Towards a rehabilitative architecture: sustainability and preservation at the Midway Barn

Gregory Maxwell

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Abstract
This thesis evaluates rehabilitation design through a case study design project that addresses both contemporary preservation principles as well as environmental design tenets so that designers may better consider the integration of sustainability within contemporary preservation practice. The proposed project is the rehabilitation of one area of the Midway Barn at Frank Lloyd Wright's Taliesin, located in Spring Green, Wisconsin. Research in the areas of architectural history, technology, sustainability, and design inform an iterative process that analyzes the site, climate, building, materials, systems, significance and character-defining elements. This serves as an analytical framework within which to consider the contemporary preservation design. A final analysis of the proposal presents the lessons from the iterative research, analysis, and design process and identifies how this research may apply to other rehabilitation projects for the benefit of practicing design professionals.

Keywords
design, rehabilitation, Frank Lloyd Wright, organic architecture, environmental

Disciplines
Historic Preservation and Conservation

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TOWARDS A REHABILITATIVE ARCHITECTURE: 
SUSTAINABILITY AND PRESERVATION AT THE MIDWAY BARN

Gregory Alan Maxwell

A THESIS

in

Historic Preservation

Presented to the Faculties of the University of Pennsylvania in 
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To Dan, who has redefined perseverance.
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Preface

While I was studying architecture at the New Jersey Institute of Technology (NJIT), I participated in a studio course, taught by Tom Ogorzalek, in which I independently focused on the potential urban-scale ramifications of rising sea levels resulting from climate change. As a way to approach that challenge, I explored architectural responses that considered buildings as part of the geography, region, and environment in which they were sited. This studio allowed me to focus on a larger site scale than was typical of the architecture studios. In this studio, I was able to design more than just a building; I designed a large-scale housing project that also functioned as an expansion of the infrastructure servicing Governor’s Island in New York City. I was fascinated to consider the nexus of infrastructure, architecture and environment; there could be a marriage between the realms of the built environment that might function in response to climate change. As a speculative and theoretical exercise, this studio piqued my interest in the future of the built environment.

This thesis explores a similar idea with an added layer, and at a different scale. Rather than speculatively design a new building, as I had done while at NJIT, I have now added the layer of historic preservation. In this thesis I was able to explore how historic buildings may be a part of the sustainability of the built environment. I sought to investigate relative priorities between function, history, technology, climate and rehabilitation. Given the fact that many existing buildings will be required to adapt to change over time, this thesis explores how design may navigate the rivaling challenges at historic sites. The Midway Barn at Taliesin in Spring Green, Wisconsin serves as a suitable case for that exploration. I hope to leverage my experience with this project in my future design explorations as part of a critical methodology that considers the integration of sustainability
and preservation. I am hopeful that architects, designers, preservation professionals and others interested in the reuse of historic buildings will find my process informative and helpful in their own design work.
1. Introduction

As cities, countries, and the world grapple with climate change, sustainability has become a significant factor in the debate about how society may continue to develop and survive; specifically, how buildings contribute to climate change. Within the context of architecture, sustainability is applicable to more than just new construction. Historic buildings do, and must continue to, contribute to the sustainability of the environment; they are the ‘greenest’, or most environmentally friendly, buildings. Already, a recent study by the National Trust for Historic Preservation has found that building reuse almost always has fewer environmental impacts, consistently and immediately reduces climate change impacts, and that the materials used in the reuse process are significant to the overall climate change impact. At the same time, designers must consider the historic criteria for significance and balance those with the priorities of sustainability surrounding building reuse. Within those parameters, this thesis evaluates rehabilitative design through a case study design project that addresses both contemporary preservation principles as well as environmental design tenets. Together, these balanced principles can provide a framework for rehabilitating historic buildings and making them a significant component of society’s response to climate change.

There are generally three levels of buildings: new, existing, and historic. New buildings have fewer limitations and may be more easily designed around concepts of sustainability. Existing buildings without cultural significance do not force designers to contend with that significance as part of the rehabilitation pro-

cess. Historic buildings are the most challenging to work with given the parameters of historic significance, value, and character-defining elements. Within those levels, the site context can present additional challenges. Rural contexts offer some freedom to siting a building and form, urban contexts have established boundaries and limitations on building mass and scale, and historic environments, like historic buildings, add a layer of challenges related to preserving the context and integrating design within that significant environment.

Rehabilitating historic buildings in historic environments is, therefore, the most challenging type of design project because of the complexity and criteria associated with significance, value, and character-defining elements of the building and site. If historic buildings are considered a part of a climate change response, then the criteria of sustainability adds an additional layer of complexity to the design process. Incorporating sustainable design strategies is most difficult when rehabilitating historic buildings because they must be balanced with the priorities of historic preservation. This thesis investigates the integration of sustainability within one of the most challenging contexts—a historic building in a historic landscape: the Midway Barn at Frank Lloyd Wright’s Taliesin, in Spring Green, Wisconsin (Figure 1).

Wright’s work and his design theories are central to the significance of the site and historic structures. A rehabilitative design strategy is one that promotes the history of a site, cultural memory, and complements that with a response to climate to provide a sustainable design solution. Research in the areas of architectural history, technology, sustainability, and design inform an iterative process that analyzes the site, climate, building, materials, systems, significance and character-defining elements. This serves as an analytical framework within which to consider the contemporary preservation design.
As part of the ongoing site interpretation, development of new visitor experience, and revitalization of the Midway Barn, the rehabilitation project has the potential to showcase a new interpretation of the site that expands the significance of the building and undergirds the proposed design and construction process.

The site is limited to the Midway Barn at Taliesin and the immediate surrounding landscape (Figure 2). The significance of the building is closely tied to that of the site overall. As such, the development of Taliesin and the culture of the site are part of the story of the Midway Barn and they contextualize its design, construction, and uses.

Research in the areas of architectural history, sustainability, energy theory, and historic preservation provided the foundation for the design theory. The first section of this thesis outlines the theory of rehabilitative architecture and how sustainability and environmental design connect to historic preservation. This establishes the guiding design thinking that connects the site, the region, the climate, and the architecture to the history and legacy of the Midway Barn.

There is no shortage of scholarship about Wright and his work. The research in this area had to focus on Taliesin; specifically the Midway Barn, his design theories, and the inherent environmental design techniques that Wright used. Interviews with practicing preservationists, including leaders at Taliesin Preservation Incorporated, and architectural historians helped compliment the research that formed the discussion focused on on the site, the building, Wright’s theories of design, the significance and the character-defining elements of the barn. It is the preservation framework for the proposed design.

Typical design approaches should include a regional analysis that surveys climate and weather data. In this case, the site analysis includes analog methods
of analysis for climate data and energy diagramming. However, this design process layers in computational analysis of some of the climate data by rendering it on a digital model of the building to provide insights about how the sun acts upon the building. This helps specify how exactly the climate impacts the building.

The design response section builds on the analyses and describes key features of the rehabilitation strategy. The program analysis identifies key points from the Frank Lloyd Wright Foundation’s rehabilitation and preservation plans for the Midway Barn. It reviews the process of design, including multiple iterations of modeling, diagramming, sketching, planning, and rendering. Lastly, it describes the sustainability features in an effort to create a rehabilitative architecture for the Midway Barn.

A final analysis of the design proposal identifies some key outcomes regarding the success of a rehabilitative design project that sought to promote sustainability and preservation together. It presents the practical lessons and takeaways from the iterative research and design process and identifies how this thesis may apply to other rehabilitation projects for the benefit of practicing design professionals. This section also includes recommendations for further study related to Wright, the Midway Barn/Taliesin, and rehabilitative design.

The Midway Barn has not been an easy building to work on. The building is complicated with various elements, multiple masses, multiple roof surfaces, and a plethora of architectural detail. The overall architectural loss and material deterioration added layers of difficulty. Under different circumstances, greater access to the site could have provided a different understanding of the existing building and conditions. However, the Coronavirus Pandemic prevented some practices which would be typical for most design projects. The site visit was prohibited because of University travel restrictions.
Ultimately the data, photographs, and drawings available for the design project were limited. The Frank Lloyd Wright Foundation provided the University of Pennsylvania’s Center for Architectural Conservation with enough materials to work through this thesis. Two classmates, Ha Leem Ro and Xiaoran Zhang recorded and measured the barn and developed a digital model that aided the design process. The research and design process relied significantly on the historic structure report (HSR) which included information about development, construction, condition, and architectural drawings of the building. The designs in this thesis are based on those drawings as well as the visual evidence from historic and recent photographs.

Figure 1. The Midway Barn, Taliesin, Spring Green WI, 1938-1952, east elevation from above, photograph by the Center for Architectural Conservation, Weitzman School of Design, The University of Pennsylvania, 2020.
Figure 2. Taliesin Estate Overview, Taliesin Estate Map, Spring Green, WI, courtesy of The Frank Lloyd Wright Foundation.
Figure 3. Buildings contribute significantly to the carbon dioxide that is emitted into the atmosphere.

Sources & Notes: Emissions data comes from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003, U.S. EPA (using the CRF document). Allocations from “Electricity & Heat” and “Industry” to end uses are WRI estimates based on energy use data from the International Energy Agency (IEA, 2005). All data is for 2003. All calculations are based on CO2 equivalents, using 100-year global warming potentials from the IPCC (1996), based on total U.S. emissions of 6,978 MtCO2 equivalent. Emissions from fuels in international bunkers are included under Transportation. Emissions from solvents are included under Industrial Processes. Emissions and sinks from land use change and forestry (LUCF), which account for a sink of 821.6 MtCO2 equivalent, and flows less than 0.1 percent of total emissions are not shown.

For detailed descriptions of sector and end use/activity definitions, see Navigating the Numbers: Greenhouse Gas Data and International Climate Policy (WRI, 2005).
II. Towards a Rehabilitative Architecture

Sustainability is a broad topic and this thesis will be limited to sustainable or environmental building design at a historic building within a historic landscape. That includes concepts regarding limiting energy use, recycling buildings and materials, maximizing building life, saving water, and minimizing construction and demolition waste.¹ While other factors of sustainability, such as community and economic sustainability, could be considered in a rehabilitation project, the scale and rural context of the Midway Barn at Taliesin make these considerations less valuable than for sites in more developed areas. The rehabilitation intervention should include a response to place and climate through sustainable design approaches. Preservation, rehabilitation, and sustainable design are all components of the proposed design theory in the subsequent sections.

Rehabilitative Architecture

Luis Fernández-Galiano’s book, Fire and Memory: On Architecture and Energy, draws on a wide array of disciplines and approaches the development of energy technology in architecture from a historical perspective through a comparative analysis of two notable architects: Frank Lloyd Wright and Le Corbusier. Through his analysis of their work, he suggests that architects should strive to rehabilitate architecture in a way that promotes a sense of place and memory, and in a way that addresses climate, technology, and society; they are factors in the development of architecture. Through this rehabilitative strategy, designers must consider history, place, technology and culture. Practically, a rehabilitative

design strategy will be one that can engage the site, climate, building, materials, systems, significance and character-defining elements, and respond to those factors with a contemporary preservation design. In this way, the design process is rehabilitative, and the architecture will be transformed and enhanced for the better.

Through a survey of the work of Wright and Le Corbusier, Fernández-Galiano articulates that the two architects considered regional design quite differently. Le Corbusier was meticulous about solar analysis; his approach may be considered more technical or scientific—his approach is one which charts the solar path through the sky. This is known as heliotechnical design and Le Corbusier’s approach is considered to be a type of solar-rationalism. Fernández-Galiano writes, “The sun designs the architecture, univocally and obligatorily, through the regular and orderly cycles of its daily rotation and annual revolution.” He correlates Le Corbusier’s solar rationalism to megalithic arrangements and cathedrals oriented to the stars.

Wright’s work is more intuitive than the the solar-rationalism that Le Corbusier champions, “To Wright, the sun is heat more than it is light, a beginning more than a regulator, a factor of change rather than of stability. His is a warm, chaotic, igneous sun: a cosmic fire.” Later, Fernández-Galiano says of Wright, “...there is little doubt that Wright’s chimneys invoke a no less archaic tradition in which fire is the soul of the house and the city, a symbol of fertility and life, a

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sacred and beneficent flame."⁵ Wright's use of the hearth and fire as an organizing principle is clear. He used this combination of heat and light, from the sun and the hearth to symbolically connect his buildings to place and incorporate the history and culture that the hearth represents.

Wright's work appears to be less scientifically designed than Le Corbusier's technical approach to design in response to the sun. Architect and historian David De Long characterized the symbolic approach that Wright took:

He sought universal meaning through attachment to place, varying his geometries not only to achieve an indivisible bond with each specific location, but, more importantly, to complete that location's underlying structure, so that each place became more fully revealed as an indivisible part of an ordered cosmos.⁶

For Wright, architecture was a component of the landscape and uniquely connected to place in a way that related more to the symbolism of the sky rather than the technical reaction to celestial mechanics. Wright's work is representative of the type of architecture that engages with place, history, climate and culture. If architecture could be viewed through a historical lens that presents it from a symbolic and functional perspective, then there is a relationship between the mechanical principles of solar-rationalism and the symbolism of fire.⁷ Therein lies the relationship between how buildings function formally and how they may operate mechanically.

A functional perspective, similar to that of Fernández-Galiano, contextualizes the architecture of the Midway Barn in a narrative of Wright's Organic

⁵. Fernández-Galiano, 31.


⁷. Fernández-Galiano, 32.
Architecture (design theories) and bioclimatic design (Wright’s approach to architectural regionalism). Thus the guiding principle of a historic rehabilitation design project should be as Fernández-Galiano articulates:

If people are diverse and buildings heterogeneous, the reconciliation of the latter’s micro-disorder with the geographical and historical macro-order in which they are inserted becomes the main task of an architecture that endeavors to rehabilitate places and memories, in quest of a climatic and technical but also social and cultural genius loci.⁸

He defines the framework for rehabilitative architecture as design that connects multivalent influences upon architecture. Geography and climate define the response; history and technology situate architecture in a cultural and social context. Through rehabilitative architecture the dual-role of buildings may be realized as both functional and symbolic. It is this analysis through the temporal and geographic influences of buildings that rehabilitative architecture can create a genius loci, or sense of place that articulates the complex influences of memory, climate and culture. In practice this means buildings are material evidence of history and technological development, yet they also support the cultural memory of that history and technology.⁹

The heliotechnical approach (such as Le Corbusier’s methodology) is sufficient to respond the climate and technically design architecture, but it fails to address the symbolism of place and memory. To do this, contemporary designers must consider the cultural context of historic buildings in conjunction with a technical climatic response. As stated, Wright’s work generally contends with the sun in an emotive way which does not always complement the tenets of solar

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⁸ Fernández-Galiano, 178.
⁹ Fernández-Galiano, 70.

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rationalism.\textsuperscript{10} Le Corbusier’s work was early in the development of solar-rationalist theories and heliotechnical design.\textsuperscript{11} However, Wright creates a sense of place through his architecture that deviates from the purely technical response to climate—though he did not ignore climatic design entirely. Wright was, in fact, practicing a type of bioclimatic design methodology before it was a fully realized trend in architectural design.

In this capacity, some of Wright’s work has been evaluated from a functional perspective by architectural historians and environmental scholars.\textsuperscript{12} In practice, Wright considered his own bioclimatic approach to building design. In his first Usonian house, the Jacobs House I (1937) in Madison, Wisconsin, he eliminated extraneous spaces and building program, simplified the tectonic nature of the house, and promoted a connection between the residents and nature (Figure 6). The exterior terrace is designed in such a way that it blocks the prevailing wind and retains warmth from the sun through its thermal mass. The southern walls are almost completely glazed to permit the winter sun to heat the house, and the concrete floor retains that heat into the night. The summer sun is blocked from entering the house by a deep overhang of the flat roof.\textsuperscript{13}

The Jacobs House II (1948) in Middleton, Wisconsin is another project for the same client (Figure 7). Wright incorporated similar ideas. He expanded upon previous design explorations by creating a partially earth-sheltered home with

\begin{itemize}
\item 10. Fernández-Galiano, 25.
\item 12. See writing by Reyner Banham, Daniel Barber, Kevin Bone, and Kenneth Frampton.
\end{itemize}
similar features as the previous Jacobs House I. As a result of his work combining the various climatic influences to inform architectural design, Wright influenced the development of the analytical framework that Victor Olgyay developed and the solar-rationalist design movement.14

Function and Energy

The sustainability of buildings can be measured many different ways. Some energy performance standards prioritize operational energy and some seek to limit carbon emissions. The United States Green Building Council’s Leadership in Energy and Environmental Design (LEED) program functions through a points-based evaluation system in which developing an existing site is highly valued. However, sustainability may also be measured by the ability for a building to fill a need without depleting resources.15

Existing buildings have a lower carbon impact than new buildings.16 This is one of the ways in which existing buildings may be defined as ‘green’.17 The amount of energy and carbon expended to extract raw materials, process it, manufacture building products, transport those products and install them is significantly lower in existing buildings—because they are already built. If designers and builders are careful about material selection and use, there may be able to limit the new energy and carbon expended when adapting existing buildings.


17. The Greenest Building.
Additionally, there are various timelines relative to the life-cycle of materials and the embodied energy present in buildings. Concepts such as cradle-to-grave and cradle-to-cradle define how material use and recycling management may alter the embodied energy in buildings (Figure 4). Generally, the total carbon emitted is significantly lower in existing buildings than all others—even those which use zero operational energy.\textsuperscript{18,19}

How buildings function programmatically is significant, but how they function from an energy perspective is too. As part of a functional analysis, energy system evaluation may provide some insight about the envelope performance or material quality of structures prior to mechanical conditioning. This is especially important in buildings such as the Midway Barn where mechanical systems were introduced long after the building was built as a result of the changing uses and requirements of Taliesin as a working farm, and the Frank Lloyd Wright Foundation operating it as a farm, historic site and a tourist destination.

Through formal and technical approaches to building form, orientation, plan arrangement, landscaping, detailing, fenestration, and material selections, Victor Olgyay’s book \textit{Design with Climate} covers a wide array of techniques for bioclimatic design. Much like Wright and Le Corbusier, Olgyay rationalized building design through a complex analysis of climatic inputs. However, his process is more technical and scientific than Wright’s. With the benefit of greater knowledge and additional technology, Olgyay developed a tool to test the performance of architectural designs in a sealed dome capable of simulating climatic conditions

\begin{footnotesize}
\begin{enumerate}
\item McDade, 13.
\item It is misleading to say there can be zero energy buildings because energy is expended to build them, and energy is used to operate them.
\end{enumerate}
\end{footnotesize}
such as wind and the sun; it was called the Thermoheliodon (Figure 5). It is also important to note that Olgyay worked at Princeton University School of Architecture, developed the Thermoheliodon and wrote *Design with Climate* long after Wright had been practicing a less scientific form of bioclimatic design.

**Sustainability and Preservation**

While environmental design strategies are part of the design process for many architects and designers, most of those strategies are geared towards new building design. With any new building project, there are a plethora of decisions to make. As presented in Norbert Lechner’s *Heating, Cooling, Lighting: Sustainable Design Methods for Architects*, one method for designers to consider sustainability from the outset is a Three-Tier design approach whereby decisions with a larger impact or larger implications are made earlier in the design process (Figure 8). In the Three-Tier design approach, designers begin with basic building design; this includes factors such as site design, form, orientation, shading and construction materials. Tier Two considers natural energies, such as passive heating, passive cooling and daylighting. The third tier is geared towards active systems, mechanical equipment and renewable energy technology, such as Heating Ventilating and Air Conditioning (HVAC) components, geothermal heat exchangers, electric lighting, and photovoltaics (PV). The efficacy of the design, based on the first two tiers, will impact the performance requirements of the third tier systems. It is important to note that this method of design is just one way to manage energy efficiency from a regulatory perspective. Energy efficiency is part of current building codes and so they require buildings to meet current standards


in energy use. This is a requirement for any rehabilitation work at the Midway Barn.

With historic buildings, designers have limited options to improve the thermal performance of the building envelope. They include insulation and fenestration improvements. Incorporating design elements such as shading devices, integrating new, efficient, HVAC systems, and incorporating energy producing technology may potentially conflict with character-defining elements of the historic architecture. To rehabilitate a historic building, the designer should consider the integration of contemporary environmental design strategies and how those relate to, disrupt, or damage historic fabric.

The Secretary of the Interior’s Standards for the Treatment of Historic Properties are the most-accepted preservation strategy in the United States. They are used as guidelines for state historic preservation offices and preservation organizations. The Secretary of the Interior’s Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings, provides limited guidance relating to the integration of historic fabric with sustainable design methods. They are more geared towards implementing strategies rather than directing integration. The guidelines suggest acceptable and prohibited alterations. These standards are lack clarity, detail and they reduce the complexity of sustainability at historic sites.

Guidance from the National Parks Service indicates that designers should consider the inherent energy efficient features of historic buildings through a thorough analysis of the site, its features, the building, its envelope, and how the building was and will be used in the future. Careful planning in this regard will help optimize the performance of historic structures without compromising the historic character and integrity. In 3 Preservation Briefs: Improving Energy Effi-
ciency in Historic Buildings, the authors articulate the need for careful consideration of the historic fabric prior to alterations of windows, insulation or wall construction. Additionally, the authors advocate for energy audits and environmental monitoring before and after alterations to verify the efficacy of any improvements to the envelope performance.\textsuperscript{22}

One detailed reference-work is \textit{Sustainable Preservation: Greening Existing Buildings} by Jean Carroon. In it, she outlines the complexities of working with existing buildings from policy through design and construction. She thoroughly presents logical steps and opportunities for interventions in building systems and envelopes in order to improve energy efficiency. This builds upon the Federal standards for preservation and sustainability. Within the frameworks of policy that she outlines, the opportunities for improving the sustainability of the buildings are many.

\textbf{Rehabilitative Design in Practice}

So how do the bioclimatic, sustainability and rehabilitative architecture theories and strategies apply to existing and historic buildings, where factors like massing, orientation, and envelope are predetermined? There are opportunities to carefully select portions of the bioclimatic design strategy that may complement the symbolism of design that promotes place and memory. Rehabilitative design is rooted somewhere between Wright’s design symbolism and Le Corbusier’s technical determinism. Through this critical approach, rehabilitative design can support the longevity of historic buildings through a close association and

appropriate response to the climate and historic fabric. A systemic approach to
design is required for designers to critically rehabilitate buildings.

Therefore, incorporating sustainability at the Midway Barn is more com-
plex than simply adding energy efficient elements. In her book Building Reuse:
Sustainability, Preservation, and the Value of Design, Kathryn Rogers Merlino ar-
ticulates a comprehensive and critical approach to sustainable design, “Sustain-
ability, as it applies to the built environment, does not come from adding individu-
al components onto the way we build, but requires a holistic way of approaching
building design and use.”23 Leveraging the alignment of characteristics, function,
and performance of historic buildings is the key for a rehabilitative architecture
that engages place, memory, technology, and culture. With a bioclimatic design
approach and in consideration of the character-defining elements of historic
buildings, rehabilitative design may successfully engage history, memory, climate
and technology and promote a genius loci as Fernández-Galiano articulates.

The design methodology will include the practical analysis of the site, cli-
mate, building, materials, systems, significance and character-defining elements.
This process of analysis will help to create a framework within which to consider
the contemporary preservation design.

23. Kathryn Rogers Merlino, Building Reuse: Sustainability, Preservation,
and the Value of Design (Seattle: The University of Washington Press, 2018), 54.
Figure 4. Life Cycle Assessment includes accounting for material life. This diagram outlines the full spectrum of material life. King, 18.

Figure 5. The Thermoheliodon was an early tool for bioclimatic simulation developed at Princeton University. Olgyay, 184.
Figure 6. Jacobs House I, Madison, WI, 1937, solar analysis of the building, image source Bone, 68, 2014.
Figure 7. Jacobs House II, Middleton, WI, 1948, solar analysis of the building, image source Bone, 84, 2014.
Figure 8. The Three-Tier design approach outlines various stages of decision making for an environmentally friendly design. Lechner, 9.
III. The Midway Barn at Taliesin

Taliesin was one of Frank Lloyd Wright’s homes and the rural Wisconsin property has multiple structures (Figure 9). The 1975 National Register of Historic Places nomination form succinctly describes the complex comprised structures including Taliesin III, Wright’s house, The Hillside School, and the Midway Barn, but there is little written in the nomination about the Barn. This place is significant because of its association with Wright, “[He] was not only one of the most important architects America produced but he was a prophet and preacher as well. Taliesin is fully representative of his theories and taste, an existing site where he spent many of the years of his life.”¹ The Taliesin property is listed on the National Register of Historic Places, and in 2019 the house (not the whole property) was listed as a UNESCO World Heritage Site along with seven other Wright buildings. The HSR identifies the significance of the barn more clearly. The author writes:

[The Midway Barn] follows all of Wright’s principals (sic) for organic architecture. Like the Taliesin residence, Midway is “of the hill,” not on top of it. Its growth over time reflects Wright’s changes in his design style... Midway [Barn] reflects all of its uses: shelter for cows and horses, storage of feed, milk processing, storage for farm vehicles, housing for fellowship members. And it does all of this in a unique way, where form not only follows functions, but is balanced, beautiful in its own way, and inspiring.²

The Frank Lloyd Wright Foundation has established two main goals for Taliesin as part of their mission statement: “[The Foundation’s] dual mission is to preserve the cultural, built and natural environments that comprise the Taliesin property and to conduct public educational and cultural programming that pro-


vides a greater understanding of Frank Lloyd Wright’s architecture and ideas.”

The action words within that mission statement (preserve and conduct) represent the future of the site as both a preserved architectural, cultural and natural landscape and as an educational facility to engage the general public about Wright’s ideas of architecture, design and, more broadly, ways of living.

As part of the current public programming on site, visitors may participate in architectural and landscape tours of the grounds, participate in events regarding design and farming, and children may partake in summer camps. This wide array of programming aims to promote Wright’s beliefs and practices and to engage directly with the landscape so that visitors may learn how Wright situated his architecture to be a component of the natural landscape.

The preservation and rehabilitation of the Midway Barn is consistent with both components of the mission statement. It can be adapted to serve as part of the educational framework that promotes Wright’s design, architecture and farming legacy. Sustainability and environmental design may be incorporated into the rehabilitation of the Midway Barn so that it provides spaces for educational activities and also represents the ideas of sustainability as part of the educational experience. It not only aids in the long-term management by reactivating the Barn, but promotes the close association with nature, which is in the spirit of Wright’s theories.


The Midway Barn

The Midway Barn is part of Wright’s Taliesin homestead. The Barn is named so because, on the property, it is approximately mid-way between the house to the north and Hillside School to the south. It is a utilitarian building that was central to the farming operations of Taliesin and served as shelter for much of the livestock that Wright owned. It was a key component of the food production of the farm, and also served as a test building for many of Wright’s students to practice design and construction.⁵ The Barn is a composite building that is part residence and part farm building. Historically, it mixed various functions related to farming and housing for guests and Taliesin Fellows.⁶ The Barn contains two separate living quarters, three silos, Cow Barns, horse stables, loading areas, a hay loft, etc.

At first, the Barn was smaller; it was comprised of the cottage, which is built into the hill, and the horse stables which are situated perpendicular to the hill (Figure 10). Over time, Wright added to the complex; he extended a bridge to the hill,⁷ in which he kept chickens, and elongated the building parallel with the hill to increase the area for cattle and machine storage (Figure 11). Ultimately, the Midway Barn took shape as a T-shaped bank barn built into the hill with access to the various spaces spread around (Figure 13 through Figure 17).⁸

⁵ White, 5-7.
⁶ White, 11.
⁷ Which is commonly referred to as ‘the train’.
⁸ The time periods outlined in the stages of formal evolution were determined by Jay White for the Midway Farm Historic Structure Report. However, these have been expanded to include intermediate and further stages of development by Xiaoran Zhang in her master’s thesis.
Bank barns or side-hill barns are a vernacular development of the traditional English barn. They are sited in a hill with a three-walled stone basement level and a wood framed upper level (Figure 12). The basement is partially earth-sheltered and open on the downhill side. The upper level is usually accessed through large doors on the uphill side. They developed as a method to prevent manure from freezing due to the cold New England winters by storing it in the lower level so that it could then be spread in the fields in the Spring. Similar climatic conditions made this a suitable building type for the rural landscape of Wisconsin. Hay storage on the upper level provided some additional thermal insulation for the animals housed on the lower level.  

As David Leatherbarrow and Richard Wesley describe in their book *Three Cultural Ecologies*, Wright’s work at the Midway Barn deviated from traditional utilitarian agrarian buildings by creating a thoughtfully designed architectural work of disparate parts. They write, “These deviations from the vernacular tradition indicate Wright’s desire to transform a utilitarian building type into an architectural work: aggregate and hybridized, yet composed.” For the rehabilitation design strategy, this means acknowledging the deviations from vernacular tradition in barn design and construction while highlighting those features that reflect Wright’s design decisions. To Wright, this was a work of architecture and far from a solely utilitarian structure.

The Barn reflects an elaborate version of a typical bank barn building typology. Though due to the additive nature and faceted plan of the building, the Barn is far more complex than a typical bank barn. Where a typical bank barn is


situated in the middle of a hill so that access to lower and upper levels is from grade on the broad sides of the barn, the Midway Barn has more than two levels accessible from multiple points along the hill (Figure 18). Additionally, Wright abandoned the compact nature of the typical bank barn plan (Figure 20 and 21). He elongated the structure, stretched the plan, and subsequently sacrificed some of the tacit climatic responses designed into the Barn.

The Midway Barn is not a “High Road” Wright building. As Stewart Brand describes in his book How Buildings Learn: What Happens After They’re Built, “High Road” buildings are those with, “high intent, duration of purpose, duration of care, time, and a steady supply of confident dictators.”11 Conversely, “Low Road” buildings are, “low-visibility, low-rent, no-style, high turnover…the most inventive creativity, especially youthful creativity, will be found in Low Road buildings taking full advantage of the license to try things.”12 Wright did indeed experiment and try things at the Midway Barn. It began as separate structures and Wright connected, adapted, and expanded the building over time to serve many roles on the farm. Since change over time is a prevalent theme in the history of the building and on site, the rehabilitation project may be framed in that same way. Any changes to the building are simply part of the next phase of evolution. The utility and practicality of the building for the future are critical and factor into the sustainability of the site. Considering the character-defining elements in context help to identify what components of the building are tolerant to change and which are not.

**Organic Architecture**


Frank Lloyd Wright promoted ideas of unity with nature in architecture. His beliefs were shaped by his Unitarian faith, Japanese culture, William Morris, and 19th century writers and philosophers such as Walt Whitman and Ralph Waldo Emerson. Wright strongly believed architecture had the power to impact the American cultural sphere; he said:

> What we call organic architecture is no mere aesthetic nor cult nor fashion but an actual movement based upon a profound idea of a new integrity of human life wherein art, religion and science are one: Form and Function seen as One, of such is Democracy.

Wright linked his designs to the immediate environment so that buildings were sited appropriately, and seemed to be of that specific place—like the building was at home. He described his views of Modern architecture in a 1939 lecture:

> Architecture already favours the reflex, the natural easy attitude, the occult symmetry of grace and rhythm affirming the ease, grace, and naturalness of natural life. Modern architecture—let us now say organic architecture—is a natural architecture—the architecture of nature, for nature.

Wright claims the mantle of Modern architecture using his own theories which are specifically geared towards architecture of a place. He calls for architecture to be natural, to reflect natural life and to be graceful within a site, not on it.


16. Wright, 3.
The Midway Barn exhibits many components of Wright’s theories of Organic Architecture and some principles are perhaps more apparent than others. Overall, they appear to be contributing factors to the design and composition of the architecture. In the book, *Frank Lloyd Wright: Architecture and Nature*, Donald Hoffman articulates the relationship between a horizontal building and the undulating prairie landscape, “Every swift and clean stroke of the horizontal stood for values that Wright cherished. A building in love with the earth became a natural companion to the horizon.”

There are seven principles of Organic Architecture: ground, shelter, materials, space, proportion, order, and technique (Figure 22 through Figure 26). Many of Wright’s buildings exemplify these tactics as a way to break down the traditional division of interior and exterior space and to force occupants to engage with the environment. This is expressed at the Midway Barn through the elongated plan which is aligned with the hill, and through the various points of entry to the Barn. The principles of organic architecture are reflected at the Barn as follows:

**Ground:** Wright built the Barn into the hill and sited the building such that there was a close relationship with how the Barn functioned. Multiple entries were located at various points along the slope of the hill to provide access to different levels of the Barn, in contrast to traditional bank barns.

**Shelter:** Wright considered the enclosure of space in conjunction with the formation of the land. He carefully considered the ground and slope of the hill in rela-


18. Klinkowitz, 144-145.
tionship to the shelter that the Barn provided for livestock, crops and equipment. The building exhibits a certain weight, and conversely, delicacy. Horizontal forms, articulated by the long low roof planes seem to float above each other and the ground. The deep horizontal shadow lines created by the roof overhangs empha-

size this.

Materials: The Barn's material palette is simple: wood and stone. Wright used wood for the structural framing and exterior cladding. The stone he used is the same as he used for the house and was quarried locally. In this sense, the Barn is built from the land.

Space: In conjunction with shelter, the space of the Barn was defined by the exterior form and the interior function. The spaces are linked but scaled appropriately to their uses; how these masses are interrelated is significant. The various spaces and uses are collected into unified forms that reflect the horizontal and undulating nature of the landscape in an effort to blend into the rolling hills of the site, but also so that the Barn could function as a barn.

Order: Formally, order is quite prevalent at the Barn. On a mostly horizontal building, there are several vertical elements that punctuate the horizontal forms at their terminus. At multiple scales, there is an articulation of the interaction between vertical and horizontal forms. The silos and milk shed frame the horizontal roof planes, and at a finer scale, the piers at the east end of the Steer Shed give rhythm and scale to the long, solid and massive Steer Shed roof.

Proportion: While Wright considered human body as a driver for the proportion and scale of the Barn, animal proportions surely also factored into his decision
making process. The low Steer Shed roof was too low at the eave for workers to comfortably stand, however for cows, it was suitable. Additionally, the relationship between the height of vertical forms and the length of horizontal forms reinforces the general horizontal nature of the architecture overall. The proportions emphasized horizontals over verticals and this helps relate the Barn to the landscape.

**Technique:** The way architectural components are constructed and formed is a significant component of this building. Generally, the Barn is wood framed, but the connection to other architectural elements, such as the stone piers, represents a careful approach to tectonics. Additionally, the technique is exemplified at the Midway Barn by the nature of the Barn’s development and construction. While this was a functional barn, this was also an ongoing project for Wright and his students so that they could learn about design and construction. The Barn had a pedagogical function that affected the techniques of construction and development.

**Significance and Character-Defining Elements**

The Midway Barn is significant in the spectrum of Wright’s work. He began the process of design and development from existing structures relocated from his uncle’s farm, and the Barn was almost constantly in development through the end of his life. In only a few other projects did he design functional structures for animal habitation. As an aggregate structure composed of various functional parts, Wright still maintained his formal and aesthetic design sensibilities. The great contradiction of this barn is that the function and form are unified, but there are still some clear aesthetic components of the design. It is not entirely clear why Wright made decisions about where to locate silos or the milking tower, or just how far to extend the Steer Shed; much of the Barn’s historic value is based
upon the architectural design. However, the cultural and social significance of the Midway Barn should not be overlooked. The Barn represents Wright’s ideas of balance between living and working.

As a precursor to designing any alterations and additions to the Midway Barn, it is critical to understand the significance it holds. Character-defining elements reflect that significance in the built fabric.

**The Rehabilitation Planning**

The Midway Barn currently serves a few roles on site: part of the Barn functions as collections storage and is climate controlled, two areas of the Barn are residential (with extremely sporadic occupancy), and much of the Barn is unused. Some areas of the building are exposed to the elements and some parts of the building envelope are not weather-tight. The Frank Lloyd Wright Foundation intends to rehabilitate parts of the Barn and restore others as part of their preservation plan.\(^{19}\)

As an ongoing part of the Taliesin mission to preserve and educate, the Barn should serve to amplify the legacy of farming and land use at Taliesin and as such the barn will become a *Center for Land Use*.\(^{20}\) The space planning table outlines the areas, current uses, program opportunities, preservation zoning and level of priority (Figure 27).\(^{21}\)

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19. Midway Barn Rehabilitation Plan. See Appendix D.

20. Midway Barn Rehabilitation Plan. See Appendix D.

21. It is important to note that the rehabilitation plans for the Midway Barn have stemmed from the 1994 Historic Structure Report. The Frank Lloyd Wright Foundation has developed the recommendations from that report and created a program for the Barn.
As part of the rehabilitation initiative, the Frank Lloyd Wright Foundation has provided a preliminary space planning table that serves as an outline for the adapted use (Figure 28). The Midway Barn will be adapted to include spaces for site interpretation, offices and some visitor conveniences such as a café and restrooms. This thesis focused on the rehabilitation of a portion of this program and a portion of the site: the former Steer Shed and Cow Barn. This isolated area of the project presents some interesting challenges with regard to preservation, reconstruction and rehabilitation. The standards and guidelines for each type of intervention in conjunction with the relative tolerance for change of this particular area of the building provide a complex framework within which to propose a design that seeks to incorporate tenets of sustainability.

The historic structure report and the Midway Barn Rehabilitation Plan outline the building’s condition and tolerance for change. The Barn requires some monitoring and stabilization. This thesis assumes that the building is structurally stable, weather-tight, free from moisture infiltration, insects and bio-growth. Part of the Barn is presently used for collections storage. This thesis assumes that the collections storage facility will be removed and relocated to another location separate from the Midway Barn. The final assumption is that the Frank Lloyd Wright Foundation will continue to operate the site as a seasonal (six to eight month) facility for visitors where access to the Barn will be limited to employees and those who work in parts of the buildings year-round.

Regarding tolerance for change, the exterior should be restored to the formal and material state of the building at the time of Wright’s death in 1959. That means there is limited opportunity to alter extant components of the structure on the exterior as they have a high degree of material integrity. The interiors are subject to a greater degree of change with the understanding that the interior
may need to be altered to facilitate the new uses, but these alterations should be made carefully.

The Frank Lloyd Wright Foundation has identified preservation zones as a ranking system to identify the historic significance and tolerance for change by space. The areas of the Barn evaluated in this thesis fall under Zones One and Two; they are of primary significance and secondary significance, respectively. The Steer Shed falls under Zone One and, even though the historic roof is not extant, restoring the image of the building is a priority. The Cow Barn interior is in Zone Two and is secondarily significant and therefore tolerant of a greater degree of change.

Wright did closely consider regionalism as part of his architectural design methodology. However, he also considered the temporal dimension and integrated the changing technology of his time. His designs changed over time:

[H]e invigorated his approach by incorporating the latest advances of his own era, so that mobility and a new awareness of change became part of his ideal landscape. He thus effected connections with both place and time, creating a modern architecture of profound, richly layered meaning.22

Wright believed architecture’s connection to place extended past the physical and spatial realm to address place, memory, technology and culture. In this regard, his design approach undergirds theories of design that seek to engage the physical, temporal, and climatic factors present at any site. This is how Wright’s work connects directly with the ideas of rehabilitative architecture that Fernández-Galiano presents. The Midway Barn rehabilitation should maintain that continuum of theory, design, and education.

22. De Long, 120.
Figure 9. This is a general Taliesin site plan included as part of the National Register nomination showing the locations of major site elements.
Figure 10. The Midway Barn, Taliesin, Spring Green, WI, 1938-1952, view looking southwest, courtesy of The Frank Lloyd Wright Foundation Archives, circa 1940.

Figure 11. The Midway Barn, Taliesin, Spring Green, WI, 1938-1952, view looking northwest, courtesy of The Frank Lloyd Wright Foundation Archives, circa 1950-1959.
Although the gable-fronted orientation would soon become the most popular design for these “side-hill” or “bank” barns, some farmers stayed with the traditional eaves-front “thirty-by-forty” English barn design for the superstructure. Dry-laid fieldstone walls typically form three sides of the basement, with the downhill side either left open or enclosed with a wooden wall and large doors and windows. Farmers also converted older English barns into side-hill barns by moving them onto new stone foundations.

Figure 2-16. Side-hill English barn, circa 1840, Shelburne, Vermont.

Figure 2-17. Side-hill English barn, circa 1830, Franklin, Vermont.

Figure 2-18. This mid-nineteenth-century side-hill English barn in Newtown, Connecticut, stands on an early-twentieth-century concrete block foundation.

Figure 12. Bank barn, Shelburne, VT, circa 1840, image source Visser, 73.
Figure 13. The Midway Barn formal evolution, 1938. Additions are highlighted with thick lines and shading.

Figure 14. The Midway Barn formal evolution, 1944. Additions are highlighted with thick lines and shading.
Figure 15. The Midway Barn formal evolution, 1948. Additions are highlighted with thick lines and shading.
Figure 16. The Midway Barn formal evolution, 1952. Additions are highlighted with thick lines and shading.
Figure 17. The Midway Barn formal evolution as it exists in 2020. Building areas drawn in blue are missing.
Figure 18. A traditional bank barn has two levels for access and is usually limited in size.

Figure 19. The Midway Barn differs from a traditional bank barn with many access points at many levels and it deviates from the traditional bank barn form.
Figure 20. The Midway Barn, Taliesin, Spring Green, WI, 1938-1952, Steer Shed plan (lower level), drawn by the Burley Partnership, 1994.
Figure 21. The Midway Barn, Taliesin, Spring Green, WI, 1938-1952, Cow Barn plan (upper level), drawn by the Burley Partnership, 1994.
Figure 22. Wright’s principles of organic design promote interaction between the site and the architecture.
Figure 23. Diagram view looking west. The Midway Barn’s long massive roof surfaces seem to float just above the surface of the ground.

Figure 24. Diagram view looking west. The Midway Barn’s deep overhangs cast shadows that reinforce the horizontal orientation of the building.
Figure 25. Diagram view looking west. The Midway Barn’s interplay of form and shadows is a character-defining element.

Figure 26. Diagram view looking west. The Midway Barn is punctuated by vertical elements that provide a sense of rhythm and a visual break from the long low horizontal roof surfaces.
Figure 27. The Midway Barn, Taliesin, Spring Green, WI, 1938-1952, plan of historical significance, courtesy of The Frank Lloyd Wright Foundation Archives.
### MIDWAY SPACE PLANNING

<table>
<thead>
<tr>
<th>Area</th>
<th>Current Use</th>
<th>Program Opportunities</th>
<th>Zoning</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steer Shed</td>
<td>Non-Existant</td>
<td>Interpretive/Presentation Space, Dining, Restrooms</td>
<td>3</td>
<td>Low</td>
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<tr>
<td>Pump Room</td>
<td>Empty</td>
<td>Utility Room</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Machine Shed</td>
<td>Non-Existant</td>
<td>Agricultural Program Support</td>
<td>3</td>
<td>Medium</td>
</tr>
<tr>
<td>Pig Barns</td>
<td>Non-Existant</td>
<td>Agricultural Demonstration</td>
<td>3</td>
<td>Medium</td>
</tr>
<tr>
<td>Chicken Coops</td>
<td>Non-Existant</td>
<td>Agricultural Demonstration</td>
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<td>Medium</td>
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**FIRST LEVEL**

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</thead>
<tbody>
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<td>Calf Pen</td>
<td>Storage</td>
<td>Agricultural Program Support, Storage</td>
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<td>Low</td>
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<tr>
<td>Loading Dock</td>
<td>Café</td>
<td>Training, Classroom, Office, Storage</td>
<td>3</td>
<td>High</td>
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<td>Cow Barn/Barn Main Level</td>
<td>Collection Storage</td>
<td>Program Unknown</td>
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<td>Low</td>
</tr>
<tr>
<td>Upper Apartment</td>
<td>Residential</td>
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</tr>
<tr>
<td>Stable</td>
<td>Empty</td>
<td>Agricultural Program Support, Office, Storage</td>
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<tr>
<td>Train/Chicken Coop Upper Level</td>
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<td>Office, Classroom</td>
<td>2</td>
<td>High</td>
</tr>
<tr>
<td>Silo (1)</td>
<td>Empty</td>
<td>Office, Classroom, Residential</td>
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<td>Low</td>
</tr>
<tr>
<td>Silo (2)</td>
<td>Empty</td>
<td>Office, Classroom, Residential</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>Mil Tower</td>
<td>Residential</td>
<td>Office, Residential</td>
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<td>Low</td>
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**SECOND LEVEL**

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<th>Zoning</th>
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<td>Hay Storage Upper Level</td>
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<td>Train</td>
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<td>Upper Cottage</td>
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<tr>
<td>Upper Guest Cottage</td>
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<td>Low</td>
</tr>
</tbody>
</table>

**THIRD LEVEL AND UP**

*All exterior spaces are rated zone 1*

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Figure 28. The Midway Barn, Taliesin, Spring Green, WI, 1938-1952, rehabilitation space planning diagram and table, courtesy of The Frank Lloyd Wright Foundation and Taliesin Preservation.
IV. Analysis

This section introduces the tools and the process of analog and digital analysis as a method of energy and bioclimatic considerations in the design process. The subsequent analysis is a method of practical engagement with the site and climate. It is part of the design process, and practically, this analysis provides a deeper understanding of the specific relationship that the Midway Barn has with the landscape and how the climate acts upon the building first through an intuitive assessment of existing features and then adding some computational analysis.

Regional climate analysis clarifies the influences of forces such as light and wind, and identifies the parameters of the immediate microclimate. Sustainable design strategies geared towards new building design, such as the Three-Tierer approach, consider orientation, form, space planning, ventilation, solar heat gain, etc. The design response would, in theory, consider these factors as part of the formal, spatial and material composition of the architecture through a direct formal and material response to the climate.¹ Similarly, an environmental building design approach that uses computational energy modeling would factor those inputs and expand the inputs throughout an iterative process to include increasingly specific levels of detail. Energy modeling would include inputs regarding form, mass, orientation, fenestration ratio, thermal performance of the envelope.²

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¹ Olgyay, 10-13.

² Some energy modeling software may include carbon impact to determine the embodied carbon based upon the material composition of the building. Programs, such as Tally, will do this, though there are less complex calculators available online for simplified Life-Cycle Assessment.
This thesis uses Rhinoscreros 3D modeling, Grasshopper, and Ladybug for computational energy analysis.³

Integration

As Wright himself promoted, form and function should be united; at the Midway Barn they are. The barn is configured to perform as a barn. It has storage spaces for housing livestock, such as cows and horses; there are large roof surfaces cover these spaces. Some areas required ventilation. The Steer Shed had few exterior walls which likely allowed for passive ventilation given the prevailing wind direction, and the hay loft walls on the east and south facades had louvers and outswing casement vents to catch the wind. Deep eaves limited the solar heat gain through the windows as is evident from the radiation analysis.

The Midway Barn used little to no operational energy for the time that it functioned as a barn. Occasional electricity may have been used, especially as the building’s residential areas increased after the initial cottage was placed on the hill in 1938. Over time, the function of the barn has changed. Currently, part of the barn is used for collections storage and it is conditioned space. Otherwise, the barn is equipped with some electric lighting and HVAC systems in the two residential areas. For the purposes of this thesis, the areas of the barn in scope can be assumed to have zero current operational energy use. The Historic Energy System diagram reveals that some heating was provided by the livestock housed in the barn. Much of the energy from water, HVAC, and electrical systems was lost as heat and/or dissipated into the environment; the septic system fed

³ In addition to Ladybug, there are other computational modeling softwares which can account for a wide array of building energy uses. These are outside the scope of this thesis, but could be incorporated in a quantifiable Life-Cycle Analysis of historic buildings with all the required information, such as envelope assembly, material integrity, and greater expertise with the software.
back into the geological processes on site through the septic field to the north of the building.

In this proposal, the climate data was used to simulate the external climate factors that impact the existing building, and where. Energy diagrams illustrate the theoretical energy flows at different stages in time. A proposed energy diagram represents the flows as they could be, and identifies opportunities to recycle or repurpose energy or material outputs. There are several improvements possible that will promote the sustainability of the site; they are related to energy generation, recycling and upgrading the building envelope. Incorporating sustainable technology, such as photovoltaics or a geothermal heat exchange can capture a great amount of energy required to sustainably operate the building. Rainwater collection can mitigate the transportation and purchase of domestic water service, improved envelope performance can mitigate heat loss and reduce the overall quantity of heating and cooling in the building. The opportunities for enhancing the sustainable performance of the building are greatest where operational energy can be reduced or wholly powered by renewable sources.4

This analysis has provided insights regarding opportunities for sustainability. However, perhaps the most important factor in the decision-making process for this project is how the integration of sustainable technology and design techniques may impact a historic structure. At the Midway Barn, this means the design process should consider how and where new technology may be located and integrated, how services and materials may be recycled, and how envelope

performance may be improved without significant changes that impact the character-defining elements.

**Energy Diagrams**

Identifying the energy flows in the barn helps to illustrate a clear picture of the operational energy of the site; this all seems to ground us in the building. Energy flows include, but are not limited to, climatic, thermal, geologic, and creative services energy, such as the energy required to design a building. Energy mapping also identifies the material inflows (sources) and outflows (waste) in the system. Additionally, energy mapping reveals the potential locations for energy system interventions; one cannot change the system without a clear understanding. Considering that the building and use have changed over time, energy diagrams for various periods in the life cycle of the Midway Barn offer a broader perspective.

Within a given energy system diagram there are stocks and flows, much like those outlined in Donella Meadows' book *Thinking in Systems*. According to Meadows, systems operate with stocks and flows, “Stocks are the elements of the system that you can see, feel, count, or measure at any given time...Stocks change over time through the actions of a flow.” From an energy perspective, there are inputs of energy from the climate: sun (heat and light), wind (heat and ventilation), geological processes and rain. Regionally, these inputs impact the weather and the energy acting upon a building, like the Midway Barn. The system boundary is limited to the region and then a subsystem of the building envelope. The larger the system, the more complex the energy flows, and thus the complexity of the diagram increases in kind. Energy flows from the region feed the

---

energy inputs through the building envelope. One example of this interaction is warm exterior air and solar radiation that acts upon a building will heat the interior air and building surfaces.

From a qualitative perspective, energy system diagrams help to outline the specific energy and material flows within a given building. From these schematic diagrams, designers may visualize the way various elements, and services impact the flow of energy in a building. Outlining the energy flows can serve as a benchmark for the historic building performance and as a means to understand the way energy flows through a building and how that energy may be used as part of building systems or services. For example, at the Midway Barn, there is an interaction between the heat acting upon the building, the passive ventilation cooling the building and the interior heating provided by building occupants such as the cows and horses.

Diagrams of historic building energy systems illustrate the operational characteristics of a building as it was (based on the available information) (Figure 29). As time passes and the building evolves, there may be new systems installed such as HVAC or lighting systems. These fit into the energy system diagram as well (Figure 30). As these systems use energy and dispel it (because no system achieves 100% efficiency) there is wasted energy either lost to heat, other forms of energy, or as a material. One major opportunity for sustainability is to redirect as much wasted energy and material as possible as it exits the system and recycle that back to be used in some capacity.

As part of the design response, the energy diagrams, analog and computational site and climate analysis establishes the outside factors that act upon the site and building. From a historic and functional perspective, Wright’s design of

the Midway Barn responded to the sun with large roofs and deep eaves and took advantage of the prevailing winds. The design response should then consider these climatic factors and historic functions as part of a sustainable design solution.

**Analog Site Analysis**

After retrieving the available weather data and visualizing it in charts, a basic diagrammatic analysis of some of the climatic conditions provided a baseline understanding of the Midway Barn’s potential interaction with weather (Figure 31). Diagramming sun paths over various views of the barn indicated which roof surfaces provided shade and those which receive the most radiation throughout the day. Prevailing wind diagrams indicate just how the roof surfaces direct the flow of air up and over the Steer Shed roof and potentially under (Figure 32 and 33). The wind from the east passes through the louvered wall at the east end of the hay loft to aid the drying of hay. Especially because the Midway Barn will be operated seasonally, the summer temperature and relative humidity contribute to occupant thermal comfort. Strategies that cool the space and ventilate it should be prioritized.

**Computational Analysis**

Computational energy modeling allows for a basic spatial and surface interpretation of the local weather data and how the weather affects the building. Where an analog analysis of the climate can only identify types and sources of weather, computational modeling of weather data allows designers to render that data as part of a three-dimensional energy model (Figure 34). Specific characteristics of the architecture, such as form, mass or orientation can be evaluated and the historic architecture may be understood through a bioclimatic lens.
The environmental building design process is iterative and requires an increasing number of data inputs at each stage. With limited information about the existing envelope construction and without interior climate monitoring data, the climate analysis and subsequent rehabilitation design may only be informed partially by the climate data. As computational energy models become increasingly sophisticated with fine levels of detail, the complexity of the model increases, and the required data inputs increase. With historic buildings this presents a problem when information about envelope or enclosure performance is evaluated; some assemblies are unknown. Other unknown factors include, but are not limited to, information about materials and material performance, interior and exterior assemblies and the potential layering of materials, and the existing tectonics and detail assemblies throughout a building. These factors may influence the building performance thermally, but they may also influence how the building mitigates solar heat gain, how water moves or how the building deflects wind. Without information about these factors, computational analysis of historic buildings may only be performed at a general level of detail.
Figure 29. The historic energy diagram illustrates the climatic and energy inputs into the region and the building and indicates how and where those material or energy flows exit the system.
Figure 30. The proposed energy diagram illustrates the climatic and energy inputs into the region and the building and indicates how and where those material or energy flows exit the system and how to recapture and recycle some material and energy outputs.
Figure 31. A hand diagram over the site plan translate the weather data onto the site plan for quick and effective comprehension of the climate.
Figure 32. A hand drawn diagram over the east elevation spatializes some of the weather data.
Figure 33. A perspective diagram begins to illustrate how the various roof surfaces interact with the wind and sun including the Steer Shed roof.
Figure 34. The Midway Barn rendered after a solar radiation analysis looking northwest.
V. The Future of the Midway Barn

Visitors at Taliesin may partake in a variety of tours; some of which include walking throughout the property. As part of the historical narrative and ongoing landscape interpretation of Taliesin, the Frank Lloyd Wright Foundation intends to adapt part of the Midway Barn to be a visitor center, event space, and interpretive space. It should also serve as a respite for visitors by providing restroom access as well as light refreshments such as coffee, tea, and snacks.¹ The adaptation of the barn represents an ongoing strategy of site interpretation to extend the narrative of Taliesin to include the story of the site as a functioning farm and as a precursor to Wright’s ideas about societal structure and democracy.² This design proposal is limited to the areas of the barn that will be rehabilitated and adapted to a new use; they are: the Steer Shed, Cow Barns (original and extension), paved court, and the open area east of the north silo.

As a ‘Land Use Center’, the Midway Barn can serve to orient visitors to the site, Wright, his architecture, and the agrarian landscape. It can complement the existing visitor center by framing the educational experience around Wright’s agriculture, beliefs, and pedagogical initiatives with the Taliesin Fellowship. Additionally, the attraction of the rehabilitated barn and some of the interior program can serve as income generators for Taliesin.³

The following rehabilitation project engages the themes and guiding principles outlined in previous chapters as part of a design strategy that connects to

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1. Midway Barn Rehabilitation Plan. See Appendix D.
2. Wright, 47.
The historic, cultural, architectural, and technical legacy of the Midway Barn. The design restores the formal silhouette of the barn, rectifies its formal relationship to the landscape at Taliesin, reactivates the vacant structure and inserts a new use to improve the visitor experience.

**The Rehabilitation Design Philosophy**

The interpretation of Wright's theories of Organic Architecture includes the tenets of bioclimatic and environmental design and this will be a component of the building's sustainability. Practically, that means if Wright sought to integrate the barn with the landscape through form and material, then creating a sustainable rehabilitation involves exploiting that integration and maintaining those geographic and material relationships to place.

Taliesin is no stranger to change. Wright tinkered with the landscape and architecture over his many years. He frequently adjusted the entrance road to create a picturesque procession as the house changed. He even manipulated the formation of the Midway Hill to soften its silhouette and create a more rounded appearance. Given the fact that Wright constantly worked and re-worked the architecture and landscape, part of the legacy of Taliesin is change. As a result, the practical conundrum is how to preserve a site with a legacy of almost annual change, especially one with such a complex history.

There are several guiding principles for the design. This design philosophy does not intend to answer every possible question or solve every design prob-

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5. Spirn, 146.

The principles are general and seek, instead, to promote an attitude about the rehabilitation design. The principles, in order of importance, are as follows:

- Restore the overall massing and formal silhouette of the building to its appearance in 1959 at the time of Wright’s death;
- Respect the tolerance for change and preservation zones established by the Frank Lloyd Wright Foundation and limit the impact on the character-defining elements as they are the reflection of significance in the built fabric;
- Understand the Barn’s original uses and stages of development, they are an important factor in the evolution of the building and landscape; they should be part of the narrative of change over time;
- Modify the building to suit its new use provided that the modifications do not contradict the formal restoration or codes, standards and guidelines;
- New configurations and materials should be in the spirit of the historic structure such that they may generally match the appearance, though some alterations would be appropriate provided that they do not conflict with the previous principles;
- Augment Wright’s ideas about Organic Architecture to include sustainable design tenets;
- Consider location and scheduling of activities to help preserve significant fabric and minimize operational costs.

The overall massing and formal silhouette of the building should be restored (Figure 35). Wright’s design placed a high value on the building form. The building massing is a component of the integration with landscape and function—both parts of Wright’s theories of Organic Architecture (Figure 36). Visitors will
garner a greater understanding of his design strategies as well as the how the building functioned as part of the farm with a completely restored building mass.

As Wright declared himself, form and function should be united. In theory this means that as the use changes, so too should the building form. However, the design should prioritize the formal restoration with select alterations to facilitate the new use. This is the primary way to maintain the site’s vitality and ensure that the building is used and maintained regularly.

Proposed configurations and materials should be in the spirit of the historic structure. Local materials and simplified tectonics are hallmarks of the Midway Barn. Natural materials such as stone and wood should be used where possible. Other materials should be used strategically so as not to draw attention compared to the existing material palette.

Augment the scope of Organic Architecture to include sustainable design tenets. This seems like a natural evolution of Wright’s theories, especially given that he designed with climate in mind (though sometimes he deviated—never guided solely by form and performance). A union between sustainability and historic preservation may promote the overall sustainability of the building and site. Aligning those themes will enhance the educational relevance for visitors, preservationists and designers.

The most basic form of sustainable design has more to do with the management and operation of the building than the formal design. Given the disconnected and aggregate nature of the Midway Barn, the rehabilitation design proposal isolates the Cow Barn and Steer Shed from other parts of the building. This means building systems can be zoned accordingly and the effective size of the building (as defined by the volume of the envelope) is much smaller than the

7. Wright, 4.
overall size of the barn. Less volume to heat, cool and light means less operational energy will be expended.

**Program Analysis**

It is important to note that the program opportunities are suggestions in this table. Some of the proposed program is better suited in other areas than are outlined in this proposal. For example, the loading dock is one of the few exterior covered spaces in the building. As a visual break, and as a way to maintain the original form of the building, it is incompatible with the proposed use as a café. That would require infill in the void between masses of the building—which is a component of the historic characteristics as previously outlined. As such, the café (originally proposed for the loading dock) should be located in the Cow Barn immediately adjacent to the Paved Court to take advantage the exterior space for visitors to enjoy. This also means the café is near a door at grade for supplies delivery. These program shifts consider appropriate uses in compatible locations.

Part of the evaluation process for the program layout included the practicalities of systems, such as the location of waste lines, but also the potential visitor movement around and through the building. Views of the building from the landscape and views of the landscape from the building are significant to the educational demonstration of the land use on site.

One major influence of the program and energy use is the seasonal nature of the site. The site is closed to visitors for the duration of the winter months and when the weather is too cold for tours. Given that fact, the sustainability of the project may be enhanced through limited use and limited operation. If part of the building does not have to function at full energy use all year, then operational energy may be limited to those areas with off-season use such as offices and residences.
Design Response

All of the aforementioned values and character-defining elements are relevant foundations of the rehabilitation design. The design proposal addresses them and engages certain aspects of them in various modes of rehabilitation and restoration. Each set of values and character-defining elements has an associated resonance and practical response through which the rehabilitation highlights.

The utilitarian and informal style of the architecture should be carefully considered by restoring the lost building forms and limiting interior alterations to what is necessary (Figure 38-40). The design draws a multitude of connections between Midway Barn’s history, design and context. It engages Wright’s design theories, promotes prolonged usefulness, tactically adapts components of the building, and engages aspects of the building that made the barn a unique project for Wright. Acknowledging that this is a unique structure for Wright means preserving and restoring the building exterior is critical. The interior has a greater tolerance for change.

Energy modeling has been influential in the design process as a way to visualize the quantitative climate data and render its influence upon the digital model of the Midway Barn (Figure 37). Though it is inherently limited based upon the available data, the energy modeling has shown how the existing building responds to the climate.

The early analytical sketches diagram the relationship that Midway Barn has to the site and climate. They illustrate visitor paths, show climate information, and target components of the building best suited to change as part of the rehabilitation. Space planning diagrams represent iterations of organization to incorporate the proposed adaptations in the existing space so that they may be ideally located.
The formal reconstructions in this thesis are in two areas: the Steer Shed and the Cow Barn flat roof that abuts the twin silos on the west side of the barn. They all represent an attempt to reconstitute the silhouette of the barn in order to rectify the formal relationship with the landscape. Especially at the Steer Shed, the roof mimics the changing slope of the hill and extends to be quite low at the eave. In historic photographs, the roof surfaces almost blend with the topography. The rehabilitation replicates that condition to complete the form of the historic roof (Figure 41). This helps to reaffirm the significance of the Midway Barn’s connection to the land.

From a space planning perspective, there are practicalities of the site that dictate where some program is best suited. Code-compliance is a significant factor in the design process that promotes life-safety and accessibility. The Steer Shed roof is quite low at the east end. To allow for code-compliant headroom, extensive excavation would be required. This presents a great risk to the existing piers. As an alternative, enclosing only half the Steer Shed presents an opportunity to capture some space at the east side of the Steer Shed for sustainable technology service space.

Locating the café in the Cow Barn on the west end allows for visitors to experience the interaction of interior and exterior space. The Paved Court on the west side of the Cow Barn had no proposed use in the space planning table. It is scaled appropriately to provide a few exterior tables for visitors to sit outside and experience the building while enjoying some food and refreshments.

Visually, the reconstructed Steer Shed roof restores the image of the barn from the fields to the east of the barn (Figure 42). It completes the image of the horizontal masses that seem to float just above grade. From the north or south the various slopes of these roof surfaces seem to mimic the slope of the hill. The
shadows cast by these roof surfaces form strong shadow lines and aid in the
dichotomy between visual mass and delicacy. Similarly, the reconstructed Cow
Barn roof extension formally ties the building to the twin silos, and formally recre-
aves the implied enclosure between the Cow Barn and the horse stables (Figure
43). While separate from the other building massing, the machine shed will com-
plete the overall composition of the site.
Figure 35. The Midway Barn proposed reconstructions outlined with a thick line and shaded; they are the Steer Shed roof, the Cow Barn roof extension, and the Machine Shed.
Figure 36: Schematic section looking north, cut through the Cow Barn and Steer Shed, showing climatic factors acting upon the building in conjunction with the reconstructed roofs and proposed building systems.
Figure 37. The proposed reconstructions to the Midway Barn rendered after a solar radiation analysis from above looking northwest.
Figure 38. Proposed Lower Level Plan.
Figure 39. Proposed Upper Level Plan.
Figure 40. Proposed Roof Plan.
Figure 41. Axonometric section through the Steer Shed.

Scale: 1/8" = 1'-0"
Figure 42. Proposed rendering of the Midway Barn looking north.
Figure 43. Proposed rendering of the Midway Barn looking northwest.
VI. Sustainability and Preservation

The impacts of sustainability and historic preservation may be aligned to better steward the built environment into the future. The rehabilitation design at the Midway Barn proposed many interventions that seek to reconstruct the historic building form as part of the site interpretation. The tenets of sustainability align with the mission of Taliesin to preserve the environment and educate visitors about the legacy of Wright’s farming practices. The following section identifies key takeaways from the design process that may inform other rehabilitation design projects at historic sites.

Process, Lessons, Outcomes

The design process began with research surrounding energy systems and thermodynamics in architecture. Diagramming those energy flows and the systemic relationships between the component parts illustrated a dynamic and open thermodynamic system that is subject to constant change over time. The early schematic design stages grappled with the building as a massive form. As the program and building characteristics informed the design, the connections between historic use and proposed use became clearer. The iterative design process is critical; early design explorations are the foundations for developing that design. The careful consideration of history, value, character and use are significant components in the rehabilitation of place. In search of a rehabilitative architecture, they are components that connect the contemporary place to the memory of place.

The design process is iterative and it requires time for reflection. Some of the energy research and analysis seems to be less impactful than was anticipated because the appearance of the building prevented drastic design changes. In
another project, its usefulness is questionable. A limited energy analysis might prove to be just as effective as the holistic diagramming and thermal analyses in this thesis. Additionally, given the preservation principles, it seems that computational energy analysis does not have an opportunity to impact the reconstruction except at a finite level of detail regarding the envelope performance. Even then, historic envelope data may be limited, and render the computational modeling application useless. Though more time and access to the building might have provided an opportunity to develop the analysis further. A rapid assessment of the climate data and its impact on the building seems to be the most applicable approach when grappling with climate and historic structures.

It seems the most effective sustainability strategy at the Midway Barn will be the seasonal use in conjunction with isolated conditioning zones. Overall, when balancing the interests of sustainability and preservation, the best attitude a designer could have is one which places a high value on the historic fabric and how that may translate into practical sustainability opportunities. Particularly as the climate continues to change, designers must grapple with the systemic impacts that changing weather and climate will have on historic structures. It is imperative that designers begin to consider historic structures in relation to the new climate without sacrificing historic character. Merging the endeavors of preservation and sustainability is one way to engage history, climate, memory and technology as designers strive to create a rehabilitative architecture.
Recommendations for Further Study

The following is a list of some opportunities for further research related to Frank Lloyd Wright, The Midway Barn, and/or Rehabilitative Architecture and Sustainability:

- A full conditions survey, analysis, and preservation plan should be performed for the Midway Barn. Based upon the photographs, there are a multitude of building pathologies worth further study;
- with more information, further iterations of energy modeling could engage the historic envelope performance with alterations and compare those with proposed envelope assemblies;
- the landscape is a significant factor in the site interpretation at Taliesin, landscape rehabilitation is an interesting area for research and perhaps a design thesis;
- Organic Architecture theoretically aligns with the tenets of environmental design, and from a preservation perspective these themes have factored into the rehabilitation proposal. However, rehabilitative design may not easily engage with architectural theory that does not prioritize a close reading of the environment and some architectural design principles may even conflict with sustainable strategies. Further study could more broadly analyze the architectural and preservation possibilities of rehabilitative design in other contexts.
Bibliography


Appendix A: Historic Site Photos

The following photographs represent part of the collection provided by the Frank Lloyd Wright Foundation Archives. They span the decades that the Midway Barn was built and expanded from 1930-1959.
Appendix B: Recent Site Photos

The following photographs represent part of the collection taken by The Center for Architectural Conservation as part of the recording effort during the Summer of 2020. Field work was performed by: John Hinchman, Evan Oski-erko-Jeznacki, Ha Leem Ro and Xiaoran Zhang.
Appendix C: Design Iterations

The following images represent iterations of the Midway Barn rehabilitation design. They are unused in the final design drawings but nevertheless show the design process.
EXIST FINISHED SURFACE

FLASHING

NEW IGU SKYLIGHT

NEW SHINGLE ROOFING
NEW ICE & WATER SHIELD
NEW RIGID INSULATION
NEW PLYWOOD DECKING

NEW TIE & WOOD CLEAT
NEW EAVE INSULATION
NEW COL. TYP

NEW BEAM, Flush face with pier below

EXISTING PIER, TYP.

LEDSER & SKYLIGHT DESIGN
N.I.S.
Appendix D: Midway Barn Documents

MIDWAY

1ST LEVEL

N

HISTORICAL SIGNIFICANCE RATING

ZONE 1  PRIMARY SIGNIFICANCE
ZONE 2  SECONDARY SIGNIFICANCE
ZONE 3  NON-SIGNIFICANCE
ZONE 4  UTILITY

SCALE

DATE: 03/05/2008
DRAWN BY: LY
Midway Barn Rehabilitation Plan

View of Midway from Highway 23. circa 1958, courtesy of Taliesin Preservation, Jim Erickson Collection

This is a preliminary proposal on how Midway Barn might be rehabilitated. It is one of a very few number of Wright designed agricultural structures. Midway offers the chance to explore the legacy of farming and land use at Taliesin. It is proposed that Midway Barn be thought of as a “center for land use”. This would allow for the expansion of agricultural and landscape activities on site. With Midway providing:

- Residential Space
- Office/Workspace
- Presentation Space
- Interpretive Space
- Accessible Restrooms

This proposal would allow for some of the spaces to be restored to their original appearance, while other secondary spaces would be rehabilitated to provide presentation and office space. The current residential units would be retained and preserved/restored/rehabilitated as needed. The entire exterior of the structure would be returned to its appearance in the 1950’s in keeping with the internal preservation zoning of the building. The machine shed would be reconstructed and could be used as interpretive space. A new building for collections storage would be built on the Michels Farm.

Farming at Taliesin has been a long-standing tradition; especially during the depression years when income from architectural work was minimal. Farming was not only a necessity but allowed Wright another way to teach young apprentices about the organic processes that were so vital to his architecture. Midway Barn was central to this farming effort. Since 2005 the agricultural acreage at the Taliesin Estate has been leased to Otter Creek Farms. In 2008 Taliesin’s farmland was certified organic farmland. This was thanks to the efforts of Otter Creek Farms.

Wright with apprentices circa 1953, courtesy Pedro Guerrero
## Land Use/Management

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<th>Natural</th>
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<td>Irrigation</td>
<td>Wildlife control</td>
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<td>Terracing</td>
<td>Pest management</td>
<td>Endangered species</td>
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*Aerial View of the Taliesin estate. circa 2015, Frank Lloyd Wright Foundation,*
Agricultural Tourism

Objective: To communicate, educate, and demonstrate the agricultural land management legacy at Taliesin and promote a healthy and sustainable food system for tomorrow.

Utilizing these key initiatives, at Taliesin we aim to enhance awareness of sustainable, healthy farming:

**Public Education and Awareness:**
- Legacy – Frank Lloyd Wright/Farm Architecture
- Workshops
- Conferences
- Competitions
- Events/Festival
- Buy Local/Farmers Markets
- Retail Packaging
- Tours: K-12
  - General Public
  - Agricultural
  - Horticultural
  - Livestock
  - Natural Landscapes
  - Industry Professionals
- Internships
- Website/Web Cameras
- Publications
- Research
- Sustainable Agricultural Practices
- Retail Packaging

**Production**
- Vegetables
- Fruits
- Heritage Seeds
- Grains
- Maple Syrup
- Beverages
- Field Crops
- Energy
- Flour
- Chickens/eggs
- Heritage Turkey
- Goats
- Sheep
- Fish
- Bees/Honey
- Grass Fed Beef
- Pigs
Level 1: Calf Pen
Level 2: Lower Apartment
Level 1: Loading Dock
Level 1: Steer Shed
Level 2: Main Barn/Collection Storage
Level 1: Pump Room
Level 1: Milk Tower
Level 4&5: Nemitin Cottage
Level 4: Upper Guest Cottage
Level 2 & 3: Train/Hayloft
Silo 1
Silo 2
Silo 3

MIDWAY SPACE PLANNING

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* all exterior spaces are rated zone 1
Approximate location of septic field

Approximate location of septic tank

Approximate location of sanitary sewer.

Line from main into building and then other sub panels. Once in the building the electric runs through the building.

Location of main panel

Main electric line

Water line goes directly into building from pump room

Location of well head and pressure tank - noted as pump room on architectural plans
Appendix E: Taliesin Weather Data
Sun-Path Diagram - Latitude: 43.200000000000003
Hourly Data: Dry Bulb Temperature (C)
Lone Rock Faa Ap_WI_USA
Wind-Rose
Lone Rock Faa Ap_WI_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 11.84% of the time = 1037 hours.
Each closed polyline shows frequency of 1.1%. = 99 hours.
Appendix F: Recommendations for Further Reading


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