

Small chips at the corners of the bricks are to be expected and are not an indication of larger, structural concerns (Snider 2020).[19] Some argue that chips in brick boost the overall charm of the street. Brick streets should be evaluated with the expectations that many bricks will not be perfectly rectangular.

Image 3: Light chipping is expected and harmless in brick streets. Many argue these small imperfections add to the aesthetic of the street.

Misconception 6: Historic bricks cannot be reused.

Historic bricks can be stored and reused affordably. Several municipalities including Lafayette, Indiana and Oakmont, PA reuse their historic bricks. Storage requires 4' by 4' pallets. Bricks can also be covered with a tarp during construction projects to limit theft of bricks. See Case Studies.

[19] Snider, B., Project Manager at Decorative Paving Company, in conversation with the authors, November 2020.

Sorting, cleaning, and palletizing the bricks cost $2.63 - $3 per square yard, according to Canton, Ohio (Loukas 2020).[20]

Misconception 7: Deicing is always more difficult for bricks.

According to municipal staff in Mt. Lebanon, salting brick streets costs 2-3 times more than asphalt streets (Sukal 2020).[21] See Financial Analysis. For Buffalo, NY, however, there is no difference in salting costs (Finn et al 2020).[22] Topography may be a critical factor in salting costs for brick streets across cities, so in some cases deicing is more difficult. More sustainable materials than salt are promoted for deicing in the Sustainability Analysis.

Survey Analysis

To capture public opinion, the first Brick Street Preference survey was distributed in Mt. Lebanon in 2020. The survey had a statistically significant response of 1,595 respondents. 1,496 of the respondents were Mt. Lebanon residents, and there was an overall 6% response rate. See Appendix B for the calculation of statistical significance.

Survey Design, Distribution, and Analysis Methodology

The survey consisted of six questions and one optional open text box for additional feedback. Aiming to obtain a comprehensive view of the perceptions of respondents, the survey consisted of four types of questions: 1) a demographic question to identify where respondents live, 2) a series of agree/disagree questions regarding statements about brick streets 3) close-ended questions to determine respondents' perceptions of and willingness to pay for brick streets, and 4) an open-ended comment section. The survey results were analyzed for all respondents, as well as for two sub-groups of respondents: those that live in Mt. Lebanon and those that live on a brick street.

The survey was distributed via Mt. Lebanon's Public Information Officer through various channels including:

- The LeboALERT system
- The municipality's website, mtlebanon.org

[20] Loukas, N., Assistant City/Traffic Engineer in Canton, OH, in conversation with the authors, November 2020.
[21] Sukal, R., Mt. Lebanon Public Works Director, in conversation with the authors, November 2020.
[22] Finn, M. et al, Commissioner of Public Works in the City of Buffalo, in conversation with the authors, October 2020.

- Commission meeting reports
- Mt. Lebanon Magazine's weekly newsletter, The Seven Ten
- Community Relations Board meetings
- PTA meetings
- Cable TV announcements

The survey results were analyzed at three levels: all respondents, Mt. Lebanon residents, and Mt. Lebanon residents who live on a brick street. The survey results were first analyzed across all respondents, including those who are not Mt. Lebanon residents, because non-residents reported to have either previously lived in Mt. Lebanon, currently work in Mt. Lebanon, drive through Mt. Lebanon, or have other interactions with brick streets. The total of 1,496 surveys completed by Mt. Lebanon residents from the 24,296 residents in Mt. Lebanon over the age of 18 (*U.S. Census QuickFacts* 2019)[23] equaled a 6% rate of response. The third level of survey analysis, Mt. Lebanon residents who live on a brick street, consisted of 424 respondents.

Discussion of Survey Results

Support for brick streets in Mt. Lebanon is strong. Three overarching findings are: 1) respondents reported that they think brick streets increase real estate values, 2) respondents expressed a willingness to pay for brick street maintenance, and 3) respondents indicated their support for brick streets due to their sustainability, safety, and place-making benefits.

1. Respondents think brick streets are positively associated with home values. Of those survey respondents who live on a brick street, 84%, 356 people, reported that they think brick streets enhance their home's property value. Over two thirds of the respondents who live on a brick street agreed or strongly agreed that brick streets positively impacted their selection of a house and street in Mt. Lebanon. Comments left in the open feedback of the survey included, "Brick streets are beautiful and enhance all residences," and, "We purchased our house on a brick street in part because of the bricks. About 18 months ago they paved half the street, not giving residents a choice in the matter. I [am] confident that given the opportunity to vote on this issue for our specific street, that me and my neighbors on my street would have elected to pay extra for the maintenance fees to refurbish and keep the bricks the town removed."

[23] U.S. Census Bureau. 2019. *QuickFacts Mount Lebanon township, Allegheny County, Pennsylvania*. https://www.census.gov/quickfacts/mountlebanontownshipalleghenycountypennsylvania

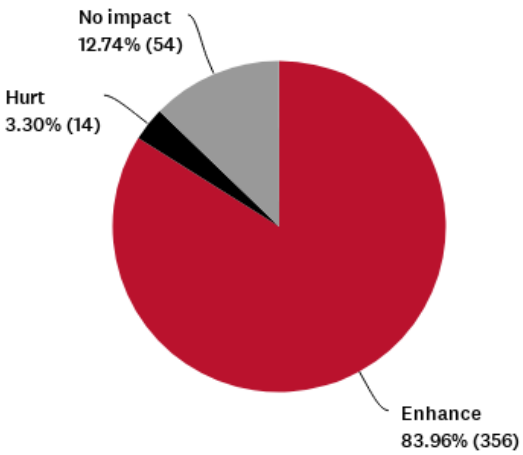

Figure 8: 84% of respondents reported that brick streets "enhance" their property values.

2. Mt. Lebanon resident respondents think brick streets have value and are furthermore willing to pay for them. Of the Mt. Lebanon resident survey respondents, 83%, 1,240 people, assigned a value to brick streets. Over half of the respondents reported that they would be willing to pay at least $11 per year to support brick streets. Of those respondents who live on a brick street, 89%, 376 people, assigned a value to brick streets, with 64% of them, 270 people, reporting a willingness to pay at least $11 per year to support brick streets.

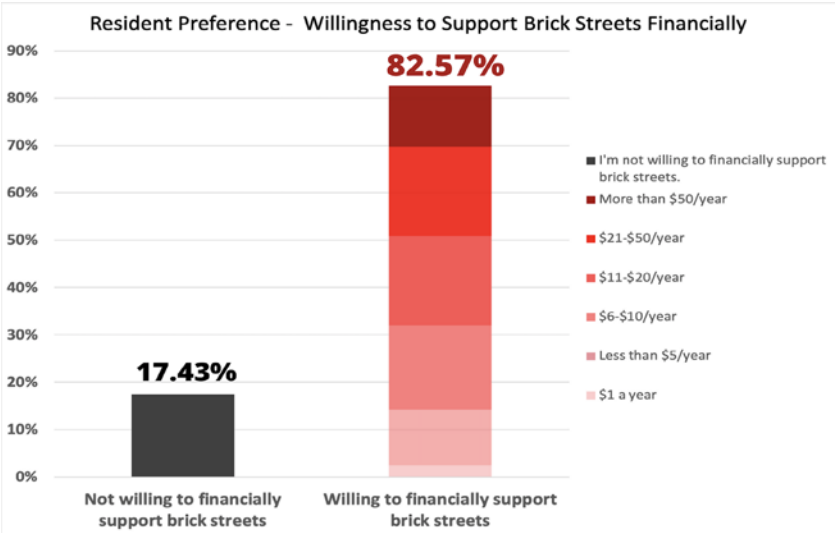

Figure 9: Over 82% of residents indicated a willingness to financially support brick streets.

3. Brick streets have place-making, sustainability, and safety benefits. A total of 94% of survey respondents, 1,531 people, think brick streets contribute to the character and historic charm of Mt. Lebanon. The majority of respondents, 991 respondents, reported

that brick streets contribute a "great extent" to the character and historic charm of Mt. Lebanon. In a word cloud analysis of the comments from the respondents, "Charm" was the most frequently occurring word, stated nearly 100 times. It appeared nearly twice as many times as "community" and "character," which tied for the second most common word.

Brick streets also contribute to sustainability goals. 62% of all survey respondents, 987 people, agreed or strongly agreed that brick streets contribute to sustainability goals. More specifically, about half of all respondents agreed or strongly agreed that brick streets contribute to stormwater management and help avoid flooding. On urban heat island effects, over half of all respondents reported that brick streets are less hot in the summer compared to asphalt streets. See Sustainability Analysis.

Brick streets promote pedestrian safety from vehicular traffic. 60% of all survey respondents, 962 people, agreed or strongly agreed with the statement, "Brick streets calm traffic. Cars slow down, increasing safety for kids and pedestrians." Furthermore, roughly 60% of all respondents, 956 people, disagreed or strongly disagreed that with the statement, "Brick streets are loud, which I believe is a negative quality." Rather, in the open feedback section of the survey, respondents left appreciative comments about the noise from brick streets, including,

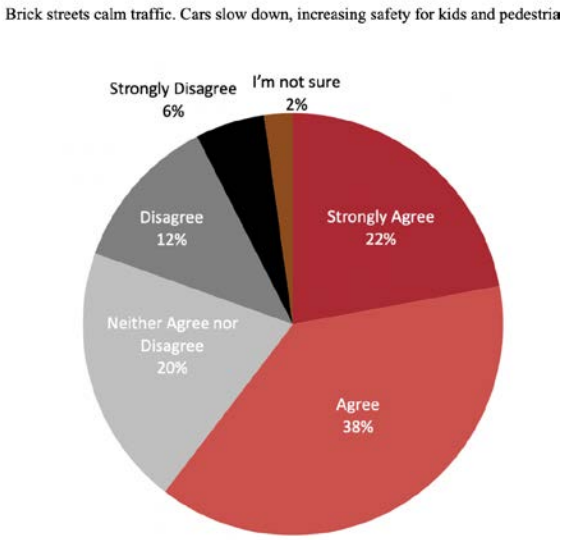

Figure 10: 60% of respondents agreed or strongly agreed that brick streets calm traffic.

> "[Brick streets are] far safer as a traffic warning. I witnessed this year a woman rescuing her child from being hit by a car because she heard the car coming on the brick street. They slow traffic, look better and never seem to need repair. I've been lucky enough to be in the same house for 40 years and NEVER needed the street repaired in front of my house. Historically, they should stay. In a city that is growing its history and uniqueness, they are a boon."

Well maintained brick streets are not dangerous. Additional survey findings indicated that the 79% of respondents agreed or strongly agreed that Mt. Lebanon's brick streets are generally in good repair. Brick streets were also not generally considered to be more dangerous for driving than asphalt streets. Over half of all respondents did not agree with the statement, "Brick streets are slicker than asphalt streets in weather conditions, which I believe is an issue." Furthermore, brick streets were reported to be an issue for personal mobility, as 73% of survey respondents, 1,165 people, disagreed or strongly disagreed with the statement, "Brick streets are challenging for me, from a personal mobility perspective."

word	count	relevance
charm	95	0.998
community	50	0.274
character	50	0.232
neighborhood	49	0.39

Table 1: Count and relevance of most frequently occurring words in survey comments

Financial Analysis

The financial analysis of brick streets includes a discussion of Mt. Lebanon's current budget, a life cycle cost analysis comparing preserving a brick street with reconstructing a brick street with asphalt, an appraisal of real estate values on and off brick streets, an understanding of brick storage, and a catalog of funding buckets available to preserve streets.

Abbreviation Table

Abbreviation	Explanation
OCI	Overall Condition Index
FT	Linear Feet, Feet
SF	Square Feet
SY	Square Yard. There are 9 square feet in 1 square yard.
LCC	Life Cycle Cost

Mt. Lebanon Municipal Budget Analysis

The 2020 municipal budget of $114,000 designated to brick streets preservation is sufficient to repair existing problem areas among brick streets. Data-driven efforts are needed to examine brick conditions regularly, however, and proactive maintenance plans should be implemented.

There are around 327 streets in Mt. Lebanon in total, which equates to 87 miles of municipal roads and paved alleys (Mt. Lebanon Streets n.d.)[24] (*2021 Manager's Recommended Budget* 2020)[25]. 76 of them are brick streets, and the remaining 251 are a mix of asphalt and concrete. Existing street types are:

- Asphalt/Brick
- Asphalt/Concrete
- Brick
- Concrete
- FD Asphalt

The municipality annually spends 6.5 times more on asphalt streets than on brick streets.

[24] Mt. Lebanon Pennsylvania. n.d. Streets A-D. https://www.mtlebanon.org/81/Streets-A-D
[25] Mt. Lebanon Pennsylvania. 2020. 2021 Manager's Recommended Budget http://mtlebanon.org/DocumentCenter/View/17868/2021-Managers-Recommended-Budget

	Brick	Asphalt
2020 Budget	$114,000	$700,000 - $1,000,000
Notes	The municipal budget for brick restoration doubled after 2019 from $50K to the current amount.[26] It allows the municipality to repair ~830 SY of brick streets.	The municipal budget for asphalt ranges from $700K to $1 million, which covers repair, overlay, bituminous pavement rejuvenation, and crack repairs. [27]

Table 2: Annual Budget Comparison between Brick and Asphalt

Unit costs for brick restoration are relatively higher. Therefore, the same amount of funds will allow the municipal to repair fewer square yards of brick streets. However, brick streets need much less maintenance over time. Once a patch is fixed, it can last for 50 years or more (Loukas 2020).[28] See Life Cycle Analysis for specific costs.

There are currently 45 brick streets with records about problem areas that require restoration, while the remaining 31 do not have recorded problem areas (*Brick Street Repairs* 2020).[29] Since 2016, 1,649 SY of brick streets have been restored (*Brick Street Repairs* 2020).[30] There are 475 SY of brick streets remaining with issues, which can be completed within one year's budget at a cost of $65,000.

Based on these facts, budget recommendations for the municipality include:

1. Continue repairing brick streets in small portions.
2. Identify and record addresses with issues on brick streets.
3. Prepare a three- to five- year maintenance plan for remaining sites on brick streets with issues and keep applying preventative maintenance. Aim to repair a minimum of 20% - 30% of the issue areas on brick streets each year.
4. Allocate a budget of at least $100,000 for brick street maintenance and repair. $100,000 is sufficient to repair the areas on brick streets that are currently listed with issues, as well as additional unexpected maintenance costs. The budget should be increased for brick repair if needed. See Funding Sources for financing opportunities.

[26] Ibid.
[27] Ibid.
[28] Loukas, N., Assistant City/Traffic Engineer in Canton, OH, in conversation with the authors, November 2020.
[29] *Brick Street Repairs 2020,* Spreadsheet shared by Mt Lebanon Public Works Director with the authors, November 2020.
[30] Ibid.

Life Cycle Cost Analysis

A life cycle cost analysis (LCCA) was conducted to understand the life cycle costs of brick streets in Mt. Lebanon under several scenarios. It shows that maintaining a brick street in Mt. Lebanon costs less than reconstructing a brick street with asphalt. One Mt. Lebanon brick street costs $200,000 less to maintain over a 50-year period than it would cost to reconstruct the street with asphalt. The brick street costs $280,000 less to maintain over a 100-year period than if it were reconstructed with asphalt.

Objective and Methodology of the Life Cycle Cost Analysis

The goal of this LCCA was to establish the relationship between upfront costs and long-term costs of brick and asphalt streets in Mt. Lebanon. Life cycle costing is a preferred term over life cycle analysis because a proper life cycle analysis would explore the life cycle of materials at a more granular level, accounting for aspects like the stored energy of bricks (Fleck 2020).[31] This was a street-level analysis to identify the costs that go into maintaining and reconstructing, including materials, labor, and potential useability lifespans.

First, scenarios were established for the municipality to consider. The analysis applies to brick streets that already exist. Therefore, the following decision scenarios apply:

1. Maintain a brick street.
2. Reconstruct a brick street completely to be an asphalt street.

There are various accounts of how long brick and asphalt streets last. Datasets and subject matter experts point to a range of 7 to 25 years for the lifespan of a residential asphalt street (Ricks 2020).[32] A figure of 20 years for an asphalt street was selected for both scenarios considering Mt. Lebanon's standards for asphalt streets are more robust than other communities (McGill 2020).[33] Datasets and experts point to a range of 50-100 years for residential brick streets (Piteo 2020)[34]

[31] Fleck, S., Sustainability Engineer/Consultant at 3R Sustainability, in conversation with the authors September 2020.
[32] Ricks K., Director of the City of Pittsburgh's Department of Mobility and Infrastructure, in conversation with the authors, September 2020.
[33] McGill, K., Municipal Manager of Mt. Lebanon, in conversation with the authors, October 2020.
[34] Piteo, J., Sales Manager Paving Products of the Belden Brick Company, in conversation with the authors, November 2020.

(Loukas 2020)[35] (*City of Columbia Brick Streets Policy Resolution FAQs 2015*).[36] To accommodate for this, the analysis offers the following time scenarios:

1. Increments of 50 years.
2. Increments of 100 years.

Assumptions regarding street conditions were based on averages in Mt. Lebanon (Sukal 2020).[37]

	Value	Unit
Length	720	Feet
Width	22	Feet
Depth	17	Inches
Area	15,680	Square Feet
	1,760	Square Yards
Percent needing repairs	15	Percent

Table 3: Brick Street Conditions based on Mt. Lebanon Average

15% of a brick street needing repairs translates to 264 SY of a single brick street in need of restoration. Most brick streets on record in Mt. Lebanon require a smaller area of restoration than 264 SY (*Brick Street Repairs* 2020).[38] The percentage of brick street repair can be modified at any time to examine different conditions of the LCCA.

Next, cost inputs were determined for the LCCA. The following sources informed the inputs, which will be expanded upon in the analysis:

- Mt. Lebanon 2021 Manager's Recommended Budget[39]

[35] Loukas, N., Assistant City/Traffic Engineer in Canton, OH, in conversation with the authors, November 2020.
[36] City of Columbia. 2014. *Brick Streets Policy Resolution FAQs*. https://www.como.gov/community-development/wp content/uploads/sites/14/2015/09/brickstreetsFAQ.pdf.
[37] Sukal, R., Mt. Lebanon Public Works Director, in conversation with the authors, November 2020.
[38] *Brick Street Repairs 2020*, Spreadsheet shared by Mt. Lebanon Public Works Director with the authors, November 2020.
[39] Mt. Lebanon Pennsylvania. 2020. *2021 Manager's Recommended Budget* http://mtlebanon.org/DocumentCenter/View/17868/2021-Managers-Recommended-Budget

- Municipality's contract with Cilenti for brick street maintenance program on 02/21/2020 (Clilenti provided the lowest bid for this program)[40]
- Niando Construction's bid in 2016 for reconstructing Morrison Drive from brick to asphalt (Niando Construction offered the lowest bid for this project)[41]
- Mt. Lebanon's Public Works Director[42]

Under scenario one, in addition to contractual maintenance to restore deteriorated brick street surfaces, there will be the contractual reconstruction of concrete curbs along brick streets and concrete base replacement. Over time, regular base repair and brick restoration are needed, assuming a 20-year frequency.

Under scenario two, the municipality would pay for upfront asphalt reconstruction, including brick removal, base repair, and asphalt overlay. Contractual curb replacement will happen in this stage to fix existing curbs as well. Then, asphalt overlay, or systematic repair takes place every 20 years. This resurfaces the entire asphalt street. Three different activities will happen once in this 20-year lifespan of a street:

1. Basic repairs that focus on the most seriously deteriorated asphalt street surface.
2. Crack repairs that seal and repair pavement cracks or joints.
3. Bituminous pavement rejuvenation.

Regardless of the road type, the municipality will deice the street with rock salt every winter and do pothole patching as needed. The difference is that brick streets generally require two to three times more rock salt than asphalt (Sukal 2020).[43]

The following tables detail the costs and frequency of each activity:

Brick Repair					
Category	**Total Cost**	**Unit Cost**	**Unit**	**Amt**	**Frequency**
Brick Restoration	35164.80	133.20	SY	264.00	One-time
Base Repair	924.00	70.00	SY	13.20	One-time
Curb Reconstruction	19349.71	100.00	LF	193.50	One-time

[40] *Municipality of Mt. Lebanon Brick Street Maintenance Program*, record of bid shared by Mt. Lebanon Public Works Director with the authors, November 2020.
[41] *Questions for Municipality re: Brick and Asphalt Street Repair/Replacement Data* shared by Gateway Engineers with the authors, October 2020.
[42] Sukal, R., Mt. Lebanon Public Works Director, in conversation with the authors, November 2020.

[43] Sukal, R., Mt. Lebanon Public Works Director, in conversation with the authors, November 2020.

Brick Restoration	23443.20	133.20	SY	176.00	Every 20 years
Partial Base Repair	660.00	50.00	SY	13.20	Every 20 years
Pothole Patching	0.00				Emergency
Deicing	495.63	79.30	Ton	6.25	Each winter, 2.5 times more than asphalt

Table 4: Costs in Maintaining a Brick Street (See Appendix D for full list of costs and assumptions)

Asphalt Reconstruction					
Category	**Total Cost**	**Unit Cost**	**Unit**	**Amt**	**Frequency**
Asphalt Reconstruction	210179.20	119.42	SY	1760.00	One-time
Curb Reconstruction	14512.28	75.00	LF	193.50	One-time
Asphalt Overlay (Systematic Repair)	41713.06	23.70	SY	1760.00	Every 20 years
Basic Repair	3645.18	41.42	SY	88.00	15 year after a resurfacing
Street Crack Repairs	2.10	1.05	LF	2.00	10 year after a resurfacing
Bituminous Pavement Rejuvenation	1830.40	1.04	SY	1760.00	10 year after a resurfacing
Pothole Patching	0.00				Emergency
Deicing	198.25	79.30	Ton	2.50	Each winter

Table 5: Costs in Reconstructing a Brick Street Completely to be an Asphalt Street (See Appendix D for full list of costs and assumptions)

The costs were discounted back to the present value with the present value formula, adjusting for inflation. Price escalation overtime was also considered given many commodities and services have prices that change at a rate away from the general inflation over time.

Present Value Formula

$$PV = F_t \times \frac{1}{(1+d)^{t}}$$

Where:
PV - present value

F_t - future cash amount occurring at the end of year t
d - real discount rate

Price Escalation Formula

$$C_t = C_0 \times (1 + e)^t$$

Where:
C_t- the cost of commodity and service at the end of year t
e - real price escalation rate

Choice of discount rate and escalation rate:
d = 0.35%
e = 0.83%

Discount rate: the 2020 real discount rate from OMB Circular A-94 Guidelines and Discount Rates for Benefit-cost Analysis of Federal Programs issued by the White House.[44]

Price escalation rate: the average 50-year GDP Price Deflator, which measures the changes in price for all goods and services produced in the economy.[45]

[44] *Discount rates for cost-effectiveness, lease purchase, and related analyses.* 2019. https://www.whitehouse.gov/wp-content/uploads/2019/12/Appendix-C.pdf
[45] Federal Reserve Economic Data. 2020. Gross Domestic Product: Implicit Price Deflator. https://fred.stlouisfed.org/series/GDPDEF

Discussion of the Life Cycle Analysis Results

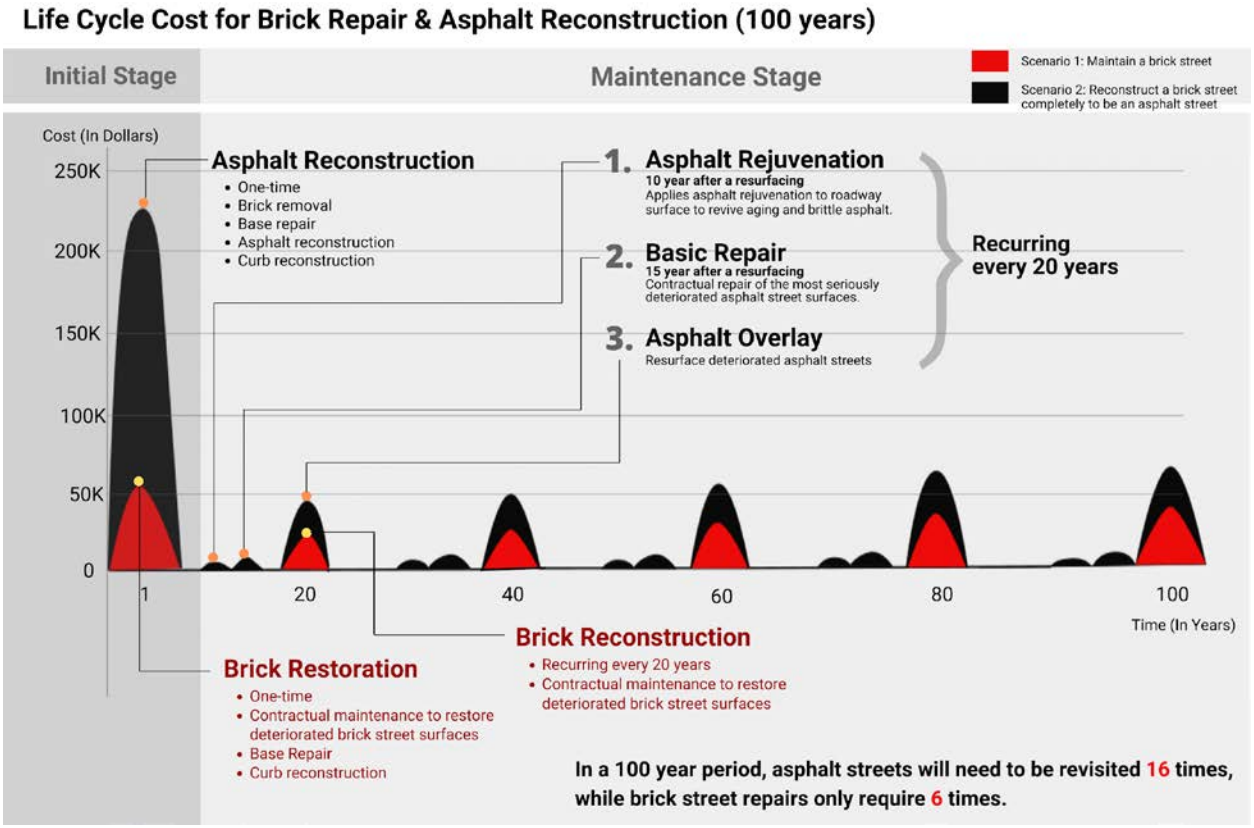

Figure 11: Life Cycle Cost for Brick Repair & Asphalt Reconstruction (100 years). Source: Author

Findings: According to this life cycle cost analysis, asphalt streets will need to be revisited for repairs more than two times (2x) more than brick streets. Over a 50-year period, one Mt. Lebanon brick street costs $208,462 less to maintain than it would cost to reconstruct and maintain an asphalt street. The cost difference increases to $284,721 over a 100-year period.

In conclusion, brick streets are more affordable to the municipality over 50- and 100-year periods than asphalt streets. Brick streets have higher unit costs, but they do not need to be repaired from end-to-end and from curb-to-curb. They require less surface area construction and less frequent maintenance than asphalt streets. While asphalt streets are cheaper to maintain once constructed, the reconstruction and repaving costs of maintenance of existing brick streets remain a financial barrier. This life cycle analysis, however, focuses primarily on materials, labor, and routine maintenance. For a more inclusive understanding of the financial value of brick streets, one must consider avoided costs, sustainability benefits, traffic calming benefits, and value added to the neighborhood. See Sustainability Analysis.

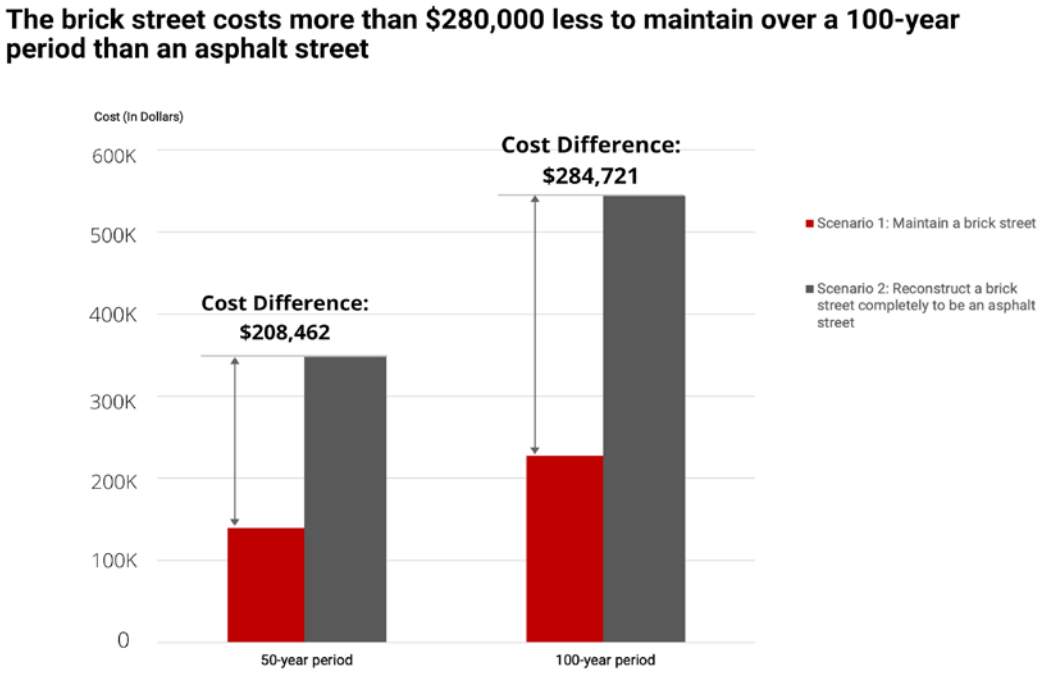

Figure 12: Cost Difference over a 50-year Period and 100-year Period. Source: Author

Additionally, maintaining a brick street remains more cost-effective even if the municipality were to pave over an existing brick street (i.e., instead of removing the bricks and reconstructing with asphalt). In this case, it would cost $39,194 less to maintain a brick street over a 50-year period, and it would cost $115,453 less to maintain a brick street over a 100-year period.

Real Estate Values

A complete assessment of the financial impact of brick streets includes their relationship with real estate values. From the survey, 84% of Mt. Lebanon residents that live on brick streets believe that brick streets enhance their property values. The pervasive belief in the real estate associations with brick streets is a strong argument and incentive to maintain the streets. Anthony Barba, a real estate appraiser based in Pittsburgh, PA, points to a "certain aura" around brick street neighborhoods that informs real estate values (Barba 2020).[46] However, working with a real estate appraiser to identify all property sales on and off brick streets would better inform this relationship, if one exists.

[46] Barba, A., of Integra Realty Resources Pittsburgh, in conversation with the authors, December 2020.

At the time of this study, there is not sufficient available data to establish statistically significant correlations between brick street and property values. The West Penn Multi List tracks data from property sales in the Pittsburgh region. That data source offers 2,100 property sales in Mt. Lebanon, and 84 of those sales were for homes on brick streets. From 2,100 sales, at least 334 sales of homes on brick streets are needed to confidently assess whether a property value association exists between these two variables.

Going forward, an appropriate methodology would require accessing data that spans more time than the last five years, be that data from the West Penn Multi List or another source. Assessing sales over the last 25 years may indicate more brick street sales. From there, one would need to confirm whether the street was brick or asphalt at the time of the sale and adjust the sales value to present value dollars.

Comparing property values on brick and asphalt streets specifically within the community of Mt. Lebanon would eliminate several important confounding variables like schools, crime rate, and amenities. In Mt. Lebanon, one could also conduct the analysis without outliers like Hoodridge Drive, a brick street with property values higher than average across Mt. Lebanon. In this limited analysis, the positive correlation between bricks and property values persisted without Hoodridge sales. Even so, the result of a more extensive analysis would be a correlation and not a causation. Nevertheless, it would be an effective estimate of brick streets' relationship with property values in Mt. Lebanon.

Image 4: In a limited analysis, brick streets correlated with higher property values even without outlier streets like Hoodridge Drive, pictured above.

Brick Storage

Another cost to consider is historic brick street storage. Historic bricks can be reused, and during reconstruction projects, bricks should be covered with tarps to minimize theft. Municipal staff from Canton, Ohio recommend paying contractors to clean and palletize the bricks. A pallet can be double- or triple-stacked to store 700-800 bricks in a 4' by 4' space (Johnston 2020).[47] The cost of sorting, cleaning, and palletizing is around $295 in total per pallet (Loukas 2020).[48]

[47] Johnston, R., Sales Manager of Indiana Brick, in conversation with the authors, November 2020.
[48] Loukas, N., Assistant City/Traffic Engineer in Canton, OH, in conversation with the authors, November 2020.

Funding Sources for Brick Streets

Multiple funding options are available to offset the upfront costs of brick streets. As previously noted, Mt. Lebanon residents have indicated a willingness to pay for brick streets in the Brick Street Preference survey. In fact, 82% of respondents were willing to pay at least $1 per household per year – with a majority willing to pay more than $10 per household per year, and many suggesting $50 per household. See Special Projects Fund Options, among other ideas.

Several grant programs that focus on historic preservation may be of assistance to Mt. Lebanon.

Historic Preservation Grants		
Grant Name	**Administering Agency**	**Description**
Keystone Historic Preservation Grants	Pennsylvania Historical & Museum Commission (PHMC)	Keystone Historic Preservation Grants supports projects that rehabilitate, restore, or preserve historic resources listed in or eligible for listing in the National Register of Historic Places. Funding is available to nonprofit organizations and local governments for small construction projects for publicly accessible historic resources (PHMC n.d.)[49]
Certified Local Government Grant Program (CLG)	Pennsylvania Historical & Museum Commission (PHMC)	CLG provides financial support to promote and support effective historic preservation programs and policies in Pennsylvania municipalities. Project grants may be up to $25,000 and a cash match equal to either 10% or 25% of the total project cost, depending on the type of activity being funded (PHMC n.d.) [50]

Based on resident responses, brick streets foster community identity and drive economic development. Therefore, another important funding source is community development grant

[49] Pennsylvania Historical and Museum Commission. n.d. *Keystone Historic Preservation Construction Grants.* https://www.phmc.pa.gov/Preservation/Grants-Funding/Pages/Construction-Projects.aspx#.Vi-CrtKrRD8

[50] Pennsylvania Historical and Museum Commission. n.d. *Certified Local Government Grant Program.* https://www.phmc.pa.gov/Preservation/Grants-Funding/Pages/Certified-Local-Government.aspx

programs such as the Community Development Block Grant (CDBG), which can be used for community/public facilities improvement projects.

Community Development Grants		
Grant Name	**Administering Agency**	**Description**
Community Development Block Grant (CDBG)	Allegheny County Economic Development (ACED)	Funded by the U. S. Department of Housing & Urban Development (HUD), CDBG are available for eligible economic development, municipal public improvements, housing and human services projects and programs. A pre-application is required when applying for public improvement funds, which includes sewer and water, street construction, catch basins, recreation, demolition, and ADA improvements. Pre-applications must be submitted to ACEDCDBGProgram@alleghenycounty.us (*ACED* n.d.) [51]
The Neighborhood Initiatives Fund Program (NIF)	The Urban Redevelopment Authority of Pittsburgh (URA)	NIF is intended to assist nonprofits, including government agencies, and community-based organizations with neighborhood-scale projects. These projects include efforts that encourage neighborhood investment through vacant property reclamation and stewardship, historic preservation, brownfield redevelopment, public infrastructure improvements, and/or other eligible efforts (*URA* n.d.).[52]

[51]Allegheny County Economic Development. n.d. *Community Development Block Grant* https://www.alleghenycounty.us/economic-development/communities/cdbg/cdbg-grants.aspx

[52] Urban Redevelopment Authority of Pittsburgh. n.d. *The Neighborhood Initiatives Fund Program* https://www.ura.org/pages/neighborhood-initiatives-fund

Redevelopment Assistance Capital Program (RACP)	Pennsylvania Governor's Office of the Budget	RACP is a Commonwealth grant program administered by the Governor's Office of the Budget for the acquisition and construction of regional economic, cultural, civic, recreational, and historical improvement projects. All grants awarded through the Redevelopment Assistance Capital Program (RACP) must be for projects included in one or more of the PA Capital Budget Project Itemization Acts (*PA Budget* n.d.).[53]
Keystone Communities (KC) program	Pennsylvania Department of Community and Economic Development	The Keystone Communities Program Development Grants are available to fund a variety of activities including public infrastructure improvements such as road rehabilitation or construction, streetscape improvements, and water and sewer improvements. Development grants may not exceed $500,000 or 30% of project costs, whichever is less (*PA Department of Community and Economic Development* n.d.). [54]

[53] Pennsylvania Governor's Office of the Budget. n.d. *Redevelopment Assistance Capital Program* https://www.budget.pa.gov/Programs/RACP/Pages/Main%20Page.aspx

[54]Pennsylvania Department of Community and Economic Development. n.d. *Keystone Communities (KC) program* https://dced.pa.gov/programs/keystone-communities-program-kcp/#:~:text=The%20Keystone%20Communities%20(KC)%20program,and%20secure%20quality%20of%20life

Image 5: Parker Drive in Mt. Lebanon, Source: Skelly & Loy Inc.

A variety of state/federal grant programs are available for local infrastructure. To finance brick street repair projects, it is recommended that the municipality to apply for the following grants for streets maintenance/transportation enhancements.

Transportation Grants		
Grant Name	**Administering Agency**	**Description**
Municipal Liquid Fuels Program	Pennsylvania Department of Transportation	The Municipal and County Liquid Fuels Programs support maintenance and construction efforts on locally owned roads, streets, and bridges (*PennDOT* n.d.).[55]

[55] Pennsylvania Department of Transportation. n.d. *Municipal Liquid Fuels Program* https://www.penndot.gov/Doing-Business/LocalGovernment/LiquidFuels/Pages/default.aspx

Multimodal Transportation Fund (MTF)	Pennsylvania Department of Community and Economic Development	MTF provides grants to encourage economic development and ensure that a safe and reliable system of transportation is available to the residents of the Commonwealth. Funds may be used for the development, rehabilitation and enhancement of transportation assets to existing communities, streetscape, lighting, sidewalk enhancement, pedestrian safety, connectivity of transportation assets and transit-oriented development (*PA Department of Community and Economic Development* n.d.). [56]
Better Utilizing Investments to Leverage Development, or BUILD Transportation Discretionary Grant program	U.S. Department of Transportation (DOT)	BUILD Grants program provides a unique opportunity for the DOT to invest in road, rail, transit and port projects that promise to achieve national objectives (U.S. DoT 2020). [57]
Transportation Alternatives Program (TAP)	Pennsylvania Department of Transportation	The TAP provides funding for programs and projects defined as transportation alternatives, including on- and off-road pedestrian and bicycle facilities, infrastructure projects for improving non-driver access to public transportation and enhanced mobility, community improvement activities, and environmental mitigation, trails that serve a transportation purpose, and safe routes to school projects (PennDOT n.d.)[58]

[56]Pennsylvania Department of Community and Economic Development. n.d. *Multimodal Transportation Fund* https://dced.pa.gov/programs/multimodal-transportation-fund/

[57] U.S. Department of Transportation. 2020. *About BUILD Grants*. https://www.transportation.gov/BUILDgrants/about

[58]Pennsylvania Department of Transportation. n.d. *Transportation Alternatives Program* https://www.penndot.gov/ProjectAndPrograms/Planning/Pages/Transportation-Alternatives-Program.aspx#:~:text=The%20Transportation%20Alternatives%20Program%20(TAP,into%20a%20single%20funding%20source.

A Special Projects Fund, financed by taxes, among other possible sources, may be options for the municipality to consider.

Special Projects Fund Options		
Option	**Description**	**Example**
Real Estate Transfer Tax	Real estate transfer taxes are a one-time tax or fee imposed by a state or local jurisdiction upon the transfer of real property.	Middlesex, PA levied real estate transfer taxes to raise a cash reserve fund (Fodi 2020).[59]
Local Option Sales Taxes (LOST)	Local option sales taxes are often used as a tool of raising funds dedicated to specific local projects with local priorities, such as streets and roads improvements projects, or downtown refurbishment. LOST is considered a fairly stable and predictable revenue source. Additionally, it makes administration easier because it "piggybacks off of an existing tax" (Chen & Bartle 2017).[60] However, LOST may favor capital construction over regular maintenance activities.	About 250 cities have levied a Local Option Sales Tax, with funds limited to maintaining and repairing municipal streets and sidewalks (DuPuis & McFarland 2016).[61]
Special Assessment Tax	A special assessment tax is a surtax levied on property owners to pay for specific local infrastructure projects, such as the construction or maintenance of	Cities that issue Special Assessment include Kansas City, MO, Bloomington, MN, Madison, WI, etc.

[59] Fodi, S., Borough Manager of Oakmont, PA, in conversation with the authors, September 2020.

[60] Chen, C. and Bartle, J. 2017. *INFRASTRUCTURE FINANCING: A Guide for Local Government Managers* A Policy Issue White Paper for ICMA (International City/County Management Association) and GFOA (Government Finance Officers Association).

[61] DuPuis, N. and McFarland, C. 2016. *Rep. Paying for Local Infrastructure in a New Era of Federalism*. National League of Cities.

	roads or sewer lines (Kagan 2020).[62] A Special Assessment Tax matches payments with benefits within a designated geographic area. However, it requires legislative approval.	
Stabilization Funds	Stabilization funds for special purposes can be an effective tool for municipalities to pay for the costs of street repair and maintenance programs. Special purpose stabilization funds offer strategic mechanisms to think thoughtfully and plan for future costs.	Massachusetts: 'Under M.G.L. c. 40 §5B, municipalities can create multiple stabilization funds, assign a different purpose to each, and take advantage of a unique funding option.'
Other common options	Some common funding sources for special projects include: Gas Taxes, or state taxes on gasoline, Motor Vehicle Registrations Fees, and a Stormwater Utility Tax.	

Other creative funding strategies can be considered as well.

Other Funding Strategies		
Option	**Description**	**Examples**
Foundation and non-profit organizations	Many public and private foundations' primary areas of giving are historic preservation, placemaking, and community development, which aligns with brick streets. As of April 2020, the number of foundations in the U.S. was	Avedis Foundation "Walk With Me" Grant Bloomberg Foundation Street Murals Initiative

[62] Kagan, J. 2020. *Special Assessment Tax*. Ivestopedia. https://www.investopedia.com/terms/s/specialassessmenttax.asp#:~:text=A%20special%20assessment%20tax%20is,will%20benefit%20from%20the%20project.

	119,791 (*Candid* 2020).[63] To find the foundations and grantmaking institutions most likely to fund brick streets preservation, the municipality can use online research tools such as Foundation Directory Online (https://fconline.foundationcenter.org/). Some of the grants can be competitive due to limited funding and high volume of applications. According to an interview with the Pittsburgh History & Landmarks Foundation (PHLF), the foundation might be able to provide assistance (Sriprasert 2020).[64]	
Crowdfunding	Crowdfunding has become increasingly popular for raising funds for relatively small municipal infrastructure projects. (Chen & Bartle, 2017)[65]	Projects that have successfully utilized crowdfunding include: a new protected bike lane on Arapahoe Street in Denver, the London sculpture walk, and the historic arches restoration project for Madeira Terrace in Brighton, UK.
New credit assistance tools	Several credit assistance tools including the Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA) Credit Assistance, Environmental State Revolving Funds (SRFs), State Infrastructure Banks (SIBs) provide credit assistance in the form of loans with	Green Street Project in Toledo, OH

[63] Candid. 2020. *Key Facts on U.S. Nonprofits and Foundations.* https://www.issuelab.org/resources/36381/36381.pdf
[64] Sriprasert, M., President of PHLF, in conversation with the authors, October 2020.
[65] Chen, C. and Bartle, J. 2017. *INFRASTRUCTURE FINANCING: A Guide for Local Government Managers* A Policy Issue White Paper for ICMA (International City/County Management Association) and GFOA (Government Finance Officers Association).

	low interest rates.	
Public-private partnerships (P3s)	P3s are increasingly popular in infrastructure projects for local governments. The National Institute of Governmental Purchasing (NIGP) defines P3s as a class of facility and infrastructure contracts that includes minimal components of design, such as construction, renovation, or rehabilitation in a single contract. (NIGP 2016)[66]	State of Pennsylvania Small Bridge Renovation and Repair (design-build-finance-maintain P3 program) (PennDOT n.d.) [67]

Sustainability Analysis

Historic brick streets provide environmental benefits such as reducing the speed of stormwater runoff entering sewer systems as well as reducing the impact of urban heat island effects. Additionally, preserving brick streets contributes to a circular economy, as bricks can be palletized and reused for over 100 years (Piteo 2020).[68]

Stormwater Management

Combined sewer overflows occur when a mixture of untreated wastewater and stormwater runoff discharges from a combined sewer system into public space, such as streets or waterways (Fischbach et al 2017).[69] Within the Allegheny County Sanitary Authority's (ALCOSAN)

[66] National Institute of Governmental Purchasing. 2016. Public-Private Partnership (P3): Facilities & Infrastructure. https://www.nigp.org/resource/global-best-practices/Public-Private%2520Partnership%2520P3%2520Facilities%2520and%2520Infrastructure%2520Best%2520Practice.pdf

[67] Pennsylvania Department of Transportation. n.d. *Rapid Bridge Replacement Project.* https://www.penndot.gov/ProjectAndPrograms/p3forpa/Pages/Rapid-Bridge-Replacement-Project.aspx

[68] Piteo, J., Sales Manager Paving Products of the Belden Brick Company, in conversation with the authors, November 2020.

[69] Fischbach J. R., Siler-Evans K., Tierney D., Wilson M. T., Cook L. M., & May L. W. 2017. *Robust Stormwater Management in the Pittsburgh Region*. Rand Corporation.

service area, there are 251 combined sewer discharge outfalls (*ALCOSAN Clean Water Plan* 2019).[70] It is estimated that nine billion gallons of sewage overflow enters Pittsburgh's rivers and streams during heavy wet weather events (ALCOSAN "Our Plan" n.d.).[71] These overflows create public health, environmental, and aesthetic problems. Furthermore, combined sewer overflows violate county, state, and federal laws and regulations, including the U.S. Clean Water Act (33 U.S.C. 1251) (Fischbach et al 2017).[72]

Based on historical data, annual precipitation in the Pittsburgh area has increased over time (*Climate Explorer Tool* 2020, see Figure 13).[73] Studies projecting the future sewer overflow vulnerability for municipalities in the ALCOSAN service area suggest that increased precipitation will likely cause higher volumes of combined sewer overflows (Fischbach et al 2017).[74]

Asphalt surfaces, including roads and pavements, allow stormwater runoff to quickly overwhelm the capacity of combined sewer systems. Conversely, brick streets slow the flow of stormwater runoff (Ricks 2020).[75] The rough texture of historic brick streets temporarily stalls stormwater from entering the sewer system which can reduce sewer overflow events.

To minimize sewer overflows and help control flooding, brick and block stone streets have been preserved or newly installed in cities around the U.S., including in Pittsburgh, PA (Ricks 2020, see Case Studies)[76] and Atlanta, GA (Turner 2015).[77]

[70] ALCOSAN. 2019. *Clean Water Plan*. https://www.alcosan.org/our-plan/plan-documents/clean-water-plan
[71] ALCOSAN. (n.d.). *Our Plan*. Retrieved November 5, 2020, from https://www.alcosan.org/our-plan
[72] Ibid, Fischbach, J. p. xi
[73] Climate Explorer Tool. (2020). Pittsburgh, PA Station id: EMSWORTH L/D OHIO RIVER Station: USC00362574. https://crt-climate-explorer.nemac.org
[74] Ibid, Fischbach, J. p. 57
[75] Ricks K., Director of the City of Pittsburgh's Department of Mobility and Infrastructure, in conversation with the authors, September 2020.
[76] Ibid, in reference to Joncaire street.
[77] Turner, K. 2015. *What's the Deal with the New Brick Streets near Turner Field?* Curbed Atlanta.

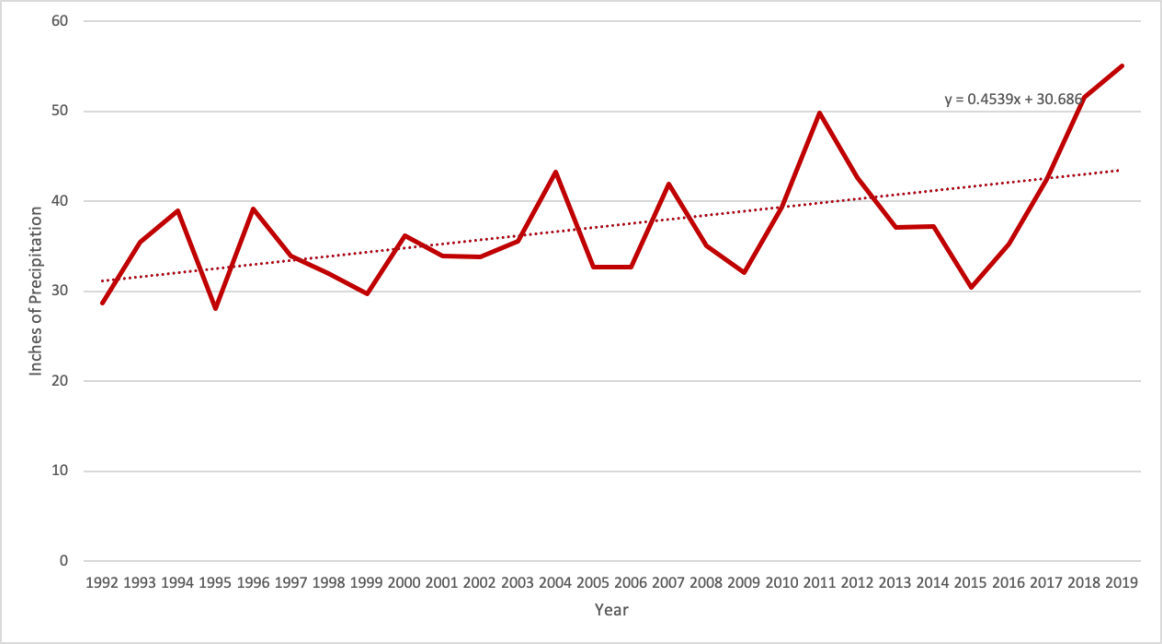

Figure 13: Cumulative Annual Precipitation in Pittsburgh (1992-2019). Source: Author

Figure 13, above, was created with data from the Climate Explorer Tool, which sources its data from the Global Historical Climatology Network-Daily dataset. This data provides freely available and accessible graphs and maps of historical and projected climate variables for any county in the contiguous United States.

Reduced Urban Heat Island Effects

The urban heat island (UHI) effect is used to describe the higher temperatures experienced in urban areas as compared to rural areas, in part due to the higher capacity of buildings, roads, and other infrastructure to absorb and re-emit the sun's heat than forests, bodies of water, or other natural landscapes (*EPA* n.d.).[78] The UHI effect can increase urban air temperature by between 5 and 15°C (Santamouris 2013).[79] Temperature increases from UHI effects not only cause environmental problems, but also impact public health and well-being by way of increasing

[78] U.S. EPA. n.d. *Heat Island Effect.* https://www.epa.gov/heatislands

[79] Santamouris M. 2013. *Energy and Climate in the Urban Built Environment. Energy and Climate in the Urban Built Environment.* 1st ed. Routledge.

thermal stress and degrading air quality (Grimmond 2007)[80] (Mohajerani, Bakaric & Jeffrey-Bailey 2017).[81]

A consistent UHI mitigation recommendation is to replace dark materials with lighter materials to increase solar reflectivity and decrease heat absorption. Paved surfaces and roads account for a greater percentage of increased surface temperatures per unit volume compared to any other man-made material or structure (Golden & Kaloush 2016).[82] Moreover, on summer days, asphalt is heated, "to a considerably higher extent than other materials" (Asaeda, Thanh Ca, & Wake 1996).[83] Brick streets, especially the tan and yellow bricks found in Mt. Lebanon, have a lighter surface color, and therefore a lower albedo than asphalt streets. With increasing projected temperatures for the Pittsburgh region (*Climate Explorer Too*l 2020, see Figure 14),[84] the UHI impact is likely to become more severe. Limiting asphalt surface area by preserving brick streets can help reduce the heating of Mt. Lebanon's microclimate.

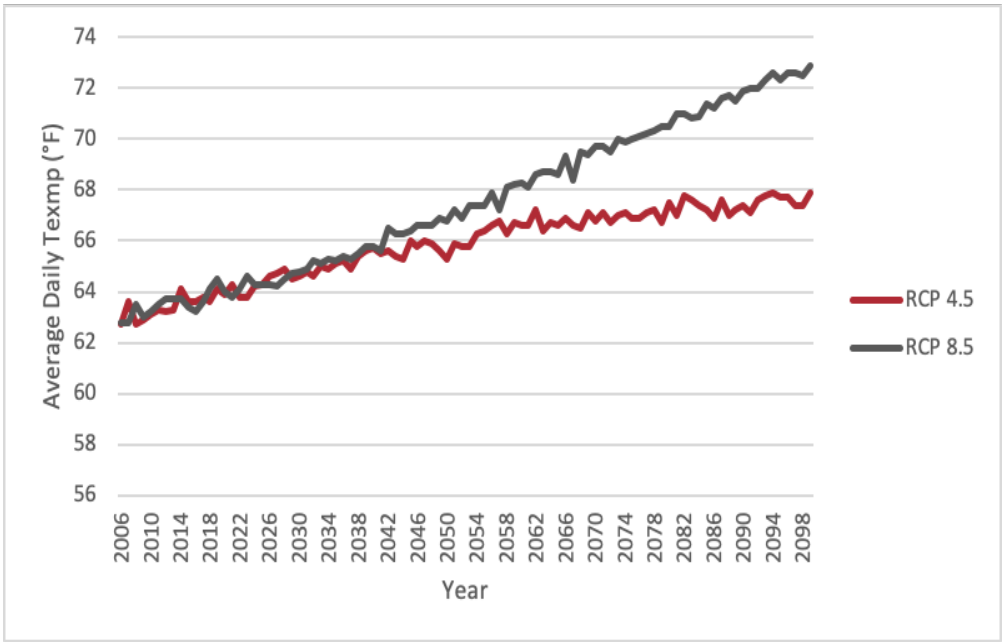

Figure 4. Projected Average Daily Temperature for Pittsburgh, PA Given Low and High Greenhouse Gas Emission Scenarios. Source: Author

[80] Grimmond, S. 2007. "Urbanization and Global Environmental Change: Local Effects of Urban Warming." *The Geographical journal* 173, no. 1,: 83–88.
[81] Mohajerani, Bakaric J., Jeffrey-Bailey, T. 2017. "The Urban Heat Island Effect, Its Causes, and Mitigation, with Reference to the Thermal Properties of Asphalt Concrete." Journal of environmental management 197: 522–538.
[82] Golden J., Kaloush K.E. 2013., *Mesoscale and microscale evaluation of surface pavement impacts on the urban heat island effects* Int. J. Pavement Eng., 7 (1).
[83] Asaeda T., Thanh Ca V., Wake A., 1996. "Heat Storage of Pavement and Its Effect on the Lower Atmosphere." *Atmospheric environment*, 1994: 30, no. 3: 413–427.
[84] Ibid. *Climate Explorer Tool.*

The data for Figure 4 was accessed from the Climate Explorer Tool, which sources its data from the Global Historical Climatology Network-Daily dataset.

The RCP 4.5 line shows the weighted mean of projected results of 19 climate models under Representative Carbon Pathway 4.5, RCP 4.5, a scenario with radiative forcing of 4.5 W/m^2 in the year 2100 that serves as a low greenhouse gas emission pathway.

The RCP 8.5 line shows the weighted mean of projected results of 20 climate models under Representative Carbon Pathway 8.5, RCP 8.5, a scenario with radiative forcing of 8.5 W/m^2 in the year 2100 that serves as a high greenhouse gas emission pathway.

Reusability of Bricks

Bricks have the potential to be reused for over 100 years (Piteo 2020).[85] As a result, if bricks are palletized and stored locally, brick street maintenance work can use entirely recycled historic bricks.

Comparatively, asphalt in Pennsylvania is typically made of between 15-50% recycled material (Henrich 2020).[86] Therefore, between 50-85% of asphalt that is used for reconstruction and maintenance work consists of new materials. Based on size estimations of asphalt street reconstruction and resurfacing jobs in Mt Lebanon (see Appendix E), the volume of asphalt needed per resurfacing and reconstruction job is approximately 300 tons and 1,500 tons, respectively. Consequently, approximately 150-255 tons of new materials including binder, filler, and aggregates processed from mineral materials such as crushed rock, sand, gravel, and slags must be processed and transported to the construction site every time an asphalt street is resurfaced. For asphalt street reconstruction, the volume of new materials needed increases to approximately 750-1,275 tons.

Salvaging bricks from sections of streets designated for deconstruction and then palletizing them for reuse in future projects minimizes resource inputs. Brick industry experts report that storage space for palletized bricks can be as minimal as 4’ by 4’ (Johnston 2020).[87] Costs for brick storage are low as well, being roughly $295 in total per pallet (Loukas 2020).[88]

[85] Piteo, J., Sales Manager Paving Products at The Belden Brick Company, in conversation with the authors of this report, November 2020.
[86] Henrich, H., Sr. Salesman at Eurovia Atlantic Coast LLC dba Northeast Paving, in conversation with the authors of this report, December 2020.
[87] Johnston, R., Sales Manager of Indiana Brick, in conversation with the authors, November 2020.
[88] Loukas, N., Assistant City/Traffic Engineer in Canton, OH, in conversation with the authors, November 2020.

Image 6: A brick pallet, shown above, requires 4 x 4 feet, and it can cost less than $300 to clean and assemble historic bricks for storage

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Case Studies

This paper has established that brick streets are popular among Mt. Lebanon residents, offer sustainability and traffic calming benefits, and cost less to maintain than reconstructing a brick street with asphalt. There is still, however, the question of best practices once a city commits to brick streets. What do other cities' preservation and maintenance procedures look like? Six case studies track key decision-making factors on brick streets in other cities, many with similar weather patterns and topography to Mt. Lebanon.

Lafayette, Indiana: Citizen engagement leads to brick preservation.

A few passionate residents can galvanize a community to protect brick streets. For Lafayette Indiana, Ken Jones was that passionate resident. As the Vice President of Lafayette's Highland Park Neighborhood Association, Jones assumed there were brick street protection ordinances on the books. In 2016, he and many other Lafayette residents were shocked by the deconstruction of North Sixth Street, one of only 10 brick streets that remained in the city (Jones 2020).[89] To protect the final nine, Jones presented to the Lafayette City Council on why they should preserve brick streets, citing their life cycle benefits, sustainability, and aesthetic charms.

In 2017, the city council approved the ordinance in a unanimous vote. With the ordinance, the remaining brick streets in Lafayette will be restored and maintained. Jones conceded, however, on the materials used for the streets, accepting new brick pavers instead of historic bricks. He also conceded any potential for new brick street construction (Jones 2020).[90]

[89] Jones, K., Vice President of Lafayette's Highland Park Neighborhood Association, in conversation with the authors, September 2020.
[90] Ibid.

Image 7: The deconstruction of North Sixth Street in Lafayette Indiana prompted a successful call for preservation by resident Ken Jones. Source: Journal & Courier.

There are several parallels between Jones' process and the Mt. Lebanon process. An unexpected street repaving brought the discussion before municipal leaders, who then discussed the bounds of brick street preservation. Also, similarly, the city did not decide to construct new brick streets; they committed to protecting assets that already exist. A critical difference, however, is the lack of availability of materials that meet Lafayette's historic brick street standards. Mt. Lebanon has access to bricks that meet their historic specifications within 100 miles, along with bricklayers available to do the proper installation (Piteo 2020)[91] (Riffe 2020).[92]

Broadly, the case of Lafayette's ordinance highlights the power of citizen engagement. Jones' passion and persuasion brought forth new policy. In some cities, however, policy has not been essential to brick street preservation.

Buffalo, NY: Engineers maintain brick streets based on nearby resident preferences.

Michael Finn, the Commissioner of Public Works for the City of Buffalo, New York, uses case-by-case citizen outreach on brick street maintenance prioritization. While the city has embraced maintaining brick streets with this strategy for decades, residents called for the restoration of brick streets covered by asphalt in 2013. Ardmore Avenue was originally a brick street that was

[91] Piteo, J., Sales Manager Paving Products of the Belden Brick Company, in conversation with the authors, November 2020.
[92] Riffe, S., Concrete Estimator at Kishmo Inc., in conversation with the authors, November 2020.

paved in asphalt in the 1960s, which was met with resistance by residents at the time (Finn 2020).[93] When Ardmore Avenue's asphalt began to chip away in 2013, the city planned to repave it. Residents, however, demanded the brick be restored and took gardening tools and hoses to the streets to remove remaining asphalt. The city responded to resident preferences and restored the street.

Buffalo follows this strategy of adopting citizen preferences. They consult with residents on a brick street when it needs to be maintained, and they adopt the course of action recommended by the residents (Finn 2020).[94]

Images 8&9: Buffalo residents chip away at asphalt over brick streets. Source: The Buffalo News

[93] Finn, M., Commissioner of Public Works in the City of Buffalo, in conversation with the authors, October 2020.
[94] Ibid.

There are advantages and disadvantages to this strategy. For advantages, a clear communication plan mitigates potential citizen backlash. The disadvantage, however, is that consulting only with current residents on the street fails to capture the inclusive benefits of brick streets. This is a street-level assessment of the street's value, rather than a community-level assessment of the street's value. A few residents' asphalt preference may cause a permanent loss of a brick street. Ardmore is a rare exception of restoration; there is little budgetary room to restore a brick street once it is paved. While this generation of homeowners may prefer asphalt, the next may not.

Image 10: Timon Street in Buffalo, New York. Source: David Steele

Informal brick maintenance also largely depends on the views of the municipal decision-maker. Buffalo's brick streets remain because Michael Finn's decision-making hinges on citizen preferences. The next person in Finn's position, however, may make decisions without considering resident preference. Institutionalizing the maintenance would minimize the variability among municipal decision-making strategies.

Resident interest played a key role in maintaining brick streets in Buffalo and Lafayette, but that is not always the primary motivator for a city to resist asphalt paving.

Pittsburgh, PA: Stormwater management is reason enough to avoid paving with asphalt.

Karina Ricks, director of Pittsburgh's Department of Mobility and Infrastructure, emphasized that the question of paving a brick street depends on what problem a community is trying to solve. The City of Pittsburgh, she noted, has 1,200 centerline miles of streets. Of those, 350 are non-asphalt, the vast majority of those are concrete, and the rest are mostly brick and block stone (Ricks 2020).[95]

[95] Ricks K., Director of the City of Pittsburgh's Department of Mobility and Infrastructure, in conversation with the authors, September 2020.

Why not just pave the rest? Ricks emphasizes differing needs. Areas that undergo large volumes of heavy truck and bus traffic are not suitable for brick, because they often have sand bases that are vulnerable to damage from large vehicles, and they will require more routine maintenance than a residential brick street (Ricks 2020).[96] A residential area, however, that undergoes less heavy truck and bus traffic is appropriate for bricks. Karina noted, "it would be better to tell the low-density residential area developer they need to build brick or block stone streets, so the city won't have to do a thing for 60-80 years" (Ricks 2020).[97]

Stormwater management, for the City of Pittsburgh, is a strong reason to avoid paving with asphalt. Joncaire Street is a block stone street in the Central Oakland neighborhood. Residents signed and submitted a petition in 2019 to pave the street because of its bumpiness, slipperiness, and bicycling difficulty. Ricks noted:

> We made the decision that we are not going to overlay the street, because we don't think that's right to overlay historical materials, particularly when they are in good condition. [The] other thing is that once it is overlaid, it is really hard to reclaim brick streets once you laid asphalt on it. The most important [element] was because of the slope … It's one of our areas experiencing a lot of combined sewer overflow. So stormwater management is a huge issue. We couldn't defend overlaying a street that would then make our stormwater management issues more difficult. It was a value decision and stormwater decision (Ricks 2020).[98]

[96] Ibid.
[97] Ibid.
[98] Ibid.

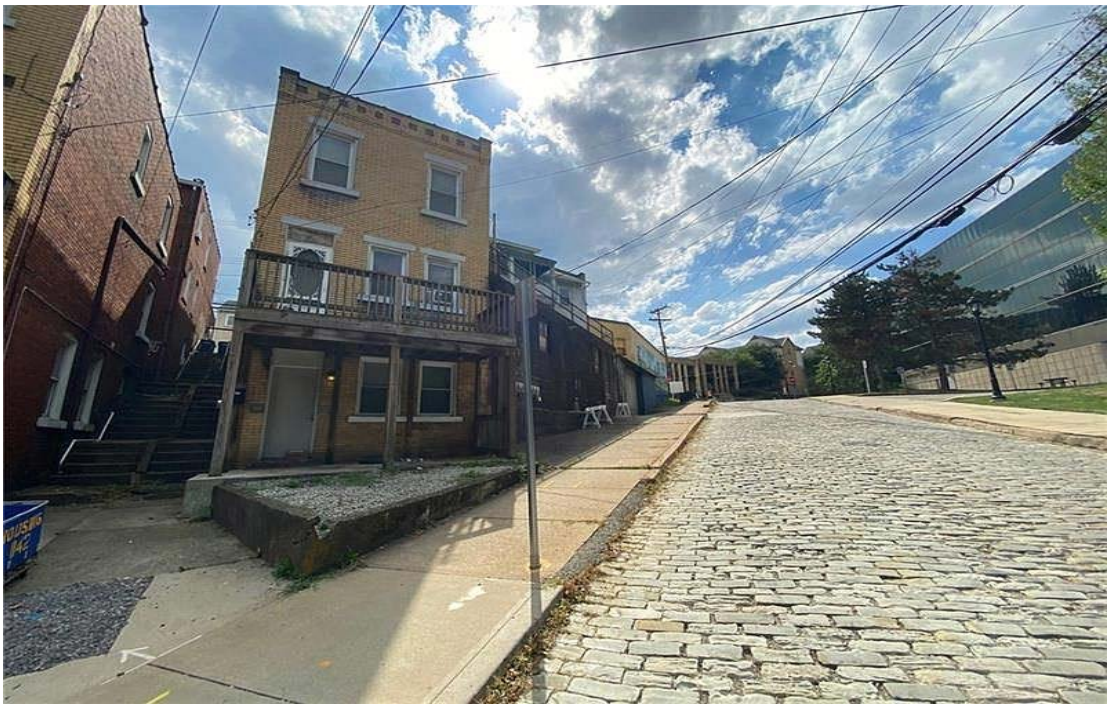

Image 11: Pittsburgh will not pave Joncaire Street because it would create significant sewage overflow. Source: Zillow

For Ricks and for the City of Pittsburgh, a given street's function and circumstances inform whether it should be paved. What types of traffic does it serve? Do stormwater benefits outweigh perceived costs by residents? Are the current materials historic and worth preserving? For the Department of Mobility and Infrastructure in Pittsburgh, they consider all of these factors for more holistic decision-making.

While the survey analysis established the overwhelming support that Mt. Lebanon residents have for brick streets, it is worth emphasizing that Pittsburgh has avoided asphalt pavement despite resident preference, given certain stormwater benefits.

Philadelphia, PA: Utilize existing resources.

In Philadelphia, there is not a question of whether to protect historic streets, but on how to protect them most affordably. Stephen Lorenz is the Chief Highway Manager for the City of Philadelphia. In 2013, the city formalized a commitment to their Historic Commission to keep cobblestone and brick streets in better repair. Their strategy was to reconstruct at least one block every two years with Capital Improvement money, a project that required between $700,00-

800,000 (Lorenz 2020).[99] One way that they minimize cost is to salvage bricks from other projects, ensuring reducing brick quantities needed per project.

Philadelphia's effort highlights the benefits of the salvageability of historic brick and the advantages of utilizing creative funding strategies to offset upfront costs. For Mt. Lebanon specifically, however, the projects would not be as large those that Philadelphia undertakes. While Philadelphia operates its brick street maintenance in increments of entire blocks, Mt. Lebanon can focus on smaller street segments.

Image 12: Workers repave a road in Germantown, Philadelphia. Source: The W. Rockland Street Project

Oakmont, PA: A brick street can inform a community's identity.

Oakmont is a suburb of Pittsburgh whose Borough Manager, Scott Fodi, emphasized the "charm" of a brick street and its importance to the overall character of the community. Allegheny

[99] Lorenz, S., Chief Highway Manager for the City of Philadelphia, in conversation with the authors, October 2020.

River Boulevard, the town's primary business thoroughfare, is paved with brick. When asked why they maintain this large brick street, Scott Fodi answered:

> I think Allegheny River Boulevard grabs a lot of attention fiscally and emotionally; the Boulevard wouldn't be the Boulevard if it wasn't brick. It's an emotional thing that it looks like an old town, with sidewalks, trees, and you are near the country club. But it slows the traffic down because we don't have asphalt. The bricks slow them down. (Fodi 2020).[100]

In Oakmont, the brick centerpiece stays for both feeling and function. The brick street evokes an image of a calmer, older town, and it literally calms the town by slowing traffic upwards of 10 to 15 miles per hour (Fodi 2020). [101]

How does Oakmont approach maintaining Allegheny River Boulevard and its other dozen brick streets? Fodi recommends budgeting repairs in units of hundreds of feet. He also recommends multi-year planning, preventative maintenance of roads in decent condition, and using capital improvement funds for roads that need more reactive reconstruction.

Image 13: Allegheny River Boulevard in Oakmont, PA. Source: PittsburghBeautiful.com

[100] Fodi, S., Borough Manager of Oakmont, PA, in conversation with the authors, September 2020.
[101] Ibid.

Canton, Ohio: Engineer preference can determine the fate of a street.

While other cities proved that strategic fiscal planning, resident preferences, sustainability considerations, and portioned maintenance all inform successful brick street preservation, Canton, Ohio evinced the importance of opinions within a municipal staff. Nick Loukas is the Assistant City/Traffic Engineer for the City of Canton. In Canton, brick street preservation is a matter of understanding the life cycle benefits of brick streets and of the opinions of the municipal staff.

When asked about brick streets, Nick said, "I grew up on brick streets. I like them. We've convinced the city of the value of brick streets" (Loukas 2020).[102] However, convincing city leaders often requires more than just liking brick streets. He confirmed that it is realistic to view brick streets as going untouched, once maintained, for more than 50 years. He prepared high level life cycle costs for the city and garnered buy-in from city leaders based on the life cycles and aesthetic of the brick streets.

Strategically, Canton categorizes brick streets as historic and non-historic. Canton conducts maintenance on non-historic brick streets using newly purchased brick. The city saves the older bricks from the non-historic streets by cleaning and storing them. The old bricks are then reused when maintenance is required on historic streets. As a result, Canton has stockpiles of historic brick ready for historic street maintenance, when necessary. This creative approach can be applied in Mt. Lebanon and other municipalities.

Importantly, Canton's maintenance is not based in policy; it is based on the preference of key decision-makers in the municipal staff. To ensure systematic, standardized decision-making, it is recommended to formalize policy measures for brick street preservation.

Image 14: A brick street in the Ridgewood neighborhood of Canton, Ohio. Source: CantonRep.com

[102] Loukas, N., Assistant City/Traffic Engineer in Canton, OH, in conversation with the authors, November 2020.

Recommendations

Brick streets are historic assets that cities, towns, and municipalities including Mt. Lebanon, PA, should embrace and prioritize. Local government officials, facilities and operational staff, and decision-makers should focus efforts on brick street repair and restoration, as outlined, so that brick streets remain in place for generations to come.

The analysis in this report has established that brick streets are vitally important to the community, financially viable, and environmentally responsible. With strong rationale in hand, the decision should not be whether to preserve individual brick streets, but how to ensure a process is followed for decision-making towards preservation of all brick streets.

The following are planning recommendations for brick street preservation strategies divided into three key areas: fund, protect, and evaluate.

High-level recommendations:

1. Fund: Prioritize and set aside funding for brick street repair and restoration projects with a multi-year planning strategy and coordination with nearby municipalities.
2. Protect: Adopt recommended Brick Street Preservation Policy.
3. Evaluate: Leverage new planning tools that use data-driven approaches for transparent decision-making, and discontinue use of older, subjective documents and scoring systems without discernable criteria, such as the 2016 PennDOT Brick Streets Plan and the Operational Conditions Index (OCI).

A complete brick street preservation plan goes as follows.

Image 15: Mt. Lebanon Brick Streets. Source: Author

Fund:

1. **Adopt a multi-year planning strategy.** To account for the different lifecycle costs of brick and asphalt streets, multi-year fiscal planning should be implemented. Planning based on single budgetary cycles can cause myopic decision-making. Multi-year plans, on the other hand, consider long-term costs and savings. To appropriately budget for brick streets, a 3-5-year maintenance plan (20%-30% per year) for repairing remaining problems on brick streets is recommended, followed by ongoing preventative maintenance activities. On patching, all utility patches must continue to be repaired with like surfaces. Brick street reconstruction should only occur when a street undergoes substantial damage, otherwise modular repair work is advised.

2. **Utilize existing annual budget for repair work.** The existing budget of $114,000 can be used to restore the remaining areas of brick streets that have issues, as identified by the Brick Street Repairs Plan 2020 provided by Mt. Lebanon's Director of Public Works.

3. **Promote competitive bidding.** For contractual brick street reconstruction, a competitive bidding process drives down the overall cost. To drive down the cost of brick bidding, brick and asphalt street reconstruction bids should be separate. To promote competition, brick street reconstruction jobs across neighboring municipalities can be packaged together.

4. **Coordinate brick projects across municipalities.** Local municipalities to consult with include Oakmont, Pittsburgh, Aspinwall, and Dormont. Coordination between municipalities can be facilitated through Congress of Neighboring Communities (CONNECT) or the Council of Governments.

5. **Utilize grant funding.** In Mt. Lebanon, the Historic Preservation Board can be charged with applying for grant funding for brick street maintenance. The Pittsburgh History & Landmarks Foundation can be consulted on this topic.

Protect:

1. **Adopt the language from the proposed Brick Streets Policy**. See Appendix G for the complete policy.

2. **Prioritize efforts by incentivizing staff to preserve brick streets**. Include accountability measures for municipal staff and contractors to encourage dialogue and foster creative strategies to save brick streets.

3. **Consider including responsibilities for preventing deconstruction of brick streets within the roles of the facilities manager or hire a sustainability manager.** As openings occur, make resiliency and environmental responsibility a priority.

4. **Prioritize sustainable practices in commission's strategic plan.** Brick road preservation can inform Mt. Lebanon's goal of becoming an EcoDistrict. See the Sustainability Analysis.

5. **Use more sustainable de-icing techniques.** Avoid or minimize the use of calcium chloride, and instead use alternative methods for snow and ice removal. Calcium magnesium acetate is cited by the Brick Industry Association as the preferred method of deicing for bricks.

6. **Investment in stormwater infrastructure**. is necessary to prevent flood damage to brick streets.

7. **Deter theft of bricks.** Reduce brick theft by ensuring bricks are protected during construction. Stockpiles of bricks can be covered with a weighted tarp to secure them against theft from the construction site.

8. **Palletize bricks in storage.** Reduce the costs of contractual brick work by storing bricks for future construction projects. Between one and three 4’ by 4’ pallets of bricks is recommended for storage. Pallets can be stacked and can accommodate 700-800 bricks with a cost of $295 per pallet.

9. **Familiarize decision-makers with local brick manufacturing companies.** This will assist in clearing up any other questions the Commission may have about brick production.

10. **Visit a brick manufacturing company.** This will assist in clarifying any other questions the Commission may have about brick production. There are three brick manufacturing companies located within 100 miles of Mt. Lebanon, see Appendix F.

11. **Establish a resident communication plan**. Resident testimonials should be solicited when a brick street is being considered for reconstruction. If a street is to be deconstructed, residents on the affected street and in the community at large should be notified via letter or other formal communication method as far in advance as possible, but at least 30 days in advance of contract RFI or RFP release. This should be conducted formally, and informal consultation with residents is also encouraged. Use a one-mile perimeter around brick streets as a cutoff when deciding with which residents to consult.

Image 16: The recommendations cover funding, protection, and evaluation. Source: Author.

Evaluate:

1. **Replace the Operational Conditions Index (OCI) and the 2016 PennDOT Brick Streets Plan, which are now to be considered obsolete, with one newly developed instrument, the Mt. Lebanon Brick Streets Preservation Guidance Indicator.** This tool is located in the accompanying Google Drive for this project. For more details on the new evaluative tool, see the Background of Mt. Lebanon and its Brick Streets.

2. **Choose updated evaluative tools that are intended for rough surfaces like brick streets.** For more details on the new evaluative tool, see the "Background of Mt. Lebanon and its Brick Streets" section.

3. **Investigate new technologies available for street assessments**. Consider the state-of-the-art artificial intelligence and imaging technologies available in the market, including but not limited to those offered by start-ups such as RoadBotics, a Pittsburgh-based software company. With newer technologies, the commission could eliminate in-person, subjective evaluations of streets, and track problems of the brick street surfaces more efficiently and objectively.

Image 16: Red Brick Street. Source: Rian K. Long

4. **Continue research for data-driven decision-making on brick streets**. Determine the metric thresholds for the new brick street categorizations with a follow-up independent study with civil engineering students or experts in the field.

Further Work

This study establishes the importance of brick streets and justifies a policy to preserve them. A continued work agenda will add more details to the financial and safety implications of the streets. The following is a work agenda for the Mt. Lebanon Commission.

1. **The Commission should replace the OCI and PennDOT as evaluation tools.** This paper offers categories of evaluation more suitable to measure brick streets than the OCI and the PennDOT Brick Streets Plan. However, the Commission should call for civil engineers to develop the thresholds necessary to use those metrics. They can assess how many "dips" in a Mt. Lebanon brick street would move the surface brick condition from "better" to "good", etc.

2. **The Commission can work with a real estate appraiser to attain all housing sales in Mt. Lebanon on brick and asphalt streets.** The attainable data from this project using the West Penn Multi List Tracks property sales only brought 84 brick street sales out of 2,100 in recent years. This was not a statistically significant sample size. To quantify the impact of bricks on property value in Mt. Lebanon, there should be a full observational study with more sales using more comprehensive data sources.

3. **The Commission can fund a traffic study to quantify the effects of bricks on speed and slipperiness.** Experts say bricks slow drivers down by 10 to 15 miles per hour, but a proper observational study is necessary to understand bricks' impact on speed. The municipality can record speeds on varying streets at different times of day and in different weather conditions and run a regression analysis to quantify the relationship. Likewise, an observational study to record the number of "slips" on a brick street versus an asphalt street in wet or icy conditions can help to quantify that relationship, though that may be more difficult to record impartially.

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Appendix

Appendix A: 2016 PennDOT Brick Streets Plan, page 5 – Old version, obsolete

Mt. Lebanon Brick Streets Plan Street Categorization														
		In Historic District	Structural Condition							Architectural Integrity				
Category			Excellent	Good	Above Average	Average	Below Average	Poor	Failing	Excellent	Good	Poor	Bad	
1	Dan Drive	X	X							X				Restore
1	Dixon Avenue (Incl. Racine Ave)	X	X							X				
1	McCann Place	X	X							X				
1	Navato Place	X	X							X				
1	Neulon Avenue	X	X							X				
1	Old Orchard Road	X	X							X				
1	Overlook Drive	X	X							X				
1	Ridgefield Avenue	X	X							X				
1	Royce Avenue	X	X							X				
1	Savannah Avenue	X	X							X				
1	Shadowlawn Avenue	X	X							X				
1	Virginia Way	X	X							X				
1	Wasson Place	X	X							X				
1	Wisteria Avenue	X	X							X				
2	Arden Road	X		X						X				Preserve
2	Baywood Avenue (Incl Summit Way)	X	X								X			
2	Beverly Road	X		X						X				
2	Buchanan Place	X	X								X			
2	Cherokee Place	X		X						X				
2	Iroquois Drive	X		X						X				
2	Lansdale Place	X		X						X				
2	Midway Road	X		X						X				
2	Morrison Drive	X		X						X				
2	Nakoma Drive	X		X						X				
2	North Meadowcroft Avenue	X		X						X				
2	Park Entrance Drive - West	X		X						X				
2	Roselawn Avenue	X	X								X			
2	South Meadowcroft Avenue	X		X						X				
2	Adeline Avenue		X							X				
2	Allendale Place	X			X					X				
2	Atlanta Drive	X			X					X				
2	Central Square - West	X		X							X			
2	Circle Drive	X			X					X				
2	Hoodridge Drive	X			X					X				
2	Jayson Avenue	X			X					X				
2	Lawncroft Avenue	X		X							X			
2	Parkway Drive	X			X					X				
2	Seminole Drive	X			X					X				
3	Academy Place			X						X				Question able
3	Central Square - East	X			X						X			
3	Country Club Drive			X						X				
3	Duquesne Drive			X						X				
3	Hilf Street			X						X				
3	McCully Street	X			X						X			
3	Oak Way	X			X						X			
3	Outlook Drive	X				X				X				
3	Park Entrance Drive - East	X				X				X				
3	Parker Drive (Incl Shot Way)	X				X				X				
3	Sage Drive			X						X				
3	Carnegie Drive				X					X				
3	Connecting Road	X					X			X				
3	Highland Road	X					X			X				
3	Kewanna Avenue				X					X				
3	Lebanon Hills Drive	X					X			X				
3	Mohican Drive				X					X				
3	Poplar Drive				X					X				
3	Pueblo Drive				X					X				
3	Serpentine Drive (Incl Altoona Pl)				X					X				
4	Audubon Avenue					X				X				Repave with other Materials
4	Birch Avenue					X				X				
4	Broadmoor Avenue - South					X				X				
4	Broadmoor Avenue - North					X				X				
4	Crystal Drive					X				X				
4	Jonquil Place					X				X				
4	Kenilworth Drive					X				X				
4	Main Entrance Drive	X						X		X				
4	Martha Avenue	X						X		X				
4	Navahoe Drive					X				X				
4	Richland Road					X				X				
4	Rockwood Avenue (Incl Whitmore Ln)					X				X				
4	Barth Avenue	X							X	X				
4	Craig Court						X			X				
4	Lincoln Way	X						X			X			
4	Earlswood Avenue							X		X				
4	Midway Way/Alley	X							X		X			
4	Pennsylvania Blvd - South	X							X		X			
4	Ross Way							X			X			
4	Pennsylvania Blvd - North								X		X			

NEW – 2021 Brick Street Preservation Evaluation Tool (see electronic file)

Name	Condition of Brick	Pre-2021 OCI Detail			Score 1 (Condition)	Score 2 (OCI)	Score 3 (Street Age)	Total
		Route	Avg. OCI	Last Paved				
Academy Place	Best	ACADEMY PLACE	49.46	1/1/1930	4	1	4	#
Adeline Avenue	Best	ADELINE AVENUE	78.64	1/1/1984	4	2	0	#
Allendale Place	Better	ALLENDALE PLACE	63.73	8/5/2005	2	1	0	#
Arden Road	Best	ARDEN ROAD	74.58	1/1/1988	4	2	0	#
Atlanta Drive	Better	ATLANTA DRIVE	52.61	1/1/1990	2	1	0	#
Audubon Avenue	Best	AUDUBON AVENUE	65.58	1/1/1930	4	1	4	#
Barth Avenue	Good	BARTH AVENUE	56.55	1/1/1983	0	1	0	#
Baywood Avenue (Incl Summit Way)	Best	BAYWOOD AVENUE	58.08	1/1/1982	4	1	0	#
Beverly Road	Best	BEVERLY ROAD	72.54	1/1/1930	4	2	4	#
Birch Avenue	Better	BIRCH AVENUE	56.84	1/1/1930	2	1	4	#
Broadmoor Avenue	Better	BROADMOOR AVENUE	69.52	1/1/1980	2	1	0	#
--Broadmoor Avenue - North	-	-	-	-	-	-	-	-
Buchanan Place	Best	BUCHANAN PLACE	76.50	1/1/1930	4	2	4	#
Carnegie Drive	Better	CARNEGIE DRIVE	65.62	1/1/1992	2	1	0	#
Central Square	Best	CENTRAL SQUARE	78.64	1/1/1930	4	2	4	#
--Central Square - East	-	-	-	-	-	-	-	-
Cherokee Place	Best	CHEROKEE PLACE	58.05	1/1/2004	4	1	0	#
Circle Drive	Best	CIRCLE DRIVE	47.84	1/1/1983	4	1	0	#
Connecting Road	Better	CONNECTING ROAD	46.68	1/1/2002	2	1	0	#
Country Club Drive	Best	COUNTRY CLUB DRIVE	65.90	1/1/1984	4	1	0	#
Craig Court	Good	CRAIG COURT	52.59	1/1/1930	0	1	4	#
Crystal Drive	Best	CRYSTAL DRIVE	54.64	1/1/1992	4	1	0	#
Dan Drive	Best	DAN DRIVE	72.84	1/1/1930	4	2	4	#
Dixon Avenue (Incl Racine Ave)	Best	DIXON AVENUE	76.25	1/1/1983	4	2	0	#
Duquesne Drive	Best	DUQUESNE DRIVE	75.94	1/1/1982	4	2	0	#
Earlswood Avenue	Good	EARLSWOOD AVENUE	57.08	1/1/1980	0	1	0	#
Highland Road	Better	HIGHLAND ROAD	43.54	1/1/1989	2	1	0	#
Hilf Street	Better	HILF STREET	71.40	1/1/1983	2	2	0	#
Hoodridge Drive	Best	HOODRIDGE DRIVE	48.23	1/1/1983	4	1	0	#
Iroquois Drive	Best	IROQUOIS DRIVE	59.12	8/5/2005	4	1	0	#
Jayson Avenue	Better	JAYSON AVENUE	67.95	1/1/1930	2	1	4	#
Jonquil Place	-	-	-	-	-	-	-	-
Kenilworth Drive	Best	KENILWORTH DRIVE	43.21	1/1/1984	4	1	0	#
Kewanna Avenue	Best	KEWANNA AVENUE	55.94	1/1/1983	4	1	0	#
Lansdale Place	Better	LANSDALE PLACE	74.49	1/1/1930	2	2	4	#
Lawncroft Avenue	Best	LAWNCROFT AVENUE	65.26	1/1/1930	4	1	4	#
Lebanon Hills Drive	Better	LEBANON HILLS DRIVE	43.46	1/1/1982	2	1	0	#
Lincoln Way	Good	LINCOLN WAY	62.90	1/1/1930	0	1	4	#
Main Entrance Drive	Better	MAIN ENTRANCE DRIVE	58.90	1/1/1983	2	1	0	#
Martha Avenue	Good	MARTHA AVENUE	53.30	1/1/1930	0	1	4	#
McCann Place	Best	MCCANN PLACE	73.69	1/1/1930	4	2	4	#
McCully Street	Better	MCCULLY STREET	70.88	1/1/1962	2	2	2	#
Midway Road	Best	MIDWAY ROAD	72.42	8/5/2005	4	2	0	#
Midway Way/Alley	-	-	-	-	-	-	-	-
Mohican Drive	Best	MOHICAN DRIVE	54.86	1/1/1930	4	1	4	#
Morrison Drive	Best	MORRISON DRIVE	66.12	1/1/1993	4	1	0	#
Nakoma Drive	Best	NAKOMA DRIVE	48.86	1/1/1930	4	1	4	#
Navahoe Drive	Best	NAVAHOE DRIVE	47.57	1/1/1983	4	1	0	#
Navato Place	Best	NAVATO PLACE	75.39	1/1/1930	4	2	4	#
Neulon Avenue	Best	NEULON AVENUE	71.84	1/1/1930	4	2	4	#
North Meadowcroft Avenue	Better	NORTH MEADOWCROFT AVENUE	74.68	1/1/1983	2	2	0	#
Oak Way	-	-	-	-	-	-	-	-
Old Orchard Road	Best	OLD ORCHARD ROAD	59.74	1/1/1930	4	1	4	#
Outlook Drive	Best	OUTLOOK DRIVE	48.22	1/1/1983	4	1	0	#
Overlook Drive	Best	OVERLOOK DRIVE	73.96	1/1/1984	4	2	0	#
Park Entrance Drive	Best	PARK ENTRANCE DRIVE	46.87	1/1/2001	4	1	0	#
--Park Entrance Drive - West	-	-	-	-	-	-	-	-
Parker Drive (Incl Shot Way)	Better	PARKER DRIVE	67.47	1/1/1930	2	1	4	#
Parkway Drive	Better	PARKWAY DRIVE	35.01	1/1/2002	2	0	0	#
Pennsylvania Blvd - North	Good	PENNSYLVANIA BOULEVARD	56.20	1/1/1930	0	1	4	#
Pennsylvania Blvd - South	-	-	-	-	-	-	-	-
Poplar Drive	Better	POPLAR DRIVE	44.73	1/1/1965	2	1	2	#
Pueblo Drive	Best	PUEBLO DRIVE	54.49	1/1/1983	4	1	0	#
Richland Road	-	-	-	-	-	-	-	-
Ridgefield Avenue	Best	RIDGEFIELD AVENUE	69.12	1/1/1930	4	1	4	#
Rockwood Avenue (Incl Whitmore Ln)	-	-	-	-	-	-	-	-
Roselawn Avenue	Best	ROCKWOOD AVENUE	39.94	1/1/1991	4	0	0	#
Ross Way	Better	ROSS WAY	31.33	1/1/1930	2	0	4	#
Royce Avenue	Best	ROYCE AVENUE	71.28	1/1/1999	4	2	0	#
Sage Drive	Best	SAGE DRIVE	78.66	1/1/1930	4	2	4	#
Savannah Avenue	Best	SAVANNAH AVENUE	58.33	1/1/1930	4	1	4	#
Seminole Drive	Best	SEMINOLE DRIVE	54.00	1/1/1983	4	1	0	#
Serpentine Drive (Incl Altoona Pl)	Best	SERPENTINE DRIVE	59.72	1/1/1968	4	1	2	#
Shadowlawn Avenue	Best	SHADOWLAWN AVENUE	78.57	1/1/1983	4	2	0	#
South Meadowcroft Avenue	Best	SOUTH MEADOWCROFT AVENUE	78.65	1/1/1984	4	2	0	#
Virginia Way	Best	VIRGINIA WAY	78.70	1/1/1930	4	2	4	#
Wasson Place	Best	WASSON PLACE	74.68	1/1/1930	4	2	4	#
Wisteria Avenue	Best	WISTERIA AVENUE	78.64	1/1/1930	4	2	4	#

*Surface conditions uses any issues visible in the bricks themselves, including dips, ice patches, and potholes rather than the OCI to inform the brick street structural condition. It accounts for metrics like drivability and safety.

**Non-surface brick conditions tracks metrics like storm water infrastructure, base, slope, and age of the street. It is a measure of the conditions beyond the surface level bricks.

***Category 1 means the street is in sufficient condition that it does not have segments in need of immediate repair in X number of years. Category 2 means the street has segments that should be prioritized.

****Resident preference refers to whether a majority of residents prefer the street to be prioritized for repair.

Appendix B: Statistical Significance Calculation for Survey Analysis

According to 2019 Census data, there are 24,296 people in Mt. Lebanon over the age of 18. The Brick Street Preference Survey's 6% response rate (1,496 Mt Lebanon residents) surpassed the sample size needed to statistically represent Mt Lebanon residents with a 95% confidence level and 5% margin of error.

To determine the sample size needed to statistically represent Mt. Lebanon residents over the age of 18 with a 95% confidence level and a 5% margin of error, the following calculation was applied:

$$Sample\ size = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2\ N}\right)}$$

Where:

N = population size, 24,296 people

e = Margin of error (percentage in decimal form), .05

z = z-score, 1.96

p= standard deviation, preset at .5

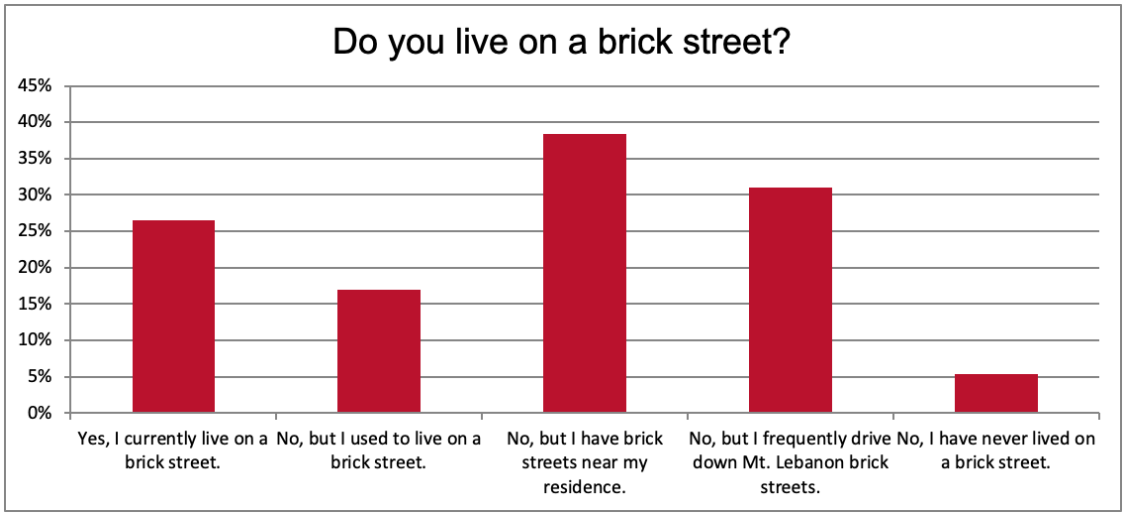
Appendix C: Detailed Survey Results by Question, with Figures

Question 1. Are you currently a Mt. Lebanon Resident?

- Of the 1,595 survey respondents, of which 94% (1,496 people) were Mt. Lebanon residents and 6% (99 people) were not Mt. Lebanon residents.

Question 2. Do you live on a brick street?

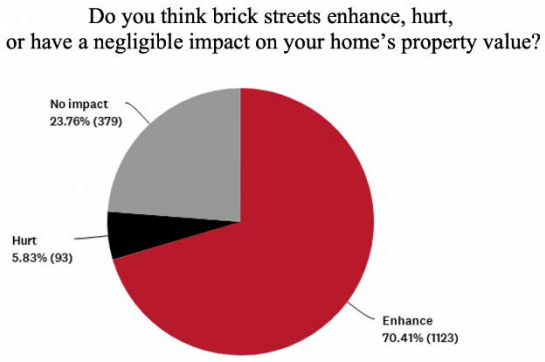
- 27% of the respondents (424 people) reported that they live on a brick street.
- 38% of survey respondents (613 people) reported that while they do not live on a brick street, they have them in their residence.
- 31% (495 people) of respondents reported that even though they do not live on a brick street, they frequently drive on Mt. Lebanon's brick streets.



These responses indicate that the survey respondents represent a variety of perspectives of people with different levels of interaction with brick streets.

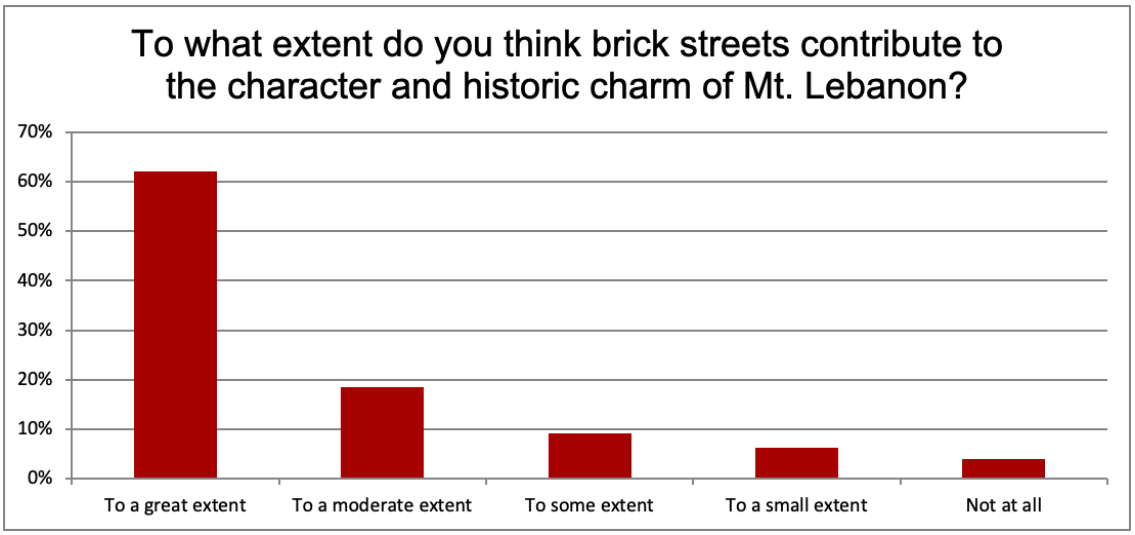
Question 3. Do you think brick streets enhance, hurt, or have a negligible impact on your home's property value?

- Of the survey respondents who live on a brick street, 84% (356 people) reported that they think brick streets enhance their home's property value. Of the 424 responses from Mt. Lebanon residents that currently live on brick streets, only 14 respondents think brick streets hurt their property value.



Question 4. To what extent do you think brick streets contribute to the character and historic charm of Mt. Lebanon?

- 94% of survey respondents (1,531 people) think brick streets contribute to the character and historic charm of Mt. Lebanon. The majority of respondents (991 respondents) reported that brick streets contribute a "great extent" to the character and historic charm of Mt. Lebanon.

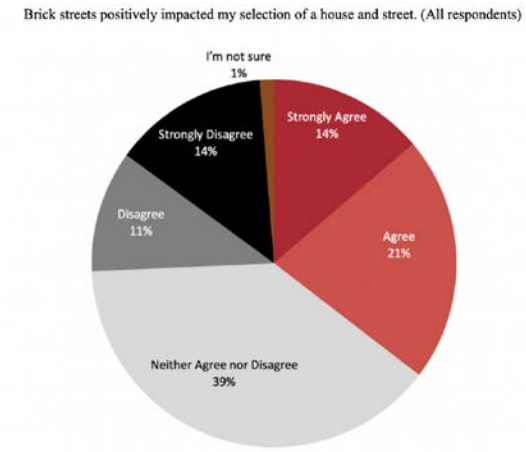


Question 5. To what extent do you agree or disagree with the following statements about having brick streets?

1. *Brick streets contributed to my decision to live in Mt. Lebanon.*

    a. 33% of all survey respondents (528 people) agreed or strongly agreed.

    b. Of the respondents who live on a brick street, 49% (209 people) agreed or strongly agreed that brick streets contributed to their decision to live in Mt. Lebanon.

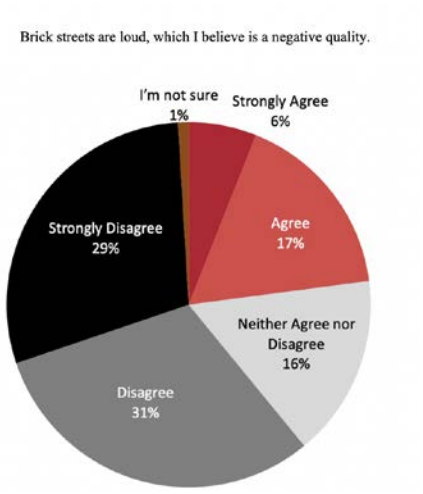


2. *Brick streets positively impacted my selection of a house and street.*

    a. Of those respondents who live on a brick street, 67% (285 people) agreed or strongly agreed that brick streets positively impacted their selection of a house and street.

3. *Brick streets are loud, which I believe is a negative quality.*

    a. 60% of all survey respondents (956 people) disagreed or strongly disagreed with this statement. Another 31% of respondents (490 people) neither agreed nor disagreed with this statement.

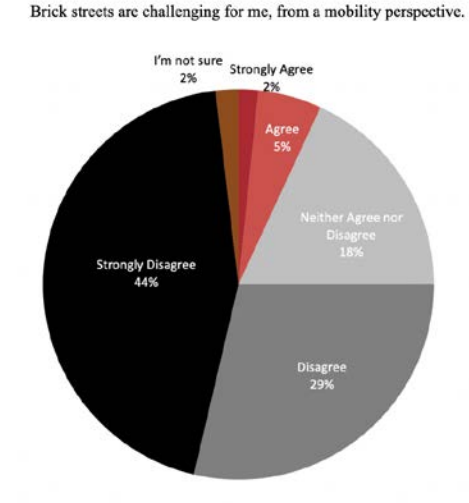


4. *Brick streets calm traffic. Cars slow down, increasing safety for kids and pedestrians.*

    a. 60% of all survey respondents (962 people) agreed or strongly agreed with this statement.

5. *Brick streets are challenging for me, from a mobility perspective.*

    a. 73% of survey respondents (1,165 people) disagreed or strongly disagreed with this statement. Another 18% of all respondents (288 people) neither agreed nor disagreed with the statement.



6. *Brick streets are challenging for me, as a bicyclist, motorcyclist or scooter rider.*

    a. 50% of survey respondents (798 people) disagreed or strongly disagreed with this statement. Another 31% of respondents (490 people) neither agreed nor disagreed with the statement.

7. *Brick streets contribute to stormwater management and help streets avoid flooding because the bricks slow down the runoff of rainwater.*

    a. 49% of survey respondents (783 people) agreed or strongly agreed with this statement

8. *Brick streets are slicker than asphalt streets in weather conditions, which I believe is an issue.*

    a. 51% of all survey respondents (813 people) disagreed, strongly disagreed, or neither agreed nor disagreed with this statement.

9. *Brick streets are less hot in summer, compared to asphalt streets.*

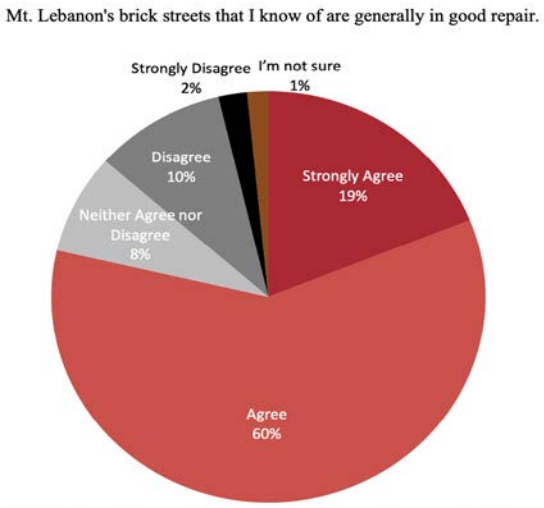
a. 58% of all survey respondents (927 people) agreed or strongly agreed with this statement. Only 2% of all survey respondents (35 people) disagreed or strongly disagreed with this statement.

10. *Mt. Lebanon's brick streets that I know of are generally in good repair.*

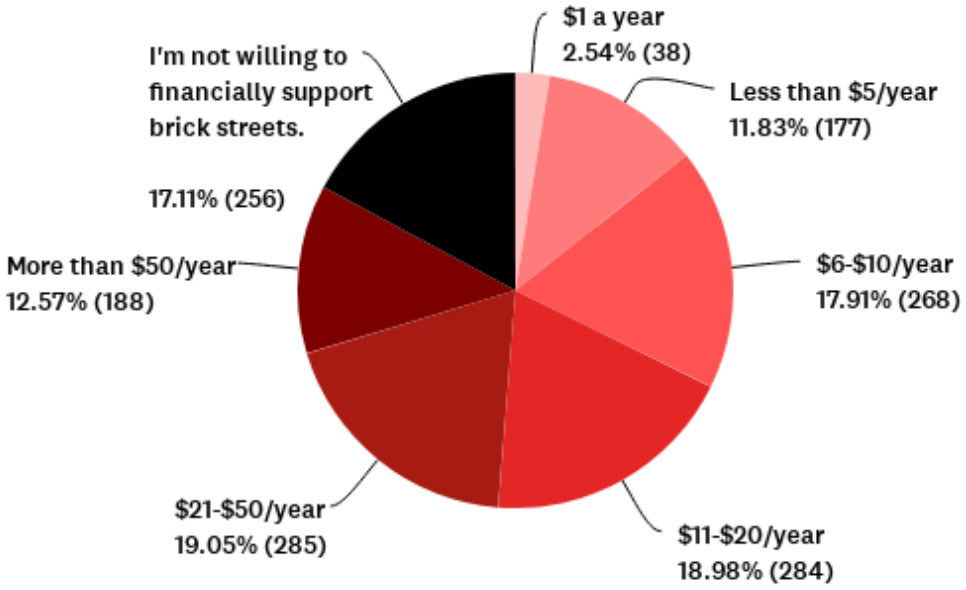
    a. 79% of all survey respondents (1,252 people) agreed or strongly agreed with this statement.

11. *Brick streets contribute to important sustainability goals for places like Mt. Lebanon.*

    a. 62% of all survey respondents (987 people) agreed or strongly agreed with this statement.



Question 6. Brick streets may have a higher initial cost per square foot to repair and maintain than other street types. If you were able to assign a value in existing municipal funds to having brick streets maintained and rebuilt (as in, fewer dips and holes) in Mt Lebanon, what would that value be to you each year, per household?



- Of the Mt. Lebanon residents that took the survey, 83% (1,240 people) were willing to pay to support brick streets.
- Of the respondents that live on a brick street, 89% (376 people) were willing to pay to support brick streets.

Appendix D: Costs Related to Brick and Asphalt Street

Brick Street						
Category	Activity	Unit Cost	Unit	Frequency	Source	Assumptions
Brick Restoration	Contractual maintenance to restore deteriorated brick street surfaces.	133.20	SY	One-time/recurring	Mt. Lebanon 2021 Manager's Recommended Budget	The municipality will initially restore x% of brick streets, and every 20 years, they will repair 10% as brick deteriorates, which is the same rate as asphalt overlay.
Curb reconstruction	Contractual reconstruction of concrete curb along brick streets. Independent of any brick maintenance program.	100.00	LF	One-time	Mt. Lebanon 2021 Manager's Recommended Budget and the municipality's contract with Cilenti, lowest bid on 02/21/2020	Curb reconstruction happens alongside the initial brick restoration. The portion is based on the municipality budget, and the price stands for the highest level listed in the contract.
Base Repair	Concrete base replacement including removal of the entire existing concrete base. The minimum depth of concrete shall be seven (7) inches of reinforced concrete as per the contract documents, complete in place.	70.00	SY	One-time	Municipality's contract with Cilenti, lowest bid on 02/21/2020	The municipality will initially repair the base, which equals 5% of the restoration area.
Partial Base Repair	Partial concrete base replacement including removal of up to three (3) inches of existing concrete base. The maximum depth of removal shall be three (3) inches, otherwise the entire slab must be removed, complete in place.	50.00	SY	One-time/recurring		Every 20 years the municipality will partially repair the base as brick moves.

Pothole Patching	Only emergency repair of brick streets occurs on a year-round basis. Winter patching with cold material is done on an emergency basis.			Emergency	Mt. Lebanon 2021 Manager's Recommended Budget	Pothole patching happens only when there is an emergency.
Deicing	Streets are salted and plowed between the hour of 4:00 a.m. and midnight using crews in small trucks.	79.30	Ton	Each winter		Deicing happens every winter. Given that one ton of rock salt will melt 64,000 SF, assuming 10 snow fall events each year. Brick streets will require 2-3 times more salt than asphalt.

Asphalt Street						
Category	Activity	Unit Cost	Unit	Frequency	Source	Assumptions
Asphalt Reconstruction	Brick removal, base repair and asphalt reconstruction. The contractor will dispose of the waste.	119.42	SY	One-time	Municipality, lowest bid from Niando in 2016 for reconstructing Morrison Drive	The municipality will pave the entire road with asphalt at the beginning of its lifecycle. The base repair cost is included, as well as the cost of deconstructing and disposing of the existing brick street.
Curb Reconstruction	Contractual curb replacement to meet required replacement for asphalt overlay.	75.00	LF	One-time	Mt. Lebanon 2021 Manager's Recommended Budget	Curb reconstruction happens alongside the initial asphalt reconstruction. The portion is the same as that for brick repair.
Asphalt Overlay (Systematic Repair)	Resurface deteriorated asphalt streets	23.70	SY	Every 20 years	Costs derived from Mt. Lebanon 2021 Manager's Recommended Budget, frequency provided by Mt. Lebanon's Director of Public Works	Asphalt streets are entirely resurfaced every 20 years.
Basic Repair	Contractual repair of the most seriously deteriorated asphalt street surfaces. Municipal crews will repair signs, guide rails and perform minor bituminous pavement repairs.	41.42	SY	15 year after a resurfacing		Repair 5% of the most seriously deteriorated asphalt street surface 15 years after a resurfacing.

Street Crack Repairs	Contractual sealing or repair of pavement crack or joints occurs throughout Mt. Lebanon.	1.05	LF	10 year after a resurfacing		Street crack repairs happen once during the life cycle of the street, 10 years after a resurfacing.
Bituminous Pavement Rejuvenation	Applies asphalt rejuvenation to roadway surface to revive aging and brittle asphalt	1.04	SY	10 year after a resurfacing		Street is rejuvenated once during the 20-year life cycle,10 years after a resurfacing.
Pothole Patching	Only emergency repair of asphalt streets occurs on a year-round basis. Municipal crews patch holes that develop in the pavement surface. Winter patching with cold material is done on an emergency basis.			Emergency	Municipality budget	Pothole patching happens only when there is an emergency.
Deicing	Streets are salted and plowed between the hour of 4:00 a.m. and midnight using crews in small trucks.	79.30	Ton	Each winter		Deicing happens every winter. Given that one ton of rock salt will melt 64,000 SF, assuming 10 snow fall events each year.

Appendix E: Asphalt Material Inputs

Asphalt in Pennsylvania is typically made of 15-50% recycled material (Henrich 2020)[103], which necessarily means that the other 50-85 % of the asphalt used for each reconstruction and resurfacing job is new material. To calculate the tonnage of asphalt needed for these construction projects, the math below was applied. The resulting tonnage was multiplied by .5 to determine the amount of new asphalt material (binder, filler, and aggregates) needed per reconstruction or resurfacing job.

Asphalt Reconstruction Assumptions

Based on information provided in an interview with Gateway Engineers and the Mt. Lebanon Director of Public Works (Sukal 2020)[104], the average size of an asphalt street reconstruction job is 1,000 feet in length, 22 feet wide, and 11 inches deep. The weight density of asphalt is assumed to be 145 pounds per cubic foot, which is the estimate used by the National Asphalt Pavement Association.

Calculations for volume of asphalt required per street reconstruction job:

1. Calculate the volume of asphalt.

$$1{,}000\ ft\ \times 22\ ft\ \times\ .91\ ft = 20{,}020\ ft^3$$

2. Multiply the weight density of the asphalt by the volume to arrive at the weight of the asphalt needed in pounds.

$$20{,}020\ ft^3 \times 145 \frac{pounds}{ft^3} = 2{,}902{,}900\ pounds$$

3. Convert the weight to tons.

$$2{,}902{,}900\ pounds\ \div 2{,}000 = 1{,}451\ tons$$

Asphalt Resurfacing Assumptions

Based on information provided in an interview with Gateway Engineers and the Mt. Lebanon Director of Public Works, as well as the average lengths of the resurfacing projects reported in 2020 on the Mt. Lebanon Road Projects Map, the average size of an asphalt street resurfacing job is 720 feet in length, 22 feet wide, and 3 inches deep (1.5 inches of wearing course and 1.5

[103] Henrich, H., Sr. Salesman at Eurovia Atlantic Coast LLC dba Northeast Paving, in conversation with the authors of this report, December 2020.
[104] Sukal, R., Mt. Lebanon Public Works Director, in conversation with the authors, November 2020.

inches of binder) (Sukal 2020)[105] (*Mt. Lebanon Road Projects Map* 2020).[106] The weight density of asphalt is assumed to be 145 pounds per cubic foot, which is the estimate used by the National Asphalt Pavement Association.

Calculations for volume of asphalt required per street resurfacing job

1. Calculate the volume of asphalt.

$$740\ ft\ \times 22\ ft\ \times .25\ ft = 4{,}070\ ft^3$$

2. Multiply the weight density of the asphalt by the volume to arrive at the weight of the asphalt needed in pounds.

$$4{,}070\ ft^3 \times 145 \frac{pounds}{ft^3} = 590{,}150\ pounds$$

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3. Convert the weight to tons.

$$590{,}150\ pounds\ \div 2{,}000 = 295\ tons$$

[105] Ibid.
[106] Mt. Lebanon Road Projects Map. 2020 mtlebanon.maps.arcgis.com.

Appendix F: Brick Manufacturers and Contractors Local to Mt. Lebanon

Manufacturers

- Bowerston Shale Co.
  http://www.bowerstonshale.com/
  515in Street P.O. Box 199
  Bowerston, Ohio 44695
  Phone: (740) 269-2921
- The Belden Brick Company
  https://www.beldenbrick.com/
  700 Tuscarawas St.
  Canton, Ohio 44702
  Phone: (330) 451-2031
- Whitacre Greer Company
  https://wgpaver.com/
  1400Mahoning Ave.
  Alliance, Ohio 44601
  Phone: (800) 947-2837

A national list of brick manufacturers can be accessed on the Brick Industry Association's website: https://www.gobrick.com/find-brick-professionals/manufacturers.

Contractors

- Kishmo Concrete Contractors
  http://kishmo.com/contactus.html
  166 Shelby Lane
  Apollo, PA 15613
  Phone: (724) 387-1749
- Pampena Landscaping and Construction Inc
  https://www.yellowpages.com/pittsburgh-pa/mip/pampena-landscape-construction-5652044
  322 Pampena Ln
  Pittsburgh, PA 15239
  Phone: (412) 798-7895
- Baiano Construction Inc.
  http://www.bcon-inc.com/home.html
  4842 Streets Run Road

Pittsburgh PA 15236
Phone: (412) 881-5411

- Niando Construction Inc.
  620 Long Rd
  Pittsburgh, PA
  Phone: (412) 242-1888
- A Merante Contracting
  https://www.amerantecontracting.com/
  4740 Streets Run Rd
  Pittsburgh, PA 15236
  Phone: (412) 884-4485
- Cilenti Construction Co Inc
  121 Squaw Run Rd
  Pittsburgh, PA 15238
  Phone: (412) 782-4464

Appendix G: PROPOSED Brick Street Preservation Policy – February 1, 2021

Introduction:

Brick streets are an asset to the community. Of roughly 1,600 people surveyed in a brick street preference questionnaire that was distributed in 2020, 96% of respondents said brick streets contribute to the historic charm and character of Mt. Lebanon, 70% believed brick streets enhanced property values, and 82% were willing to pay to support brick streets. Additionally, a life cycle cost analysis conducted by four Carnegie Mellon University Heinz College graduate students found that maintaining a brick street (rather than deconstructing and repaving with asphalt) saves about $285,000 over a 100-year period. Compared to asphalt, brick streets need less maintenance over time and can be repaired in modular portions rather than undergoing curb-to-curb construction. Brick streets also contribute to sustainability goals by slowing the flow of stormwater into sewer systems which helps prevent combined sewer overflows, and by helping to limit the urban heat island effect by absorbing less heat than dark-colored asphalt. Finally, brick streets also improve safety via their traffic calming effects. Given the abundance of benefits from brick streets, these assets deserve to be maintained and preserved.

Purpose:

The purpose of this policy is to preserve Mt. Lebanon's brick streets to the extent possible in accordance with this policy and in consideration of all relevant facts and circumstances.

This policy is intended to establish a systematic and consistent decision-making process for when a municipal street throughout the municipality of Mt. Lebanon which is constructed of brick is being evaluated for repair, reconstruction, or removal. This policy outlines an action plan and procedures designed to leverage data, increase transparency, and enhance communications and outreach to residents and stakeholders.

Brick Street Policy Statement:

It is the policy of the Municipality of Mt. Lebanon to generally preserve brick streets, and to remove or cover a brick street (including a brick street that has reached the end of its useful life) only as a last resort when other avenues and options have been exhausted. This policy will act as a guide to direct proactive actions to help extend the useful life of brick streets, including maintenance and repair, and establish a systematic framework for preservation when a brick street has reached the end of its useful life.

Action Steps:

1. Update a Brick Streets Preservation Action Plan (the "Plan") every five years.
    1. Classify brick streets into two categories: (i) preserve, or (ii) evaluate for reconstruction with other materials with resident input.

2. The Plan will utilize the recommendations detailed in "Preserving Brick Streets with Data," the 2021 report prepared by researchers at Carnegie Mellon University.
3. The updated Plan will include resident input sessions via a formal communications and individualized outreach campaign.

Responsibility: The HPB, the Municipal Engineer, and municipal staff.

2. Incentivize municipal staff to identify ways to lower costs related to brick street repair.
    1. Utilize the Life Cycle Analysis and recommendations for brick repair in "Preserving Brick Streets with Data."
    2. Pursue options to pay for any funding gaps between the life cycle costs of brick versus asphalt or concrete.

    Responsibility: Municipal staff and the HPB.

3. Continue the Brick Street Repair program in 2021 and annually thereafter using a more transparent data source than the OCI.
    1. Continue an annual assessment of the brick streets that are classified as "Preserve," and prioritize the streets for annual repair based on need for safety upgrades and extension of their useful life.
    2. Inclusion within the Mt. Lebanon Historic District will not be considered in decision-making parameters.
    3. Replace the OCI with the categorization Flow Chart detailed below.

    Responsibility: Municipal staff and the Municipal Engineer will present the annual assessment at an HPB meeting and to the Commission.

4. Assess opportunities on an ongoing basis.
    1. Identify historic preservation and engineering best practices and recommend options to enhance this policy and/or procedures to preserve brick streets. For example, explore options for brick reclamation and storage for purposes of re-use.
    2. Identify grants and other resources to offset costs.

    Responsibility: The HPB, in partnership with the Brick Streets Steering Committee, will report to the Commission annually and as needed on identified opportunities.

Procedures:

This section of the policy covers the steps the Municipality will take to preserve brick streets.

1. Brick streets at the end of useful life:
    1. Streets classified as “Preserve“ will be reconstructed with brick modularly. Brick streets will be evaluated via separate bidding process, and processes for gap funding will be the subject of the HPB’s recommendations in partnership with the Brick Streets Steering Committee.
    2. Brick streets classified as “Evaluate for reconstruction with other materials” will be assessed for the best course of action to reconstruct the street.
    3. Residents on the affected and surrounding streets will be notified as far in advance as possible but at least 30 days in advance of contract RFI or RFP release and/or decision making via letter as well as a formal communications and individualized outreach campaign.

2. Brick streets not at end of useful life:
   Any brick street in need of utility or other infrastructure work will be required to be repaired with brick of a similar color or HPB-approved substitute not more than thirty (30) days of repair work completion.

3. During the annual budget process, street repair program the Commission, Municipal Engineer, staff and the Municipal Manager will consider the Plan, street repair needs, and input from the HPB and when deciding what funds to budget for repair, reconstruction, studies and/or deposit into a reserve fund for future brick street-related costs.

4. The municipal staff will ensure that residents on brick streets that are to be repaired, reconstructed, or will be impacted by emergency repairs are notified as far in advance as possible but at least two weeks in advance of contract RFI or RFP release and/or decision making via letter as well as a formal communications and individualized outreach campaign.

Exemptions and Clarifications:

The Commission may receive advice from the Municipal Engineer, the Director of Public Works, the Chief of Police, the Fire Chief, or any of their designees regarding potential exemptions from the Brick Street Policy due to considerations under their respective purview. The Commission shall consider exemptions from this policy when the use of brick to reconstruct a street would create public safety risks for motorists and other users.

If the Municipality becomes aware of a safety issue on a brick street that warrants repair, before removing or covering the street (other than temporary solutions to address imminent safety concerns), the municipal staff or the Municipal Engineer will present to the Commission, a plan or cost to repair the street that cures the unsafe issue while minimizing the impact on the brick street.

This policy is authored by:

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Categorization_Flowchart: