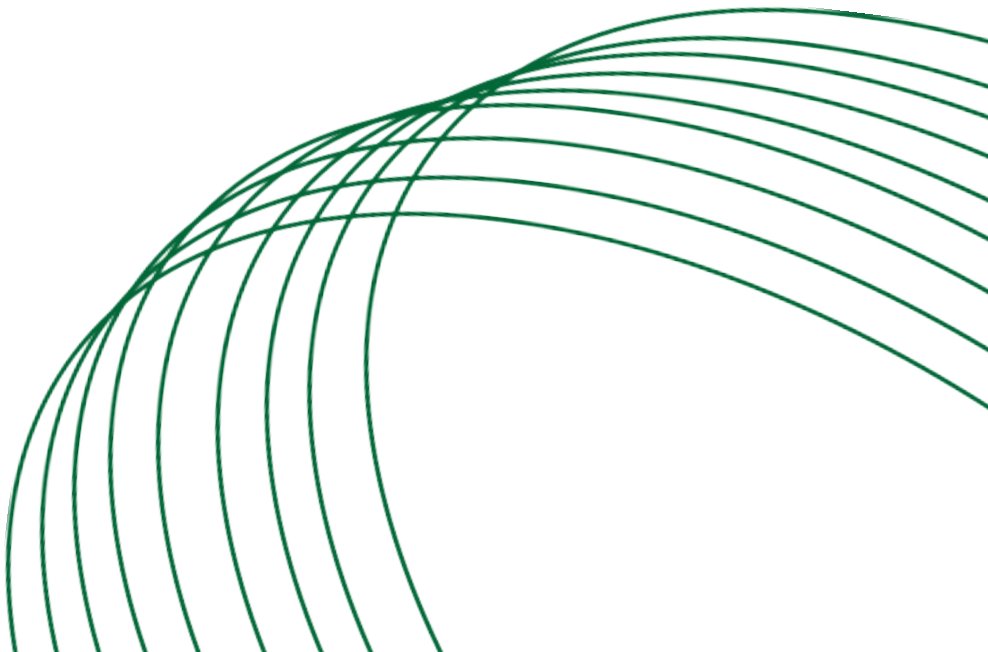
Building Diagnostic Robotics Inspection Report

Building Scanned:
Sample Building

Location:
111 ABC Street, NY, 10001

Test Date:
27th February, 2024 10:07 AM

On Site Engineers:
EngineerA, EngineerB, EngineerC



Contents

List of Figures

1. Executive Summary

The following executive summary provides a brief overview of the moisture damage and visual anomalies detected in the building.
Survey conducted on: 27th February, 2024 10:07 AM
Address: 111 ABC Street, NY, 10001

The following table provides a summary of the moisture damage in each section of the building.

Section Number	Moisture Percent	Risk Level	Square Footage	Area Damaged
1	19.08%	High-Risk	3080 sq.ft.	587 sq.ft.
2	15.72%	High-Risk	9160 sq.ft.	1439 sq.ft.

Total Assessed Area: 12240 sq.ft.
Total Rooftop Area: 18604 sq.ft.

The following table provides a summary of the visual anomalies detected in each section of the building.

Anomaly Type	Section 2
Base Flashing-Coated Metal	21
Base Flashing-Membrane Material	12
Debris And Vegetation	2
Defective Seams	10
Flashed Penetrations	3
Improper Equipment Supports	1
Interior Drains And Roof Level Scuppers	1
Membrane Support Deficiencies	1
Ponding	15
Ridges	9
Splits	1

Recommendations:
Section 1: Retain a specialist roof consultant to monitor roof condition and suggest repairs to lengthen the life of your roof asset. Roof likely has between 5 and 15 years of remaining roof life. Roof life can be extended by an additional 10 to 15 years by reroofing or adding a second roofing layer.
Section 2: Retain a specialist roof consultant to monitor roof condition and suggest repairs to lengthen the life of your roof asset. Roof likely has between 5 and 15 years of remaining roof life. Roof life can be extended by an additional 10 to 15 years by reroofing or adding a second roofing layer.

2. Introduction

The facilities were scanned and evaluated at Sample Building, located at 111 ABC Street, NY, 10001. This report covers the scope, findings, and recommendations based on the data collected.

2.1 Authorization

The evaluation was conducted under the authorization of AuthorityA, AuthorityA, with oversight from the Building Diagnostic Robotics team. For inquiries, contact ContactA at +1 (123)-456-789, ContactA@email.com.

2.2 Scope

The roof evaluation was conducted employing a suite of methodologies, including Ground Penetrating Radar (GPR) moisture surveys, detailed visual inspections, and LiDAR point cloud capture. These methodologies were applied across various sections of the roofing structure as deemed necessary. The resultant dataset encompasses an aerial representation of the roofing system, locations of visually apparent defects, delineations of water accumulation on the membrane's surface, and detailed mappings of moisture intrusion below the membrane. The report details the type of roofing material used.

Included within the report are several visual aids: full roof maps highlighting moisture presence both above and beneath the membrane, photographic evidence of the roof's general condition, and a full roof map synthesizing all collated data. Moreover, sectional views of the roofing structure are provided to detail areas of sub-surface moisture penetration and to identify visual impairments, thereby facilitating strategic decision-making regarding necessary maintenance, repair, or replacement interventions.

2.3 Purpose

The primary purpose of this evaluation is to gain a comprehensive understanding of the damages present on the roof. Through a detailed analysis, we aim to identify all issues affecting the roof's integrity and functionality, ensuring that all necessary repairs or maintenance actions can be accurately planned and executed.

2.4 Limitations

This report incorporates advanced technologies, including Ground Penetrating Radar (GPR) and LiDAR, to assess the condition of the roof. However, several factors can impact the accuracy and comprehensiveness of our findings, which are outlined below to ensure a clear understanding of the report's scope and limitations.

The presence of ponding water on the roof, potentially exacerbated by recent rainfall, may obscure our ability to accurately assess moisture levels directly beneath these areas. Such conditions can create abnormally large areas of standing water, hindering precise moisture detection.

Similarly, ice and ice dams can significantly impede our ability to detect moisture beneath the roof's surface. These conditions pose additional challenges to the assessment's thoroughness and accuracy.

Ground Penetrating Radar (GPR) is a promising technology with proven capabilities in detecting sub-surface moisture and structural issues. However, as GPR is still undergoing development and testing, it may encounter unexpected situations in novel applications. For mission-critical assessments, we advise clients to supplement GPR findings with standard roof assessment practices, including requesting core-cuts, to ensure a more comprehensive evaluation.

The report also utilizes an advanced image processing model to identify visual defects. It's important to recognize that this model is continuously being improved, which may affect the accuracy of defect detection over time.

Furthermore, LiDAR-based measurements and localizations are provided with an accuracy within 30 cm (approximately 1 foot) and a likely accuracy within 10 cm (approximately 0.33 feet). This precision level is important for interpreting spatial data and making informed decisions based on LiDAR findings.

Together, these technologies and methodologies provide a robust framework for assessing the roof's condition. However, acknowledging these limitations is crucial for interpreting the report's findings accurately and making informed decisions.

2.5 Disclaimer

Please note that the inspection work detailed in this report was conducted by professionals who are trained and experienced in evaluating the condition of building roofs. However, it is important to clarify that our team does not include Registered Roof Consultants (RRC), Registered Roof Observers (RRO), or Professional Engineers (PE). Our assessments are based on extensive experience and training in roof inspections and condition evaluations. This report is intended to provide a comprehensive overview of the roof conditions within the specified portfolio and should be used as a guide for further detailed inspection and decision-making by qualified professionals.

3. Methodology

3.1 Equipment Used

In the course of our comprehensive roof assessment, we leverage a suite of state-of-the-art equipment and cutting-edge software technologies. Each component plays a crucial role in enabling us to deliver precise and insightful analysis.

The Proceq GP8800 SFCW Ground Penetrating Radar (GPR) serves as a foundational tool in our moisture detection efforts. Its advanced capabilities allow for deep penetration and high-resolution imaging, essential for identifying moisture beneath the roof's surface and detecting structural anomalies. For spatial mapping and architectural details, we utilize the Livox Mid360 LiDAR system. This equipment offers exceptional accuracy in capturing the intricate geometries of building façades and roof structures, facilitating detailed analysis of physical features. The Insta360 Air camera is employed to obtain comprehensive 360-degree imagery of the site. This visual data is crucial for creating immersive visualizations that enhance our understanding of the roof's condition. Positioning and accuracy are further enhanced by the u-blox ZED-F9P GPS-RTK system. This high-precision GPS technology ensures that our data is geospatially accurate, allowing for precise mapping and localization of findings.

The analysis of GPR data is revolutionized by our proprietary deep learning-based neural network. This sophisticated AI algorithm interprets GPR signals to identify and quantify sub-surface anomalies with unprecedented accuracy. Similarly, our proprietary image analysis neural network plays a pivotal role in processing visual data. By leveraging deep learning, this system efficiently detects and categorizes visual defects across roof surfaces. Lastly, our approach to LiDAR data interpretation is enhanced by a modified open-source LiDAR SLAM (Simultaneous Localization and Mapping) algorithm. This modification allows for accurate 3D mapping of complex structures, providing a foundational layer for our comprehensive analysis.

Together, these advanced technologies and proprietary algorithms enable us to conduct thorough and precise assessments of building envelopes. By integrating these tools, we provide our clients with detailed insights and actionable recommendations, ensuring the longevity and integrity of their structures.

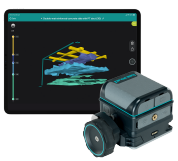


Figure 3.1: Proceq GP8800 SFCW Ground Penetrating Radar

The GPR used for roof moisture scanning is the Proceq GP8800 SFCW Ground Pen-

etrating Radar.

Figure 3.2: Livox Mid360 LiDAR system

The LiDAR used to collect localization and mapping data is the Mid360 LiDAR from Livox.

Figure 3.3: Insta360 Air camera

The 360° camera used to collect RGB data for visualization is the Insta360 Air camera.

3.2 Explanation of Visualizations

3.2.1 Moisture maps

Moisture mapping utilizes data from a robotic sensor platform to create four specific maps:

1. **GPR-Captured Moisture Map:** Shows both surface and subsurface moisture to identify interference patterns.
2. **LiDAR-Captured Moisture Map:** Details surface moisture, such as ponding water and ice, excluding snow.
3. **Below Membrane Moisture Map:** Generated by subtracting LiDAR-captured moisture from the GPR-captured moisture data, this map accurately locates subsurface moisture indicative of membrane compromise.

4. **All Membrane Moisture Map:** Generated by layering LiDAR-captured moisture data over GPR-captured moisture data, this map provides the location of all detected moisture in and on the roofing assembly.

These analytical maps offer targeted insights into moisture distribution, crucial for addressing membrane integrity issues.

LiDAR-Captured Moisture Map

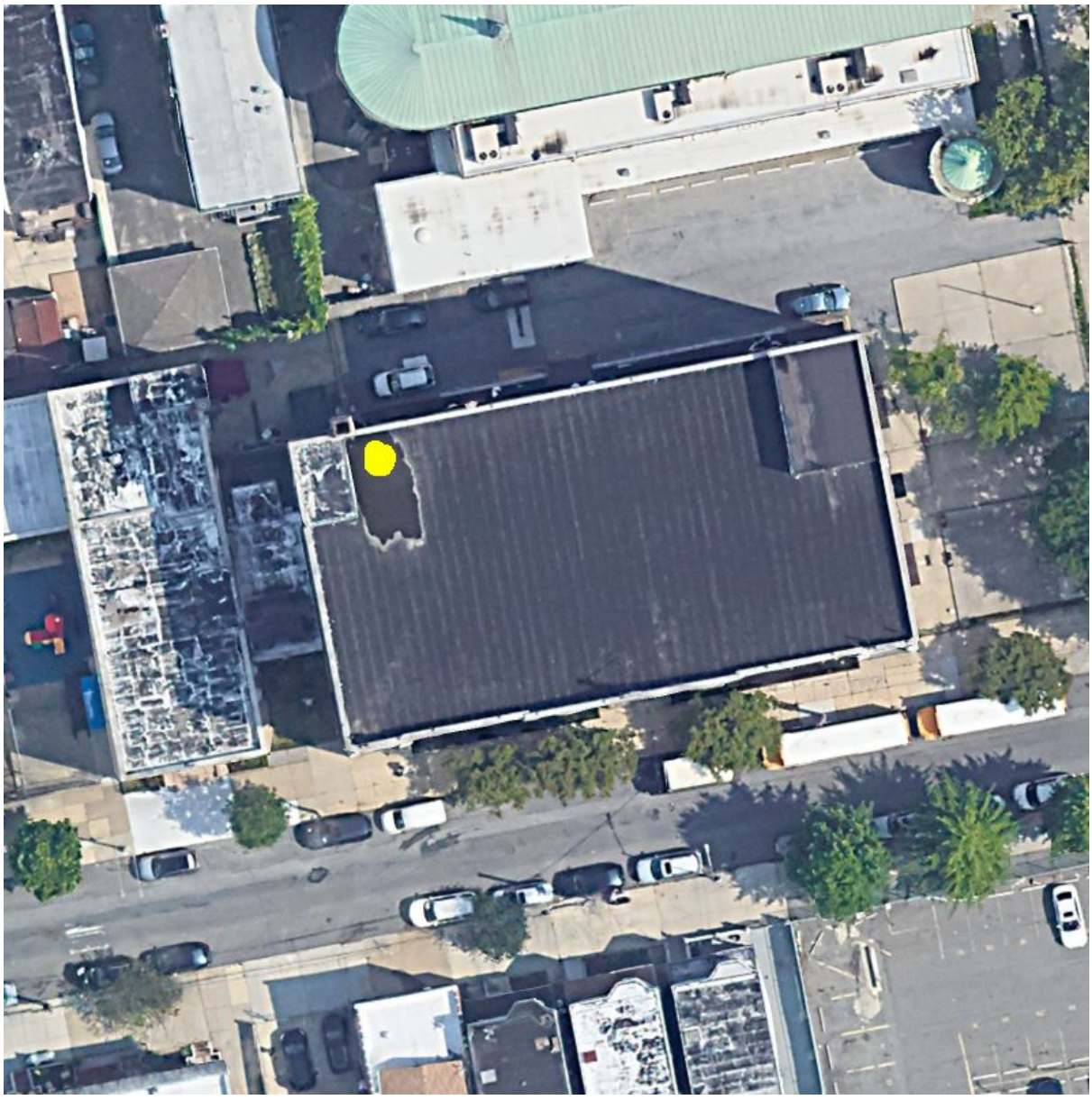


Figure 3.4: Areas in yellow indicate moisture found via LiDAR

This map has been relegated to the Appendix A for reference purposes and will not be included in the main body of the report to ensure clarity and prevent potential confusion among readers.

Below Membrane Moisture Map

Figure 3.5: Areas in green show all detected sub-surface moisture

All Moisture Map

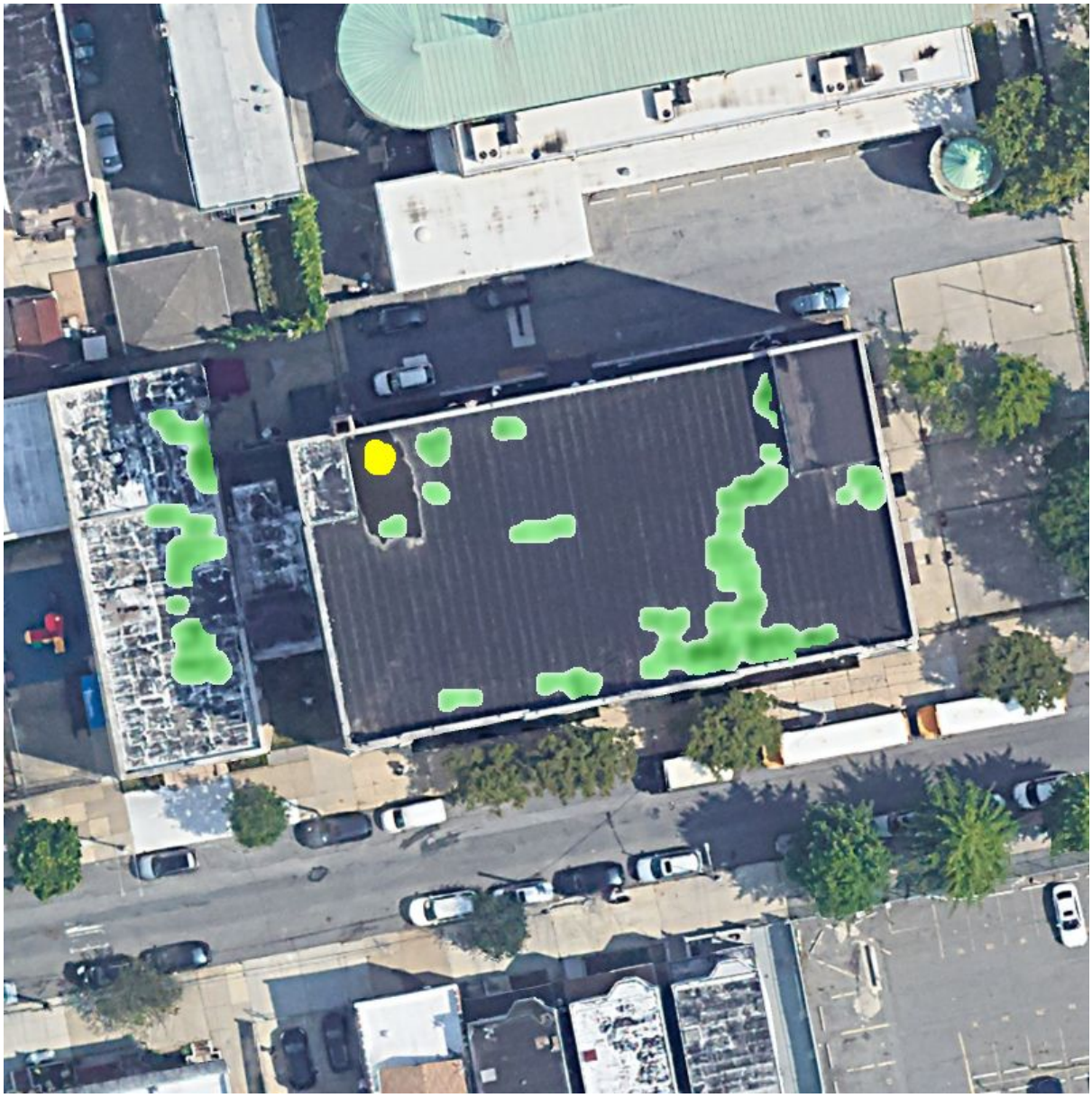


Figure 3.6: Areas in green show all detected sub-surface moisture, areas in yellow show all above-surface moisture

3.2.2 Visual Deficiencies

Visual deficiencies are identified through a sophisticated image analysis deep learning model. Leveraging SLAM (Simultaneous Localization and Mapping) data, informed by LiDAR and GPS inputs, we precisely map the location of these issues on the roof for targeted examination.

Visual Deficiencies Map

This map provides an overview of visual deficiencies, with the legend associating specific colors to identified issues. It displays all visually detected deficiencies and their approximate locations. To enhance clarity, due to potential congestion, the map may be segmented by deficiency type upon request; contact Bilal Sher at bilal.sher@bdx-robotics.com for more details.

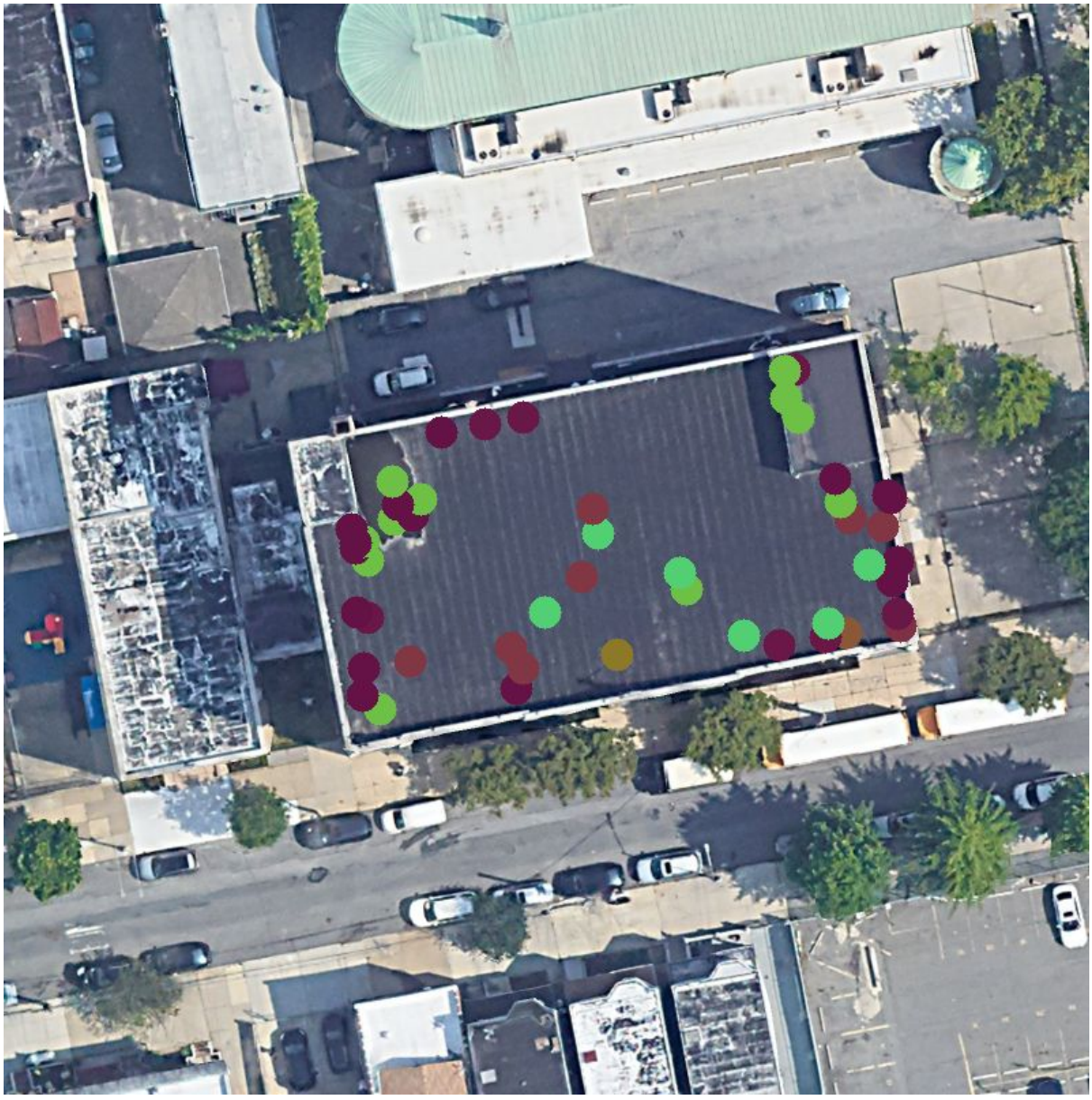


Figure 3.7: Maps of this type will showcase the location of visually observed issues

Visual Deficiencies Photographs

360° cameras capture more data than traditional photography. The captured images are post-processed using an image analysis software and AI to annotate defects with high precision. Each image is split into four views—Front, Right, Left, Back—based on the camera's direction during capture.

This report provides the segmented front, right, left, back images in order to facilitate a reader in better understanding the visual conditions on the roof.

All relevant images and their detected deficiencies are cataloged in an Appendix B for detailed review.

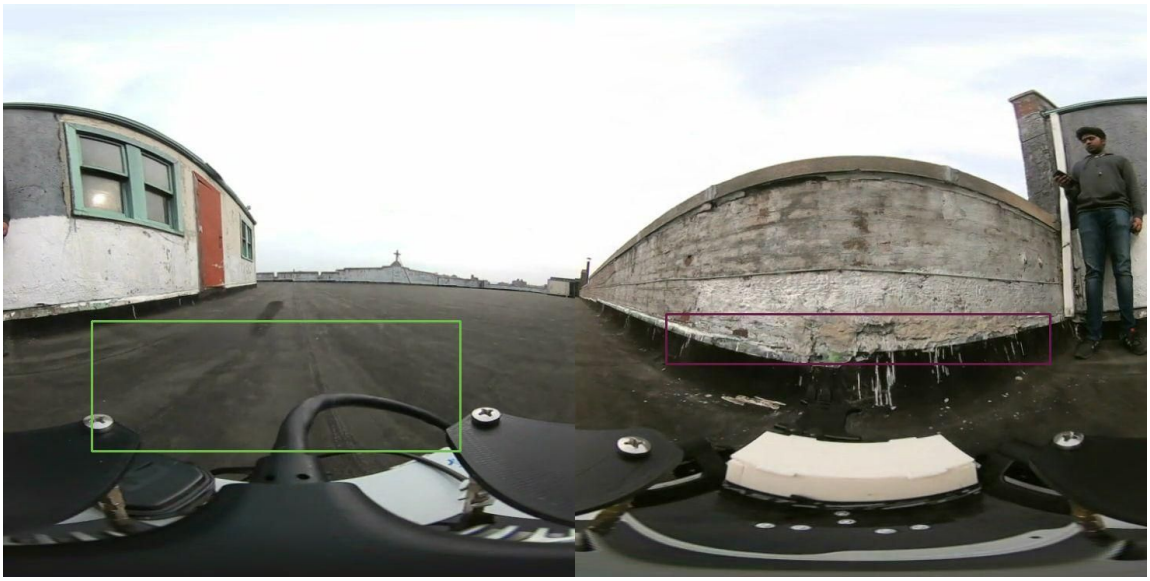


Figure 3.8: Example of 360° image with annotations

3.3 Exclusions

Our report delivers in-depth assessments using advanced technology, with certain services and data not included in the standard offering. These additional services may be available upon request, subject to specific conditions:

1. **LiDAR Roof Plans:** Provided only if explicitly requested, subject to data security protocols.
2. **AI Models for GPR and Image Analysis:** Due to their proprietary nature, our AI models for analyzing GPR scans and images are not available for external provision.
3. **SLAM Algorithm for LiDAR Analysis:** The specialized SLAM algorithm used for LiDAR data analysis remains proprietary and is not provided externally.
4. **Captured Video:** Available upon request, contingent on established data security measures.

4. Results & Discussions

4.1 Weather

The weather report for 27th February, 2024 05:38 PM indicates a temperature of 50.7°F, with a wind speed of 12.8 mph coming from the South-Southeast. The humidity level was 68.2%, and cloud cover was at 68.5%. Atmospheric pressure measured at 1012.1 inHg. The last recorded rainfall was 1088323.64 hours before the scan and in the last 48 hours, there were 0.46 inches of precipitation.

4.2 General Conditions of Roof

The roof inspection has identified several critical issues that require immediate attention. Base flashing made of coated metal is showing signs of wear and corrosion, which can lead to water leaks. Ponding, where water accumulates on the roof, is also a significant concern as it can weaken the structure and cause water damage.

Moreover, base flashing made of membrane material is showing signs of deterioration, which could compromise its ability to keep water out. Defective seams in the roofing material pose a risk of water infiltration, further exacerbating the existing problems.

These issues collectively indicate that the roof is at risk of significant water damage and structural issues. It is crucial to address these issues promptly to prevent further deterioration and ensure the roof's integrity and functionality. Immediate action is necessary to safeguard the building and prevent costly repairs in the future.

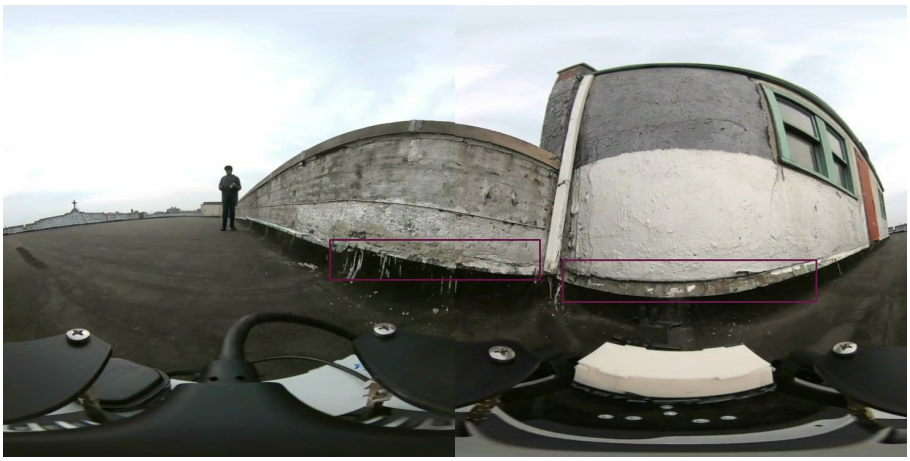


Figure 4.1: Base Flashing-Coated Metal

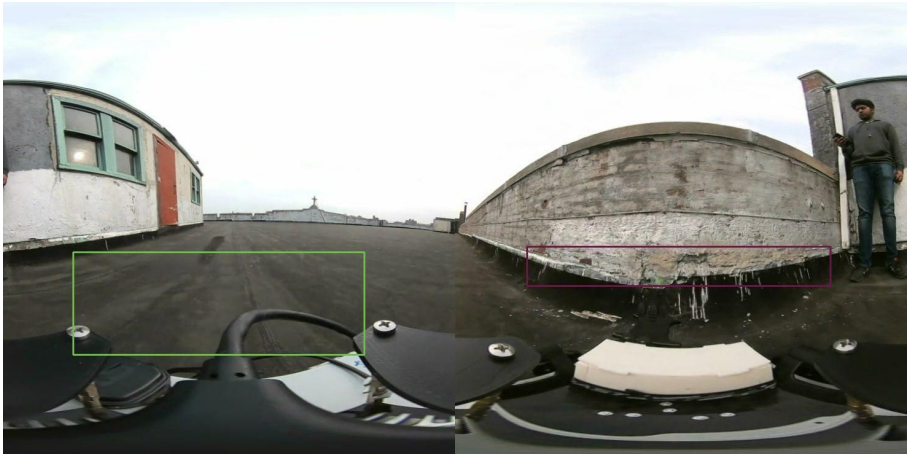


Figure 4.2: Ponding

Figure 4.3: Base Flashing-Membrane Material

Figure 4.4: Defective Seams

4.3 Full Roof Maps

4.3.1 All Observed Deficiencies Map

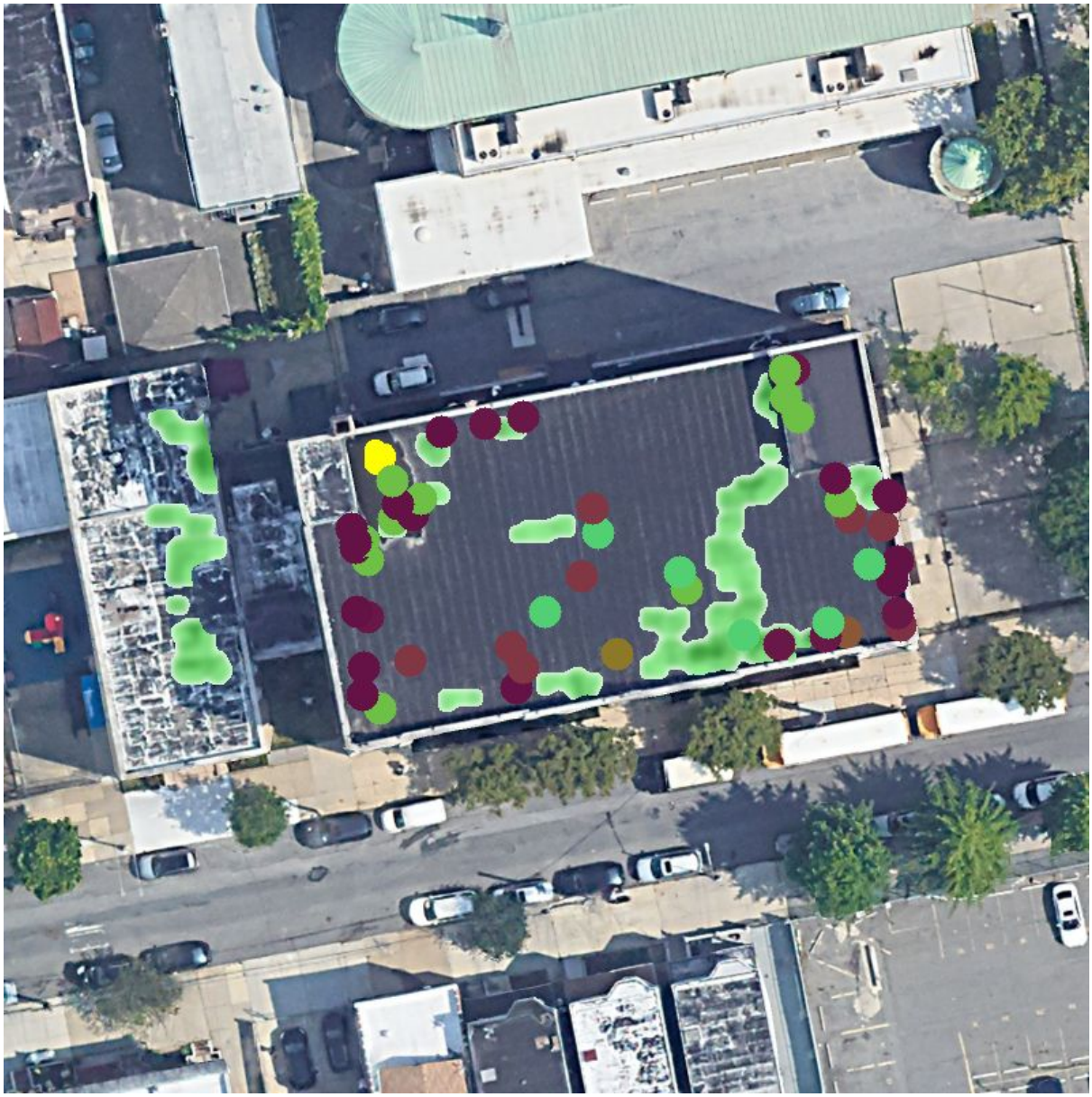


Figure 4.5: All Observed Deficiencies Map

This map consolidates all detected issues into a single visual representation, streamlining the dissemination and interpretation of information. Please refer to the sectional maps on the following pages for more detailed and granular discussions of the issues noted here.

4.3.2 Below Membrane Moisture Map

Figure 4.6: Below Membrane Moisture Map

This map shows the below membrane moisture map for the roof across the entire complex. This provides an overview to illustrate the overall condition of the roofs in this complex.

4.3.3 Sections of Roof

Figure 4.7: Sections of Roof

The roofs in this complex were divided and numbered for analysis in order to facilitate clearer communication. This map provides a visual overview of all examined sections.

4.4 Roof Section 1

SUB-MEMBRANE MOISTURE WAS DETECTED IN THIS SECTION

4.4.1 Introduction to Section 1

The roof membrane material for this section is EPDM (Ethylene propylene dienemonomer). The underlying insulation type cannot be determined without a core-cut, but is statistically likely to be polyiso (Polyisocyanurate). A spatial analysis reveals that 19.08% of the roof is affected by sub-membrane moisture damage.

4.4.2 Below Membrane Moisture

Based on a spatial analysis, 19.08% of this section is affected by sub-membrane moisture damage. These highlighted portions are considered moisture damaged and in need of repair. This presence of damaged roofing means that this section has a hazard classification of **High-Risk**. Retain a specialist roof consultant to monitor roof condition and suggest repairs to lengthen the life of your roof asset. Roof likely has between 5 and 15 years of remaining roof life. Roof life can be extended by an additional 10 to 15 years by reroofing or adding a second roofing layer. The map displayed below is based on captured and processed GPR and LiDAR data that capture different aspects of above and below membrane moisture. For reference and clarity, these maps can be found in Appendix A.

Figure 4.8: Below Membrane Moisture

This section was not scanned for visual deficiencies.

4.5 Roof Section 2

SUB-MEMBRANE MOISTURE WAS DETECTED IN THIS SECTION

4.5.1 Introduction to Section 2

The roof membrane material for this section is EPDM (Ethylene propylene dienemonomer). The underlying insulation type cannot be determined without a core-cut, but is statistically likely to be polyiso (Polyisocyanurate). A spatial analysis reveals that 15.72% of the roof is affected by sub-membrane moisture damage. The roof inspection data reveals significant concerns that demand immediate attention to preserve the integrity of the structure. The presence of base flashing made of coated metal and membrane material indicates vulnerable points where water infiltration may occur, potentially leading to water damage and mold growth. Ponding issues, characterized by standing water on the roof surface, pose a threat to the roof's structural stability and can accelerate deterioration.

Defective seams across the roofing components are clear indicators of wear and tear, increasing the risk of leaks and compromising the entire roofing system's effectiveness. Addressing these issues promptly is crucial to prevent further damage to the property and ensure the roof's longevity.

To safeguard the building and its occupants, it is essential to prioritize repairs and maintenance to address these identified roofing issues efficiently. By taking proactive measures now, you can mitigate the risk of costly repairs and potential safety hazards in the future.

4.5.2 Below Membrane Moisture

Based on a spatial analysis, 15.72% of this section is affected by sub-membrane moisture damage. These highlighted portions are considered moisture damaged and in need of repair. This presence of damaged roofing means that this section has a hazard classification of **High-Risk**. Retain a specialist roof consultant to monitor roof condition and suggest repairs to lengthen the life of your roof asset. Roof likely has between 5 and 15 years of remaining roof life. Roof life can be extended by an additional 10 to 15 years by reroofing or adding a second roofing layer. The map displayed below is based on captured and processed GPR and LiDAR data that capture different aspects of above and below membrane moisture. For reference and clarity, these maps can be found in Appendix A.

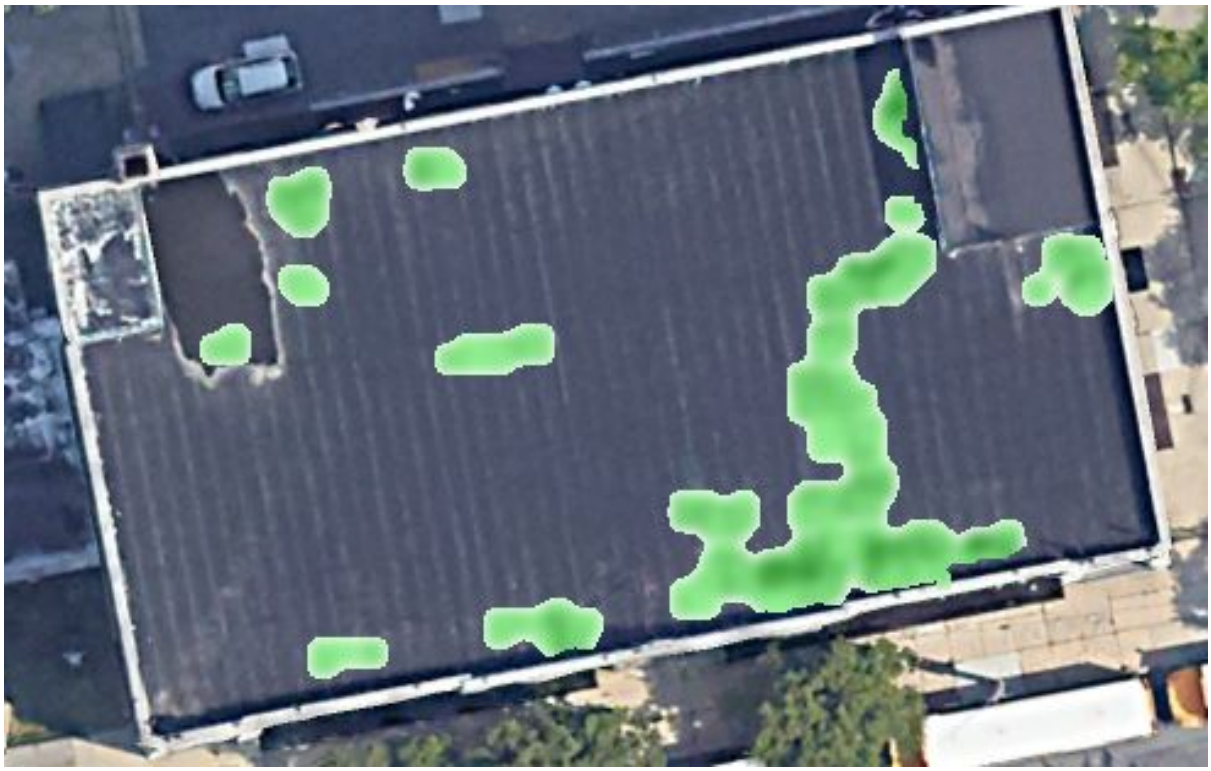


Figure 4.9: Below Membrane Moisture

4.5.3 Visual Deficiencies

The inspection identified multiple visual defects, as illustrated in the map below which depicts the distribution of membrane defects. The subsequent table details the specific types of defects and their observed frequencies within this section, providing a clear overview of the roof's condition. Photographic records of these issues and conditions can be found in Appendix B.

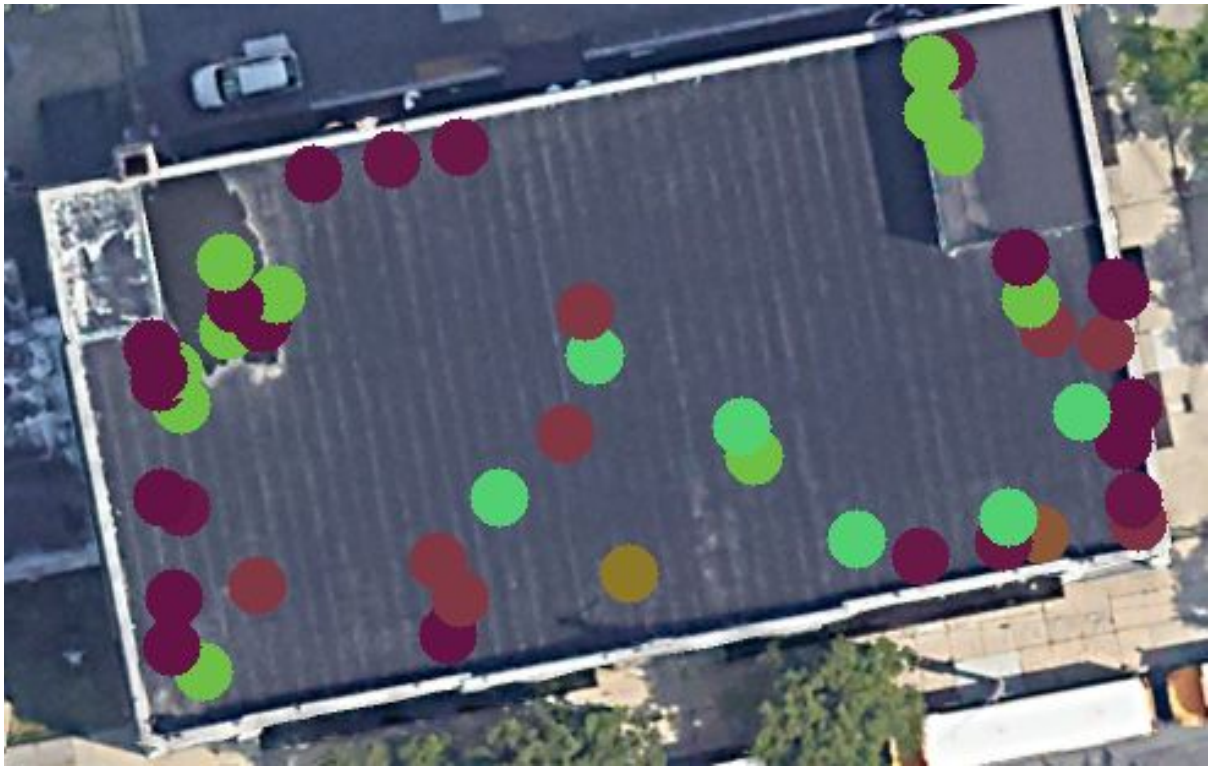


Figure 4.10: Visual Image

Color	Defect Type	Count
	Base Flashing-Membrane Material	12
	Flashed Penetrations	3
	Debris And Vegetation	2
	Base Flashing-Coated Metal	21
	Ponding	15
	Interior Drains And Roof Level Scuppers	1
	Splits	1
	Defective Seams	10
	Improper Equipment Supports	1
	Ridges	9
	Membrane Support Deficiencies	1

Table 4.1: Summary of Visual Defects for Roof Section 2