Seismic Detonation and the Effects on Residential Structures: Impact of Seismic Detonation on Residential Structures Near Mining Activities in Naples, Florida

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Project Details:

Proposed Start Date: January 2025
Proposed End Date: May 2025
Budget: Self-funded as part of the academic requirements for the Master's in Engineering program in Construction.

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PROJECT SUMMARY

This study investigates the impact of mining-induced seismic detonation on residential structures concentrating on the Golden Gate Estates area of Naples, Florida, with particular emphasis on the 846 Mine. Local homeowners have expressed significant concerns regarding potential structural damage resulting from blasting activities. Despite these apprehensions, there is a notable lack of data specifying the threshold vibration levels at which seismic activity leads to structural harm. The primary objectives of this study are to determine the minimum vibration levels at which structural damage occurs and to assess whether the effects of mining-induced seismic activity exceed these thresholds. Through the utilization of field-acquired seismic data, rigorous seismic analysis, and comparative evaluations with existing studies, this research explores how seismic waves interact with various types of residential structures and the consequent potential for damage. By integrating direct seismic data, structural analysis, and documented damage reports from homeowners, this study aims to establish correlations and define precise damage thresholds. The results will delineate a range of vibration levels associated with varying degrees of structural damage, thereby providing critical evidence to assess the broader impacts of mining-induced seismic activity on nearby communities. This study seeks to deliver evidence-based insights for policymakers, mining companies, and homeowners, offering recommendations for risk mitigation and the development of regulatory standards for blast-induced vibrations. Furthermore, it underscores the importance of advancing predictive models for seismic damage, guiding the adoption of safer and more sustainable mining practices.

1.0 PROJECT DESCRIPTION

Mining activities, particularly blasting operations, are a cornerstone of resource extraction, supplying essential industrial and economic development materials. However, these operations can generate significant ground vibrations, which have the potential impacts on adjacent areas, including residential communities. In regions where mining activities occur near populated neighborhoods, the consequences extend beyond geological considerations, encompassing safety concerns, potential structural damage, and diminished quality of life for residents. The Golden Gate Estates area in Naples, Florida, exemplifies the complex interplay between industrial mining operations and residential stability. Local homeowners have expressed growing concerns regarding the potential structural damage to their homes caused by seismic vibrations originating from the 846 Mine. The 846 Mine, spanning approximately two square miles, specializes in the extraction and processing of limestone, a critical raw material for cement production, which is integral to construction and infrastructure development. This context highlights the critical need for an in-depth investigation into the relationship between mining-induced seismic activity and its potential effects on nearby residential structures. The findings of such a study could inform strategies to balance the demands of industrial operations with the need to ensure the safety, property integrity, and well-being of affected communities.

The coexistence of residential and industrial activities presents unique challenges in regions like Golden Gate Estates, where housing developments have encroached upon areas proximate to mining operations. Homeowners in such regions frequently express concerns about the effects of ground vibrations caused by blasting activities. These vibrations have the potential to induce structural stresses that may result in visible damage, such as cracks in walls or foundation instability, as well as less apparent, long-term impacts, such as the progressive weakening of structural integrity. Vaughan and Chiu (2017) provided critical insights into this phenomenon, demonstrating how mining-induced vibrations can compromise the structural soundness of residential properties over time (Vaughan & Chiu, 2017). In addition to physical damage, the prospect of property devaluation exacerbates homeowners' concerns, particularly when visible damage becomes evident These issues are not purely technical; they are profoundly personal, as families worry about the implications for the safety and longevity of their homes. Effectively addressing such multifaceted challenges requires an interdisciplinary approach that integrates geotechnical engineering, structural analysis, and proactive regulatory frameworks, as demonstrated in studies by D’Amato et al. (2020). Their study successfully employed such an approach to assess seismic vulnerabilities in mining regions, offering a model for developing comprehensive mitigation strategies (D’Amato et al., 2020).

In Golden Gate Estates, three homeowners have reported noticeable damage to their residences, which they attribute to the seismic activity stemming from detonations at the 846 Mine, located approximately one mile away. Reported issues include cracks in masonry walls, concerns regarding foundation stability, and apprehensions about overall structural soundness. These cases underscore valid concerns about the potential for mining-induced vibrations to inflict structural damage, particularly given the proximity of the affected homes to the blasting site. However, a systematic evaluation is critical to validate these claims. Factors such as natural soil settlement, the age and construction methodologies of the homes, and environmental influences, including fluctuating temperatures, precipitation, and vegetation growth, must be carefully analyzed to ensure a fair and accurate assessment. This rigorous approach will help distinguish mining-related effects from other contributing factors and provide an accurate framework for understanding the impact of seismic detonations on residential structures.

This research seeks to examine the potential correlation between seismic vibrations generated by the 846 Mine and the reported structural damage to nearby residential properties. By analyzing a comprehensive range of variables, including the frequency and intensity of seismic vibrations, local soil composition, and the construction characteristics of the affected homes. This study aims to assess whether the mine's operations have directly contributed to the observed damage. Additionally, the research will explore the possibility of cumulative effects, wherein repeated exposure to vibrations over time may exacerbate pre-existing structural vulnerabilities. This multifaceted approach is designed to provide a nuanced understanding of the interactions between mining-induced seismic activity and residential infrastructure, offering valuable insights for mitigating risks and informing future practices.

The findings from this study are anticipated to have significant implications. Should a definitive link between blasting vibrations and structural damage be established, the results could inform the development of stricter regulatory frameworks, enhance best practices for mining operations, and provide affected homeowners with evidence to support mitigation efforts or compensation claims. Alternatively, if no direct correlation is identified, the study will help identify alternative contributing factors, offering homeowners greater clarity and reassurance regarding the root causes of the observed damage. Regardless of the findings, this research will contribute valuable insights into the dynamic interaction between industrial activities and residential infrastructure, serving as a foundation for fostering a more sustainable harmonious coexistence between these competing interests.

A detailed map of the study area is provided, highlighting the location of the 846 Mine and the three properties under investigation (Figure 1). The map includes an overlay of the Plasticity Index across the study area. The Plasticity Index (PI) is a critical geotechnical parameter, defined as the numerical difference between a soil's liquid limit and plastic limit. It represents the range of water content within which a soil plasticity, behaving as a malleable solid (U.S. Department of Agriculture, 2024). Figures 2 and 3 provide further context, illustrating the precise locations of the properties under study and the seismic monitoring setup. These properties are essential for understanding the soil's response to external forces, such as vibrations or seismic activity, as it directly influences the soil's potential for deformation under stress. By correlating the Plasticity Index with seismic data, this study aims to assess the likelihood of soil failure of settlement in response to mine blasting. This analysis is essential for evaluating the risks posed to nearby residential structures, as soils with high plasticity may experience significant deformation under sustained seismic stress. Additional details regarding the Plasticity Index Map and its implications are provided in the Appendix. Figure 2 depicts Properties A and B, which are located approximately one mile from the 846 Mine, along with the placement of a seismic monitor installed at Property B to record vibration levels. Figure 3 shows the location of Property C, situated approximately half a mile from Properties A and B. This detailed spatial analysis supports a comprehensive evaluation of the interaction between mining-induced seismic activity, soil behavior, and structural vulnerabilities in the study area.

Figure 1: Plasticity Index Map of Study Area (United States Department of Agriculture)

Figure 2: The locations of Properties A and B as well as the Siesimic Monitor on Property B. (Google Earth)

Figure 3: The locations of Property C. (Google Earth)

Research of seismic frequencies near residential areas suggests that Peak Particle Velocity levels exceeding 50 mm/s (millimeters per second) are closely associated with cosmetic and structural damage to residential buildings (Siskind et al., 1980; Ghee et al., 2018). Peak Particle Velocity (PPV) is a widely used metric for evaluating the impact of ground vibration caused by activities such as blasting from a mine. However, the response of residential structures to seismic vibrations is highly dependent on factors such as construction materials, structural age and local soil conditions (Grange & Little, 2020). For instance, some studies suggest that older homes or those constructed with less resilient materials may be more susceptible to damage from lower PPV levels (Nadolski, 1969).

Recent advancements in monitoring technology have facilitated real-time PPV tracking and predictive modeling, enabling more accurate assessments of damage risks (Hao & Lu, 2001; Zhang & Huang, 2019). For instance, Zhang and Huang (2019) leveraged machine learning algorithms to analyze seismic wave propagation and predict structural damage under various blast scenarios. Similarly, Hao and Lu (2001) developed numerical models to simulate explosion-induced stress waves, providing valuable insights into how these waves impact nearby buildings. The application of PPV monitoring systems is increasingly recognized as a critical tool in regions where mining operations and residential areas overlap, as it allows for both immediate impact assessments and long-term studies on cumulative effects (Singh et al., 2016).

Despite these advancements, a significant research gap remains regarding the cumulative effects of frequent low-level mine blasts on residential structures. Most existing studies fail to account for specific geographic and soil conditions of regions like Golden Gate Estates, where sandy soils and other unique characteristics may alter the propagation and impact of seismic vibrations (Grange & Little, 2020). Addressing this gap is crucial for accurately evaluating risk, tailoring mitigation strategies, and developing robust regulatory guidelines for mining activities near residential communities.

Existing guidelines for safe PPV thresholds differ significantly across jurisdictions, reflecting variations in geological conditions and construction practices. There is a pressing need for standardized criteria that account for the specific vulnerabilities of residential structures near mining activities. Research has shown that homes built in regions prone to seismic activity may benefit from different construction techniques designed to enhance resilience against vibrations (Vaughan & Chiu, 2017; D'Amato et al., 2020). Despite established guidelines for safe PPV thresholds, there is limited research investigating whether observed damage in residential areas exceeds these thresholds, particularly in the context of cumulative exposure to repeated low-level vibrations from nearby mining activities. This gap is significant as it raises concerns about the safety and structural integrity of homes near blasting operations. Furthermore, existing studies often lack specificity regarding the effects of sustained low-magnitude vibrations, which could collectively lead to notable structural issues over time. This study aims to address these gaps by providing empirical data on the minimum vibration threshold associated with structural damage, offering critical insights to inform the development of more consistent standards and mitigation strategies.

2.0 RESEARCH OBJECTIVES

This study seeks to address the critical research gap by focusing on the question, **"What is the minimum vibration threshold at which mine detonation activities begin to cause damage to nearby residential structures in the study area, and does the observed damage exceed this threshold?"** By targeting this specific question, the research aims to comprehensively examine the impact of blasting operations from the 846 Mine on the structural integrity of nearby homes. It emphasizes identifying the minimum threshold for potential damage, and providing empirical data to correlate the frequency and intensity of vibrations with observed structural effects. Additionally, the study will analyze the influence of design variations, construction materials, and local soil conditions to determine whether these factors contribute to structural vulnerabilities and the potential negative effects of mining activities.

The primary objectives of the research are as follows:

1) **<u>To assess the minimum vibration threshold for damage in residential structures</u>**: This will involve analyzing seismic data collected from the 846 Mine and correlating it with documented damage reports from affected homeowners. A detailed statistical analysis will be conducted to link specific PPV measurements to the extent of observed structural damage.

2) **<u>To evaluate the impact of construction materials and soil conditions on structural vulnerability</u>**: This will entail categorizing homes based on construction types (e.g., wood frame, masonry, and concrete) and analyzing how these building materials influence their susceptibility to vibrations. Additionally, the analysis will evaluate the role of local soil composition in amplifying or mitigating vibration effects.

3) **<u>To determine the relationship between cumulative vibration exposure and structural integrity</u>**: This objective will require a longitudinal analysis of vibration data and visual inspections of affected homes. The aim is to establish a clearer link between cumulative exposure to vibration and the emergence of structural issues over time.

The tasks to achieve these objectives are as follows:

- Perform on-site inspections and structural assessments of the homes in question, documenting all observed damages in detail.
- Conduct an in-depth analysis of seismic data from the 846 Mine, focusing on vibration patterns and peak measurements.
- Review relevant literature to frame findings within the broader context of existing research, ensuring that the analysis highlights unique regional factors that may influence outcomes.
- Analyze the correlation between vibration exposure and observed damage, accounting for variations in construction and soil type, and formulate recommendations for homeowners and regulatory bodies.

3.0 METHODOLOGY

The study encompasses the period from April 1, 2023, to October 1, 2024, as defined by the timeframe of the seismic monitors' earliest and latest reports. Seismic data collection commenced in April 2023, providing a baseline for assessing ground vibration levels prior to the first recorded homeowner complaints on September 14, 2023. The additional six months of data preceding the homeowners' initial complaints are crucial for assessing whether mining activity increased during this period.

3.1 Subject Properties

The study will consist of three homes located in Golden Gate Estates. The homeowners are present as well during the inspections to help point out areas of greatest concern.

- Property A (2020): Stem wall foundation, masonry block walls, adjacent to Property B (Inspected on 07/02/2024)
- Property B (2019): Stem wall foundation, masonry block walls, adjacent to Property A (Inspected on 07/15/2024).
- Property C (1998): Slab-on-grade foundation, wood-framed construction, half a mile from the other properties (Inspected on 07/15/2024).

3.2 Soil Composition

The soil conditions at the study sites are a critical factor in understanding how seismic vibrations from mine blasting interact with nearby residential structures. Properties A and B are located in Zone 117, classified as Immokalee Fine Sand, which constitutes 25.1% of the study area. Immokalee Fine Sand is a well-drained, sandy soil commonly found in flatwood regions, characterized by low organic content and minimal plasticity (U.S. Department of Agriculture, 2024). The low Plasticity Index of this soil indicates poor water retention and limited deformation under stress, suggesting it is less likely to amplify seismic vibrations. However, its lower stability under dynamic loads may still influence structural responses to vibration.

Property C, on the other hand, lies in Zone 102, classified as Cypress Lake Fine Sand, which accounts for 3.1% of the study area (U.S. Department of Agriculture, 2024). Cypress Lake Fine Sand is a poorly drained soil typically associated with wetland areas and contains a slightly higher organic content compared to Immokalee Fine Sand. While its low Plasticity Index also indicates limited water retention capacity, its poor drainage can result in localized soil saturation. This condition may influence how vibrations propagate through the ground, potentially increasing the intensity of seismic waves in specific circumstances. Figure 1 illustrates the distribution of Zones 117 and 102 across the study area, providing a visual reference for the spatial variability of these soil types. Further details about the Plasticity Index Map can be found in the Appendix. These distinctions in soil characteristics are integral to assessing how local soil variability affects the structural response to mine blasting activities.

In addition to the Plasticity Index, hydrologic soil groups provide further insight into how local soil conditions may influence the transmission and impact of seismic vibrations on residential structures. Hydrologic soil groups classify soils based on their runoff potential, which is determined by the rate of water infiltration under conditions where the soil is not vegetated, thoroughly saturated, and subjected to prolonged storms (U.S. Department of Agriculture, 2024). Immokalee Fine Sand, located in Zone 117, is classified as Hydrologic Soil Group B/D. Soils in this classification exhibit high infiltration rates, meaning water is absorbed quickly into the ground with minimal runoff. This suggests that seismic vibrations may propagate more efficiently through this soil type, its rapid drainage reduces the likelihood of ground saturation, which could otherwise dampen vibrations. Cypress Lake Fine Sand, found in Zone 102, is classified as Hydrologic Soil Group A/D. Soils in this group have low infiltration rates, resulting in higher surface runoff and longer water retention. The increased water retention and poor drainage associated with these soils may affect the propagation of seismic waves, potentially amplifying vibrations in certain conditions. Localized soil saturation due to poor drainage could also affect the soil's dynamic response to external vibrations, making this soil type more susceptible to changes in wave propagation.

These hydrologic variations provide valuable context for understanding how the local soils' ability to manage water could affect their response to seismic activity. The implications of these hydrologic soil properties are explored further in the Appendix, where additional details on the Hydrologic Soil Group Map are provided.

3.3 Equipment

The seismic monitors utilized are a "**GeoSonics, Inc. Remote Seismograph System, Serial No. 9420**". These seismic monitors were placed at various locations, including one in the front yard of Property B, to track vibrations generated by mining blasts (Figure 4). These monitors automatically produce reports detailing the frequencies emitted by each blast (Figure 5). These reports were generated on a bi-weekly basis.

Figure 4: Seismic Monitor located on Property B.

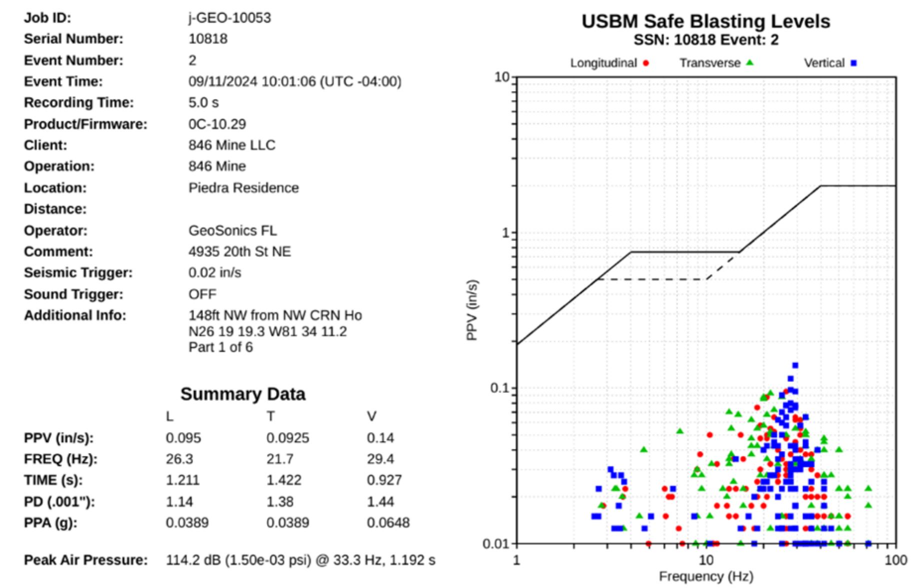

Figure 5: Example of Generated Seismic Report (Dated: 09/11/2024)

3.4 Physical Data Collection

This study primarily relies on the documented physical damage observed during site inspections, complemented by seismic data reports. During each site visit, inspections began with thorough examination of the exterior, focusing on identifying signs of structural distress, such as cracks in masonry walls or concrete slabs. Interior inspections involved assessing ceilings and walls for stress cracks and examining tiled floors for fractures or other visible signs of damage. Comprehensive photo and video documentation was conducted at each visit to capture the extent of physical damage in detail. Additionally, homeowners' comments and observations were recorded to provide supplemental context for the assessment. All documented damage was systematically categorized based on its severity, classified as minor, concerning, or major, allowing for a structured evaluation of the potential correlation between seismic activity and the observed structural issues. (I.e. Minor, Concerning, Major).

3.5 Quantitative Data Analysis

The physical data, including photographs, videos, and detailed notes, along with seismic reports, have been provided to a licensed seismic professional for expert analysis. An independent analysis will also be conducted to validate these findings and ensure consistency. The independent analysis of all the seismic reports will commence in January 2025. To create a precise independent study of the seismic data from the reports, academic journals, and videos will be utilized in learning the various components to correlate the documented damage. Understanding the fundamentals of seismic shifting will be crucial in interpreting the data from the seismic graphs. Following P.P.V. levels at each blast as well as measuring the distances between wavelength peaks will assist in determining the strengths of the blasts.

Following the independent analysis, a graphic representation will be created to illustrate the frequencies of mining blasts from April 1, 2023, to October 1, 2024. The graphic that will be developed will play a crucial role in visually presenting the relationships between key factors such as the age of the homes, their construction design, soil composition, and the recorded blast vibrations, offering a clear comparison that will help assess the potential effect of the blasts. By categorizing homes into "Damage Causing" (D.C.) or "Non-Damage Causing" (N.D.C.) based on the 50 mm/s threshold (Siskind et al., 1980; Ghee et al., 2018), the graphic will allow for a direct comparison of which properties experienced damage and which did not, relative to the seismic forces they were subjected to. This comparison will also take into account the variability in construction and soil conditions, which can alter how seismic waves propagate through different materials, affecting how the buildings respond to vibrations. Previous studies have shown that factors like soil type and construction design are critical in understanding structural response to seismic events (Ghee et al., 2018). For instance, homes built with more resilient materials or located on more stable soils may exhibit greater resistance to damage, even when exposed to blasts that exceed the threshold, compared to those built with weaker materials or on more susceptible soil types.

The graphic will help identify patterns and correlations between these variables, offering insight into how specific combinations of factors influence the likelihood of damage. This visualization will allow researchers to quickly identify whether there is a clear pattern of damage associated with blast-induced vibrations or whether other factors, such as the soil composition and building age, play a more significant role in determining structural vulnerability. By grouping the homes according to these criteria, the graphic will facilitate a more comprehensive understanding of the data and assist in determining whether or not the blasts have had a discernible effect. Additionally, this method can be replicated in future studies by applying the same criteria for vibration thresholds and categorizing homes based on similar factors, enabling researchers to explore the relationship between seismic activity and structural damage in various contexts.

3.6 Study Limitations

A key limitation of this study is the small sample size, as only three homes are being evaluated. While this limits the generalizability of the findings to broader populations, the diversity in construction types, ages, and soil conditions among the homes provides a meaningful foundation for analysis. Each home represents distinct variables that allow for a nuanced understanding of how different factors contribute to structural vulnerability. To mitigate the limitations of the small sample size, the study employs a comprehensive methodology, combining qualitative assessments with seismic data analysis. By integrating objective seismic measurements with visual inspections and soil analyses, the research can identify patterns and draw conclusions that extend beyond the individual cases studied.

Additionally, while the sample size is limited, the study lays the groundwork for future research. The methodologies and findings can serve as a template for scaling up the study, providing a framework for more extensive investigations in similar residential areas affected by mining activities. By acknowledging the sample size constraint while demonstrating how this research can still generate valuable insights, the study overcomes this limitation and adds meaningful contributions to the field.

Another limitation of this study is the potential bias in homeowners' accounts of structural damage. Homeowners may unintentionally overstate or misinterpret damage, attributing it directly to mining activities due to preconceived notions or heightened concerns about blasting effects. This attribution bias could result in subjective reporting that may not fully align with objective observations or measurements. To address this, detailed site inspections, conducted by trained professionals, focus on objective criteria for damage assessment, such as identifying stress cracks, foundation shifts, or material deterioration. Photo and video documentation further ensure that damage is evaluated consistently and transparently.

The study also relies on seismic data to correlate reported damage with measurable ground vibrations, providing a scientific basis to validate or refute claims. In cases where damage cannot be directly linked to recorded blasting events, findings will be carefully framed to avoid overstating causality. Additionally, the triangulation of data—integrating seismic analysis, homeowner reports, and independent professional evaluations—adds a layer of verification, ensuring that conclusions are not unduly influenced by subjective perceptions. By proactively addressing the potential for homeowner bias through rigorous methodologies and data triangulation, the study enhances the validity of its findings and ensures a balanced, evidence-based approach.

4.0 EXPECTED RESULTS

4.1 Deliverables and Outputs

Deliverables:

- **Seismic Data Repository**: A comprehensive database of vibration measurements collected from the 846 Mine, including frequency and Peak Particle Velocity (PPV) values.
- **Structural Assessment Reports**: Detailed documentation of observed damages, categorized by property type, age, and soil composition.
- **Damage Threshold Graphic**: A graphic that will categorize homes based on vibration levels, construction materials, and soil conditions to identify whether the recorded blast vibrations exceed the 50 mm/s threshold for structural damage, thereby helping to assess the correlation between these factors and the likelihood of damage.
- **Final Research Report**: A professionally compiled report summarizing all findings, methodologies, and recommendations, submitted to stakeholders, including the homeowners and mining company.

Outputs:

- Identification of vibration patterns linked to structural damage in the study area.
- Statistical correlations between PPV levels and the extent of structural damage across the three homes.
- A published preprint detailing the study's methodology and findings.

4.2 Outcomes and Impacts

Outcomes:

- **Improved Decision-Making**: Homeowners and stakeholders will gain a clear understanding of the risks associated with mining vibrations, enabling informed decisions about property maintenance and future developments.
- **Regulatory Insights**: Local authorities may use findings to refine zoning laws and vibration thresholds, addressing community concerns and protecting residential areas.
- **Enhanced Engineering Practices**: The study's model and data can guide engineers in designing homes with better resistance to mining-induced vibrations, particularly in regions with similar soil compositions and construction methods.
- **Knowledge Dissemination**: Increased awareness among homeowners and local policymakers about vibration impacts and structural vulnerabilities.

Impacts:

- **Strengthened Public Confidence**: A transparent investigation of the mining company's activities will foster trust between the company and the community.
- **Improved Residential Safety**: Long-term structural integrity of homes in mining-adjacent areas may improve as a result of revised building codes and construction practices.
- **Academic Contribution**: The research will fill a critical gap in the literature, especially regarding the cumulative effects of low-level vibrations, providing a valuable reference for future studies.
- **Economic Stability**: Reduced damage to homes could minimize repair costs for homeowners and liability risks for mining companies, contributing to economic resilience in the area.
- **Policy Evolution**: The study may serve as a basis for revising state or national guidelines on vibration thresholds, promoting sustainable coexistence between mining operations and residential communities.

5.0 PROJECT TIMELINE

Research for this project began on July 2, 2024, with the first on-site inspection. Standard site visits typically last one hour but may extend to two hours if needed. The research is expected to conclude by May 2025. The Preliminary Phase is scheduled to be completed by December 2024. The Preliminary Phase of this study takes into account several key factors:

- Coordination and scheduling of site visits.
- Duration of each inspection.
- Compilation and organization of photos, videos, and seismic reports.
- Selection of a seismic specialist for professional data analysis.

Following the Preliminary Phase, the succeeding Independent Analysis Phase will span 14 weeks. At this time, the independent research and analysis of the seismic data will commence. This will entail studying other academic sources and conducting mathematical equations found in scholarly sources for similar studies. This phase will also consist of online lectures and lessons on seismic vibrations published by other members of academia, as well as weekly meetings with an academic instructor for feedback and guidance. The timeline below depicts in greater detail how this phase will commence (Figure 6).

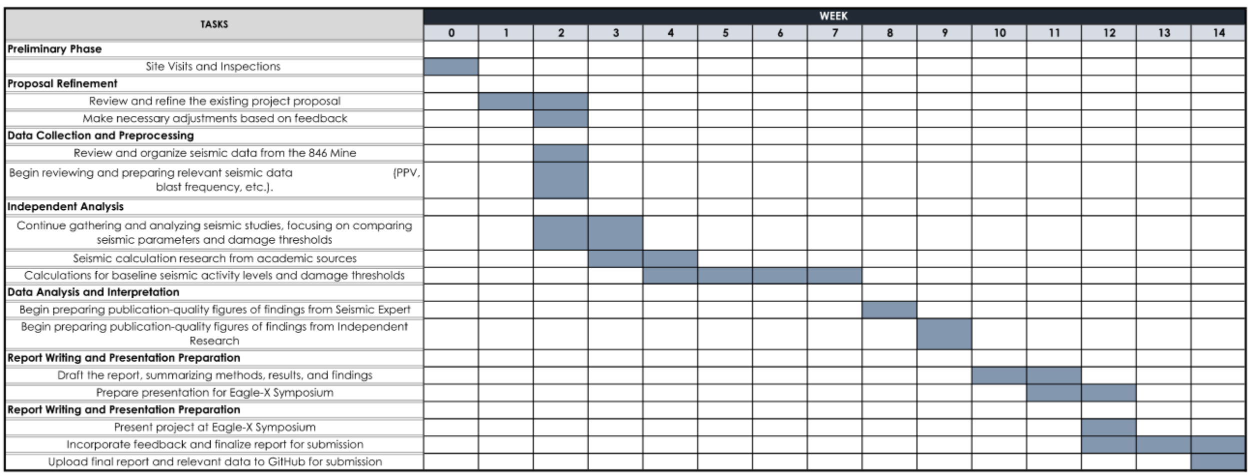

Figure 6: Timeline for the Independent Analysis Phase

5.1 Contingency Plan

Risk: Insufficient time for all seismic data calculations within the study period.

Contingency Plan:

- The research will be narrowed to focus on a single month's data, which will allow for thorough analysis within the given timeframe.
- To mitigate potential setbacks, the most critical months, based on seismic activity, will be selected for detailed analysis.
- If time constraints persist, the remaining months will be deferred for future analysis, utilizing the built-in buffer time to adjust for unforeseen challenges.

6.0 ETHICAL CONSIDERATIONS

Ethical considerations form a cornerstone of this study, ensuring that all research activities are conducted transparently, professionally, and with respect for all stakeholders. Permission has been obtained from the homeowners whose properties are being studied. The homeowners have explicitly granted access to their properties for the purpose of conducting inspections and documenting any observed damage. Prior to initiating inspections, the full intent and scope of this investigation were disclosed to the homeowners' representative, ensuring their understanding and agreement with the study's objectives.

All aspects of this study are carried out with complete transparency. Homeowners have been informed that the study aims to evaluate the potential impact of seismic vibrations from mining activities on residential structures. Furthermore, it is disclosed that this study is being funded by the mining company operating the 846 Mine. While this funding introduces the potential for a perceived conflict of interest, the research team is committed to maintaining strict impartiality. The primary goal is to provide an accurate and unbiased assessment of the situation, ensuring fairness to all parties involved.

The research team adheres to the highest professional and ethical standards as engineers. All inspections, data collection, and analyses are conducted with objectivity and diligence, ensuring that conclusions are based solely on empirical evidence. The funding source does not influence the methodology or interpretation of results. Professional integrity and independence are prioritized throughout the research process.

The privacy of homeowners and the confidentiality of the data collected are paramount. All documentation, including property damage reports and seismic data, is treated with strict confidentiality. Identifiable information about homeowners and their properties is not shared beyond the context of this study without explicit consent.

Recognizing the potential influence of biases—whether from homeowners' perceptions or the funding source—the research team has implemented measures to ensure objectivity. Data collection is based on measurable, scientific criteria, and findings are validated through independent analysis. Using multiple data points, including seismic measurements and professional structural assessments, ensures a balanced evaluation that minimizes subjective interpretation.

By maintaining transparency about the study's funding, obtaining informed consent, adhering to professional standards, safeguarding privacy, and implementing safeguards against bias, this research is conducted with the utmost ethical integrity. The study aims to provide a fair, impartial, and scientifically sound assessment, upholding trust and accountability to all stakeholders involved.

7.0 DATA MANAGEMENT

This Data Management Plan outlines the strategies for collecting, storing, analyzing, and disseminating data for this study. The plan adheres to the principles of FAIR—Findability, Accessibility, Interoperability, and Reusability—to ensure the responsible management of research data while maintaining ethical considerations.

7.1 Data Collection

Data Types:

- **Seismic data**: Collected from vibration monitors placed on or near residential properties.
- **Structural inspection data**: Includes photographs, videos, and written documentation of observed damage.
- **Homeowner comments**: Qualitative data gathered through interviews or statements from homeowners.

Collection Methods:

- Seismic monitors record vibrations, generating detailed frequency and Peak Particle Velocity (PPV) data.
- Site visits are conducted to document visible damage, using standardized inspection checklists to ensure consistency.
- Homeowners' verbal and written accounts are recorded for reference.

7.2 Data Storage and Security

- **Storage Locations**:
    - Raw seismic data is stored on secure, encrypted servers managed by office firmware.
    - Inspection data (photos, videos, and notes) is stored in a password-protected cloud storage system with restricted access.
- **Backup Strategy**:
    - Data is backed up weekly on redundant servers to prevent loss.
    - Offline backups are made monthly on encrypted external drives.
- **Confidentiality**:
    - Personal information of homeowners is anonymized in all datasets to protect privacy.
    - Access to raw data is limited to authorized personnel directly involved in the study.

7.3 Data Analysis and Validation

- Seismic data is analyzed using professional software by an independent seismic engineering firm.

- Structural damage data is categorized by property age, construction type, and soil composition, enabling cross-comparison.
- Qualitative homeowner accounts are triangulated with quantitative data to minimize bias.

7.4 Data Sharing and Accessibility

- **FAIR Principles**:
  - **Findability**: Data is indexed and stored with metadata describing the source, type, collection method, and analysis performed. Metadata complies with international standards such as Dublin Core.
  - **Accessibility**: Anonymized datasets will be made available upon request after the study's conclusion, with access controlled via a licensing agreement to ensure ethical use. A preprint will also be published online following the completion of the study.
  - **Interoperability**: Data formats such as CSV, JSON, and standard image formats are used to enable compatibility with various software tools. Metadata uses standard schemas to facilitate integration with external datasets.
  - **Reusability**: Clear documentation accompanies all datasets, including methodology, analysis procedures, and ethical considerations, ensuring data can be reused in future research.

7.5 Long-term Data Preservation

- Data will be preserved in a secured server indefinitely.

7.6 Ethical Compliance

- All data collection follows informed consent protocols, with homeowners fully aware of the study’s purpose and how their data will be used.
- Personally identifiable information is removed before data sharing to comply with privacy standards.

<u>Appendix</u>

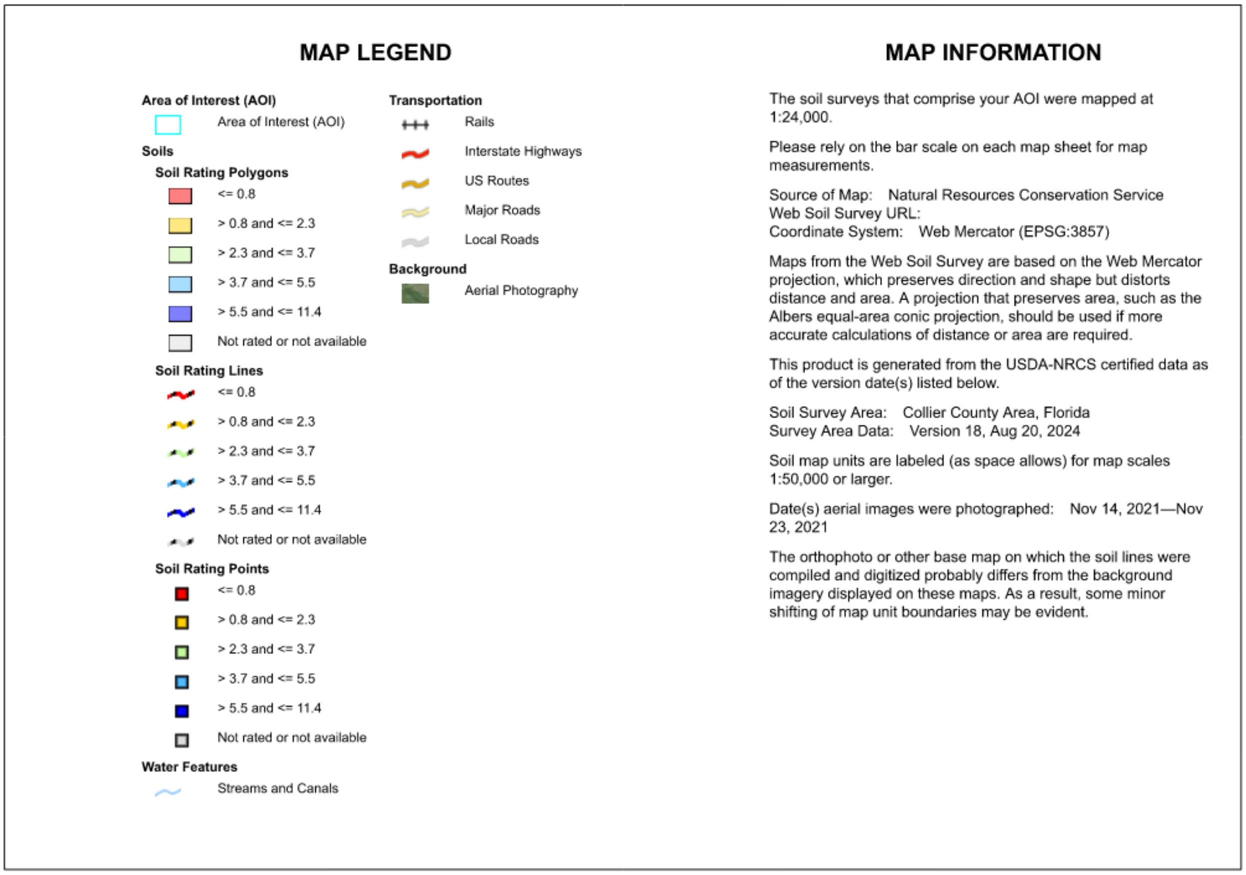

Figure 7: Legend for the Plasticity Index Map (United States Department of Agriculture)

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
3	Malabar fine sand, 0 to 2 percent slopes	1.7	105.8	3.3%
7	Immokalee fine sand, 0 to 2 percent slopes	0.0	528.6	16.5%
8	Myakka fine sand, 0 to 2 percent slopes	0.0	130.1	4.1%
14	Pineda fine sand, limestone substratum, 0 to 2 percent slopes	5.5	18.2	0.6%
16	Oldsmar fine sand, 0 to 2 percent slopes	3.7	89.5	2.8%
17	Basinger fine sand, 0 to 2 percent slopes	0.0	23.2	0.7%
23	Holopaw-Okeelanta, frequently ponded, assocaition, 0 to 1 percent slopes	0.8	7.5	0.2%
25	Cypress Lake-Riviera-Copeland fine sands, frequently ponded, association, 0 to 1 perent slopes	1.7	60.7	1.9%
27	Holopaw fine sand, 0 to 2 percent slopes	1.8	91.7	2.9%
43	Winder, Riviera, limestone substratum, and Chobee soils, frequently ponded, 0 to 1 percent slopes	11.4	5.2	0.2%
99	Water		14.9	0.5%
101	Basinger fine sand-Urban land complex, 0 to 2 percent slopes	0.0	267.4	8.4%
102	Cypress Lake fine sand-Urban land complex, 0 to 2 percent slopes	1.4	98.2	3.1%
103	Cypress Lake-Riviera-Copeland fine sands, frequently ponded-Urban land association, 0 to 1 percent slopes	1.7	12.2	0.4%
113	Holopaw fine sand-Urban land complex, 0 to 2 percent slopes	1.8	64.0	2.0%

Figure 8: Plasticity Index Table A (United States Department of Agriculture)

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
117	Immokalee fine sand-Urban land complex, 0 to 2 percent slopes	0.0	801.5	25.1%
120	Malabar fine sand-Urban land complex, 0 to 2 percent slopes	1.7	487.5	15.2%
122	Myakka fine sand-Urban land complex, 0 to 2 percent slopes	0.0	317.2	9.9%
125	Oldsmar fine sand-Urban land complex, 0 to 2 percent slopes	3.7	51.8	1.6%
129	Pineda-Riviera fine sands-Urban land association, 0 to 2 percent slopes	2.3	23.6	0.7%
Totals for Area of Interest			**3,198.9**	**100.0%**

Figure 9: Plasticity Index Table B (United States Department of Agriculture)

Figure 10: Hydrologic Soil Group Map of Study Area (United States Department of Agriculture)

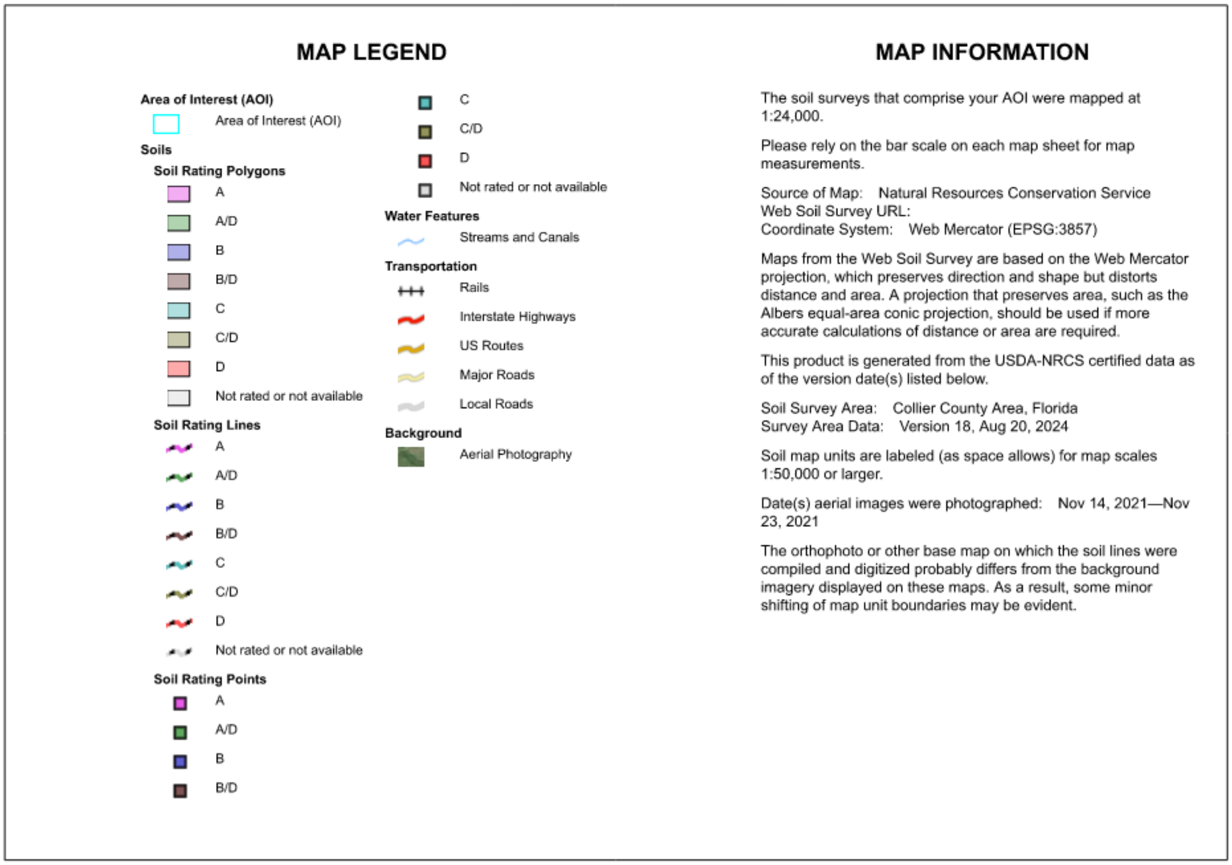

Figure 11: Legend for the Hydrologic Soil Group Map (United States Department of Agriculture)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Malabar fine sand, 0 to 2 percent slopes	A/D	105.8	3.9%
7	Immokalee fine sand, 0 to 2 percent slopes	B/D	390.7	14.3%
8	Myakka fine sand, 0 to 2 percent slopes	A/D	130.1	4.8%
14	Pineda fine sand, limestone substratum, 0 to 2 percent slopes	C/D	0.3	0.0%
16	Oldsmar fine sand, 0 to 2 percent slopes	A/D	41.4	1.5%
17	Basinger fine sand, 0 to 2 percent slopes	A/D	23.2	0.8%
25	Cypress Lake-Riviera-Copeland fine sands, frequently ponded, association, 0 to 1 perent slopes	A/D	20.4	0.7%
27	Holopaw fine sand, 0 to 2 percent slopes	A/D	84.9	3.1%
99	Water		14.7	0.5%
101	Basinger fine sand-Urban land complex, 0 to 2 percent slopes	A/D	254.2	9.3%
102	Cypress Lake fine sand-Urban land complex, 0 to 2 percent slopes	A/D	96.7	3.5%
103	Cypress Lake-Riviera-Copeland fine sands, frequently ponded-Urban land association, 0 to 1 percent slopes	A/D	9.2	0.3%
113	Holopaw fine sand-Urban land complex, 0 to 2 percent slopes	A/D	57.4	2.1%
117	Immokalee fine sand-Urban land complex, 0 to 2 percent slopes	B/D	700.1	25.6%
120	Malabar fine sand-Urban land complex, 0 to 2 percent slopes	A/D	435.0	15.9%
122	Myakka fine sand-Urban land complex, 0 to 2 percent slopes	A/D	317.2	11.6%

Figure 12: Hydrologic Soil Group Table A (United States Department of Agriculture)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
125	Oldsmar fine sand-Urban land complex, 0 to 2 percent slopes	A/D	28.5	1.0%
129	Pineda-Riviera fine sands-Urban land association, 0 to 2 percent slopes	A/D	23.6	0.9%
Totals for Area of Interest			**2,733.6**	**100.0%**

Figure 13: Hydrologic Soil Group Table B (United States Department of Agriculture)

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