Future-Proofing

Seeking Resilience in the

Historic Built Environment

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Future-Proofing: Seeking Resilience in the Historic Built Environment

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Table of Contents

List of Figures

List of Tables

Abstract

Future-proofing is the process of anticipating future events and developing methods of adaptation. This process includes mitigation of negative effects while taking advantage of positive effects of changes, shocks, and stresses imposed on buildings. This thesis defines future-proofing, develops the Principles of Future-Proofing historic buildings, and creates a future-proofing rating system for evaluating interventions in historic buildings.

Based upon a literature review of the use of the terms “future-proofing” and “resiliency” in the architecture, engineering, and construction [AEC] industry and other industries, attributes of “future-proof” were derived. Meaning and application of these attributes to the historic built environment are explained and developed into the 12 Principles of Future-Proofing.

A rating system for future-proof capability is developed based upon existing criteria from the RELi Resilience Rating System, LEED, Envision, and other rating systems. The Future-Proofing rating system is applied to four case study restoration projects. Three “Restore the Core” projects completed between 2000 and 2010 at the Seattle campus of the University of Washington were analyzed.

They were Clark Hall, Playhouse Theater, and Savery Hall. Analysis of these projects showed that objective application of the Principles was possible and complimented the subjective application of the Principles. Unexpected consistency of the rating system results was discovered to be a result of a consistent approach to the projects by the University of Washington's Capital Project Office despite the differing use, location, and nature of the projects. An additional case study of the Spokane and Interurban Electric Railroad Building (SIERR Building) restoration demonstrated that the future-proofing rating system demonstrated the applicability of the rating system to building types in different regions and for differing uses. The SIERR Building scored significantly higher on the rating system than the UW buildings because of the historic nature of the building and a focus on long term use of the building. This resulted higher scores for durability, adaptability, and flexibility at the SIERR Building compared to the UW buildings.

This research concludes that (1) the attributes of future-proof items can be codified as a set of Principles, (2) Future-Proofing embodies a broader definition of sustainable and resilient design and life cycle assessment than popular concepts of resilience, (3) the Future-Proofing rating system is a valuable tool for objective evaluation of future-proof capacity, (4) subjective application of the Principles of Future-proofing is valuable during the process of making design decisions, (5) Future-proofing is a flexible system that can be adapted to different building and construction types in different regions and adjusted to support project specific goals, and (6) that continuous revision of the rating system is required to maintain compatibility with the rating systems upon which it is based.

Acknowledgements

I begin my acknowledgments with recognition of my thesis committee. First, I'd like to thank Kathryn Rogers-Merlino – a long time friend and professor who served on the King County Landmarks with me – for first suggesting the topic of future-proofing. Next, I'd like to thank Jeffrey Karl Ochsner for offering advice regarding development of the concept of future-proofing through early classes and has been generous enough to chair my thesis committee. Thanks also to Tyler Sprague who has been a stalwart supporter and critic of my work on future-proofing as well as a friend while we served on the APT Northwest Board. Their incisive and insightful critique has been essential to shaping this thesis.

I also recognize and appreciate the multitude of other University of Washington professors, classmates, and preservation professionals in the Seattle region who have been receptive to the concept of future-proofing and have given me invaluable feedback.

Last, but arguably most important, I honor my wife and son, Joanne and Yan, for the tireless support and latitude they have given me as I have pursued research, writing, and presentations on future-proofing. Without them, my world would stop turning. You are the joy in my life that has made this work possible and I hope you see it change the world for you.

Preface

It is not uncommon to see problems of deterioration in our built environment, and more particularly in our built heritage. Older buildings have had more opportunity to deteriorate than newer ones. However, what we too often also see, perhaps without recognizing it, is that this deterioration might have been avoided with a better understanding of building materials and construction techniques associated with them.

In 2012, I visited Lewis and Clark High School in Spokane, Washington, a beautiful historic brick and glazed terra cotta school building that had been rehabilitated. The school had been gutted and all new interior construction and systems had been installed, compliant with the latest of codes. But there was something wrong. On close investigation of the terra cotta from the roof, it was clear that there was a systematic problem with spalling of the glazed terra cotta surface. Had this been an older issue, I would not have been so concerned because it could have been a problem developing over a long period of time. However, here, the spalling had only started after the completion of the rehabilitation of the school. It is now

Figure 1: The Lewis & Clark High School in Spokane, WA, was recently renovated. Credit: Brian Rich, 2012.

clear that moisture gathered under the glazing and in the variable day to night climate of the area, this moisture froze, expanded, and caused the glazing to spall off. No damage like this had occurred in the prior 80 years of the school's existence. Now the terra cotta has been opened to further water penetration and the damage that may cause to the rest of the structure, not to mention the loss of the historic building fabric. Here was a case where a modern intervention, meant to give the building renewed life, had led to new deterioration.

Figure 2: Spalled stone due to rust jacking at a balustrade at Rittenhouse Square in Philadelphia, PA. Credit: Brian Rich, 2013

In another instance, in 2013, I was in Philadephia at Rittenhouse Square, a 102 year old park designed by Paul Cret. I observed that some of the limestone balustrades that had been built to surround the inner cobblestone area had spalled where a mild steel pin. an added reinforcement, had corroded so badly that rust jacking forced the stone to split [REFERENCE].

These are a few examples of many similar observations of deterioration that might have been prevented with more thoughtful consideration of the design. While these two examples focus on decorative architectural elements, similar observations extend deeper into structural, building systems, programming and appropriate use issues. At the Spokane school, I wondered what had gone wrong. Did the rehabilitation cause the problem or was it some unusual event that led to the damage. In Philadelphia, I wondered if the original designers had known that steel would corrode. Or did they care? Perhaps they were not thinking toward the long term preservation of the park – or the memories and investment of time materials, and money it cost to create. Why not?

During the time I have had at the University of Washington to further my specialization in historic preservation architecture, I have also had the opportunity to reflect upon the practice of architecture in general and my own career in particular. In the course of this reflection, I found myself troubled by the choices made in interventions in historic structures. Often these well-meaning designs would be part of a project to extend the use of a building or structure, yet some aspect of the design or construction would cause the building new damage, ultimately degrading its ability to serve its purpose into the future.

Through the course of over twenty years of practice as an historic preservation architect, my project roles have typically been in the technical design of buildings and/or managing the construction administration process for the design team. These projects have included rehabilitation of several vaudeville theatres in Chicago and the Midwest, and educational and institutional facilities at the K-12 and collegiate levels. I have also volunteered for different historic preservation service positions, including service as the Chair of the King County Landmarks Commission's Design Review Committee and Chair of the Commission itself, as President of the Northwest Chapter of the Association for Preservation Technology International [APTI], and as a member of the 4Culture Historic Preservation Advisory Committee and the AIA Seattle Historic Resources Committee.

Since 2014, I have pursued the application of my technical experience and understanding of the historic built environment and construction as a Construction Manager both at Capital Plannign and Development at the University of Washington and in private practice. In these roles, as in my volunteer roles, I have sought to apply the lessons I have learned for the benefit of our built heritage. As I have reflected on my practice during my Master's degree work at the University of Washington, I began to wonder at why the terra cotta and stone spalled and why we could not do better. Could we develop an approach to designing interventions in historic buildings that would truly help them to serve people for hundreds of years into the future?

In a discussion of these concerns with one of my professors and friends in 2014, the idea of "future-proofing" our built environment was first mentioned. I am fortunate that Professor Kathryn Rogers-Merlino had the wisdom to share this keyword for me. Since this discussion, I have pursued a better understanding of future-proofing and have shared this concept with other professionals. With the support of Professor Jeffrey Ochsner, an amazing intellectual and mentor, and Tyler Sprague, a friend and fellow board member for APT northwest, I wrote and submitted my first article on the topic of future-proofing to the *Journal of Preservation Education and Research,* published in 2014.

I discovered, through the process of submitting my article for publication, that the term "future-proofing" was significantly different from other concepts of sustainable design and resiliency. The idea of future-proofing is broader and more inclusive than other concepts. Where sustainable design has focused primarily on energy conservation, construction materials, and the indoor environment, and resiliency has focused primarily on its origin of ecological systems, nothing has comprehensively addressed the needs of historic buildings, their management of panarchy (change over time) and their future stewardship through adaptive cycles. The concept of future-proofing and the "Principles of Future-Proofing," presented in this thesis, are my effort to develop better stewardship of our historic built environment.

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Chapter 1: Introduction

“Future-proofing” pro-actively endeavors to extend the service life of the historic built environment through the development of sensitive, thoughtful interventions. Future-proofing is differentiated from resilience by the specific development for, and application to, the built environment, as well as encompassing a broader definition of resilience. While “future-proofing” is a term that is regularly used in journal articles and other writing, it is rarely defined well in those articles. The term’s use, however, provides contextual clues about the writer’s intent and can be synthesized into a complete definition of the concept.

Refining the definition of the term “future-proofing” as applied to the historic built environment is the first of four major purposes of this thesis. Testing the applicability of this concept and the principles of future-proofing for real world projects is the second purpose. The third purpose is to develop a rating system to asses the future-proof capacity of a building on an objective basis. Last, through the case study buildings, is to determine whether this rating system can be applied everywhere.

This thesis is partly based upon prior research. This research developed preliminary definitions and principles for this idea. The early definition and principles were carried forward and tested with additional research. Previous research has included analysis of the walrus tusk repairs at the Arctic Building in Seattle and consideration of the incorporation of future-proofing in a cultural heritage policy document which could be applied to rehabilitations of existing historic buildings. Additional research addressed materials and life cycle issues. Other research tested the application of future-proofing at larger scales: the Fort Lawton Historic District.[1]

Synopsis

This thesis focuses on broadening the understanding of future-proofing and testing its application through analysis of real world projects at the building scale. This thesis clarifies the basis for future-proofing and demonstrates its application through analysis of three

1 The Principles of Future-Proofing and the Arctic building case study have been published in a recent article in the *Journal of Preservation Education and Research*. Several additional interviews and articles have been published on the topic of future-proofing. These are made available in the appendices.

projects of the Restore the Core Capital Improvement Program at the University of Washington as well as one non-university project in Spokane, Washington. The thesis is organized as follows:

Chapter 2 discusses the context in which the concept of future-proofing has been developed and is anticipated to be applied. Preservation practices, resource shortages, sustainable design, and economic context are important considerations.

Chapter 3 develops the definition of "future-proofing" based on reviews of the literature of a variety of different fields that use the term. In addition, several topics such as sustainable design, resilience, and other related subjects are discussed.

Chapter 4 presents the proposed Principles of Future-Proofing and provides commentary on each of the Principles.

Chapter 5 presents the research questions which are pursued in the case studies in subsequent chapters.

Chapter 6 discusses the approach and methodology taken in the course of the case study research.

Chapter 7 describes the development of the Restore the Core Program at the University of Washington and briefly summarizes the projects completed to date under the program. This chapter also discusses the future-proofing rating system scores for Clark Hall, Playhouse theater, and Savery Hall at the University of Washington.

Chapter 8 describes the fourth case study building, the SIERR Building, and discusses the future-proofing rating system scores for this case study.

Subsequent chapters analyze the successful and unsuccessful strategies of future-proofing and discuss the broader possible applications and implications of future-proofing, including areas of further research on the subject.

Following the Bibliography, the Appendices contain additional research on future-proofing that has previously been published, additional drawings and information on the case study buildings, and a transcript of the thesis presentation and discussion.

Chapter 2: The Context for Research on Future-Proofing Historic Buildings

The context for pursuing research and developing the concept of future-proofing for the historic built environment has shaped the development of the proposed Principles of Future-Proofing presented in this thesis. There are many broad trends today which suggest the need for a different approach the historic built environment.

The Changing Understanding of Cultural Heritage

Over the last few decades, and most particularly, the beginning of the twenty-first century, the understanding of historic preservation practice and it's role in cultural heritage conservation has been changing. Preservationists have come to understand that the built environment is continually evolving, that it must embrace and convey a broader understanding of history. This must be accounted for in the concept of future-proofing that is developed in this thesis.

During the early and middle of the twentieth century, the practice of historic preservation was perceived as freezing historically significant buildings in time. This is often observed where historic buildings were not allowed to evolve to accommodate new uses and users. "Freezing" buildings in time is characterized by the popular perception of the "house museum" which is perpetually kept in the same state as when the historically significant individuals occupied the house. As Larry Ford, an SDSU professor and urban geography expert, noted in 1979, "Americans gloried in a distant past... and have attempted to recreate settings frozen in time" (Ford, 1979). Sohmer and Lang of the Fannie Mae Foundation describe twentieth century preservation similarly: "The preservation movement began as an effort to save endangered buildings notable for their architecture. Given their focus, preservationists have tended to create sites frozen in time, museums of the past" (Sohmer and Lang, 1998).

However, Sohmer and Lang go on to state that, starting in the late twentieth century, this perception has been changing to one to "favor[ing] context-sensitive historic preservation that accommodates the... needs of individual neighborhoods" (Sohmer & Lang, 1998. Donovan Rypkema confirms this perception in 2005: "Quality, living cities will neither be frozen in time nor look like they were built yesterday.... Historic preservation has moved from being and end in itself - save old buildings in order to save old buildings - to becoming a vehicle for achieving broader ends...” (Rypkema, 2005).

Similarly, the understanding of what constitutes cultural heritage is changing as well. Jokilehto documents the evolution of the term “cultural heritage” through 2005, citing many guiding principles and documents that have been proposed and accepted. Here, Jokilehto notes that the Venice Charter of 1964 refers to cultural heritage as “historic monument[s] embrace[ing] not only the single architectural work by also the urban or rural setting” (Jokilehto 2005).

By 1989, UNESCO defined ‘cultural heritage’ as “the entire corpus of materials signs – either artistic or symbolic – handed on by the past to each culture” (Jokilehto 2005). The concept of the building in stasis persisted in the United States far longer than the international heritage conservation profession which has evolved to include vernacular structures, cultural landscapes, underwater cultural heritage, sacred mountains, mural paintings, and intangible cultural heritage (Jokilehto 2005).

Today, the practice of historic preservation in the United States is evolving to encompass the concepts internationally known as heritage conservation. Heritage conservation is inclusive of multiple different stages of history, states of being, different peoples and cultures that surround historically significant structures.

This evolution of the understanding of cultural heritage is important the concept of future-proofing, because future-proofing include the need for buildings to evolve to accommodate new uses. If the goal is to ensure that all cultural heritage is appreciated appropriately for the multitude of cultures that create it as well as the complex layering of impacts from different cultures over time, then future-proofing should accommodate this broad understanding of cultural heritage.

Preservation Practice in the Northwest and the United States

Preservation practice in the Pacific Northwest is significantly different from that in many regions of the United States. Preservation specialist firms in the Northwest are largely small to medium sized firms with limited capacity to complete significant sized projects. Large preservation projects are often not designed by specialists in preservation, but are more often done by firms that may have an in-depth understanding of a particular building use or by significantly larger firms that subcontract preservation issues to specialists. This approach is exemplified in the recent completion of the King Street Station by ZGF which hired in Artifacts as a consultant; Weaver Architects, which designed the rehabilitation of the Arctic Building as a boutique hotel, but possessed only limited historic preservation experience; and the adaptive reuse of the Coliseum Theater as the Banana Republic store by NBBJ. As noted above, sometimes these firms hire preservation specialists, sometimes they do not. In either case, they obtain expertise to reduce the risk of designing inappropriate preservation treatments

By contrast, in the eastern United States, preservation projects are often championed by large firms specializing in preservation. For example, Einhorn Yaffee Prescott and Beyer Blinder Belle are large firms that regularly complete large preservation projects without the support of outside specialists. Projects by these firms include the Empire State Building and Grand Central terminal by Beyer Blinder Belle, and Federal Hall and Washington Legislative Building by Einhorn Yaffee Prescott. Similar large project firms are designed in other regions by firms such as Mendel Messick and Architectural Resources Group. The combination of the scale of the firm and their preservation specialty knowledge enables these firms to pursue large preservation projects in contrast to Pacific Northwest firms.

How preservation is practiced is important for the application of the principles of future-proofing because both specialized practitioners and generalist firms may benefit from a well-structured approach to considering interventions in historic structures. It also provides a framework to discuss projects with the general public.

Construction Economics: Materials Versus Labor

Material resource costs and labor costs are continuing to increase leading to increasing construction costs. While construction costs are often quite volatile, there has often been a steady rate of construction inflation that is greater than the Federal Reserve Board's Consumer Price Index (CPI) (ENR 2004, 52). It is prudent, therefore, to take advantage of the embodied materials and labor that are available in existing structures in the most efficient way possible. Maximizing the reuse of existing buildings in a rehabilitation project allows for more funds to be put towards labor while conserving material resources and reducing material costs on a project. In addition, funds put towards labor typically stay within the local area, boosting the local economy, rather than sending money to other places for new materials.

Typically labor costs for a construction project can be higher than material costs. However, there are periods of time when shortages in material supplies cause significant escalation. Such escalation occurred in the late 1970s and the 2000s. In the late 1970s, material "prices were in the grip of hyperinflation triggered by an energy crisis and a construction boom that caused severe shortages" (Grogan 2009, 36). During the post-9/11 recovery, the construction industry was "reeling from an across the board onslaught of material price escalation" that continued until the recession of 2009-2011 (ENR 2004, 52). In 2004, the largest material cost change in terms of annual price increases were "plywood, up 48%; rebar, up 34%; copper pipe, 32%: lumber, up 28%: and structural steel, up 23%" (ENR 2004, 52). While the construction material inflation of 2004 subsided in subsequent years (Reina, Nicholson, and Grogan 2005), it still remained higher than the Consumer Price Index over the next few years. A similar situation presents itself today in the United States (and in the Pacific Northwest in particular). Consideration of how to counter such inflationary costs should lead both owners and designers to consider retaining existing building fabric to reduce material costs.

Disposable Consumption-Based Society

In the twentieth century, there was a deliberate effort to create a consumer based society. "For the World Economy to expand, Western societies needed to keep consuming more" (Maxton and Maxton 2011, 24-25). Globalization during the twentieth century brought many unpleasant side effects. The "quality of many goods fell: they were designed to break, become obsolete or become unfashionable quickly, because this encouraged even more consumption" (Maxton and Maxton 2011, 24-25).

Inherent in the sustainable and resilient design strategies is an acknowledgment that a disposable- and consumption-based society is not viable for long term stewardship of the planet. However, it has proved very difficult to move away from a consumption-based society. Social, aesthetic, and cultural values may appeal to those not motivated by sustainable strategies.

This argues that future-proofing is the next step beyond sustainable design and resilience because it incorporates sustainable design strategies as well as incorporation of social, aesthetic, and cultural values. Future-proofing, as discussed in this thesis, also incorporates the social and cultural capital that is inherent in the historic built environment. Future-proofing can move society away from a disposable consumption-based model towards one that is stable and more secure due to less financial and environmental debt.

Global Resource Management Challenges

There are broad global resource shortages of food, water, energy, building materials, and other natural resources, even if they have not impacted the daily lives of many of us yet.

According to the World Wildlife Fund's *Living Planet Report* 2014, "our demand for renewable ecological resources and the goods and services they provide" is more than 150% of the planet's capacity. In the United States, per capita ecological footprint is more than three times the global average (WWF 2014, Figure 23). If everyone on earth lived like a resident of the United States, it would take five times the resources of the planet to support the current global population (Network 2015).

As a result of this global resource shortage, prudent management of existing resources is needed. While energy conservation has been a common issue since the oil embargo in the early 1970s, recent efforts have intensified the focus on energy use reduction as human impacts on the planet have become more evident in climate change. However, there has been less focus on building materials themselves until the development of the LEED rating system. Even so, the value of existing building materials is only beginning to be recognized. The research discussed above suggests that there is a much higher value to the existing built environment than is often recognized.

Limitations of Sustainable Design

Sustainable design practices have been accepted in many forms. LEED, "a framework for identifying and implementing practical and

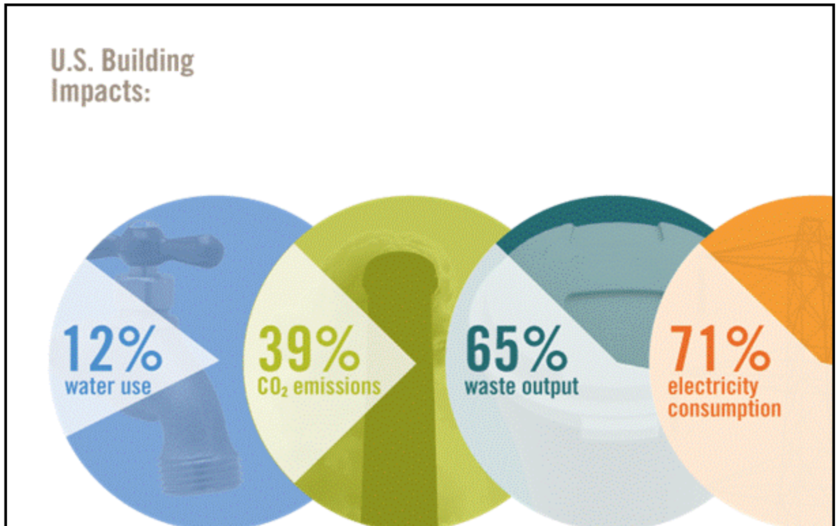

Figure 3: Environmental impacts of buildings on the environment (Credit: USGBC)

measurable green building… …solutions," has become an accepted standard for promoting sustainable design in several different types of projects (USGBC 2015). By focusing on dozens of individual quantifiable metrics, LEED guides building designs toward reduced environmental impacts. There are also other standards such as the Whole Building Design Guide, a collaborative private and public agency database that seeks to provide "one stop access… …on a wide range of building related guidance, criteria, and technology from a 'whole buildings perspective,' rather than focusing on individual metrics" (WBDG 2015). "Cradle to Cradle" design seeks to improve the quality of products in terms of human end environmental health (C2C 2015).

However, these concepts of sustainable design can be pushed further by more holistic views of the built environment as a valuable resource. Many of these sustainable design guidelines do not give appropriate weight to issues such as life cycle analysis (with the exception of Cradle to Cradle), embodied energy, and social and cultural heritage capital vested in existing structures. Instead they

This study finds that it takes between 10 to 80 years for a new building that is 30 percent more efficient than an average-performing existing building to overcome, through efficient operations, the negative climate change impacts related to the construction process. This table illustrates the numbers of years required for new, energy efficient new buildings to overcome impacts.

Building Type	Chicago	Portland
Urban Village Mixed Use	42 years	80 years
Single-Family Residential	38 years	50 years
Commercial Office	25 years	42 years
Warehouse-to-Office Conversion	12 years	19 years
Multifamily Residential	16 years	20 years
Elementary School	10 years	16 years
Warehouse-to-Residential Conversion*	Never	Never

Figure 4: Years of carbon equivalency for existing building reuse versus new construction. Credit: National Trust for Historic Preservation.

seek to address new advances in materials and building systems to achieve their goals.

By contrast, the National Trust for Historic Preservation's Preservation Green Lab has demonstrated the energy efficient nature of pre-World War II buildings, achieving the same goals as LEED while retaining the historic environment (Frey et al. 2011, 19). The existing built environment has significant value not as only material, but as an alternative to the increasing carbon impacts of new construction.

Common Concepts of Resilience

The concept of resilience is derived from ecology and has not been well developed for application to the built environment, despite its increasing use in the media. The Resilience Institute and Resilient Design Institute focus on the ability of a system to adapt to changing circumstances and are not focused on sustainable design the same way as the previously mentioned rating systems (Institute 2013). In addition, these resilient design approaches do not address the issues of historic built environments and social and cultural heritage capital.[1]

Summary

The context in which this research has been conducted involves several influencing factors that should be made clear. These factors include a changing understanding of cultural heritage toward recognition of multiple points of view of history and recognition of more ways in which our cultural heritage is represented. They include a growing awareness of global resource shortages and the need for resource management as well as an increasing awareness of resilience. These factors also include an awareness of our disposable consumption-based society and how preservation in practiced in the Pacific Northwest. Last, these factors also include an understanding of the economic context in which buildings are designed and built. One of the goals of future-proofing as proposed in this thesis is to address these factors.

1 Resilience and future-proofing are discussed in detail in the literature review.

Chapter 3: Literature Review

The Concepts of Future-Proofing and Resilience

Due to the complexity of buildings and the design and construction process, it is difficult, if not impossible, to know that design solutions will always be successful. The concepts of future-proofing and resiliency, two closely related subjects, can provide guidance for the design of interventions in historic buildings. These concepts indicate ways to achieve enduring and sustainable built environments. Whereas future-proofing is a concept found largely outside the United States, "resiliency" is a term increasingly used within the United States. Both are found in a variety of industries. There are also several related concepts already contained within architectural historic preservation and heritage conservation theory and practice.

Future-Proofing in the AEC and Related Industries

The concept of future-proofing is the process of anticipating the future and developing methods of minimizing its negative effects while taking advantage of the positive effects of shocks and stresses from future events. While the connotations of the term "future-proofing" may be considered negative if the future is thought of in a negative light (similar to bullets and bullet-proofing), future-proofing can also be taken in a positive light. Buildings are able to take advantage of the changing attributes of a continually evolving environment, such as the restoration of blighted neighborhoods. If the term "future-proofing" is unpalatable to preservationists, one could also argue for a wider definition of "resiliency" since both promote similar concepts.

Future-proofing is a concept that is found in multiple different industries, although use of the term was uncommon in the architecture, engineering, and construction (AEC) industry until the past fifteen to twenty years (since the year 2000). Future-proofing is a concept that has been developed largely outside the United States and outside the AEC industry. The industries where future-proofing is used include electronics, data storage, utilities systems, industrial design, environmental and ecological design, and energy conservation. Within the AEC industry, the term "future-proofing" is found most often in discussion of sustainable design. The concepts of future-proofing are more widespread in the AEC industry, but have not been brought together as a coherent approach to building design projects.

In the electronics industry, future-proofing references data and image storage and computer electronics. In future-proof electrical systems, buildings should have "flexible distribution systems to allow communication technologies to expand," according to Raul Barreneche (Barreneche 1995, 123). Thomas and other designers at Bell Laboratories, Lucent Technologies Australia, focus heavily on the ability of a system to be reused and to be flexible in order to continue competing in the marketplace (Thomas et al. 2003).

In one region of New Zealand, Hawke's Bay, a 2012 study by the consulting firm Page Bloomer Associates specifically sought to understand the existing and potential water demand in the region as well as how this potential demand might evolve with climate change and more intense land use. This information was used to develop demand estimates that would inform the improvements to the regional water system. Future-proofing thus includes forward-looking planning for future development and increased demands on resources (Bloomer and Page 2012, i-vi).

In industrial design, future-proofing strives to encourage people to acquire fewer products by creating objects that hold more value through time for the purchaser (Kerr 2011, 7). Kerr goes on to state that future-proof products should have a degree of atemporality. As a product wears and ages, its overall desirability should be maintained (Blanco-Lion, Pelsmakers, and Taylor 2011). Ideally, desirability exemplifies a positive change; the product can fit into society's paradigm of "progress" while simultaneously changing that paradigm by introducing new products or changing the parameters of why the product is valued (Kerr 2011, 9).

In the realm of sustainable and environmental issues, the term future-proof is used to describe the ability of a design to resist the impact of potential climate change due to global warming, based on research by faculty at University of Bristol and the University of Moratuwa in Sri Lanka. Two characteristics describe this impact. First, dependency on fossil fuels must be replaced by renewable energy sources. Second, society, infrastructure, and the economy must adapt to the residual impacts of climate change (Godfrey, Agarwal, and Dias 2010, 180). In the design of high-performance dwellings, "buildings of the future should be sustainable, low-energy and able to accommodate social, technological, economic and regulatory changes, thus maximizing life cycle value." Georgiadou, Hacking, and Guthrie believe that the goal of future-proofing in design is to reduce the likelihood of a prematurely obsolete building design (Georgiadou, Hacking, and Guthrie 2013, 9).

The concept of future-proofing also appears in some literature with specific regard to sustainable preservation strategies. Initial studies on climate change and historic structures were carried out by English Heritage in 2004, and scientific research such as *Engineering Historic Futures* and the European Union's *Noah's Ark Project* have been completed (Cassar 2009). Cassar, for example, is interested in sustainable rating systems if durability is incorporated as a metric for evaluating buildings. Cassar also argues that historic buildings must fully engage in the process of "adaptation to climate change," lest they become redundant and succumb to "environmental obsolescence" (Cassar 2009, 7). Cassar also recommends a "'long life, loose fit' strategy to managing historic buildings," meaning that impact of sustainable design strategies must be adapted to the particular circumstances of each building and balanced with the loss of original features rather than applied to the entire built environment with broad brush strokes (Cassar 2009, 8). Most important, Cassar highlights one of the underlying values of future-proofing— the "historic built environment is a finite and non-renewable resource"—and concludes that "heritage must adapt to changes, physical and intellectual, within its environment" (Cassar 2009, 10).

Because embodied energy comprises a significant percentage of energy consumed over a building's life, the preservation and adaptation of buildings plays a "central role in conserving the past and the future" (Holland 2012, 5). For example, the hygrothermal performance of the original building materials at the Hudson Bay Department Store in Victoria, British Columbia, was carefully analyzed to ensure that improvements would not reduce the "building's time-proven durability" (Dam 2011, 47). In reference to the Marquette Railroad Depot in Bay City, Michigan, Tyler and Dilcher note that "the use of durable, long-lasting materials was cost effective 100 years ago, and restoring those materials today extends their service into the next century" (Tyler and Dilcher 2010, 24). All of these articles on sustainable preservation strategies discuss various concepts of future-proofing, including durability, doing no harm, extension of service life, adaptability, and avoiding obsolescence.

As mentioned above, a future-proof building is also one that does not become obsolete. Reed and Warren-Myers state that in the valuation of real estate, there are three traditional forms of obsolescence: physical, functional, and aesthetic. Physical obsolescence occurs when the physical material of the property deteriorates and needs to be replaced. Functional obsolescence occurs when the property is no longer capable of serving the intended use or function. Aesthetic obsolescence occurs when fashions change or when something is no longer in style. A potential fourth form, sustainable obsolescence, occurs when a property no longer meets one or more sustainable design goals (Reed and Warren-Myers 2012). Resisting obsolescence is an important characteristic of future-proofing a property because it emphasizes the need for the property to continue to be viable.

In Australia, research commissioned by Health Infrastructure New South Wales explored "practical, cost effective, design-related strategies for 'future-proofing' the buildings of a major Australian health department" (Carthey et al. 2011, 89). This study, conducted by several faculty and staff at the University of New South Wales, concluded that a focus on a whole life cycle approach to the design and operation of health facilities would have clear benefits (Carthey et al. 2011, 106). By designing flexible and adaptable structures, one may defer obsolescence and consequent need for demolition and replacement, thereby reducing overall demand for building materials and energy (Carthey et al. 2011, 106). In 1997, the MAFF laboratories at York, England, were described by Lawson as "future-proof" by being flexible enough to adapt to developing rather than static scientific research (Lawson 1997). In 2012, a New Zealand–based organization promoting future-proofing outlined eight principles of future-proof buildings: smart energy use, increased health and safety, increased life cycle duration, increased quality of materials and installation, increased security, increased sound control for noise pollution, adaptable spatial design, and reduced carbon footprint (CMS 2012). Future-proofing, as evidenced in the above industries, offers several concepts that may guide enduring interventions in the existing built environment as well. These concepts include resisting obsolescence, durability, adaptability, sustainability, local materials and labor, atemporality, forward planning, and re-use.

Future-Proofing and Resilience

In the AEC industry and many other industries in the United States, the closely related concept of resilience has gained a significant following and offers several key concepts as well, as we will see in the discussion that follows. “Resilience” is a term used to describe architecture and environments that can withstand external shocks. The term has been part of research literature since the 1970s, but has grown since 2000 to include more definitions as well as reference to more entities and systems. Today, the term has been applied to ecological systems, infrastructure, individuals, economic systems, and communities according to the National Academy of Sciences (Science 2012, 18). While commonly used in the popular media, the term “resilient” has also received significant attention in recent scholarly articles. Not only has the term become common in reference to the built environment, but it is also widely used in reference to computing and networking systems, environmental and biological studies, and individual people.

As Jill Fehrenbacher notes, “In November 2012, ‘Resilient Design’ was a trending search term in Google, moving from near obscurity in the months before the devastating super storm to a popular catchphrase post-Sandy” (Fehrenbacher 2013). The Resilient Design Institute (RDI) offers a succinct summary of the principles of resilient design (Institute 2013). Intended to be broadly interpreted and applied, they are not specifically focused on the built environment. They do, however, offer some vital clues about resilience that can be applied to the built environment:

- Resilience transcends scales.
- Resilient systems provide for basic human needs.
- Diverse and redundant systems are inherently more resilient.
- Simple, passive, and flexible systems are more resilient.
- Durability strengthens resilience.
- Locally available, renewable, or reclaimed resources are more resilient.
- Resilience anticipates interruptions and a dynamic future.
- Find and promote resilience in nature.
- Social equity and community contribute to resilience.
- Resilience is not absolute. (Institute, 2013)

Very few scholarly articles specifically discuss "resilient architecture." Many of the articles that do discuss "resilient architecture" focus on networks and technology systems. For example, Shi and Khan use resiliency to describe shared-memory multicores for computing and communication networks (Shi and Khan 2013). Another article discusses resiliency in off-shore wind farm communication networks, suggesting that a resilient communication network "can be achieved through a combination of redundancy and quality of service" (Gajrani, Gopal Sharma, and Bhargava 2013, 023139-1). According to Applegath et al. (Applegath et al. 2010), the principles of a resilient built environment include:

- Local materials, parts, and labor
- Low energy input
- High capacity for future flexibility and adaptability of use
- High durability and redundancy of building systems
- Environmentally responsive design
- Sensitivity and responsiveness to changes in constituent parts and environment
- High level of diversity in component systems and features. (Applegath et al. 2010)

Where the RDI list is developed to be applied to broader environments in general, Applegath's list is focused on the built environment and eliminates some of RDI's principles. For example, RDI's principles about transcending scales and providing for basic human needs are not present in Applegath's list of principles. Similarly, RDI's principles of resilience in nature, social equity, and resilience is not absolute are not included in Applegath's list. RDI's "simple, passive, and flexible" is similar to Applegath's "low energy input," but both are valuable insights.

One approach to cities is an integrated multidisciplinary combination of mitigation and adaptation to raise the level of resilience of the city. In the context of urban environments, resilience is less dependent on an exact understanding of the future than on tolerance of uncertainty and broad programs to absorb the stresses that the urban environment might face. The scale of the context is important: events are viewed as regional stresses rather than local. The intent of a resilient urban environment is to keep many options open, emphasize diversity in the environment, and perform long-range planning that accounts for external systemic shocks (Thornbush, Golubchikov, and Bouzarovski 2013). Options and diversity are strategies similar to ecological resilience, discussed below. This approach again points out the importance of flexibility, adaptability, and diversity to future-proofing.

Personal resiliency is a common theme in the discussion of recovery from the Boston Marathon bombing (Sanchez 2014) and other natural disasters such as Hurricane Sandy (Bernstein 2012). Important in stories of personal resilience is the ability of people to persevere in spite of severe physical and mental injuries, "shattered bones, severe burns, and shrapnel wounds" (Sanchez 2014). Resilience in the workforce in China is the subject of another paper. Increasing performance pressure is requiring employees to be more resilient. The paper notes that there is an "increasing overlap between the key attributes in resilience and soft skills. This overlap of resilience and soft skills is identified in 9 dimensions: vision, determination, interaction, relationships, problem-solving, organization, self-confidence, flexibility & adaptability, and pro-activeness" (Wang, Cooke, and Huang 2014, 135).

In its common usage, "resilience" describes the ability of something to recoil or spring back into shape after bending, stretching, or being compressed. In ecology, the term "resilience" describes the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state (Applegath et al. 2010). Resilience in the natural environment is a subject of current research as humans take more interest in the impacts of human activity on the planet. In an article about the development of urban social-ecological systems, Schewenius, McPherson, and Elmqvist argue that "urban futures that are more resilient and sustainable require an integrated social-ecological system approach to urban policymaking, planning, management, and governance" (Schewenius, McPhearson, and Elmqvist 2014, 434).

Biological resilience is commonly discussed in research focused on the ability of a living organism to resist and even thrive despite changes to its natural environment. In biological studies off the coast of Italy, oceanic sediment bacteria are described by Kerfahi et al. as resilient in the face of rising levels of carbon monoxide in the ocean waters. Here, resilient is taken to mean that the bacteria are resistant to the increasingly corrosive waters (Kerfahi et al. 2014).

In an environmental study by Hoggart, "coastal habitats surveyed are relatively resilient to flooding due to their species rich nature and their ability to adapt to flooding. However, specific groups of plants such as grasses are more affected by flooding and less able to recover" (Hoggart et al. 2014, 170). This suggests that adaptability and the ability to recover from flooding are important attributes of resilience.

Through this sampling of recent articles on resilient design and resiliency in computer networks, personal resiliency, and resiliency in urban, ecological, and biological systems, it is clear that the term has been widely used. From these articles, it is also clear that there are several characteristics of resiliency that can become concepts of future-proofing for historic buildings. These characteristics include redundancy, diversity, flexibility, durability, adaptability, and local resources such as materials and labor, to anticipate systematic shocks in a changing future.

Future-Proofing and Climate Change in Heritage Resources

Resiliency and future-proofing are also at the core of the discussion of the impacts of climate change on cultural heritage. The Getty Conservation Institute (GCI), Association for Preservation Technology (APT), National Trust for Historic Preservation, UNESCO, and English Heritage all have focused on this issue in recent years. The Spring 2011 issue of *Conservation Perspectives, the GCI newsletter*, is dedicated to the intersection of the impacts of climate change and heritage. In this edition of the newsletter, Cassar states that climate change "poses significant challenges for cultural heritage" (Cassar 2011, 11)). Much of what Cassar discusses describes the need to understand the impacts of climate change on our heritage and developing policies to address these impacts. The policies Cassar promotes address how to respond to climate change in a way that will help physical heritage endure. The concepts of future-proofing are an essential component in responding to climate change by providing the framework for implementing the policy Cassar promotes developing.

In the same issue of *Conservation Perspectives*, Jean Caroon states that "there's no way to make a building that doesn't have an environmental impact," but that "you can lessen the environmental impact by taking existing objects and extending their service life" (Caroon 2011, 19). Decreasing environmental impacts and extension of service life are two important concepts in future-proofing. This edition of *Conservation Perspectives* concludes with a list of several other sources that discuss the impacts of climate change on cultural heritage and the need to respond to these impacts.

One of these other sources, APT, dedicated a symposium to the subject of climate change. In 2004, the APT formed a Technical Committee on Sustainable Preservation and a subcommittee on climate change. The Halifax Symposium held at the 2005 APT Annual Conference, identified several concepts that were found in common between sustainability and the mission of APT. The principal concepts, summarized by Lesak, include:

- Understanding the importance of stewardship and planning for the future
- Building to last, including material selection and treatment, craft, and traditional building techniques
- Durability and service life of materials and assemblies and their implications for life cycle assessment
- Understanding extending buildings' service lives and systems renewal (Lesak 2005)

These concepts also included a system of evaluation of existing buildings that included "creating sustainable building stock… …by assessing material value and energy value" (Lesak 2005, 4). The last level of evaluation included a "product rating system to establish, test, and/ or confirm effectiveness, durability, life cycle impacts, [and] renewability" of building materials and products (Lesak 2005). One of the latest developments at APT is a special issue of the *APT Bulletin* that focuses on climate change and preservation technology (Rankin 2014). From these statements, several concepts of future-proofing are highlighted, including forward planning, durability, extension of service life, including building systems, and life cycle assessment.

UNESCO has published several documents that address climate change and heritage conservation, most notably World Heritage Report 22 titled *Climate Change and World Heritage* (UNESCO 2007). This report discusses predicting and managing the impacts of climate change and offers strategies for implementing responses. Much of Report 22 discusses developing a better understanding of the impacts of climate change through modeling, monitoring, and research and appropriate dissemination of the information (UNESCO 2007). However, the report also discusses the need for "adaptive design" in several places as well as identification and promotion of "synergies between adaptation and mitigation" (UNESCO 2007, 41). The report also recommends "increasing resilience of a site by reducing non-climactic sources of stress" and "adapting to the adverse consequences" of climate change (UNESCO 2007, 11). These statements demonstrate the characteristics of adaptation and increased fortification of heritage sites, both of which are important concepts in future-proofing and resiliency.

English Heritage's *Conservation Bulletin* dedicated its Spring 2008 issue to climate change, under the title "Adapting to a Changing Climate." In this issue, Cassar identifies several key research outputs that are necessary to address climate change that are similar to the approach to resilient cities discussed above. These include "adaptations to climate change" and "damage mitigation strategies for materials and assemblies" (Cassar 2008, 11). These statements reflect the need for heritage to be reinforced and made more durable to resist the future impacts of climate change.

Clearly, resilience and climate change have moved toward the center of discussions on cultural heritage both within the United States and internationally. These discussions often focus on key aspects of future-proofing and resilience, including adaptation to climate change, extension of service life, and mitigation of the effects of climate change.

Hazard Mitigation

In most cases of severe hazard risks, the parameters, timing and secondary effects are unknown variables. By nature, natural hazards are difficult to forecast, difficult to assess and difficult to recover from. Therefore, preparing for natural hazards requires resilience, adaptability, creativity, and prior assessment. Together the methods of hazard mitigation, future proofing, and panarchy create a symbiotic and comprehensive strategy necessary to forecast, prepare and react to potential natural hazards.

The National Academy of Sciences has defined the resilience as "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" (Science 2012). The role of developing higher levels of resilience is to allow better anticipation of disasters and reduction of losses due to a natural disaster, according to the National Academies. Thus, the discipline of hazard mitigation is important to future-proofing and is considered in further depth here.

Hazard Mitigation is "any sustained action taken to reduce or eliminate the long-term risk to human life and property posed by hazards" (FEMA 2009). It is usually divided into four phases: pre-disaster mitigation (preparing for a disaster), during the disaster, disaster response, and post-disaster recovery (a re-building phase). Natural hazards are viewed as neutral changes until they interact with and impact humans, at which point it is referred to as natural disasters. Disasters may also be created by humans, including terrorism and climate change, or be technological or accidental in origin. Disasters may impact built capital, natural capital, or social capital, or any combination of these three. Future-proofing focuses on the impacts to the built environment that are both natural and human-induced and generally on the pre-disaster phases of mitigation.

There are two basic categories for managing disaster risk: construction related and non-construction related. Construction related includes levees, flood walls, seismic retrofits, moving a building, and other disaster resistant construction (Homeland Security 2013, 43).

Within the construction related strategies, there are three common strategies to mitigate risk from a disaster: retreat, accommodate, or protect. Within the built environment, these strategies are employed to achieve a long term reduction in vulnerability to hazards. To retreat is to move away from the hazard, as was recently completed for the Cape Hatteras Lighthouse, a landmark that would have been lost due to erosion of the shoreline. Retreat may include lateral or vertical movement, or even moving to a different part of the world. Accommodating a hazard means to allow it to sweep past without significantly impacting the physical environment. A good example is flood hatches installed in the walls around a crawl space to allow floodwater to pass through and not damage a building. Last, protection is focused on hardening or fortifying the physical environment from the impacts of a hazard. Structural seismic

Figure 5: The Cape Hatteras Lighthouse being moved away from the eroding shoreline in a strategic retreat. Credit: www.images.nationalgeographic.com

retrofits are common to reduce the risk and severity of damage due to a seismic event.

The goals of hazard mitigation are to encourage communities to become more flexible and adaptable, guide integration of mitigation activities with existing community planning and program activities in a coordinated and economic manner, consider future growth and development trends, and to make a "community more disaster resilient" (Seattle 2014). To be more specific one of the explicit goals of the *Seattle All Hazards Mitigation Plan* is to protect natural, cultural, and historic resources by providing "climate adaptation strategies" and "promote mitigation of historic buildings and key cultural assets" (Seattle 2014, Table 6-1).

Many of the goals of hazard mitigation correlate closely to the characteristics of future-proofing that have been discussed above, especially flexibility, adaptability, consideration of future trends, and resilience. In addition, the strategies of retreat, accommodate, and protect are inherently future-proof actions: by actively employing one of these strategies, the assets can be protected from predictable natural hazards.

Panarchy and Adaptive Cycles

When considering hazard mitigation for infrastructure systems, the hazard mitigation may become more complicated due to the time it takes for a large infrastructure system to be created, maintained, and modified. Due to this extended period of time, the concept of panarchy becomes an important factor. "Panarchy" is the process by which ecological and social systems grow, adapt, transform, and,

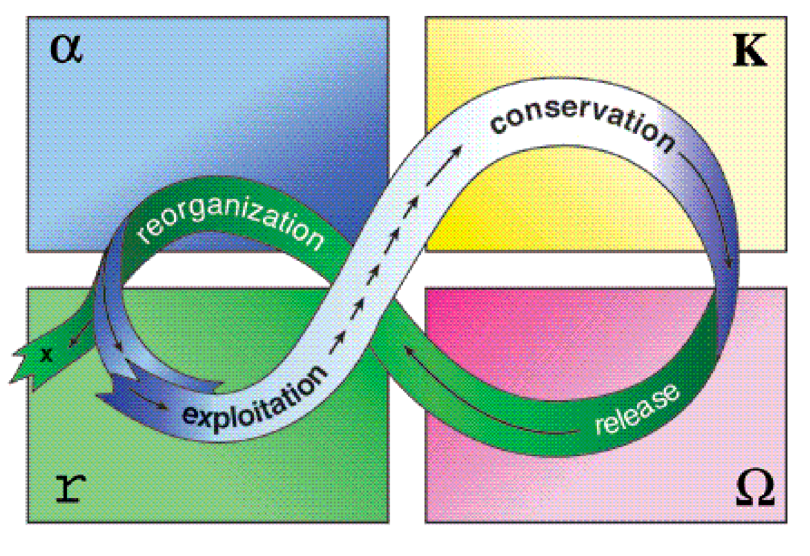

Figure 6: The basic adaptive cycle diagram as developed by Holling and Gunderson, 2002. The 4 phases include: entrepreneurial exploitation (r), organizational consolidation (K), creative destruction (Ω), and re- or destructuring (α). Credit: From Panarchy edited by Lance H. Gunderson and C.S. Holling. Copyright © 2002 Island Press. Reproduced by permission of Island Press, Washington, DC.

ultimately, collapse over extended periods of time (Gunderson and Holling, 2002). In the context of the built environment, panarchy refers to a framework for conceptualizing adaptive cycles in human and built environment systems (Gunderson and Holling, 2002).

As described above, panarchy is a framework for understanding adaptive cycles in the human/built environment ecosystem. Panarchy contains four phases: exploitation, conservation, release, and reorganization; it can be observed at multiple scales of time, space, and speeds. Panarchy can have an added dimension of resilience during certain phases and feedback loops of remembrance and revolt, as described below.

"Engineering resilience" is a term used by Holling and his colleagues to describe a more traditional "equilibrium steady state, where resistance to disturbance and speed of return to the equilibrium are used to measure the property" (Gunderson and Holling 2002, 27). Engineering resilience is often how the built environment is perceived – steady, unchanging, and always present. Indeed, societal and psychological stability may be often founded on the permanence of certain structures. (This is, partially, why the destruction of the World Trade Center in 2001 was so disturbing to many people.) The second definition of resilience is "ecosystem resilience" which is "measured by the magnitude of the disturbance that can be absorbed before the system changes its structure" (Gunderson and Holling 2002, 28). This second definition is the focus of the discussion of adaptive cycles, panarchy, and resilience that are discussed by Gunderson and Holling. However, when applied to the built environment, both understandings of resilience are important. A future-proof built environment should embrace "'the two opposites: growth and stability on one hand, change and variety on the other'" (Homer-Dixon 2006).

In describing the concept of panarchy and adaptive cycles, Gunderson and Holling state that there is no such thing as a "highly resilient natural system" (Gunderson and Holling 2002, 31) In such a system, there would be no fundamental change and, thus, a loss of diversity. Holling and Gunderson further suggest that resilience is never infinite and every system is, eventually, replaced by something else. This idea is important to the understanding of how future-proofing applies to the built environment because it suggests that nothing should be planned for a permanent state of stasis. The built environment should, they would argue, be able to be flexible and adaptable to new circumstances. "Resilience of the system must be a dynamic and changing quantity that generates and sustains both options and novelty, providing a shifting balance between vulnerability and persistence" (Gunderson and Holling 2002, 32).

The concept of adaptive cycles and panarchy was first developed to describe natural ecological systems in the 1970's and 1980's by C.S. Holling and Lance Gunderson, and other ecologists. It is possible to apply the theory to the built environment. Central to understanding panarchy is the adaptive cycle process and the four ecosystem functions within it. The concept of panarchy is described by a figure eight mobius strip with entry and exit points at certain phases, as seen in Figure 6. Gotts summarizes the four phases of the adaptive cycle:

> In the r phase, potential and connectedness are low but resilience is high; in K, resilience decreases while the other values increase. Eventually, some internal or external event triggers the Ω phase, in which potential crashes; finally, in α, resilience and potential grow, connectedness falls, unpredictability peaks, and new system entrants can establish themselves (Gotts 2007).

The adaptive cycles described by Hollings, et al, may also be evident at multiple different scales, from cells to ecosystems to societies to cultures. Similarly, adaptive cycles may be discovered in different scales of the built environment, from buildings to neighborhoods to cities and regions, different scales of time, from days to years to millennia to epochs, and speeds of cycles, from slow to fast (Holling, 2004). Adaptive cycles can also be additive, similar to the increase

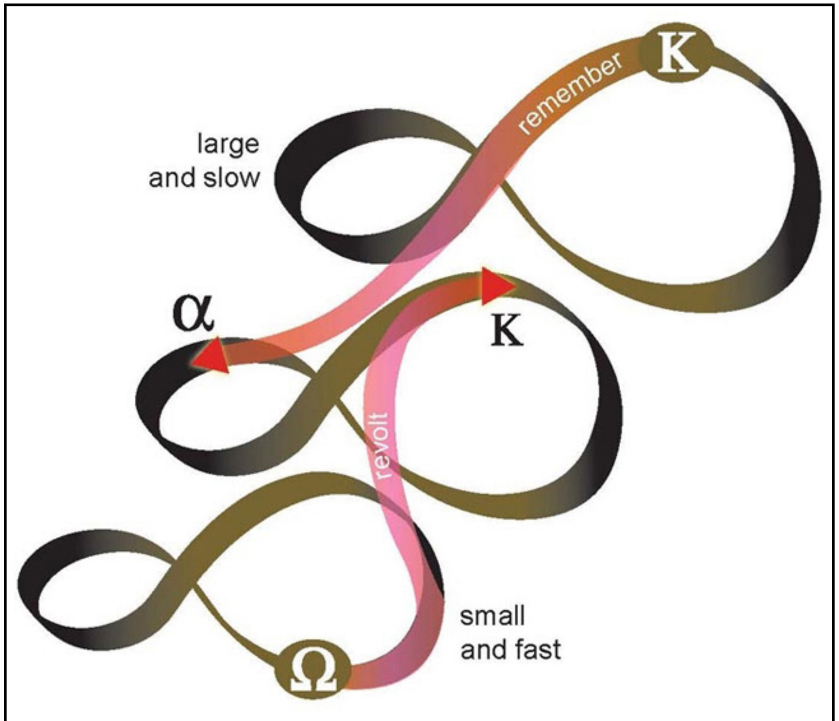

Figure 7: Adaptive cycles at multiple scales impact each other through remembrance and revolt. Systems are subject to large impacts due to small changes at the release (Ω) and reorganization (α) phases. Credit: From Panarchy edited by Lance H. Gunderson and C.S. Holling. Copyright © 2002 Island Press. Reproduced by permission of Island Press, Washington, DC.

in amplitude of sound waves when they overlap. The exposure to vulnerability is significantly greater when a set of adaptive cycles align and peak at the same time and the collapse significantly more extreme (Dixon, 2006). Such cumulative effects often shift an ecosystem over a threshold and into a new state of equilibrium, or metastable regime (Gotts 2007). Figure 7 shows an illustration of adaptive cycles at multiple scales.

There are three essential properties of the adaptive cycle, as described by Holling:

> Potential sets limits to what is possible – it determines the number of options possible options for the future. Connectedness determines the degree to which a system can control its own destiny, as distinct from being caught by the whims of external variability. Resilience determines how vulnerable a system is to unexpected disturbances and surprises that can exceed or break that control (Gunderson and Holling 2002).

"Human systems with foresight and adaptive methods... ... stabilize variability and exploit opportunity" in ways that natural ecosystems cannot, giving the illusion of permanence (Gunderson and Holling 2002, 53). Holling, et al, describe three potential types of change: (1) incremental changes in the r and K phases which are smooth and fairly predictable, (2) abrupt change in the transitions from K through Omega and alpha, and (3) transformational learning, meaning change involving several panarchical levels and interaction between different sets of labile variables (Gotts 2007). Indeed, it is precisely the potential for destructive change that humans seek to moderate with ingenuity and manufactured stability. Despite human

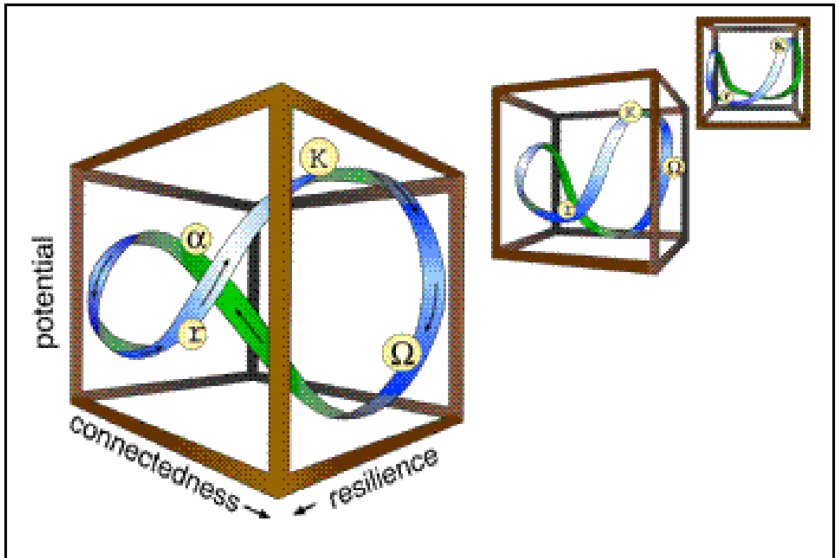

Figure 8: Adaptive cycles with the added dimension of resilience. Note the 3 axes: potential, connectedness, and resilience. Resilience is high during the exploitation and conservation phases, but is low during release and reorganization phases. Credit: From Panarchy edited by Lance H. Gunderson and C.S. Holling. Copyright © 2002 Island Press. Reproduced by permission of Island Press, Washington, DC.

efforts toward stable environments, stable and artificially stabilized systems will eventually change. The question is often how can one best control the release phase of the adaptive cycle.

Future-proofing is one way to guide the conception and execution of interventions in the built environment, but the concepts of panarchy and adaptive cycles also inform the concept of future-proofing. The most important conclusion is that future-proofing should not be conceived as creating an absolutely fixed built environment forever. In fact, future-proofing endorses change through flexibility and adaptation of a building to the different conditions in which it exists. Such adaptation is the only way for the service life of a structure to be extended. However, future-proofing should also suggest that a system build upon its existing attributes by strengthening (preventing decay, fortifying, and increasing durability and redundancy) or replacing its weaknesses (extending service life and reducing obsolescence).

"Humankind's understanding of complex systems is growing, but whether our understanding and ability to manage these systems is outpaced by our transformation of them will ultimately determine the longevity of our current regime" (Allen et al. 2014). Homer-Dixon suggests that we are "overextending the growth phase of our adaptive cycle" and argues that "we will no longer be able to regulate or control the stresses building deep inside the global system" (Homer-Dixon 2006). The desire for longevity of our current regime thus requires the inclusion of panarchy and adaptive cycles in the concept of future-proofing. More particularly, adaptive cycles should be included from the point of view of "ecological resilience" in addition to "engineering resilience," in order to solve the resource limitations and environmental problems of the present time and the future.

Panarchy's strength is in its resilience and acknowledgment that there is no way to forecast a situation perfectly. Panarchy is best defined as a dynamic system of trying to return to steady-state equilibrium. Future-proofing allows people to do a risk assessment, evaluate vulnerabilities in different scenarios and from those scoping studies, compare and evaluate the solutions in the context of economics, logistics, and feasibility. Hazard mitigation is a used to determine how to alter, in a structural or non-structural way, a critical infrastructure system, or service to prepare it for the different natural hazards.

The 5/10/50 Year Design Strategy: A Case Study

The 5/10/50 year design strategy is a system for clarifying the degree of permanence of a building element. Building elements are classified as to whether they are intended to remain in place for 5, 10, or 50 years. 5 year walls include walls that are intended to be

Figure 9: One of the Great Rooms at the Lakota Middle School in Federal Way, WA. Credit: Brian Rich, 2014.

readily removed and consist of studs, drywall and no plumbing or electrical components. 10 year walls were the same as 5 year walls, except that they often had electrical branch circuits and low voltage systems in the walls. Branch circuits were connected to ceiling-mounted electrical junction boxes with flexible conduit to allow them to be easily removed and terminated. 50 year building components included structural, major plumbing and mechanical systems that would take significant effort to relocate. (Bassetti, 2010).

The intent of this system is to color code the components of the building such that one could easily see which components would compromise the ability of the building to be adapted for different uses in the future. This strategy suggested clustering of 50 year building components to allow other building areas to be more flexible.

The 5/10/50 year design strategy was recently used and discussed in the marketing literature for the Lakota Middle School, a project designed by Bassetti Architects (Bassetti, 2010).[2] The intent of this strategy is to differentiate portions of a building that are critical long term components from short term components. This strategy allows a team to understand how to design in flexibility and adaptability through thoughtful spatial organization and system design. 50 year building components included the structure, central mechanical, electrical, and plumbing components, elevators, and the exterior shell of the building. 10 year components were typically walls that had minimal electrical and data systems installed in them. 5 year walls were typically partitions that held no structural, mechanical, electrical, or plumbing systems and could be readily removed with minimal effort.

By analyzing the design through the 5/10/50 lens, the design team determined that building components such as restrooms, electrical rooms, and elevators needed to be co-located to cluster 50 year building components. "Opportunities for adaptability are made explicit by designating each wall within the school as a 5, 10 or 50 year wall. Mechanical and electrical systems are designed with flexibility" (Bassetti, 2010). As a result, large areas of the building were available for potential alteration in the future. See Figure 9, an image of an interior great room and Figure 10 – an example of a 5/10/50 plan.

The ability to change room configurations easily allowed for multiple different teaching pedagogies and administrative approaches to be employed by the school district as the district's preferences changed over time. For instance, classrooms clustered in groups of four were separated with 5 year walls. These classrooms were separated from a common "Great Room" space by 10 year walls. This separation allowed for accommodation of the standard 30 student class sizes and the single class pedagogy in current use at the school. However,

2 This author was the Project Manager and Project Architect and worked through the application of the 5/10/50 design strategy during the project design.

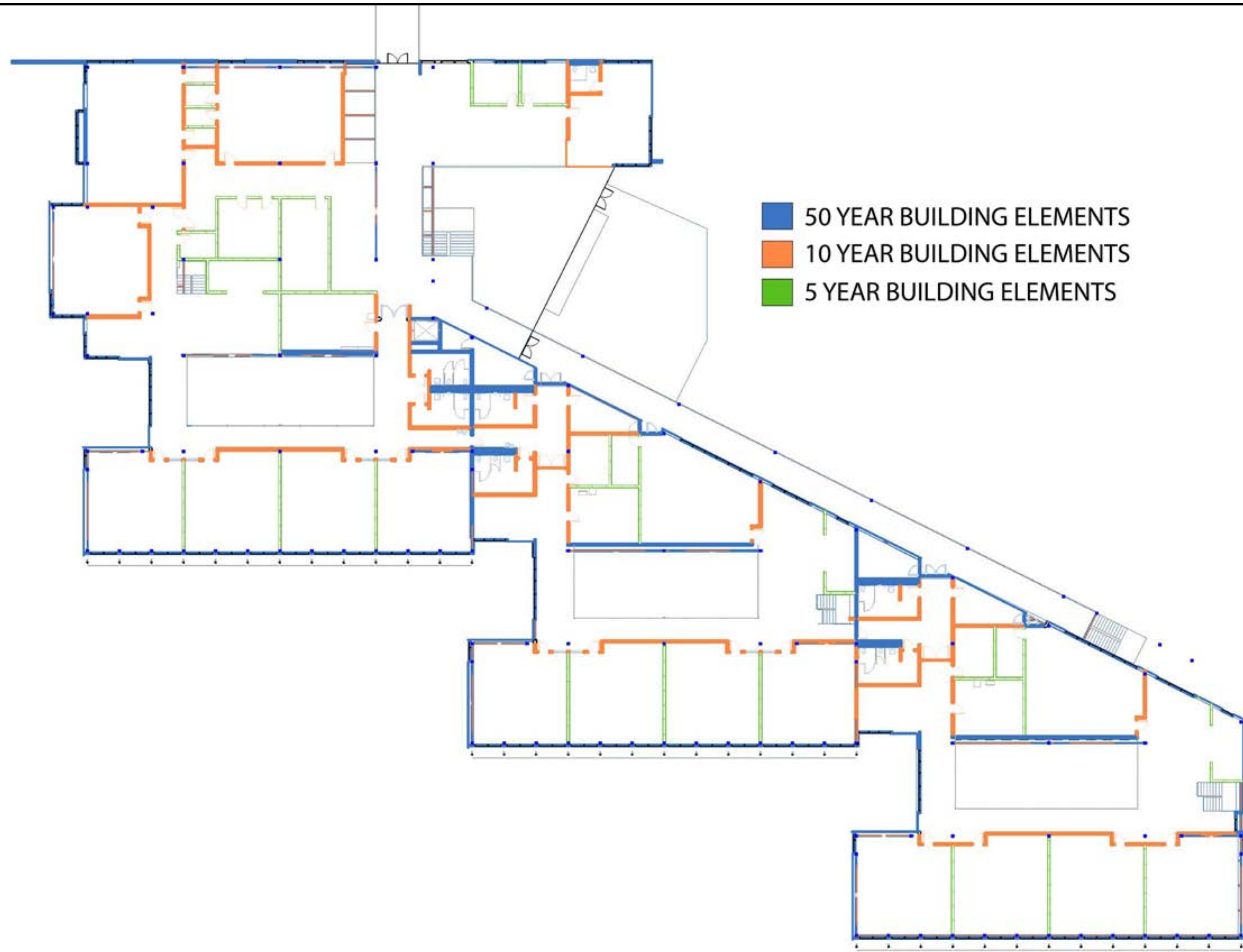

Figure 10: The upper floor plan of the Lakota Middle School in Federal Way, WA. The different colors represent the different categories of building elements: 5, 10, and 50 years. Credit: Bassetti Architects, 2008

if there was an interest in team teaching, the 5 year wall could be removed and two classrooms joined together to create a larger classroom. If project-based learning was to be employed, the two lower level classrooms could have the wall separating them from the "Great Room" removed as well as the wall between them. While this requires more work, it allows the classroom space to double in size to meet curriculum requirements that require more space.

There were several other factors influencing the design of the building, including cost, energy conservation requirements, and accommodation of the current student population and teaching pedagogy. However, the 5/10/50 year strategy carried into the details of the design. For example, where 10 year walls were required to provide power, a junction box was installed in the ceiling above. Power was then routed through flexible conduits to the receptacles. In the event that the wall was removed, the power could be easily removed back to the junction box and terminated in a code compliant manner – or it could be routed to a different location. Similarly, gas fired furnace units, considered a 50 year component, were located within the roof structure, another 50 year building component. Light gauge metal and flexible duct were then used to distribute heat to specific locations within the space. This system also employed individual furnace units for each classroom to create multiple zones and localized controls. Because of the easily modified ductwork, multiple zones, and local controls, the system could be easily modified to fit different room configurations. Last, classroom spaces were designed to accommodate multiple different uses. Labs and studios were designed to accommodate science, art, food preparation, and other special uses. Offices were designed to be used for multiple different roles in the school administration.

The resulting design for Lakota Middle School was unique in its appearance and configuration. However, it was noted by the Facilities Director for the Federal Way School District, Rod Leland, as the project that most closely met the design goals of the District for its ability to accommodate curriculum and organizational changes (Leland 2011). This project emphasized the importance of flexibility and adaptability of the building. It also addressed the idea of material durability which was compromised on the project due to budget constraints.

How Buildings Learn

In his book, *How Buildings Learn*, Stuart Brand brings together comments and critiques of many other architects and other knowledgeable experts. Brand's philosophy about buildings has aspects similar to characteristics of future-proofing. For example, Brand quotes Robert Campbell about adaptive re-use projects: "The best buildings are not those that are cut, like a tailored suit, to fit only one set of functions, but rather those that are strong enough to retain their character as they accommodate different functions" (Brand 1994, 104). The idea of a building is "crystalline," whereas the word 'building' is a verb, and thus fluid, and captures the nature of a building's life (Brand 1994, 3). Brand argues that all buildings change through time, and the most important question is whether the buildings change gracefully or with great challenges or perhaps fail. "Jane Jacobs draws the distinction between 'cataclysmic money and gradual money,' noting that cataclysmic money is destructive whereas gradual money is wholesome and adaptive" (Brand 1994, 85). "Slow money" achieves the gradual transformation desired of the release phase of adaptive cycles described by CS Holling, et al, above.

Brand is brutally honest about the requirement for maintenance of buildings, stating "no maintenance, no building," meaning that a building will deteriorate and quickly collapse (Brand 1994, 110). Brand even quotes John Ruskin's advocacy of maintenance: "'Watch an old building with anxious care; guard it as best you may, and at any cost, from every influence of dilapidation'" (Brand 1994, 111). Brand advocates regular preventive maintenance and durability of materials in buildings. He states that preventive maintenance is somewhat rare, but that, to prevent deterioration, the alternative is "designing and constructing a building in such a way that it doesn't need a lot of maintenance" (Brand 1994, 112). Finally, Brand believes that "close, sustained attention to the cumulative effect of sporadic bursts of maintenance and repair is essential to conscious 'learning' in a building" (Brand 1994, 128). Maintenance done well leaves no obvious marks. Its result is invisible and goes unnoticed. With good maintenance, "everything is the same as it ever was," (Brand 1994, 130) and the service life of the building is extended.

Brand admires the approach of Clem Labine regarding preserving the character of old buildings: "As much as possible of the original fabric of the building is to be saved" (Brand 1994, 105). "Buildings tell stories, if they're allowed – if their past is flaunted rather than concealed" (Brand 1994, 4). Brand advocates taking all that preservationists have learned about materials, space-planning, scale, mutability, adaptivity, functional tradition, functional originality, and sheer flash, and apply it to new construction as well as rehabilitation of existing buildings. Brand admires understanding a building's history by looking at the existing fabric.

According to Brand, the 'inside-out' approach to modern design, based on making the building fit the needs of the occupant, "made the profound mistake of taking a snapshot of the high-rate-of-change 'organic life' within a building and immobilizing it in a confining carapace…. …Form froze function," rather than freeing it (Brand 1994, 157). Modern design epitomizes Brand's lament that "almost no buildings adapt well. They're *designed* not to adapt; also budgeted and financed not to, constructed not to, administered not to, maintained not to, regulated and taxed not to, even remodeled not to. But all buildings (except monuments) adapt anyway, however poorly, because the usages in and around them are changing constantly" (Brand 1994, 2). Often, the awkward adaptation is in the form of "satisficing," or implementation of solutions that are "inelegant, incomplete, impermanent and inexpensive" (Brand 1994, 165).

Brand dislikes "grand, final-solution buildings [that]obsolesce and have to be torn down because they were too overspecified to their original purpose to adapt easily to anything else" (Brand 1994, 28). The alternative to obsolescence of buildings of this type is constant revision (Brand 1994, 37). Brand recommends that a building be designed for "loose fit" and future adaptability and flexibility and deplores architects as an obstacle to "adaptivity" in buildings because they design for a single use (Brand 1994, 53). "Adaptivity is a fine-grained process. If you let it flourish, you will get a wild ride, but you also get sustainability for the long term" (Brand 1994, 170).

For Brand, durability of the building materials is also important. While "deterioration is constant, in new buildings as much as old," "durability counts for more and more as our decades grow hastier" (Brand 1994, 5, 91). Brand also deplores the mismatch between building materials with differing service lives, citing the contrast between the anticipated 300 year service life of the roof shells at the

Sydney Opera House and the mastic used to seal the joints that had a project 12 year service life (Brand 1994, 120).

"Even if architects and builders were perfect, most buildings would maladaptively freeze up or lose their way because of other pressures" such as use value and market value (Brand 1994, 72-73). Here, Brand is suggesting that there are instances where outside values may force a building to accommodate a particular use for which it is not best suited. Brand would rather that the use be appropriate to the building.

Brand advocates an architecture that is "future-responsible" (Brand 1994, 209). He believes that buildings should be responsive to "*future-hindsight* – perpetual later reappraisal and adjustment" (Brand 1994, 188). In the end, "a building is not something you finish. A building is something you start" (Brand 1994, 188). This approach to the built environment, similar to Brand's description of MIT's approach, relies on loose fit, robust construction, and horizontality to achieve buildings that are long lasting, slowly changing over time, well maintained to prevent deterioration, avoid obsolescence, and are highly durable, while celebrating their history.

Built For Change

Stuart Brand includes many references to Anne Vernez Moudon's study of San Francisco in her book, *Built For Change*. When he asked whether Moudon thought the Victorian homes of San Francisco were designed for change, the reply was "no, they were just designed to appeal to a variety of tenants" (Brand 1994, 193). However, through her discussion of resilience both at the building and city scales, Moudon documents several other characteristics of wood framed bearing wall buildings that endure, ranging from lot sizes to room sizes, control, and density to breathing spaces.

Lot size and configuration are enormously influential in controlling the rate and severity of the change. Small lots make for constant fine grain adaptation instead of the sudden, devastating changes that can come with larger parcels: change is slow and incremental (Moudon 1986, 139). In her discussion of lot sizes and configurations, Moudon states that "what comes first remains" and continues to have a profound impact in the future. This seems to be true not only of lots, but also of buildings and spaces in wood framed bearing wall buildings (Moudon 1986, 134). While it is certainly true that buildings may be demolished wholesale, it is also true that rehabilitation designs of existing buildings are influential in the design process. These vestiges can and should remain not only influential, but also recognizable to people using the building.

For Moudon, the best word to describe the ability of urban blocks to accommodate change is resilience. "Resilience balances continuity and change in space" (Moudon 1986, 157). Moudon notes that others use the terms breathing space, slack, and loose fit to describe the ability to accommodate change. Regardless of the term used, the important characteristic is that the space (room, building, or lot) be able to "assume a variety of functions as well as meanings" (Moudon 1986, 157).

Like Brand, Moudon also discusses resilience of buildings in terms of flexibility and adaptability, but more clearly differentiates the two. Flexibility requires a substantial alteration of the space to accommodate a new use, whereas adaptability does not require major disruption of the space (Moudon 1986, 178). In other words, adaptable spaces more easily extend service lives of buildings, are less prone to obsolescence, and are certainly more sustainable because they provide "a great deal of control... ...without undue modification" (Moudon 1986, 179). Basic flexibility comes through generous dimensions of rooms (Moudon 1986, 188). However, Moudon suggests that higher levels of flexibility come by creating spaces that will accommodate multiple different uses, make the rooms expandable through variable connections to adjacent rooms, and allowing activities to spill into exterior spaces (Moudon 1986, 182).

In addition to flexibility and adaptability of space, resilience is found in the ambiguity of the spaces such that they will accommodate multiple different social functions. "Physical space should be able to welcome fluctuations in social space over long periods of time... ...without major disruption" while also maintaining the integrity of the physical space. (Moudon 1986, 178-179). This ambiguity opens the possibility of interpretation and variety, leading to the of spaces to be flexible because rooms and transitions between rooms can be designed to allow for "overspill" into adjacent rooms (Moudon 1986, 179, 188). Rooms and buildings that do not provide such opportunities run the risk of becoming socially obsolete because they do not accommodate the changing social space needs. This idea is very similar to functional obsolescence described in the real estate industry.

In the same manner that Stuart Brand praises the flexibility of "low road" buildings because of their unfinished character, Moudon encourages unfinished attics and basements. These are spaces that are versatile and "can be easily and inexpensively manipulated for a variety of purposes" (Moudon 1986, 188).

While Moudon's book, *Built For Change*, was specifically addressed to Victorian houses in San Francisco, several important attributed of future-proof buildings are documented. These characteristics include leaving recognizable vestiges of the building or site's origins, and flexibility and adaptability through ambiguous spaces, generous dimensions, and unfinished spaces to prevent social obsolescence.

Attributes of Future-Proofing in Historic Preservation and Heritage Conservation

There are many attributes of future-proofing that are inherent in aspects of historic preservation and heritage conservation theory and philosophy. Cultural heritage, while including the built environment referred to by the term "historic preservation," is also understood to include a broader realm of artifacts and intangible characteristics of a society, including artwork, sculptures, dance, clothing, and other expressions of unique human identities. In the context of historic buildings, the writings of Georg Morsch, James Marston Fitch, and Bernard Feilden offer examples of how the concepts of future-proofing are embedded in preservation theory. The writings of Cesare Brandi, Paul Philippot, and Ernst Van de Wetering also address aspects of future-proofing and resilience in cultural heritage, advocating careful consideration of our heritage that is the goal of future-proofing. Each of these more nuanced approaches to conservation demonstrates some of the characteristics of future-proofing, but these characteristics have not been brought together as a single system of principles until now.

Georg Morsch's concept of conservation, outlined in 1980, includes two major goals: "first, that historical evidence and vestiges must be decipherable; and, second, that evidence and vestiges must be decipherable by a broad public which requests flexible approaches on certain conservation concepts" (Burman 1997, 278). The goials for interventions in historic buildings point out the need for flexibility while retaining a clear understanding of the historic fabric of the building.

James Marston Fitch argues that obsolescence of buildings is often determined on the basis of “superficial examination and inadequate data” (Fitch 1990, 63). Fitch goes on to suggest that there are important new techniques available that make the rehabilitation of historic buildings much more feasible, alluding to extending the service life, fortifying, and increasing the durability and redundancy of historic buildings. Modern preservation technologies make it possible to “reclaim even seriously damaged building fabrics and extend their effective life for decades into the future” (Fitch 1990, 105). Fitch also argues that “interventions for adaptive use will ordinarily be more conservative externally than internally,” allowing for flexibility and adaptability to accommodate the new uses within the building (Fitch 1990, 169). Last, Fitch argues that the “reworking of extant structures to adapt them to new uses is as old as civilization itself” and has significant life cycle benefits as the “characteristic mode of energy conservation” (Fitch 1990, 165).

Bernard Feilden calls conservation “primarily a process that leads to the prolongation of the life of cultural property for its utilization now and in the future” (Feilden 2003, x). Feilden advocates evaluation of all practical alternatives in a rehabilitation “to find the ‘least bad’ solution” (Feilden 2003, xi). Despite the awkward phrasing, this idea is derived from the Hippocratic approach of “do no harm,” which he obliquely references and which is the basis of the future-proof concept of preventing decay. Feilden also advocates rehabilitation by keeping buildings “in use—a practice which may involve what the French call ‘mise en valeur,’ or modernization with or without adaptive alteration” (Feilden 2003, 10), another goal of future-proofing.

The concept of different approaches to conservation and rehabilitation is captured in the variety of heritage conservation policy documents used across the globe. From the four different Standards developed by the National Park Service in the United States to the multitude of documents available to members of the World Heritage Convention, general and specialized guidelines are available. Flexibility and adaptability of treatment and use, maintaining authenticity, differentiation of additions, and implied support for the extension of the service life of historic buildings are characteristics of all these documents. In the words of Burman, the goal of interventions should be to "treat a historic monument in such a way that it could serve as an example for other cases, not as a straightjacket" (Burman 1997, 286).

The goal of heritage conservation is to preserve for all eternity the objects thought of as the world's patrimony (Appelbaum 2007). In this process, there are a myriad of different possibilities for the goals of the conservation treatment as well as the actual treatment methods and materials. Just as architectural historic preservation theory has evolved, so has conservation theory. Today, many of the key attributes of heritage conservation are similar to the concepts of future-proofing and resiliency.

By the middle of the twentieth century, the understanding of restoration evolved to include the functional restoration of a work of art and architecture as well as painting and sculpture. Cesare Brandi writes about art and architecture as equally valid works of art. However, the functional properties are still held secondary to the "primary or fundamental aspect that respects a work of art as a work of art" (Brandi 1996a, 230). In contrast to Viollet Le Duc's definition of restoration, Brandi holds that "restoration is the methodological moment in which the work of art is appreciated in its material form and in its historic and aesthetic duality, with a view to transmitting it to the future" (Brandi 1996a, 231). Brandi suggests that for buildings, the exterior appearance is primary, but that, in line with modern preservation requirements and designation of significant features, interior walls and structures may be altered to improve the building. This is important to the understanding of future-proofing and resiliency because it allows for flexibility and adaptability as well as the extension of service life, reduction of obsolescence, fortification, and increased durability and redundancy.

Brandi goes on to say that while "patina documents the passage through time of the work of art and thus needs to be preserved," the patina should be an "imperceptible muting" of the original materials and must be brought into equilibrium with the original materials (Brandi 1996b, 378). Brandi's intent is that the patina should not overwhelm and disguise the original, nor should patina be completely removed, but rather a balance must be sought between the two. This approach promotes the understanding not only of the original material but also the aging and interventions that it has been subjected to over its history.

For Philippot, it is the authentic relationship between past and present that must be integrated "into the actualization of the work produced by the intervention" (Philippot 1996c, 225). This idea is similar to the concept of promoting understanding of the historic structure both before and after rehabilitation. Most important here is recognition and respect for the *gesamkunstwerk*, or "unity resulting from the cooperation and collaboration of the various arts and crafts" that made the historic building (Philippot 1996a, 271). A natural consequence of this approach becomes evident when considering lacunae, or missing pieces, and new interventions; these interventions should be made in such a way as to "reestablish continuity … while being easily identified on closer inspection" (Philippot 1996b, 359). This statement underscores the importance of understanding the evolution of an historic structure.

Conservation theory has evolved to understand that "each treatment, or even non-treatment, nevertheless involves an interpretation of the object" (Van De Wetering 1996, 193). "Restoration has a certain autonomy independent, to some extent, from the artist's intentions" (Van De Wetering 1996, 196). However, similar to arguments by John Ruskin, Van de Wetering also holds that there is a "growing awareness that we will never understand the artist's intentions to their full extent and that consequently our interpretations… …never entirely cover the truth" (Van De Wetering 1996, 196). Restoration approaches will vary; depending on the subject of the rehabilitation, different approaches may be appropriate. One approach, that of the collector, "prefers no restoration over authentic appearance," or, alternatively, one recognizes that "interventions are often inevitable" and are the "concrete manifestation of an interpretation" of the historic object (Van De Wetering 1996, 197). Like Brandi and Philippot, Van de Wetering argues for the ability to understand the original aged object as well as its history, and, further, that this be conveyed to future observers.

Appelbaum suggests that there are potential differences between the "ideal state for the object" and the "realistic goal of the treatment" (Appelbaum 2007, xx). The goal of conservation is to protect the object, extend its service life, and reduce its obsolescence by making the object desirable to keep (Appelbaum 2007, xxvii). As noted by Van de Wetering, a treatment involves an interpretation.

A treatment, then, is "an interpretation chosen to enhance the meanings for which the object is valued and to accommodate its intended future" (Appelbaum 2007, xxi). "Treatments that improve aesthetics, usability, or lifespan of an object all increase its utility" (Appelbaum 2007, xxvi). Appelbaum goes on to say that "slowing an object's deterioration also increases utility," "an object that cannot be used … provides no benefit," and "treatment is supposed to provide the physical strength to make those improvements last" (Appelbaum 2007, xxvii). Appelbaum's statements contain many references to future-proof concepts, including preventing deterioration and decay, reduced obsolescence, and extension of service life, among others.

Implicit in the dozens of cultural heritage policy documents that address both heritage conservation and historic preservation are the doctrines of minimal intervention, reversibility, and differentiation.

The concepts of reversibility are embedded in the *Secretary of the Interior's Standards*, the *Venice Charter*, and multiple other documents. Yet, as Muñoz Viñas points out, true reversibility is not possible and the concept is thus evolving to that of "removability" or "retreatability" (Muñoz Viñas 2005). Indeed, the phrasing of *Rehabilitation Standard 10* already softens the relentless intent of reversibility by allowing for the "essential form and integrity" of an historic property to be returned (Weeks 2000). Minimal interventions are typically recommended to prevent loss of original historic fabric. Article 13 of the *Venice Charter* requires that additions do not "detract" from the historic building or its context (ICOMOS 1964). Similarly, the *Secretary of the Interior Rehabilitation Standard 7* requires that treatments use the "gentlest means possible" (Weeks 2000). Differentiation is explicitly included in the *Rehabilitation Standard 9*: "the new work shall be differentiated from the old" (Weeks 2000). Articles 9 and 12 of the *Venice Charter* speak to differentiation as well, requiring that "work which is indispensable must be distinct" and "distinguishable" from the original historic fabric (ICOMOS 1964). In the discussion of the concepts of future-proofing and resilience, the doctrines of minimal intervention, reversibility, and differentiation can be incorporated through inclusion of cultural heritage policy documents.

The fields of historic preservation and heritage conservation have evolved since the nineteenth century to offer many concepts similar to future-proofing and resilience. However, historic preservation and heritage conservation have not developed a coherent theory or set of principles around these concepts. Future-proofing and resilience have developed clearer definitions in different industries, as discussed above. These have many common characteristics. This analysis of the concepts of future-proofing and resiliency and their applications in a multitude of industries, including historic preservation and heritage conservation, may be brought together to develop a new set of guidelines to support the rehabilitation process and avoid unsuccessful designs.

Chapter 4: The Principles of Future-Proofing the Historic Built Environment

Through study of concepts of future-proofing and resiliency, significant and compelling ideas beneficial to the development of design solutions in the historic built environment and, more specifically, historic buildings may be developed. When the concepts of future-proofing, expressed in multiple industries and disciplines, and resiliency are brought together, certain attributes were repeated often and found to be in common. These oft repeated attributes became the basis of the Principles of Future-Proofing.

The Principles are organized along a spectrum from conceptual to concrete. Principles 1 through 8 are conceptual and can be applied during the early design process. Principal 9 and 10 are more technical issues that are intended to be applied later in the design process. Principles 11 and 12 were added to emphasize the importance of historic preservation and its role in future-proofing historic buildings. Principle 11 focuses on the designation and design review phases of working with interventions in historic buildings. Principle 12 focuses on the construction involved in executing and intervention.

The following set of guiding principles for the historic built environment is the result of the literature review.

Principle #1: Prevent decay.

It is natural for all building materials to deteriorate. Promote building materials, methods, maintenance, and inspections that prevent, rather than accelerate, premature deterioration of the built environment. Interventions in existing buildings should use equally durable building materials. Do not mix short-term materials with long-term materials. Materials that deteriorate more quickly than the original building fabric require further interventions and decrease the service life of a building. Building designs should either include components with similarly long service lives or be designed for disassembly for replacement of the shorter life components.

The Principle "Prevent Decay" is derived from the writings of Bernard Fielden, Appelbaum, Brand, and the adaptive cycles of Holling, et al. While Brand suggests that designing a building not to require a lot of maintenance through the use of high durability materials, deterioration will eventually occur and must be addressed. Low maintenance design does not preclude the need for a regular maintenance regime.

Highly durable materials deteriorate more slowly and redundancy prevents deterioration by providing backup in case the primary system fails. These characteristics of future-proofing are found in multiple different sources and even recommended as a metric for sustainable design by Cassar. Dam refers to a building's time-proven durability and Tyler and Dilcher believe durable long lasting materials are cost effective. The Resilient Design Institute, Fitch, Brandi and Brand, Applegath, et al, believe durability and redundancy are important to resilience. Durability of building materials is an important criteria for sustainable buildings according to the APTI Halifax Symposium.

The intent of this principle is to prolong the life of cultural property as long as possible by preventing material decay and protecting the building from critical and systemic failure. Further, as Appelbaum notes, slowing deterioration increases utility of a building. Preventing decay of the building enclosure through regular maintenance is important because the enclosure protects other building fabric from deteriorating more rapidly. For example, regular maintenance of sealant joints prevents the intrusion of water into a building which may cause deterioration of masonry ties, degradation of insulation, freeze-thaw cycle damage, and structural damage. Maintenance of the building enclosure is required on a regular schedule.

A well developed maintenance regime incorporates a clear understanding of the working life spans of all building materials and includes funding for replacement of deteriorating materials. In addition, a maintenance plan should also account for the different exposures of each material. Exposures that cause materials to deteriorate more rapidly should be checked and addressed more frequently.

The intent of this principle is not to replace long lasting materials due to deterioration for as long as possible. Rather, replacement of sealants, flashings, and similar key elements is required to protect longer-lasting materials. Inevitably, longer lasting materials will also deteriorate. However, regular maintenance will slow this deterioration.

“Demolition by neglect” ordinances are often incorporated into preservation law to prevent deterioration to the point where a cultural asset is lost. Preventive maintenance is an integral part of avoiding the loss of our cultural heritage.

Durability of materials is important for ling term viability of a building. Thoughtful design and craftsmanship also play an important role in the durability of a building. Without careful consideration of roof overhangs and control of rainfall, wood materials deteriorate rapidly. Similarly, stone that is bedded incorrectly begins to spall quickly. Durability of materials can overcome some bad design and craftsmanship decisions, but when looking toward the over 200 year life span of a building, durability, design, and craftsmanship all become important.

Principle #2: Stimulate flexibility and adaptability.

Flexibility and adaptability of the built environment and the attitudes toward it are essential to retention of the built environment in a consumption-based society. The interventions in an existing structure should not just allow flexibility and adaptability, but also stimulate it while minimally impacting the historic building fabric. Adaptability to the environment, uses, occupant needs, and future technologies by keeping a diverse array of options open is critical to the long service life of a historic building.

Principle 2 focuses on stimulating flexibility and adaptability because several sources, including Applegath's resiliency principles, Wang, Cook, computer networking, personal resiliency, and urban, ecological and biological systems. In addition, calls for flexibility are found in Morsch's, Fitch's, Brandi's, Brand's and Moudon's philosophies, as well as the Seattle All Hazards Mitigation Plan, adaptive cycles and the 5/10/50 year design strategy.

Flexibility is, in Moudon's definition, the ability to change the use of a space with minimal alterations to the built environment. Brand's "stuff" (furnishings and decorations) are easily moved from one space to another to change its use. Flexibility also comes through ambiguity of spatial boundaries and lack of purpose built rooms that are only suitable for one use. "Loose fit" strategies recommended by Cassar and Brand also support the ability of a space to accommodate different uses. As long as they provide enough space, they are infinitely flexible for any multitude of uses.

If adaptability is the ability to accommodate a different use with minimal disruption, then unfinished space and "low road" buildings are some of the most versatile spaces. Adaptability can also be designed into a space. This is exemplified by the Lakota Middle School Project and the 5/10/50 year design strategies.

Flexibility and adaptability are the hallmarks of an ecologically resilient society and specifically in people. Humans have adapted to different environments, foods, and climates. It is thus ironic that humans show significantly less flexibility and adaptability in their built environment. Principle 2 encourages flexibility and adaptability in attitudes as well as in the built environment itself. Compromises are required in response to global resources shortages. Flexibility and adaptability are equally important in minimizing destructive release phases in adaptive cycles.

Principle #3: Extend service life.

Extend the service life of the built environment so it may continue to contribute to our economy, culture, and sustainable society. Regular maintenance and appropriate interventions in existing buildings help to make the buildings usable for the long term future rather than shorten their service life.

Extending service life is an integral part of historic preservation. This Principle comes from the philosophies of preservationists, including Tyler and Dilcher, Caroon, Cassar, Fitch, the APTI Halifax Symposium, and the *Secretary of the Interior's Standards for Rehabilitation*. Brand believes that maintenance will done also extends service life, whereas Moudon argues for flexibility and adaptability of spaces as support for extended service life. Extension of service life is implicit in the ability to accommodate new and different uses in existing spaces. While physical and functional obsolescence are more important to extending service life of a building, aesthetic and sustainable obsolescence are not.

Extending the service life of a building is the result of the cumulative implementation of the other Principles and goes along with re-using the cultural assets. Buildings with long service lives are more desirable due to the reduced expectation of maintenance. The often perceived understanding of historic house museums is that they are frozen in time at the moment that the last family lived in the space. This perception, while attempting to prolong the ability of a structure to convey its historic significance, deprives such structures of the lives they once had as regularly occupied buildings. Respectful use of cultural assets continues to keep buildings engaged and relevant in today's and tomorrow's societies.

Extension of service life is not just about uses. While closely related to maintenance recommended in Principle 1, extending the service life of a building can also involve far more than daily or annual maintenance. A building's mechanical and electrical systems deteriorate over longer periods of time and often require a more significant effort to maintain. For example, mechanical systems may last 20 to 30 years before needing replacement of major components. Replacement of major building systems are intermediate measures which are not as significant as full building renovations, but are required to keep a building functioning in good order.

Principle #4: Fortify!

Fortify our built environment against climate change, extreme weather, and shortages of materials and energy. Interventions should prepare buildings for the impacts of climate change by reducing energy consumption; reducing consumption of materials; and helping them to withstand extreme natural events, such as hurricanes, floods, and tornadoes.

Principle 4 finds its origins in many of the sources that discuss durability as well as managing change events. Fitch believes in fortification to prevent building obsolescence, and hazard mitigation planning often includes fortification against natural disasters.

As a result of increasing the engineering resilience of a building, fortification can also increase durability and help to deter the impacts of natural hazards. Such fortification may range from covering windows to prevent hurricane damage or seismic retrofits to minimize or even prevent damage from seismic events. Fortification can also be implemented to resist weather and other deterioration mechanisms. Common decay mechanisms include acid rain, dry deposition, salt crystallization, freezing water, and biodeterioration. Some of these can be easily fortified against, but others are much more difficult. In some cases, the causes of deterioration are out of control if the stewards of the building. Other decay mechanisms depend on the nature of the material. For example, wood is subject to rot and termite infestation. A common method of fortifying wood against termites is the use of borate rods inserted into holes drilled in the wood. Similar methods of fortification are possible for most building materials.

Fortification of a building can also be understood to mean managing climate change in a new way. Added insulation helps to reduce heat loss and gain. Shading mechanisms help to reduce heat gain. Many pre-World War II buildings are designed with passive controls for the indoor environment and one need only open the transom windows to allow heat at the ceiling to be released, thereby requiring less fortification against climate change.

Fortification is important to future-proofing because it requires implementing engineered resilience to resist change events in addition to addressing other ways to accommodate change. Caution should be used with fortification, however, because it is possible to fortify a building in a way that will make it less able to be adapted later in its service life.

Principle #5: Increase redundancy.

Redundant systems provide backup in the event that a primary system fails and allow a building to continue to function.

Redundancy includes closely related strategies to help buildings survive longer. Redundancy prevents deterioration of building components. For example, by installing backup flashing or a second method of catching and directing water flow in a building envelope, interior building elements are better protected from deterioration. Contemporary design often includes backup flashing layers and second layers of sealant to prevent water infiltration.

Principle #6: Reduce obsolescence.

Don't accept planned obsolescence. The built environment should be able to continue to be used for centuries into the future. Take an active approach to preventing physical, functional, aesthetic, and sustainable obsolescence. Regularly evaluate and review current status in terms of future service capacity. Find the most appropriate uses for the building, even if that means it has to be unused for a short period of time.

Reducing obsolescence, Principle #6, is a critical aspect of future-proofing because an obsolescent building is one that is likely not occupied and is therefore subject to rapid deterioration. Reducing obsolescence is targeted at countering the disposable consumption-based society for which manufacturing design creates products. Physical, functional, aesthetic, and sustainable obsolescence are central to real estate markets. Georgiadou's goal is to prevent premature obsolescence, and Cassar recommends that buildings adapt to climate change or succumb to environmental obsolescence. Carthey believes flexibility and adaptability prevent obsolescence. Recommendations to reduce obsolescence are found in many philosophies and design strategies, from Fitch's superficial determination of obsolescence to Appelbaum's less obsolete equals more desirable, Brand's over-specified obsolescence, and Moudon's adaptability prevents obsolescence, philosophies.

Reducing obsolescence is important to future-proofing because an obsolete building is one that will not receive needed investments in maintenance or making significant improvements. As a result, maintenance is deferred and building elements not in use deteriorate quickly. Reduction of perceived obsolescence is as important as real obsolescence because perceptions are often understood the be the reality of a situation. Where a building is perceived to be a lost cause, investors will not be willing to allocate the resources that would sustain it and occupants will not want to use it. A building in use will continue to be maintained because it is useful and a well maintained building will continue to be used because it is seen as valuable.

Principle #7: Plan Ahead

Plan for scalability, future expansion and adaptation of the building to prevent the need of major interventions. Should major interventions be necessary, plan to include the best materials and techniques to prevent future decay, the best phasing of the implementation to minimize waste of resources and maximize efficiency of time funding, and materials.

Planning ahead may sound trite, but is incredibly important for long term future-proofing of a building. Knowing that uses and occupants in buildings will change over time, it is important to attempt to anticipate those changes and provide methods and places for the change to occur. Planned areas for building expansion, flexible wiring systems and 5/10/50 year analysis of buildings are examples of ways in which potential future change can be anticipated and accommodated without major interventions in the existing building.

Planning ahead for future expansion and adaptation of an historic building is important to long term use of a building. Interventions can be implemented which allow for, rather than complicate, future changes. Often, re-use of a building may be considered unreasonable because of the challenges and financial burden of created by poorly considered interventions. When interventions are overly complicated, the building may considered to be obsolete as discussed in Principle 6.[3]

3 The Principle "Plan Ahead" is also derived from the application of the preceding principles to large infrastructure projects which often take decades to implement and then take further decades to modify and improve. Due to the significant time frames involved, planning must look ahead to potential changes including natural hazards, economic changes, shifts in population and viability of cities and regions. Thornbush, et al, recommend long range planning to account for external systemic shocks. While it is challenging, if not impossible, to anticipate all of the potential changes that may affect a building or infrastructure system, it is possible make reasonable accommodation for known possibilities.

Principle #8: Diversify

Systems are ecologically resilient precisely because they do not depend on only one aspect of a system to dominate and hold fast. Ecological systems allow for multiple stable states, including different uses, capabilities, and economic models. A diverse built environment, as an ecosystem for humans, can support multiple different economic, social, cultural, and functional uses.

Diversification and ecological resilience find their origins in the concept of panarchy and adaptive cycles. As described by Applegath in resilient built environments, and Holling, Gunderson and others in their research on ecological systems, diversity allows for more tolerance of uncertainty and helps to keep many different options for managing stresses available.

Ecological resilience requires the ability to absorb impacts rather than resisting them. Diversification helps to resist the destructive impact of the release cycle by creating multiple smaller adaptive cycles. For example, diversity of occupants in a building with multiple tenants make it less reliant on the health of only one company and help it to absorb the lost income when a business leaves.

Principle #9: Be local and healthy.

Incorporate nontoxic, renewable, local materials, parts, and labor into our built environment. The parts and materials used in designing and implementing building interventions should be available locally and installed by local labor where possible. This means that the materials and manufacturing capabilities will be readily available in the future for efficient repairs.

Principle 9 incorporates many of the goals of common sustainable design standards such as LEED. However, it also includes recommendations to use local labor as well as materials. It is important that buildings not rely upon expertise that must travel long distances to build, maintain, and operate buildings. The intent here is to have labor forces readily available to complete work on the building to prevent the possibility of physical obsolescence. When local labor forces are available, repairs can be implemented sooner for a building system that fails, reducing the possibility of further damage.

Often times, however, a specialist preservation craftsman is not locally available and retention of the building system must necessarily be carefully considered. In the case of decorative plaster, there are relatively few master plasterers available across the United States, but plaster often is a valuable building component and is worth restoring. The unavailability of master plasters may also be considered a reason to describe a building system as being not future-proof. However, plastering was a common practice through the middle of the twentieth century, and would likely have been considered a future-proof building system at the time. Therefore it should also be understood that construction practices and building systems change over time. Careful consideration of the long term availability of a building system is encouraged.

Principle #10: Consider life cycle benefits.

Analyze the long-term life cycle benefits of interventions in the built environment. The embodied energy and material resources in existing structures should be incorporated in environmental, economic, social, and cultural costs for any project.

Life Cycle Assessment (LCA) is a standardized method of analyzing the environmental impacts of products and processes through their entire life cycle and is formalized in *ISO Standard 14040* and several supporting standards (Simonen, 2014). This standard can be applied to interventions in historic buildings to analyze impacts from raw material extraction through installation in a building to end of life demolition or recycling. With respect to future-proofing, life cycle analysis can be used to support decisions regarding retention or demolition of a building. Research by the National Trust for Historic Preservation's Preservation Green Lab demonstrated that retention and rehabilitation of existing structures almost always had a lower environmental impact than demolition and new construction (Frey et al. 2011). Further, life cycle assessment research compared the 200 year life cycle impacts of retaining an existing structure and found similar results (Rich 2014).

LCA does not include economic impacts nor does it include all environmental impacts of design decisions. The strength of LCA is that it provides simple, predictable, and quantifiable data that can be compared between products and processes. The weakness of LCA is that it is time consuming, and can provide incomplete results based on incomplete databases. Despite these weaknesses, as Simonen notes, Life Cycle Assessment is "just one measure of performance that should be added to the multiple quantitative and qualitative performance criteria by which we evaluate buildings and must be placed within a larger decision making framework" (Simonen 2014).

Principle #11: Take advantage of cultural heritage policy documents.

Typically applied during the design phases of a project, cultural heritage policy documents provide excellent guidance for the long-term retention of an historic building. Above all, in striving to meet the above principles, respect the historic building as a work of art, including its past interventions.

Cultural heritage policy documents address historic preservation and heritage conservation practices and techniques which have been shown to have several attributes in common with future-proofing. In the philosophies of Morsch, Fitch and Feilden and the writings of Brandi, Philippot, and Van de Wetering, the attributes of future-proofing are clearly advocated.

From the *Secretary of the Interior's Standards* to the World Heritage Convention's charters, documents, and declarations, these documents offer invaluable guidance, including the concepts of minimal intervention, reversibility, and differentiation, when working with historic buildings and existing buildings.

While future-proofing is not explicitly discussed in such documents, similar concepts are found in historic preservation and heritage conservation, and it is clear that preservationists often think in similar terms. Preventing deterioration, understanding of the historic structure, flexibility and adaptability, durability, redundancy, fortification, prolonged service life, reduction of obsolescence are all expressed as important characteristics of preservation as well as future-proofing.

Principle #12: Promote understanding.

Renovation, rehabilitation and other types of alterations to existing buildings should allow for understanding of the built environment and its place in our built heritage through minimal interventions that remain distinguishable from the original structure. Construction should respect historic fabric and seek to protect it. Interventions should remain distinguishable from the original structure.

As the character of historic preservation and cultural heritage changes, it is all the more vital to ensure that the original historic building fabric remains perceivable regardless of future interventions. Understanding the historic nature of a building has been a basic component of much of preservation philosophy throughout the tewntieth century, including Boito, and the *Secretary of the Interior's Standards*. Understanding was also advocated at the APTI Halifax Symposium, Georg Morsch's concept of conservation, Brandi's concept of patina, Philippot's concept of continuity of heritage, Allen's connection between understanding and longevity, Stuart Brand's understanding historic buildings through examination of historic fabric.

Understanding of the historic fabric is important from several perspectives, not the least of which is a clear perception of the history of a cultural asset. The origins and reasons behind the creation of cultural heritage assets are often more important than the asset itself because they represent ideas and concepts that were important at the time these assets were created. The ability to understand an historic structure allows future generations to understand and learn from the ideas that generated the structure.

In addition, understanding an historic building is critical to any future interventions. It allows architects and engineers to be able to plan for and accommodate the character and original intent of the structure and account for it in their designs. Often buildings can be designed to be "teaching tools" by demonstrating common physics through the structure and art and architecture through the finishes. Other building systems can similarly be learned such as the attributes of buildings that were used to passively control climate such as high ceilings, mass masonry, and transom windows.

Minimal interventions in existing structures allow future students of history to understand and appreciate the original historic building and *gesamkunstwerk*, or unity of craft, as well as the patina.

Conclusion

These twelve Principles present a holistic approach to interventions in the historic built environment which addresses the concerns expressed in Chapter 2 regarding the context within which this research has been completed. The proposed "Principles of Future-Proofing" are responsive to sustainable design, global resource management, support a move away from a disposable consumer-based society, address the economics of building construction and the character of preservation practice.

Chapter 5: Thesis Question: Future-Proofing as a Rating System?

Initial investigations preceding this thesis have focused on 4 phases of development of the concept of future-proofing: First, determining the attributes of future-proofing and developing a definition of future-proofing. Second, developing Principles of future-proofing that can guide the design of interventions in historic buildings. Third, initial investigations of the meaning of selected Principles.[4]

The first three phases have been developed through the literature review, preliminary research, and investigations of specific principles of future-proofing as discussed in chapters 2 through 4. Through the first three phases, the Principles have been developed sufficiently to be applied to design projects in a process of subjective evaluation. The Principles are useful to designers who are able to take the concepts into consideration and make judgements about whether a specific design solution meets the goals of future-proofing better. However, such evaluations cannot be easily compared to design decisions on other projects. How is future-proofing measured? While the Principles are based on the substantial evidence, they remain subjective until an objective rating system can be developed.

Developing and testing a numerical rating system for rating the future-proof character of interventions in historic buildings is the primary focus of this thesis. In the absence of an objective numerical rating system, evaluations of historic buildings are not comparable except in relative terms. The Principles of Future-proofing would have limited appeal to the general public and would likely be applied only by those with specialized knowledge and interest in architectural design and historic preservation. An objective system is more readily understood by the general public because it is comparable and one is not required to understand all of the details of a project to understand that one is more successful than another.

Therefore, the problem statements for this thesis are:

Can the Principles of Future-Proofing as applied to the historic built environment be codified in an objective rating system?

Can this rating system be successfully applied through case study projects?

4 This research was conducted by this author over the course of work in the UW Masters degree program from 2013 through 2016.

Chapter 6: Research Methods: Development of a Rating System

Introduction

The Principles of Future-Proofing elaborated in the previous chapters are subjective in character as presented. However, these principles can be made into a more objective rating system. This chapter explores how the Principles have been developed as an objective system to "score" and compare projects. Chapters 7, 8, and 9 show how the system has been tested with four case studies.

To move the Principles of Future-Proofing from subjective criteria statements to an applicable system the general statements need to be elaborated so that individual criteria can be evaluated and points scored similar to the LEED and Envision rating systems. These other systems provide measurable results which can be compared to multiple projects. However, these systems do not allow for emphasis on certain categories of points to reflect regional or design goals of the project except through earning more points in a given category and they are not specifically applicable to interventions in historic structures..

Developing a Rating System

The goal of applying the Principles of Future-Proofing to interventions in historic structures is to use a criteria-based system that accounts for subjective as well as objective evaluation of a project, regional emphasis, and results in a clear evaluation of the buildings. To achieve this, credits developed in multiple rating systems are combined with credits developed specifically for future-proofing.

RELI Resilience Rating System

The RELI Resilience Rating System was developed by Doug Pierce, a Principal at Perkins and Will and Co-Chair of the AIA Minnesota Committee on the Environment (COTE), and several other groups in a coordinated effort (Pierce, 2015). The most recent version available, Pilot Version 1.1, dated July 12, 2015, has been used in this research. RELi is focused on "highly actionable steps that can be influenced through design, the built environment, and project related organizations" (Pierce et al. 2015). It includes over 260 credits and "poly-credits" divided up into 8 categories: Panoramic Approach, Hazard Preparedness, Hazard Adaptation + Mitigation, Community

Cohesions, Social + Economic Vitality, Productivity, Health + Diversity, Energy, Food + Water, Materials + Artifacts, and Applied Creativity, Innovation + Exploration. RELi is based upon five "interwoven living design lenses":

- Resilience – Shock Resistant + Flexible | Adapt
- Restorative – Revitalize after damage | Repair
- Regenerative – Self-reconstructing + producing | Replenish
- Sustainability – Maintain Capacity + Potential | Endure
- Wellness – Multi-dimensional Vitality | Health

(Pierce et al. 2015)

The RELi system itself is a compilation of credits from twelve rating systems, including LEED, Envision, 2030 Palette, and other, to establish criteria for individual points. It uses a total of 274 credits for scoring the resilience of a project, but not all are incorporated into the future-proofing scoring system. Table 1 is an analysis of the 128 credits in the RELi rating system that have been incorporated into the Future-proofing rating system and their sources.

Many of the credits from the RELi system are acceptable because they have been developed in other established rating systems. However, while the RELi rating system has a significantly broader point of view about the resilient strategies, it suffers from some flaws similar to the LEED and Envision rating systems and is incomplete. First, the credits for each category within the system, like LEED, do not allow for regional or project-specific emphasis for a particular project. A second flaw is that access to all of the other rating systems is required to properly evaluate the credits available. Third, approximately 30% of the credits rely upon new credits developed as part of the RELi rating system. Information available online in 2015-16 did not provide complete information about requirements for some of these RELi credits. (Inquiries into draft versions of the RELI credits have not yielded further information regarding these credits.) Next, many of the RELi credits focus on human disaster preparedness or broader community issues, and are

Source	Rating System	Number of Credits
RELi	LEED V4	37
RELi	Envision	26
RELi	Fortified	2
RELi	RELi	38
RELi	2030 Palette	7
RELi	AutoDesk (adapted)	2
RELi	SMART (adapted)	1
RELi	LEED NC 2009 (adapted)	2
RELi	LEED V4 (adapted)	1
RELi	LEED Pilot Credit (adapted)	1
RELi	Envision (adapted)	4
	Total	128

Table 1: A list of the sources for credits used to evaluate the future-proof capacity of buildings.

not specifically applicable to building design. As a result, many RELI credits are not applicable or not able to be used at this time and were not employed in this research. The remaining applicable credits have been analyzed to determine to which Future-Proofing Principles they might apply. Several credits are applicable to more than one Principle. An additional complicating factor is that RELi uses multiple versions of LEED (including v2.1, 2009, NC v4, ND v4, BD+C v4, pilot credits, and Schools v4) , Envision, and other rating systems. Completed projects may use earlier editions of their rating systems and/or did not use all of the rating systems incorporated into RELi. Thus, direct translation of data from completed projects is not possible.

Development of Additional Credits

In addition to the 121 selected RELi credits, 13 new future-proofing credits are proposed as a part of this thesis research. Analysis and attribution of the RELi criteria to Future-Proofing Principles result in several specific and well defined criteria for most of the Principles. However, some future-proofing principles have a limited number of credits to evaluate the success of a project, so this research developed new future-proofing credits. For example, Principles 11 and 12 focus on historic buildings. Principle 11 emphasizes designation of a landmark

Source	Rating System	Number of Credits
RELi	LEED V4	37
RELi	Envision	26
RELi	Fortified	2
RELi	RELi	38
RELi	2030 Palette	7
RELi	AutoDesk (adapted)	2
RELi	SMART (adapted)	1
RELi	LEED NC 2009 (adapted)	2
RELi	LEED V4 (adapted)	1
RELi	LEED Pilot Credit (adapted)	1
RELi	Envision (adapted)	4
Future-Proofing	Future-Proofing	13
	Total	134

Table 2: A list of the sources for credits used to evaluate the future-proof capacity of buildings.

and use of cultural heritage policy documents during the design of an intervention. Such policy documents include the *Secretary of the Interior's Standards for the Treatment of Historic Properties*, the 1964 *Venice Charter*, the 1994 *Nara Document on Authenticity*, or the 1996 *Declaration of San Antonio*. Specialized documents are also available to address specific topics such as landscapes, underwater and timber buildings that are significant parts of our cultural heritage. Principle 12 focuses on the execution of an intervention in an historic building. Guidance from these documents is valuable whether a building is designated as a landmark or not.

Eight credits account for designation of historic structures and application of preservation standards to the design of an intervention in an historic structure are included in the future-proofing rating system. Four credits account for life cycle impacts, including three that focus on building and material re-use and one credit for completion of a life cycle assessment for the project. Last, one credit emphasizes design for flexibility using the LEED v4 Material resources credit. Thus credits have been developed which support these Principles and which can earn further points toward future-proofing a project.

Table 2 (below) summarizes the sources of the credits and the number of credits from each source.

Attribution of Credits to the Principles of Future-Proofing

134 criteria are distributed to the 12 Principles of Future-Proofing based upon which Principles they clearly supported. For example, the added credit "Design for Flexibility" supported the goals of future-proofing in 6 credits, including Principles 2, 3, 6, 7, 8, and 10. Principal 2 specifically focuses on flexibility. Principle 3 relies on the flexibility of building systems to support changing uses over the life of the equipment. Principles 6, 7,and 8 rely upon the flexibility of a building to accommodate new and different uses, future changes to the structure, and accommodation of multiple different uses at the same time. Last, this credit supports Principle 10 by reducing life cycle impacts because a flexible building can accommodate different uses over time. Therefore, the "Design for Flexibility" credit can earn up to 6 points in the future-proofing rating system.

Similarly, RELi credits for Fundamental Emergency Operations: Back-up Power and Operations supports Principles 4, 5, and 7. Back-up power

Future-Proofing Principle	Number of Credits
1. Prevent decay	5
2. Flex/adapt	6
3. Service life	24
4. Fortify	21
5. Redundancy	13
6. Obsolescence	63
7. Plan ahead	38
8. Diversify	17
9. Local/healthy	76
10. LCA	17
11. Understanding	8
12. Policy docs	14
Total	302

Table 3: Credits available for each Future-Proofing Principle.

is vital to fortification of a building against the impacts of extreme weather events and power outages and supports Principle 4. Because of the redundancy of power systems in the building, Principle 5 is also supported. Last, provisions for emergency operations in general are the result of careful planning ahead which is encouraged by Principle 7. As a result, this credit can earn up to 3 points in the future-proofing rating system.

When all of the credits are distributed to the 12 Principles, it results in a total of 302 total points possible. A summary of the Principles and how many credits apply to them are shown in Table 3. The complete list of 134 credits and a list of the Principles with the distributed credits is included in Appendix 4

A Proposed Future-proofing Rating System

Initial proposals for the rating system allowed a series of buildings to be compared to each other rather than an absolute standard. This was achieved by scoring the projects for points earned and then normalizing them relative to each other. While this approach showed the relative success of one project compared to another, it would not allow comparisons for projects completed in different regions or with an emphasis on different criteria. Thus the basic rating system must be applied first and then the "weighting" for a particular locale or building type is applied.

Establishing confidence in the rating system is critical. Therefore the sequence of activities in rating a project is important. In order to prevent the possibility of "cheating" or rigging the results, the points scored from the RELi and Future-proofing checklist must first be evaluated against an absolute scale. If project-specific weightings were employed first, a project design team may decide to overweight one or two Principles and score only a few points in those categories and yet appear to be producing a highly future-proof project. This approach keeps all Principles in effect but allows weighting as appropriate to a region or a building type.

The ranking and weighting process was simplified into a single spreadsheet, resulting in a hierarchical list of priorities for a project. A Principle may be over-emphasized by assigning a high percentage to it or under-emphasized by assigning a low percentage. Mitigating potential bias is achieved by using an absolute scale first and then limiting the range of potential weightings of each principle. Therefore, percentage values for the rank of each Principle are manually entered after the raw scores are calculated and are limited to fall between 5% and 15%, requiring some weighting of all principles. The spreadsheet tool gives errors when the percentages exceed this range or do not add up to a total of 100%.

All principles of future-proofing are considered important and this proposal requires that they all be evaluated without over- or under-emphasis on one particular Principle. It is important that all of the Principles be considered and some level of success achieved for each. A building will be more successful at being future-proof by achieving some level of success in each Principle because there will be fewer significant weak points.

The final rating system requires a four step process to determine a future-proofing score.

Step 1. Score the project on each of the 134 Future-proofing credits. Linked spreadsheets attribute the scores on the 134 credits to each Principle and generate absolute raw scores for the project.

Step 2. Review absolute raw scores and absolute percentage scores for baseline comparison.

Step 3. Enter percentage weightings for each of the 12 Principles of Future-Proofing. At this point, one may also rank each principal from 1 to 12 and sort them in order to assist in understanding of priorities.

Step 4. Compare the weighted scores and the weighted percentages.

Chapter 7: Application of the Future-Proofing Rating System: UW Restore the Core Program Case Studies

Background: The University of a Thousand Years

Called the "University of a Thousand Years" by University President Henry Suzallo, the University of Washington was initiated on 10 acres of land on Denny's Knoll in 1861. By 1894, the Denny's knoll site was clearly too small and the university acquired 580 acres of land in "Interlaken," north of downtown (Johnston 2001). Denny Hall was built in 1895, followed by the Jacobsen Observatory[5] and two dormitories, Lewis and Clark Halls and a science building named Parrington Hall.

Since then, the campus of the University of Washington has grown to include a student population of over 55,000 students and an annual budget of almost $7 billion in 2016 (UW OPB 2016). Today, the UW has expanded to over 600 buildings and includes campuses in Seattle, Bothell, and Tacoma (UW OPB 2014). "The UW Seattle Campus alone has over 680 acres; approximately 22 miles of public roads, drives, streets and pathways; approximately 12 million gross square feet of building maintenance and operations; and over 8 miles of walk-through utility tunnels used to distribute power, steam, chilled water, communications, and other utilities to campus" (UW OPB 2014).

The UW's primary mission to preserve, advance, and disseminate knowledge is partially supported by maintaining and building infrastructure and facilities that insure the highest level of integrity, compliance, and stewardship of their resources (UW OPB 2014). Considering this mission, it is important for the University to maintain its buildings and infrastructure. With more than 50% of the buildings on the Seattle campus over 50 years old, there is a significant strain on the capital budgets to maintain existing buildings let alone construct new buildings and structures (UW OPB 2014). This puts a high emphasis on developing a future-proof campus which will serve the University's mission as the "University of a Thousand Years."

Restore the Core Program

The "Restore the Core" Program was initiated in 2004 with the UW Building Restoration and Renewal Prioritization Study. Many buildings on the UW Seattle campus were evaluated for their condition, building

5 Jacobsen Observatory was built from leftover stone from the construction of Denny Hall.

University of Washington's Critical Building List					
Building Name	**Year Constructed**	**Assignable Square Feet**	**Number of Floors**	**Facilities Condition Index**	**Year Renovated**
Anderson Hall	1925	21,417	3 w/basement	0.99	
Architecture Hall	1909	27,996	2 w/basement	1.3	2007
Brooklyn Building	pre-1927	13,284	3 w/basement	1.17	Demolished
Clark Hall	1896	15,503	3	1.36	2009
Denny Hall	1895	49,214	4 w/basement	1.2	2016
Eagleson Hall	1922	10,380	3 w/basement	1.19	
Guggenheim Hall	1929	33,075	4	1.21	2007
Harris Hydraulics Lab	1920	16,373	3	0.98	
Hutchinson Hall	1927	34,050	3	0.96	
Johnson Hall	1930	70,858	4 w/basement	1.03	2005
Lewis Hall	1896	13,892	3 w/attic	1.71	
MHSC/H	1950	91,566	6	1.01	2008
Miller Hall	1922	43,092	4	1.04	
Playhouse Theater	1931	6,869	1 w/basement	1.1	2009
Savery Hall	1916/19	54,616	4	1.08	2009

Table 4: Buildings on the UW campus considered in the Restore the Core Program. (Table reconstructed from Committee 2004). "Year Renovated" column added by author. A Facilities Condition Index above 1.00 indicates that it is more cost efficient to replace the structure than to renovate it, though most have been renovated nonetheless.

use, and type of space available. Condition assessments included reports from the University's Facility Management Database (FACMAN) and included space program analyses from the University's Space Information Management System (SIMS). In addition, information from the 1991 Earthquake Readiness Advisory Committee study, Critical Facilities Index rank, Facilities Condition Index, ADA status, and known major building deficiencies were also included (Charvat 2015). The Facilities Condition Index, a ratio of the replacement cost of the building to the cost to remedy deficiencies, indicated that the buildings had an "average age [of] 88 years: each with an FCI near or above 100%" (Charvat 2015). With an FCI near or above 100%, it may be more effective "to replace the entire building than to attempt to correct its deficiencies" (Vanderweil 1998).

The result of this study was a wealth of data that included information such as the last major renovation, building efficiency, area, number of stories, classification, occupancy, historical classification status, and more. This information was used to prioritize specific buildings for renovation and to develop a timeline for each to be renovated in sequence (Charvat 2015). The result of the prioritization study was the "University's Critical Building List" consisting of fifteen buildings central to the mission of the university that served thousands of students daily that had not been renovated due their ongoing daily usage. "Too valuable to remove, increasingly expensive to maintain, and difficult to upgrade on a piecemeal basis, these buildings have reached a threshold where the University must decide whether to undertake major renovations of these facilities, or demolish and construct new facilities" (Committee 2004). The Critical Building List became the basis of the "Restore the Core" Program. While these buildings were to be renovated, Condon Hall, the former Law School building, served as "surge space" or temporary homes for the displaced departments. (Charvat 2015)

By 2009, when funding for the program was halted, seven buildings had been renovated and one had been demolished. Combined state and local funding for RTC went from over $130 million in 2003-2005 biennium to about $15 million in the 2005-2007 biennium to over $92 million in the 2007-2009 biennium, and then to less than $1 million from 2009 to 2013 (Charvat 2015). As a result, as of May 2016, several projects had not been completed. However, the renovation of Denny Hall, which was stopped in 2009 prior to construction, has recommenced and the project is projected to be completed in 2016.

The renovations pursued in the RTC program had several goals that guided design of the projects. These included structural seismic upgrades, complete renovation of interior spaces to suit contemporary pedagogies, uses, and occupancies. RTC renovations often included restoration treatments of the historic building fabric that balanced the campus aesthetic with the need for better energy and thermal performance and new building systems. The renovations also improved handicap accessibility and removed hazardous materials.

The RTC buildings were initially considered for this research because they are geographically constrained to the Seattle campus of the University of Washington, built at approximately the same time, and renovated at the same time and with the same philosophical approach. Their renovations are chronologically constrained by the duration of the "Restore the Core" Program from 2003 to 2009. The hiatus in the

RTC program from 2009 to 2013 was due to the recession from 2008-2011 and reflected decreased capital project funding from the State of Washington (UW Board of Regents 2009). This hiatus provides a clean break with successor projects and affords the opportunity for evaluation of the first part of the program.

Case Study Building Selection

Selection of case study projects was limited to those completed as part of the Restore the Core Program between 2004 and 2009. Eight projects were completed in this time period and one building was demolished. Due to the complexity of the RTC projects, three were selected to represent a diversity of rehabilitation techniques, design approaches, and programmatic and departmental requirements. In addition, a variety of projects was sought to understand the impacts of the different project types upon the evaluation of their future-proof capability. In addition, projects were required to have completed LEED Certification so that data could be used in the future-proofing ratings. The selection of Savery Hall, the Playhouse Theater, and Clark Hall met these criteria. A brief description and history of these three buildings follows as well as a description of the completed renovations

Figure 11: Clark Hall was the third building on the UW Seattle campus , built in 1896. Credit: UW Special Collections, negative number UW19737z, ca. 1900.

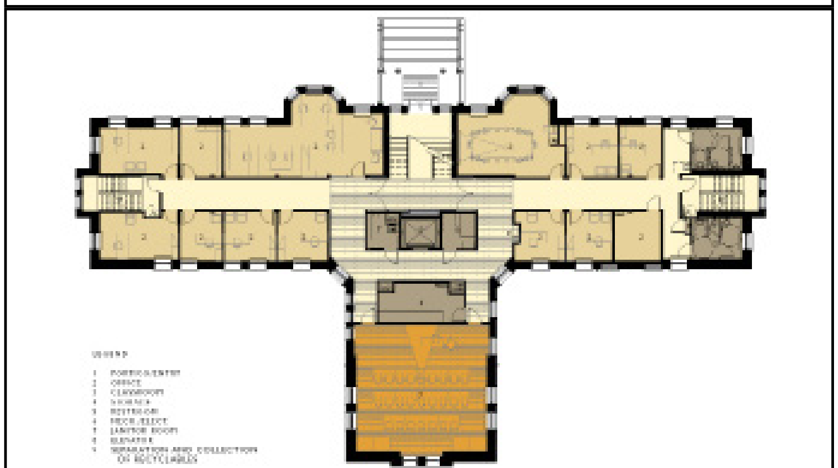

Figure 12: Clark Hall second floor plan from the 2009 renovation. Credit: Mahlum Architects, courtesy of UW CPD

Clark Hall – General History, Description, and Rehabilitation

Originally built simultaneously with Lewis Hall, and completed in 1896, Clark Hall served as a women's dormitory until 1939. The building was designed by Josenhans & Allen and was known as Pierrepoint Hall until 1917. Lewis and Clark Halls were the third and fourth permanent buildings completed on the new campus in the Interlaken area north of downtown Seattle. After 1945, Clark Hall was converted and used by the Associated Students of the University of Washington (ASUW) until 1950. At that time the Navy ROTC program took over the building and several small remodelling projects were completed in the 1960's and 1970s. In 1980, it was renovated to accommodate the Army and Air Force Reserve Officer Training Corps (ROTC) programs at the university in addition to the Navy (UW Facilities Services n.d.-a). The focus of many protests during the 1960s and 1970s, Clark Hall was damaged by a firebomb in 1969 (Johnston 2001).

The three story "T" shaped building sits on a relatively level site. The primary façade faces nearly due west. The entry is centered on the primary façade and one enters up a broad set of stairs through a sandstone entry portico. Four Doric columns support a simple entablature at the portico roof. Above the portico roof is a dormer

Figure 13: The main staircase in Clark Hall during demolition. Credit: Staff photo courtesy of UW CPD, 2008.

window projecting from the hipped roof running along the main east-west axis of the building. This main entry is flanked by three-story octagonal bay windows. Broad wings to the north and south terminate in shallow rectangular bay windows. The roof over the octagonal bay windows comes to a free standing point rather than extending back into the main roof structure (Josenhans & Allen 1896). The main roof areas have a 12:12 slope and the bay windows slope at either 13:12 or 22:12 (Mahlum 2010).

Clark Hall was originally a wood framed structure, although steel trusses were added later to span larger spaces. It was clad in brick (once painted and now restored) and sandstone with wood double hung windows and a shingle roof. Stone was treated as a cladding material and backed up by 2 or 3 wythes of brick. It also featured copper gutters and ridge caps (Josenhans & Allen 1896).

The 2010 Renovation of Clark Hall was designed by Mahlum Architects. The architectural drawings are available through the Campus Engineering records at UW Facilities Services (Mahlum 2010). The renovation made significant changes to the interior of the building while leaving the exterior with only minor changes. On the interior, the entire building was gutted to the structure. Steel trusses added during the life of the building were removed along with all of the original floor, wall, and ceiling finishes, and interior building systems were removed to allow for new construction meeting new programmatic needs. The attic space, which had been captured as usable space in prior alterations to the building fourth floor, was also entirely gutted to

Figure 14: Clark Hall interior during demolition showing the removal of major portions of the interior construction. View looking north. Credit: Staff photo courtesy of UW CPD, June 2008.

the structural framing. Hazardous materials were removed from the building to the extent feasible. On the exterior of the building, several non-historic features were removed such as railings at the portico and a fire escape at the back of the building. Selected historic features were also removed such as the portico itself and all of the windows.

New construction on the building included a completely new interior and several reconstructed or replicated exterior features. On the interior of the building, new stairs, elevators, restrooms, offices classrooms and communal spaces were installed. New interior partitions were installed and the exterior wall was furred out with metal studs, R-11 mineral wool insulation, and a vapor retarder under the new drywall. The roof was insulated by spraying two inches of foam on the underside of the baffles that created an air space under the roof deck and provides a vapor barrier. Fiberglass blanket insulation was installed below the foam to meet energy code requirements. Additional structural floor joists and roof rafters were installed to supplement the existing structure. New structural seismic bracing was installed to stabilize the building in the event of an earthquake. New building systems, such as mechanical, plumbing, electrical, fire protection, and more, were installed to comply with current code.

On the exterior of the building, the portico was reconstructed of glass fiber reinforced concrete (GFRC) clad steel structure to match the profile of the original stone, the brick was repointed, windows were replaced with aluminium clad insulated wood units to match the historic appearance of the original windows. Several different types of stone repair were completed and brick masonry was pinned to resist seismic forces. In addition, several large skylights were added at the roof to allow light into the recaptured fourth floor attic spaces. A new asphalt composition roof was installed with reconstructed sheet metal gutters, roof flashing, and ridge caps to mimic the original shapes.

In summary, while significant portions of the exterior of the building were replaced, the character of the building was preserved by reconstructing the original shapes and configurations of the building. On the interior, however, none of the historic fabric remains. The entire interior of the building was demolished and new construction was installed to meet current programmatic requirements and replace obsolete systems.

Figure 15: The courtyard at the Playhouse Theatre was a welcoming space to socialize. Credit: UW Tyee Yearbook, 1958.

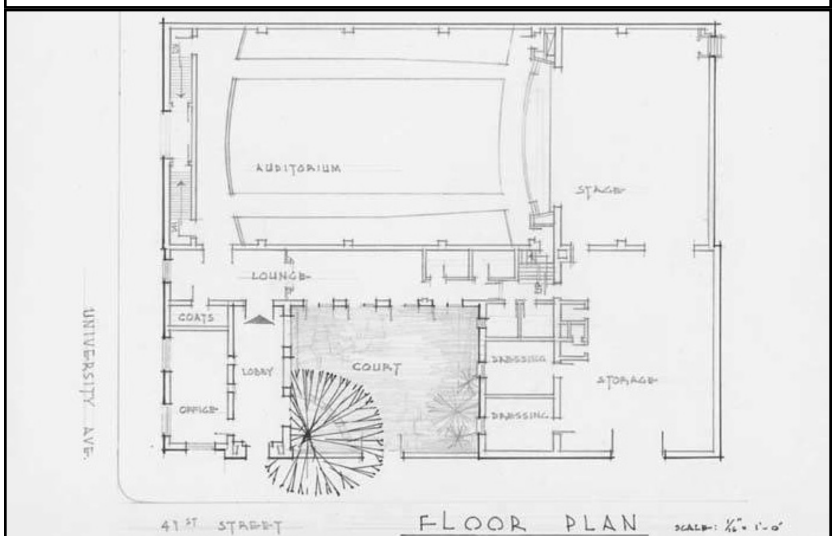

Figure 16: The floor plan of the 1951 remodel of the Playhouse Theater. Credit: Vern Delgatty, 1956. Courtesy of UW Special Collections

Playhouse Theater – General History, Description, and Rehabilitation

After teaching drama at Cornish School in the mid-1920s, Florence and Burton James established the Seattle Repertory Playhouse in 1928, renting stages around town. The Playhouse Theater was designed for them by local architect Arthur Loveless in 1930 and became their permanent location (Dorpat 2013).

The original brick and tile warehouse on this site was remodelled by Walter & Brady to become the home of the Seattle Repertory Theater (Delgatty 1965). In 1951, the University of Washington purchased the theater for $70,525. It was remodelled in 1951 based upon designs by Donald N. McDonald. It was called the University Playhouse until 1966. In 1968, the building was thoroughly remodelled based on designs by Nelson, Sabin & Varey. The space was completely reconfigured so that the stage was on the south side of the building rather than the west side. Called the Hughes Playhouse until 1992 and then the Playhouse Theater until 2007, when the building became known as the Floyd and Delores Jones Playhouse Theater after the “Restore the Core “renovation. (UW Facilities Services n.d.-b)

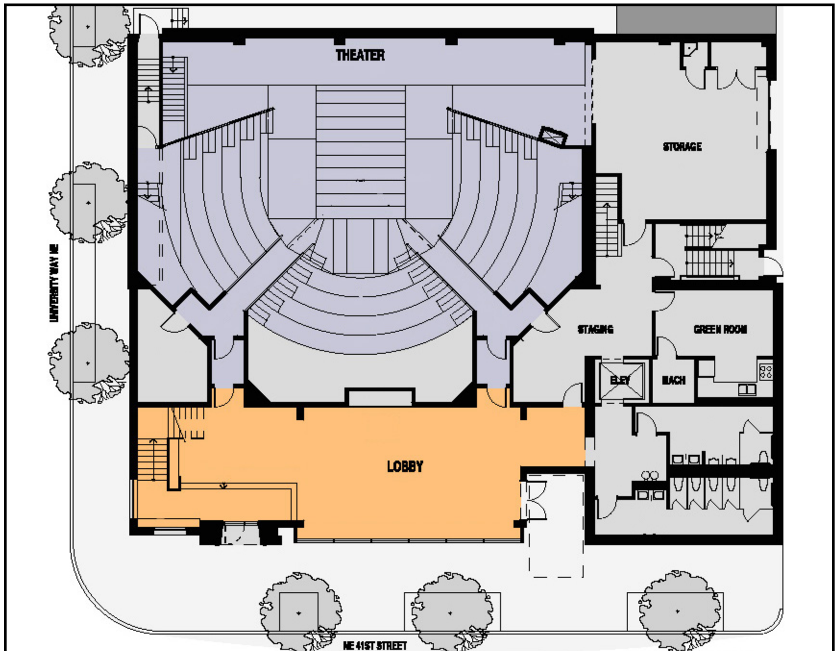

Figure 17: The 2009 floor plan of the Playhouse Theater showing the new stage configuration. Credit: LMN Architects, courtesy UW CPD.

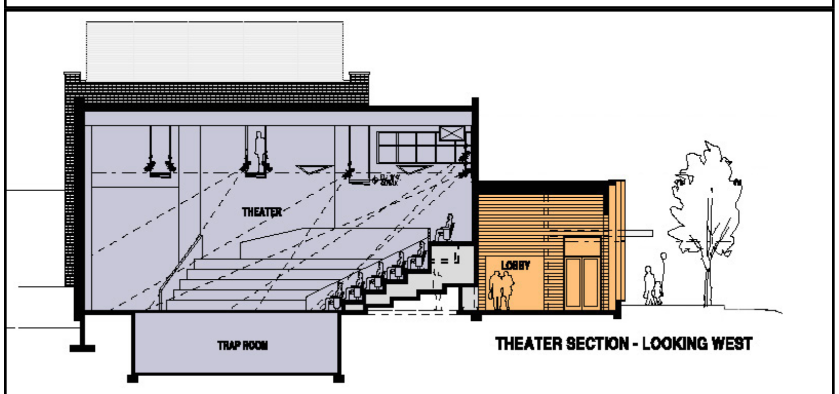

Figure 18: Section through the auditorium and lobby of the theater. Credit: LMN Architects, 2009, courtesy of UW CPD.

The original 1930 building was a "U" shaped building that occupied one quarter of the block at the intersection of University Avenue and NE 41st Street. Situated at the southwest corner of the intersection, the auditorium ran along the south wall of the building in a long narrow shoebox space with the stage at the southwest corner of the building. The "U" shape enclosed a courtyard for casual outdoor gathering before or after shows that separated vehicular traffic from the patrons (Delgatty 1965).

Of the major alterations described above, it is important to consider the 1968 remodeling in more detail. (There are also a number of minor alterations that have been completed over the history of the building.) The 1968 remodeling of the theater made significant changes in the configuration of the theater. The new orientation of the stage also included a major change in the type of stage. The original stage was separated from the audience with a proscenium, whereas the new configuration focused around a thrust stage with the audience surrounding it on three sides. To accommodate this stage, the courtyard created by Loveless was filled in with lobby space and expanded support spaces for the theater. In addition to typical roof repairs, a fire alarm system was installed in 1978 and the entire stage lighting system was replaced in 1988. Minor mechanical and electrical alterations followed in 1993

The “Restore the Core” renovation of the building took place in 2007-09. The LEED Gold certified renovation of the 8,030 square foot theater cost $6 million and now provides 210 seats. LMN Architects was the lead design firm on the project.

The project converted the building from one to two stories allowing dressing rooms to be moved upstairs and restrooms adjacent to the lobby to be enlarged. Inside the theatre, the entire volume of the thrust and semi-surround seating became the performance space. Circulation was greatly improved with direct access from the stage to the rear audience cross aisle acting as a passarelle and the addition of two vomitory entrances so that actors can enter the theatre out of view of the audience, thus achieving a true sense of intimacy and interactive communication between the performer and audience. (Auerbach-Pollack-Friedlander 2016)

In addition, interior renovations included new restrooms, lobby and concession spaces, elevators, egress improvements, handicapped accessibility improvements, theater lighting and rigging systems, floor traps at the stage, mezzanine and catwalk floor structures, and

Figure 19: The interior of the stage looking at the catwalks during construction. Credit: Staff photo, UW CPD, 2008.

Figure 20: The exterior wall of the historic main entry was retained. Credit: Staff photo, UW CPD, 2008.

Figure 21: Exterior view of the Playhouse Theater looking southeast at the new lobby space. Credit: UW World Series, ca. 2013.

Figure 22: The auditorium and stage after the 2009 renovation of the Playhouse Theater. Credit: © Lara Swimmer Photography, 2010.

new penthouse roof framing. Seismic improvements were limited to some cross bracing and a limited number of new masonry shear walls because of the small and relatively light weight nature of the structure. Similar to Clark Hall, entirely new mechanical, electrical, plumbing and other building systems were installed to meet code requirements.

The impact on the exterior of the building was significant while retaining and giving preference to the 1930s north- and west-facing brick façade that remained after the 1968 remodeling. The new volume over the stage is clad in dark brown metal siding and rises several feet above the original roof of the entry to the theater. The former courtyard space is now a narrow lobby facing to the north with broad expanses of glass recalling the original courtyard configuration of the building.

In contrast to Clark Hall, significant portions of the exterior of the building were removed. The historic character of the buildings is conveyed by relatively the relatively small potions of the original building that remain. On the interior, none of the historic fabric remains. The entire interior of the building was demolished and new construction was installed to meet current programmatic requirements and replace obsolete existing systems.

Figure 23: A 1926 aerial photo of the UW Seattle campus looking north. Savery Hall is in the middle left. Credit: UW Campus Engineering Records #3097767.

Savery Hall – General History, Description, and Rehabilitation

What is known today as Savery Hall actually consists of two buildings. The north part of the building, Commerce Hall, was built in 1916. Commerce Hall was the first building paid for by the use of student tuition funding in the State (Johnston 1995). This north section was renamed Guthrie Hall in 1956. The south part of the building, Philosophy Hall, was built in 1919. The southern portion of the building was renamed Savery Hall in the late 1930s. In 1972, these two buildings were joined together and the combined building became known as Savery Hall. Bebb and Gould were the architects for both portions of the building. (UW Facilities Services n.d.-c)

Throughout the period from 1920 to the 1990's the building went through several minor alterations for fire egress, asbestos abatement, and departmental remodels. Major alterations include the following: Fire safety and egress improvements were undertaken in 1988 and 1990. In 1958, a major remodel of the fourth floor offices and replacement of the original windows with single glazed steel frame and sash windows was completed. In 1990 extensive classroom remodeling was undertaken. In 1993, GGLO developed drawings for alterations to the Department of Economics totalling 2600 square feet

Figure 24: All interior construction was demolished to allow for new building systems. Credit: John Stamets, 2008, courtesy UW CPD.

Figure 25: The 2009 renovation retained the structure and historic shell of Savery Hall. Credit: John Stamets, 2008, courtesy UW CPD.

of area. In 1994, a major roof replacement project designed by S. M. Stemper Architects was undertaken focusing on the flat roof areas in the middle of the building. Alterations such as these are typical of the evolving requirements of the UW campus buildings as they accommodate changes in academic programs, staffing, and student body size. (UW Facilities Services n.d.-c)

The "L" shaped building is oriented to the northwest and forms one corner of the Liberal Arts Quadrangle (the Quad). Primary entries to the building are from the Quad, though additional entries are available at all sides of the building. The main entries facing the Quad are indicated with sections of ornate glazed terra cotta. The building consists of four stories with mezzanines in selected areas, though the fourth floor is mostly mechanical rooms for the building. Mezzanines were possible due to the significant floor-to-floor height of approximately eighteen feet. The roof is characterized by steep sloped slate sections at the perimeter and large low slope areas at the center of the building.

The 2009 "Restore the Core" renovation of Savery Hall was designed by the SRG Partnership. The architectural drawings are available through the Campus Engineering records at UW Facilities Services (SRG Partnership 2009), unless otherwise noted. While the Savery

Figure 26: The first floor plan of Savery Hall for the 2009 renovation. Credit: SRG Architects, 2008, courtesy of UW CPD.

Hall renovation has several common characteristics with Clark Hall, there are also some unique aspects. Typical of the approach to major renovations at the UW, demolition in the existing building included removal of all interior partitions, finishes (such as wall surfaces, multiple layers of flooring and ceilings), equipment, doors, windows and casework. In addition, all existing structural elements were exposed in preparation for a seismic retrofit of the building and allowing additional mezzanine floors to be installed. All building systems such as mechanical, plumbing and electrical were removed. Vertical transportation elements, such elevators and as many of the stairwells, were removed. Hazardous materials were also removed throughout the building.

On the exterior of the building, some character-defining features were removed, although most were retained. All exterior windows and doors were removed. Stairs on the north and west sides of the building were removed to make way for new basement access points. The exterior brick and glazed terra cotta were retained as was the slate roof areas and the majority of the built up roofing system. Openings were created in the built-up roof areas for mechanical equipment supports and installation of mechanical equipment in the attic spaces.

Similar to Clark Hall, the renovation included several new features in both the interior and exterior construction. In the interior, the mezzanine concept was extended through more of the south building to increase usable floor area. All new interior walls and finishes were installed in addition to all new building systems such as mechanical, electrical, and plumbing. The interior of the building was brought completely up to current (2009) code, including energy code requirements. Some elements of the historic interior building fabric were retained. The two main entries from the Quad were restored, including the stair treads and balustrades. Original slate chalk boards, selected light fixtures, and window shutters were salvaged and reinstalled. Some

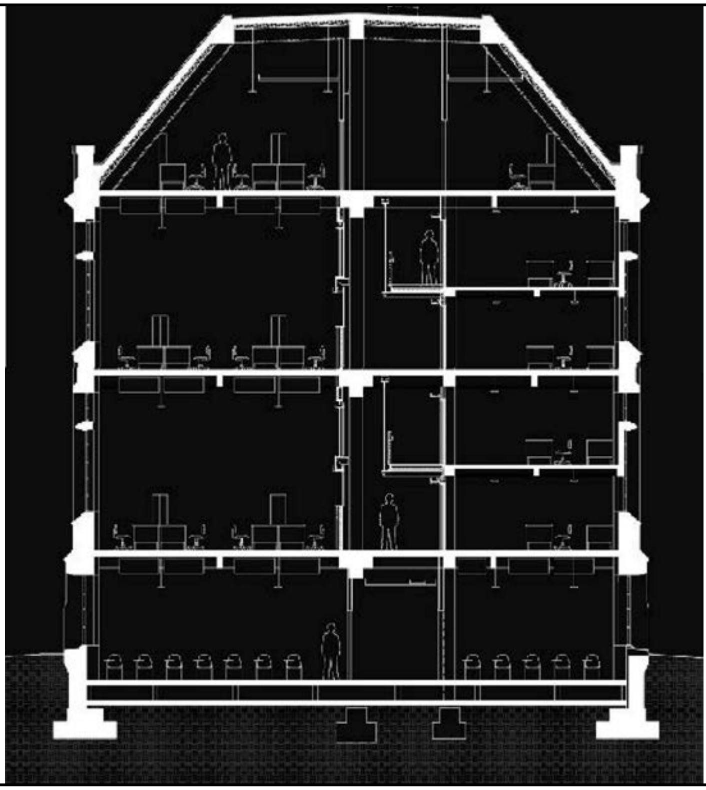

Figure 27: This section through Savery Hall reveals the mezzanines that are possible due to the large floor to floor height. Credit: SRG Partnership, 2008, courtesy of UW CPD.

sections of interior plaster partitions with leaded privacy glass were retained in place. Interestingly, structural improvements were limited to providing new openings and supports for other building systems, filling in old openings, and limited interventions to provide new concrete wall backup for the original hollow clay tile walls. Two new structural components included a new basement entry on the north side of the building and adjacent bike shelter.

On the exterior of the building, the most significant change was that the windows were replaced with new aluminium clad wood windows with thermally broken insulated glass units and simulated divided lights. Security screens were provided in selected locations on the interior to present a consistent exterior appearance of the windows. Copper staining and biological growth were removed from the stone and brick on the exterior the building. Deteriorating and spalling sandstone was tooled and re-dressed. Repointing of the masonry was completed in limited areas.

The terra cotta received extensive repairs that included removal of cracked and spalling pieces of original building fabric as well as removal and replacement of previous terra cotta patches and repairs. Terra cotta window sills received several repairs and helical anchors were installed to hold fractured pieces in place. The terra cotta repairs were completed with new materials to match the original, that is, new glazed terra cotta pieces. However, rather than anchor the new pieces with mild steel rods as was originally done, stainless steel pins were used to prevent future corrosion and spalling. (SRG Partnership 2009) The most significant challenge in repairing the terra cotta was a

Figure 28: The renovation preserved the exterior shell of Savery Hall. Credit: Mason Contractors Association of America, 2009.

Figure 29: The second floor mezzanine at Savery Hall. Credit: © Lara Swimmer Photography, 2009.

lead- and asbestos-containing coating that had been painted onto the terra cotta to protect the fragile pieces. This coating was failing and concealed prior repairs and failures of the terra cotta and had to be completely removed. (MCAA 2009)

In summary, the 2007-09 renovation of Savery Hall was respectful of the exterior of the building in general. Limited removal of historic building fabric combined with sensitive restoration of the remaining building envelope retained the character of the building. The exterior terra cotta and masonry were cleaned and repaired with materials, colors, and techniques designed to restore the exterior appearance while preventing future deterioration. However, consistent with the approach to several buildings on campus, the older interior of the building was almost completely removed to the structure and completely rebuilt with new materials, finishes, and systems.

Case Study Scoring: Approach

The case study projects were scored by a step by step process as described in this section.

The three projects were found on the USGBC website. LEED Certification of the projects was verified as well as the version of LEED that was used. All three case study buildings are LEED Gold certified and all used LEED BD+C for New Construction, version 2.1. LEED Checklist information was downloaded as PDF files and converted into a spreadsheet format to be used with the future-proofing scorecards. LEED 2.1 credits were translated into LEED v4 credits, which the RELi Rating system used, as best as possible.

Additional project information was sought as well. Record documents for projects were accessed via UW Facilities Services online Document Search (FS-DOS) by searching the database by building name.[6] The database includes a synopsis of the history of the buildings as well as drawings, specifications, and photos for the original construction and almost all of the past alterations, including major renovations. The RTC renovations fell into the latter category. All drawings were saved as single files in a TIFF format for later reference.

Additional historic building information was found at the UW Special Collections, including historical photos of the campus buildings that were downloaded.[7] Additional research for each building was done using online search engines such a Google Images.

Once the building data were gathered, evaluation of the RELi and future-proofing credits began. First, the LEED Checklist credits were translated from LEED v2.1 to V4 and copied into the RELi spreadsheet. Since data for all three case study buildings had been converted into one spreadsheet, this was extended to the RELi spreadsheet and all LEED credits were accounted for.

The buildings were next evaluated for possible credits from other rating systems. Detailed review of the criteria for each credit and review of project drawings and/or specifications determined if the

6 Access to secured files from the University of Washington was required and achieved because the author is a professional staff member as well as a student. File names were not reflective of the content and TIFF file formats resulted in large data files requiring a significant amount of data storage space and file organization.

7 Similar to FS-DOS, historical and bibliographical information was divorced from the database once the file was downloaded and saved. Image files were renamed to correlate to the database and the historical and bibliographical information was copied into a separate file to ensure no data was lost.

project met the applicable credits. Through this process it was found that credits from some of the rating systems such as Health Impact Assessments and personal emergency preparedness kits did not apply to the subject buildings and were eliminated from the scoring system. All 134 future-proofing credits were reviewed for each building.

Once the individual credits were evaluated, spreadsheet links translated the individual project credits for each of the twelve principles. Many of the future-proofing credits were applicable to more than one Principle; therefore, as noted in Chapter 6, a total of 302 credits could be earned.

The scorecards for the three "Restore the Core" projects are presented on the next several pages followed by analysis. The scorecards follow the 4 step process of evaluating and scoring the projects. Step One of the process is scoring the projects on the 134 credits, so these spreadsheets start with Step Two.

Principles of Future-Proofing	Raw Scores				
	Clark	Playhouse	Savery	out of	Total
1. Prevent decay	2	2	2	out of	5
2. Flex/adapt	1	1	1	out of	6
3. Service life	8	8	8	out of	24
4. Fortify	3	2	3	out of	21
5. Redundancy	2	1	2	out of	13
6. Obsolescence	33	34	25	out of	63
7. Plan ahead	7	6	7	out of	38
8. Diversify	3	2	2	out of	17
9. Local/healthy	54	47	46	out of	76
10. LCA	8	7	9	out of	17
11. Understanding	2	0	1	out of	8
12. Policy docs	7	7	9	out of	14
Total	**130**	**117**	**115**	**out of**	**302**

Table 5: Future-Proofing Scorecard, Step 2: This table shows the raw scores for points earned under each future-proofing criteria. The green highlighted cells show consistent scoring across all three projects. The yellow highlighted cells show anomalous scores. The anomalous scores represent where a building scores either higher or lower than the other two buildings and indicate which Principles a project was more or less successful.

Principles of Future-Proofing	Percentage Scores		
	Clark	PlayHouse	Savery
1. Prevent decay	40%	40%	40%
2. Flex/adapt	17%	17%	17%
3. Service life	33%	33%	33%
4. Fortify	14%	10%	14%
5. Redundancy	15%	8%	15%
6. Obsolescence	52%	54%	40%
7. Plan ahead	18%	16%	18%
8. Diversify	18%	12%	12%
9. Local/healthy	71%	62%	61%
10. LCA	47%	41%	53%
11. Understanding	25%	0%	13%
12. Policy docs	50%	50%	64%
Total	**43%**	**39%**	**38%**

Table 6: Future-Proofing Scorecard, Step 2, continued: This table shows the raw scores converted into percentages which are calculated by the spreadsheet automatically. The highlighted cells represent consistent and anomalous scores.

Principles of Future-Proofing	Rank	Adjusted Weighting
1. Prevent decay	2	10%
2. Flex/adapt	3	5%
3. Service life	1	15%
4. Fortify	3	5%
5. Redundancy	3	5%
6. Obsolescence	2	10%
7. Plan ahead	3	5%
8. Diversify	3	5%
9. Local/healthy	1	15%
10. LCA	3	5%
11. Understanding	2	10%
12. Policy docs	2	10%
Total		**100%**

Table 7: Future-Proofing Scorecard, Step 3: Each of the Principles may be weighted to indicate their relative importance to a particular project. The weightings are limited to between 5 and 15 percent to prevent excessive or under-weighting of a specific Principle which could lead to distorted results. The weighting process can be supported by ranking the Principles first and the rows sorted to allow quick comparison of the individual Principles. Principles assigned the same rank should also be given the same percentage weight. All percentages must total 100% and formula driven formatting highlights the total percentage when it does not add up to 100%. An average weighting for all of the Principles would result in each point valued at 8.3%. Percentage weights above this average will over-weight a Principle and, similarly, percentages under this average will under-weight a Principle.

Principles of Future-Proofing	Rank	Adjusted Weighting	Weighted Scores				
			Clark	Playhouse	Savery	out of	Total
1. Prevent decay	2	10%	2.0	2.0	2.0	out of	5.0
2. Flex/adapt	3	5%	0.5	0.5	0.5	out of	6.0
3. Service life	1	15%	12.2	12.2	12.2	out of	24.0
4. Fortify	3	5%	1.5	1.0	1.5	out of	21.0
5. Redundancy	3	5%	1.0	0.5	1.0	out of	13.0
6. Obsolescence	2	10%	33.7	34.7	25.5	out of	63.0
7. Plan ahead	3	5%	3.6	3.1	3.6	out of	38.0
8. Diversify	3	5%	1.5	1.0	1.0	out of	17.0
9. Local/healthy	1	15%	82.6	71.9	70.4	out of	76.0
10. LCA	3	5%	4.1	3.6	4.6	out of	17.0
11. Understanding	2	10%	2.0	0.0	1.0	out of	8.0
12. Policy docs	2	10%	7.1	7.1	9.2	out of	14.0
Total		**100%**	**152.0**	**137.7**	**132.6**	**out of**	**302.0**

Table 8: Future-Proofing Scorecard, Step 4: Weighted point scores are automatically calculated by the spreadsheet for each Principle.

Principles of Future-Proofing	Rank	Adjusted Weighting	Weighted Percentages		
			Clark	Playhouse	Savery
1. Prevent decay	2	10%	41%	41%	41%
2. Flex/adapt	3	5%	9%	9%	9%
3. Service life	1	15%	51%	51%	51%
4. Fortify	3	5%	7%	5%	7%
5. Redundancy	3	5%	8%	4%	8%
6. Obsolescence	2	10%	53%	55%	40%
7. Plan ahead	3	5%	9%	8%	9%
8. Diversify	3	5%	9%	6%	6%
9. Local/healthy	1	15%	109%	95%	93%
10. LCA	3	5%	24%	21%	27%
11. Understanding	2	10%	26%	0%	13%
12. Policy docs	2	10%	51%	51%	66%
Total		**100%**	**50%**	**46%**	**44%**

Table 9: Future-Proofing Scorecard, Step 4, continued: Weighted percentages are calculated by the spreadsheet for each Principle.

Analysis of the Future-Proofing Scorecards – Clark Hall, Playhouse Theater, Savery Hall

The case studies were expected to indicate a significant variation between the future-proof capacity of Clark Hall, the Playhouse Theater, and Savery Hall. The results were expected to differ because of the different functions, histories, materials and characteristics of the buildings. Use, configuration, size, and location and multiple other unique aspects of each building were anticipated to result in some of the buildings being more future-proof than others. However, the results indicated that all three buildings were relatively similar on the future-proof scale. Summary spreadsheets are included after a discussion of the results and variations in the scoring systems that were tested in this research.

Despite varied character of the buildings, the approach taken for each was relatively consistent due to the same university administration context for the projects. The projects were managed by the same group, UW Capital Projects, and were completed in similar academic environments, and in very similar geographic and climatic areas. The consistency of the approach to the projects likely over-rode the differences among the buildings themselves. Discovery of the consistency of the results was supported by ease of scoring Envision points, for example. Scoring the Envision-based credits was required to evaluate the 134 future-proofing credits. All three "Restore the Core" projects were scored simultaneously. Once one project had been examined, the author discovered that the same design approach was applied to all projects and the scoring of a project on the Envision-based points became fairly predictable.

Because of the similarity of the three projects overall, individual categories were minimally higher and lower depending on the Principle examined. All three projects scored between 40 and 60 percent of the possible point available. Clark Hall scored higher points under Principle 9 for local and healthy design, giving it a higher score than Playhouse Theater or Savery Hall. After weighting the scores, the relative differences between the projects remained nearly the same, confirming the consistency of the approach to renovation projects on the University of Washington campus.

Figure 30: The Spokane and Inland Empire Railroad (SIERR) Building at McKinstry Station after the 2011 renovation, looking to the northeast. Credit: Dean Davis, 2011. Photo courtesy of McKinstry.

Chapter 8: Additional Testing: The SIERR Building Case Study

To validate the system and the future-proof scores for the UW Restore the Core buildings, one additional case study was conducted late in the thesis process. This fourth case study addressed a building of similar vintage and scope of renovation: the SIERR building at McKinstry Station in Spokane, Washington. However, the building was selected for several differences with the UW "Restore the Core" buildings. First, the building is not owned by the University of Washington and is not located on campus. Second, it is a privately owned building, rather than publicly owned. Third, the building was abandoned and near condemnation prior to rehabilitation. Last, the uses, both before and after the renovation, were and still are significantly different from the "Restore the Core" buildings.

The Spokane & Inland Empire Railroad Car Facility (SIERR Building) "played a pivotal role in advancing the western US development of the electric interurban and city railroads in the first decade of the twentieth century" (Day 2010). Built on the banks of the Spokane River, the "existing building complex was completed in 1907, with an addition completed in 1908" (Day 2010). The building, an "austere, industrial

Figure 31: The windows and doors at the SIERR Building were fully reconstructed from existing materials. View looking southeast. Credit: Dean Davis, 2011. Photo courtesy of McKinstry.

Figure 32: Thousands of cubic yards of contaminated soil were removed from the riverfront side of the site at the right of the photo. Credit: Dean Davis, 2011. Photo courtesy of McKinstry.

variation of the Romanesque Revival style," served as the center for maintenance of electric street cars, although the vast majority of the equipment and maintenance features were removed from the building prior to a 1950s conversion for trucking and warehouse uses (Day 2010). "The architect of the complex was Albert Held, [a] prominent Spokane architect, and the builder was the P.L. Peterson Company" (Day 2010). The building began a rapid decline after 1911 as the SIERR Company's fortunes began to decline due to (1) a rapid decline of electric street railways, (2) a decline in the Spokane real estate market, (3) the rapid rise of the private automobile, and (4) the resignation of SIERR President, Jay P. Graves (Day 2010). Since the completion of the 2011 renovation, the SIERR building has served as the home office of McKinstry, an HVAC and plumbing construction company, as well as providing "common spaces shared by all tenants and the Innovation Center, an accelerator for sustainable and high-tech businesses" (Budd and Lang 2014a).

Over the years of its existence, alterations stripped the building of many of its character-defining historic features. Most of the door and window openings in the building had been infilled with brick or concrete block as the wood materials deteriorated or were found unnecessary. Almost all of the features that were particular to the

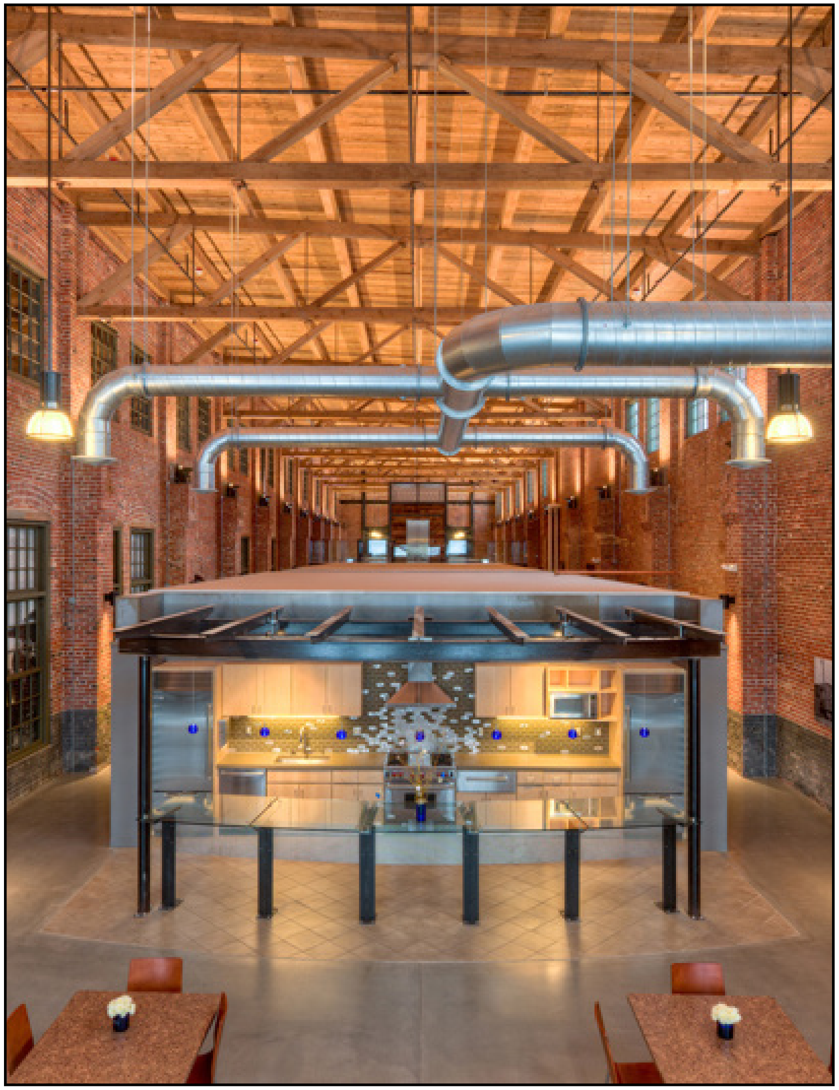

Figure 33: The 2011 rehabilitation made preserved the spacious feeling of the maintenance bays by holding new construction to the center of the space allowing the volume to be clearly understood. Credit: Dean Davis, 2011. Photo courtesy of McKinstry.

street car maintenance were removed. This included the interior track and turntable system, repair pits, boilers, cranes, and railroad related equipment (Day 2010). In addition, multiple stud framed drywall partitions were installed, the exterior grade of the building was lowered approximately three feet and the railroad tracks removed in several areas to facilitate truck loading. The skylights and large wooden shutters for the train portals were removed. Periodic flooding from the Spokane River has affected the landscape surrounding the building. Immediately prior to the 2011 renovation, a hazardous materials cleanup was undertaken aimed at removal of lead deposits from the railroad use of the building (Day 2010).

Several artifacts were found in the building and salvaged, refinished, and installed in the completed building. The major features remaining consisted of the exposed brick masonry of the building shell and the massive wood trusses spanning the maintenance bays. It was determined that the building retained enough integrity that the project team designated it as a local landmark and successfully listed it on both the Washington and National Registers of Historic Places (Day 2010).

The building is configured as an L-shaped structure with the

Figure 34: Interior interventions also captured the character of McKinstry's business as a mechanical and plumbing contractor with a minimal impact on the historic building material. Credit: Dean Davis, 2011. Photo courtesy of McKinstry.

maintenance bays making up the legs of the "L." The Spokane Historic Register Nomination goes on to describe the building as follows:

> "The complex appears as one contiguous building but is essentially composed of a series of long, contiguous train sheds with low sloped roofs. The majority of the building spaces are single storey plus basement level (which originally contained a series of repair pits), with some second floor additions inserted into the building volumes in the 1950's or later. The train sheds originally allowed for train cars to enter and exit the repair and fabrication facilities on rails with turntables, and repair pits were incorporated below. The interior and exterior walls are constructed of red brick in a common bond pattern, above a foundation of rough hewn granite, concrete and mixed stone. Wood roof trusses are typically supported by iron and/or heavy timber columns, or by brick pilasters and engaged columns." (Day 2010)

The 2011 renovation of the SIERR Building was deliberately focused on the long term service life of the building while still restoring the historic character of the building. "Because McKinstry intends to occupy the SIERR Building for 50 years or longer, they focused on long-term savings and invested in improvements that would last another 100 years" (NAIOP 2013).

On the exterior, the vast majority of the original windows and doors had completely deteriorated and the openings infilled. 160 windows

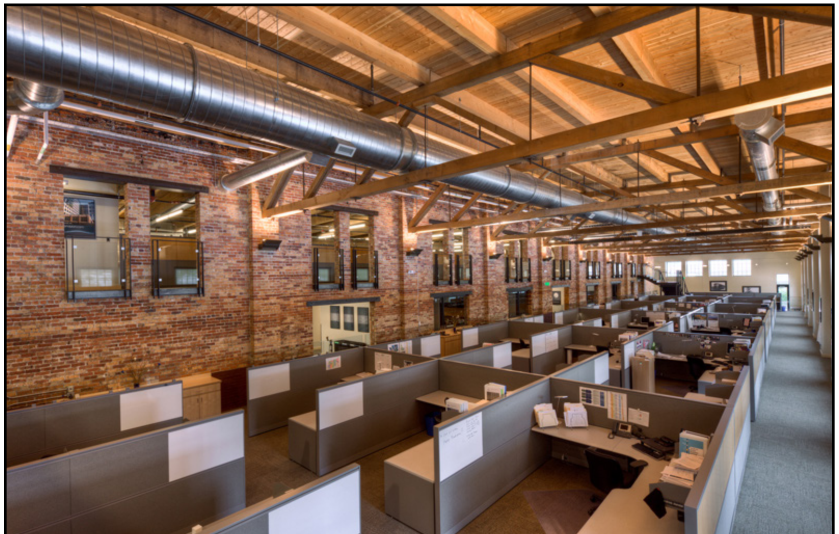

Figure 35: The project incorporated office spaces for McKinstry's home office while allowing common spaces for other tenants to share. Credit: Dean Davis, 2011. Photo courtesy of McKinstry.

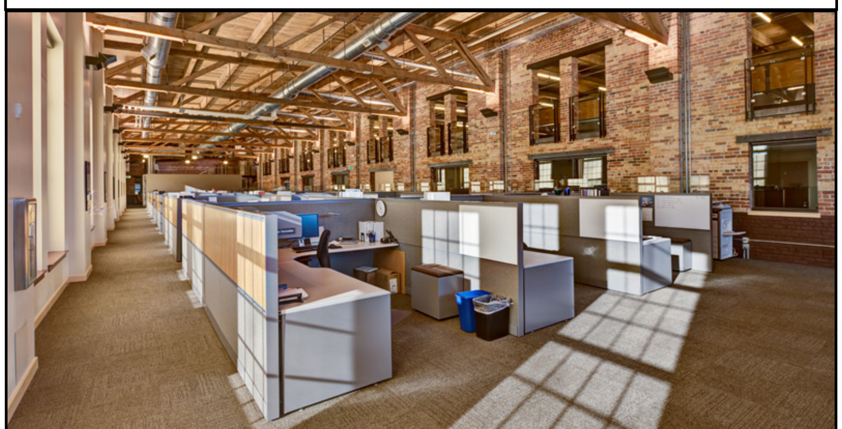

Figure 36: In addition to McKinstry's offices, the building provides incubator spaces for business startups. Credit: Dean Davis, 2011. Photo courtesy of McKinstry.

were replicated based on the few that survuved with minor energy improvements and there were limited insertions of new storefront systems (Budd and Lang 2014b). Only one operating pair of barn doors survived when the building was renovated, so the others were reconstructed based on the original designs (Budd and Lang 2014b).

Interior changes included a new mezzanine, elevator, and office spaces within the maintenance bays. Insulation in the wall and roof systems was strategically placed to meet energy code requirements, but not compromise the visual integrity. The interior was designed to allow the appreciation of the large maintenance spaces, heavy timber trusses, and the brickwork. "Twelve different cleaning methods were tested on the masonry before finding that medium-pressure steam was the solution that did not damage either the brick or mortar" (Budd and Lang 2014a).

Structural steel was used for the seismic bracing system to differentiate the intervention and minimize visual impact. Footings are concealed beneath the floor. Roof system uses drag struts to transfer loads to a minimal number of braced frames. Similar to the UW Restore the Core projects, new mechanical, electrical, and plumbing systems were installed from the connections at the edge of the site throughout the

Figure 37: The main entrance of the SIERR Building after it's 2011 rehabilitation is an example of the sensitive interventions completed in the rehabilitation where new construction is inserted into the historic building. Credit: Dean Davis, 2011. Photo courtesy of McKinstry.

building. Ground source heat pump system, heat recovery systems, and radiant floor heating and cooling systems in the concrete floors minimize the visual impact of the new thermal comfort system (Budd and Lang 2014b).

The project now provides spaces for offices and employee accommodations while still showing the cavernous interior open spaces and the character of the original materials throughout the building.

Principles of Future-Proofing	Raw Scores			Adjusted Raw Scores			Percentage Scores
	SIERR	out of	Total	SIERR	out of	Total	SIERR
1. Prevent decay	5	out of	5	4	out of	5	78%
2. Flex/adapt	4	out of	6	4	out of	6	60%
3. Service life	14	out of	24	13	out of	24	52%
4. Fortify	5	out of	21	5	out of	21	24%
5. Redundancy	6	out of	13	6	out of	13	46%
6. Obsolescence	45	out of	63	32	out of	63	51%
7. Plan ahead	15	out of	38	14	out of	38	36%
8. Diversify	6	out of	17	5	out of	17	29%
9. Local/healthy	73	out of	76	51	out of	76	67%
10. LCA	13	out of	17	10	out of	17	59%
11. Understanding	6	out of	8	6	out of	8	75%
12. Policy docs	10	out of	14	9	out of	14	63%
Total	**202**	**out of**	**302**	**157**	**out of**	**302**	**52%**

Table 10: This table shows the raw, adjusted, and percentage scores for the SIERR Building. Note that the adjusted scores included reducing the raw scores by a ratio of 69/110 to adjust for the increased number of points available under LEED 2009.

Principles of Future-Proofing	**Rank**	**Adjusted Weighting**	**Weighted Scores**			**Weighted Percentages**
			SIERR	**out of**	**Total**	**SIERR**
1. Prevent decay	2	10%	4.0	out of	5.0	79%
2. Flex/adapt	3	5%	1.9	out of	6.0	31%
3. Service life	1	15%	19.1	out of	24.0	80%
4. Fortify	3	5%	2.6	out of	21.0	12%
5. Redundancy	3	5%	3.1	out of	13.0	24%
6. Obsolescence	2	10%	32.6	out of	63.0	52%
7. Plan ahead	3	5%	6.9	out of	38.0	18%
8. Diversify	3	5%	2.5	out of	17.0	15%
9. Local/healthy	1	15%	78.1	out of	76.0	103%
10. LCA	3	5%	5.1	out of	17.0	30%
11. Understanding	2	10%	6.1	out of	8.0	77%
12. Policy docs	2	10%	9.1	out of	14.0	65%
Total		**100%**	**170.9**	**out of**	**302.0**	**57%**

Table 11: Once adjusted for the LEED rating system, the scoring process for the SIERR building remained the same. The ranking and adjusted weighting were kept the same to keep the points as comparable as possible. This table shows the weighted point scores and percentages for each Principle.

The future-proofing scores were generated using the same method as was applied to the "Restore the Core" projects. After the project information was obtained, each of the 134 credits were evaluated to determine if the project had achieved the credit. The major difference in the scoring for the SIERR Building was in the adjustments for the LEED credits were counted due to the differences between LEED systems used on each project. This adjustment is discussed in more detail below. Once the LEED scores were adjusted, the remining spreadsheet scoring followed the same process as the first three case studies to ensure consistency int he results.

The future-proofing scores for the SIERR Building were significantly higher than those for the UW Restore the Core Buildings. The SIERR Building achieved a raw score of 202 points compared to raw scores between 114 and 130 for Clark Hall, Playhouse Theater, and Savery Hall. The significant difference was unexpected because while the SIERR building was chosen specifically for its differing ownership, uses, configuration, history, location, and several other factors, the approaches to renovation were relatively similar in many ways.

Further investigation of the raw scores was undertaken to better understand the significantly different scores. The SIERR Building renovation scored higher on Principles 11 and 12 because the building was designated a landmark at local, state and national levels during the renovation process and followed many best practices using the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. There were several other credits from the Envision rating system that this project also achieved. However, the most significant change discovered was the use of a different LEED rating system for the project.

The scoring for the SIERR Building was adjusted because the renovation was completed under LEED 2009 rather than LEED version 2.1. This is important because the number of points available increased from 69 to 110 under LEED 2009. When this increased number of points was translated into the Future-Proofing scoring system, it led to a significant advantage in most of the point categories. The greatest increase in points scored was seen under Principle 6, Obsolescence, and Principle 9, Local and Healthy. Points scored under other Principles increased from 50% to 100%. The scores were adjusted to balance the differences between the different LEED rating systems and yield comparable results. The ratio of LEED points available was applied to the LEED points earned by the SIERR building resulting in a proportional reduction of the points scored. Points earned under other criteria, such as Envision, were not adjusted. The adjusted scores for the SIERR Building were used throughout the remainder of the analysis. The remainder of the scoring process was the same as for the UW Restore the Core case studies and the weighting of the Principles was also kept the same. The raw score points and the adjusted points are shown in the table below.

The adjustment to the LEED scores for the SIERR building did not significantly change the results of the future-proofing rating. The SIERR Building scored and adjusted weighted 171 points total compared to 130 points for Clark Hall. The strong LEED scores helped contribute to Principle 9. However, this project earned fewer points for LEED-based credits than Clark Hall after the adjustment for the LEED rating system differences, so high LEED scores do not explain the success of the project.

Two major differences contributed broadly to higher scores: first, the design goal to make the building last for another 100 years and, second, the historic character of the project. The focus on extending he building's service life for another 100 years resulted in design decisions that earned more points for durability, adaptability, and flexibility and long term monitoring and maintenance under Principles 1, 2, 4, 5, 7, and 8. In addition, the SIERR Building earned more points under Principles 11 and 12 due to designation at local, state, and national levels, tax credit benefits, and the application of the *Secretary of the Interior's Standards* during design and agency review of the project. Completion of the designation and design review process at multiple levels earned the project many more poins than the "Restore the Core" projects.

The adjustment made to accommodate the increased number of points under LEED 2009 while convenient, remains problematic. The adjustment has revealed a critical issue in the use and application of the future-proofing scoring system. The system will need to be continuously updated to reflect the current scoring systems that fed into the future-proofing scores. The use of a proportional adjustment of the scores was convenient for this research, but the scoring systems that contribute to future-proofing evaluations are continually evolving. This evolution of the LEED scoring system results in new point totals that cannot easily be compared to earlier versions as new points are added, old points become prerequisites or are removed, and individual criteria have changing numbers of points. The LEED system is not intended to be a static system, but rather is intended to evolve to "raise the bar" and encourage growth in sustainable design.

The evolution of the underlying that fed the future-proofing system suggests that while future-proofing principles will remain constant, the scoring and evaluation will similarly need to evolve over time.

The results from the fourth case study using the SIERR Building demonstrated that the future-proofing scoring system can be applied to different types of projects in different locations and with differing goals. However, it also revealed that the system must be updated periodically to be applicable to projects completed using differing point scoring systems. The proportional adjustment of the scores is not a viable option over the long term development of a rating system for future-proofing historic buildings.

Chapter 9: Interpretation and Generalization of the Case Studies

The concept of future-proofing historic buildings is a valid approach to evaluation of designs for interventions in historic buildings. When applied to interventions in historic buildings, future-proofing can extend the service life and promote better management of the built environment as a resource rather than as a commodity.

The twelve Principles proposed for a future-proofing system for interventions in historic buildings capture the essential attributes and develop guidance that can be applied during a design process. The success of the application of the principles can be measured by evaluating a proposed design against the criteria of the future-proofing rating system. It is important to recognize that this rating system need not be applied after a project is completed, as was done with the four case studies. The ideal place for future-proofing analysis is in the design process as an evaluative tool that helps in the development of design approaches and design details to prevent damage to historic structures before contractors are on site. Future-proofing can also inform the maintenance of an historic building.

The Future-Proofing rating system, as presented in this thesis (in June 2016), is based upon criteria developed by several other rating systems such as RELi, LEED, Envision. This has the advantages of utilizing pre-formed ideas and criteria, but is also limited by what has been developed and the evolution of those rating systems. However, it must be admitted that the proposed future-proofing system does not necessarily capture all aspects of the ways in which buildings are future-proof. See Chapter 11 for additional thoughts on the development of a rating system for future-proofing.

The rating system for future-proofing developed in this research can be broadly applied to different renovation projects. Early investigations into the Principles of Future-Proofing suggest that a broad spectrum of projects, can benefit from this concept (see Appendix 1). In addition, the four case studies demonstrate that the rating system can be applied to projects in different locations, climatic conditions, building uses, levels of deterioration, and landmark designations. This rating system can be applied regardless of who the owner, design team, or contractors are, when it is completed, regardless of the design, construction, and delivery process of the project. Future-proofing is a proactive approach to preventing deterioration and reduction of building service life for buildings of all kinds.

Chapter 10: Conclusions About Future-Proofing and the Rating System

Several conclusions result from the research on future-proofing, development of the Principles of Future-Proofing, and the creation of the future-proofing rating system.

1. Attributes of a "future-proof" can be derived from the use of the term in scholarly literature. Analysis of weekly Google Alerts listing articles using the term future-proof have shown continuing use of the term with consistent attributes. These attributes can be codified as a set of Principles to guide design processes and subjectively evaluate historic buildings.

2. Future-Proofing is valuable because it embodies a broader definition of resilience. Sustainable design focuses on minimizing impacts on earth's water, air, energy, and material resources. Popular concepts of "resilience" focuses on resistance to seismic events and climate change through an engineering resilience. Life Cycle Analysis focuses on the environmental impacts on the planet. Future-proofing is the only system that combines these valuable attributes of contemporary design, but also adds other dimensions such as cultural heritage to arrive at a system for holistic management of our built environment as a resource rather than a commodity.

3. The Future-Proofing rating system is a valuable tool for objectively evaluating interventions in historic buildings. The rating system conveys the priorities and goals of future-proofing by valuing their achievement in each project. More importantly, it enables the comparison of multiple projects from around the planet to be compared on a system that accommodates differing priorities depending on the circumstances of the project. These priorities can be a result of client preferences, important regional issues, climatic conditions or other issues. Because of the way preservation is practiced, both specialized practitioners and generalist firms can benefit from a well-structured approach to considering interventions in historic structures. Future-proofing offers guidance for the stewardship of historic structures for future generations without compromising the ability of these structures to serve people today. It also provides a framework to discuss projects with the general public.

4. Future-proof capacity can be measured by specific, objective criteria as well as subjective application of the Principles. The criteria developed to assess future-proof capacity are applicable to any

intervention in an historic building. While the Principles of Future-Proofing are consistent, the means by evaluating future-proofing will evolve due to changes in the underlying rating systems. This evolving rating system allows for further development of what makes an historic building future-proof.

5. There is no one-size-fits-all solution for future-proofing historic buildings. Future-proofing is designed to be a flexible system that can be applied to different types of buildings in different regions and climates and accommodate different design goals for each project. There are multiple ways to create and manage a future-proof built environment and this rating system allows for accommodation of those differences.

6. Continuous revision of the rating system is required. Continuous updating of the system would be required to prevent obsolescence of the system. As noted above, the underlying reating systems are evolving over time. In order for this rating system to continue to be applicable, the credits used to evaluate future-proofing must also be updated. As new credits are developed and incorporated into the underlying rating systems, old credits may continue to be valuable since they may continue to represent valid future-proofing strategies.

Chapter 11: Future Research

The research in this thesis focuses on the application of the Principles of Future-Proofing to existing and historic buildings. it is also possible to consider further, broader applications of the Principles to other parts of the built environment and to other industries. Additional research and testing could explore aspects of future-proofing in more detail to develop a better understanding of some nuances of future-proofing. The rating system developed in this thesis might also be refined.

Future-Proofing the Historic Built Environment

The version of the Principles presented in this thesis can be further developed and tested. One question is whether there are other aspects of future-proofing that have not been considered to date. Further development of the Principles themselves may prove valuable as there may be aspects of the meaning of future-proofing that have not yet been identified.

One potential aspect of the Principles that is not included is the use to which an historic building is put. Buildings deteriorate when they are not used. When a building is being used, people care about the building. A building in use provides shelter and provides physical and psychological security as well. Owners and occupants are inherently interested in protecting a building so that it continues to give them shelter. A Principle called "Use It!" might be added to the Principles of Future-Proofing.

Principle #13: Use it!

"A building lived in, is a building loved, is a building lasting" (Brian Rich, 2014). Buildings that are not used are neglected and fall into further and further deteriorated states, eventually resulting in the loss of the building. Using a building helps to prevent physical obsolescence and precludes functional obsolescence.

Sustainable design is important to future-proofing because it demonstrates a way of critically thinking about our built environment, but future-proofing a building challenges sustainable design to address larger issues in resource management. If, as Carl Elefante noted, "the greenest building is the one already built," then the retention of embodied energy and viable building materials is an essential step in managing consumption of resources (Elefante 2014). This suggests that the approach taken by the "Restore the Core" program to demolish all of the interior features of a building could be considered contrary to the intent of sustainable design strategies. However, when the full implications of the work needed in an historic building is considered, full interior demolition may be justified. For example, in the "Restore the Core" buildings, elecrical and mechanical systems are likely outdated an require complete replacement, structural seismic interventions require access to the existing structure, and room configurations may not support current department or pedagogical needs.

Future-proofing is found in discussions of sustainable design, often in relation to sustainable obsolescence (see Chapter 3). Georgiadou, et al, found sustainable housing to be more future-proof and preservationists have argued for years that historic buildings are more sustainable than new construction, as evident in the National Trust for Historic Preservation's report entitled "The Greenest Building" (Elefante, 2014).

The future-proofing rating system developed in this thesis utilizes credits developed under several other rating systems. This approach proved convenient and recognized the thoughtful development of those other systems. However, this rating system still seems to not capture some of the characteristics that are important to the concept of future-proofing. The development of additional points is merited as part of the ongoing development of this research. Potential research on new credits can include topics such as:

- Large span structural bays;
- Over-designed structural system;
- Move structural braced frames and shear walls to perimeter
- Design with future expansions of the building incorporated – expansion upward or outward;
- Test designs to accommodate different uses in the future;
- Better definition of durable materials;
- Focus on installation to prevent weather intrusion of the elements;
- Specify installation sequences and exposures that will prevent interim deterioration of materials;
- Required mockups for all exterior building systems – sometimes already done with envelope consultants;
- Use sealants less (ideally none) in building enclosures.

Further research into how the Principles can be incorporated into historic preservation practice could be undertaken. The international system of cultural heritage documents is evolving in a way that allows for the addition of new and more refined approaches to preservation. This evolution is shown in the list of cultural heritage policy documents available by the Getty Conservation Institute (Getty, 2015). In contrast, the system of preservation in the United States seems limited by the adoption of the *Secretary of the Interior's Treatments for Historic Properties*. These Standards have been incorporated into codes for thousands of independent jurisdictions across the country. This makes it very difficult to alter the system to accommodate new and changing approaches in preservation. The U.S. system has resulted in fewer guiding policies being developed, tested, and adopted compared to international preservation practice. This difference becomes important as the current movement towards value-based preservation becomes recognized as the standard approach to our cultural heritage.

Research on the following questions would also support a better understanding of future-proofing:

1. Can there truly be a future-proof building if deterioration is constant? Will every building eventually be unable to serve its functions?

2. When is a building future-proof? After 100 years? 200? 500? How long does it have to last?

3. Development of recommended weightings for different building types, regions, or other factors would be useful as guidance for future applications of the Principles of Future-Proofing.

4. Does the use of local traditional building materials mean a return to pre-industrial building methods?

5. Investigation of total project cost over the life span of a future-proof building and its impact on the economy would help to develop an economic argument for future-proofing.

When considering some of the expansive research below, it is also important to consider if there are derivative variations of the Principles that must be developed. These derivatives may be required to adjust the Principles to focus on aspects of future-proofing that are specific to a particular industry.

Expanding the Application of Future-Proofing Beyond Historic Buildings

Many fields or professions in the built environment use a criteria-driven design process. Design disciplines such as structural, mechanical, electrical, and other fields of engineering may also be able to apply future-proofing to their work. Future-proofing can also be applied to larger contexts such as landscape design, urban design, and infrastructure design and development. Future-proofing can be applied to the construction industry as a lens through which to discover better approaches to building assembly and repair. Similarly, other design-based industries could apply future-proofing such as industrial design or product design. The goal should be to develop products that hold long lasting value, as opposed to today's consumption-based society.

In addition to other disciplines within the AEC industry, future-proofing may also be applied to other industries. Where much of the economy since World War II has been based on the development of a consumer society that has resulted in the view that we live in a disposable society, future-proofing as explored in this thesis proposes to reverse this trend and focus on managing resources in a way that does not simply dispose of them when they are considered obsolete or no longer useful. As seen in the literature review, other industries use the term "future-proof." Their meaning varies little despite the variety of industries and the context in which the phrase is used. An ongoing Google Alert for the term "future-proof" has revealed not only the consistency in the use of the term, but also the vast array of industries that seek to develop future-proof products. These industries include everything from manufacturing, computers and medical equipment, industrial design and many others. However, some individuals and companies now seek to develop products with lasting value that will differentiate them from their competition.

Additional questions include:

1. Investigation of the impacts of the seismic retrofit codes that are under development. These may future-proofing our local buildings against specific threats, but do they go far enough in making the buildings future-proof?

2. How does economics work on a finite planet with consumption exceeding the resources that are available? Scarcity in an age of declining resources is an essential question.

Other philosophies could be considered in relation to the Principles of Future-Proofing. Concepts such as the Transition Principles developed by the Transition Network, Permaculture Principles, scarcity, and the Repair Manifesto may inform the understanding of future-proofing. Development of an understanding of how to continue to live and prosper in our resource limited world is essential to our future. the Principles of Future-Proofing contribute to this development. Further research can improve upon the Principles of Future-Proofing.

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Appendices

Appendix 1: Previously Published Articles on Future-Proofing

All articles reprinted with permission from the respective publishers and by permission of Brian D. Rich. Articles are listed chronologically.

Kelley, Peter. 2014. "'Future proofing': Present protections against challenges to come." UW Today. November 4, 2014. http://www.washington.edu/news/2014/11/04/future-proofing-present-protections-against-challenges-to-come/.

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Rich, Brian D. and Gattuso, Meghan. 2016. "Future-Proofing Critical Water Infrastructure from an Economic and Hazard Resilience Perspective." Originally published in the Association of Collegiate Schools or Architecture, 104th Annual Meeting Proceeding, Shaping New Knowledges., Seattle, WA. Corser, Robert and Haar, Sharon, Co-chairs. Pp. 636-643.

Appendix 2: Case Study Information

UW Clark Hall
UW Playhouse Theater
UW Savery Hall
The SIERR Building at McKinstry Station

Appendix 3: RELI Rating System

Appendix 4: Development of the Future-Proofing Rating System

Appendix 5: Thesis Presentation and Discussion

Appendix 1: Previously Published Articles on Future-Proofing

November 4, 2014

'Future proofing': Present protections against challenges to come

Peter Kelley
News and Information

You can't predict the future, but you can prepare for it.

That's the thinking behind the concept of "future proofing" in design, architecture, engineering and construction: Taking steps now to prevent or lessen building damage or structural challenges yet to come.

Architect – and architecture graduate student — Brian

And though architect and University of Washington staff member Brian Rich doesn't claim to have coined the term, he seeks to clarify future proofing, as it pertains to historic buildings, in a paper accepted for publication in the Journal of Preservation Education and Research.

Rich studied repairs to the the walrus heads adorning Seattle's Arctic Building as he compiled information for his journal article on "future proofing." ***Brian Rich***

Rich is an associate construction manager with the UW Capital Projects Office as well as a graduate student working on a master's degree in architecture with a certification in historic preservation. He has a professional background in preserving old buildings, especially theaters from the vaudeville age, and has his own architectural firm, called Richaven PLLC.

Future proofing, Rich said, is similar to the widely accepted term "resilience" — defined by the Resilient Design Institute as "the capacity to adapt to changing conditions and to maintain or regain functionality … to bounce back after a disturbance or interruption of some sort."

Rich sought a definition with a slightly different context. "Their understanding of resilience was very broad. I am looking more specifically at existing and historic structures — and how we can design interventions in those structures that would be beneficial, as opposed to causing more problems for the building."

He reviewed literature on the topic from recent years, "focusing on how the term is used in a multitude of different contexts, and trying to put together a coherent theory of future proofing," he said. "One of the cornerstones is flexibility and adaptability — leaving the building in a way that it can be changed in the future."

Ten principles of "future proofing" historic buildings, by Brian Rich

- Promote prevention of

Other basic principles of future proofing, Rich writes, include fortifying the "built environment" against climate change, considering long-term benefits and problems when intervening to improve historic deterioration of our built environment.

- Allow understanding of the built environment and its place in our heritage.
- Stimulate flexibility and adaptability of our built environment and our attitudes toward it.
- Extend service life of our built environment.
- Fortify our built environment against climate change, extreme weather and shortages of materials and energy.
- Increase durability and redundancy of our built environment.
- Reduce the likelihood of obsolescence.
- Consider long-term life-cycle benefits of interventions in our built environment.
- Incorporate nontoxic, renewable, local materials, parts and labor into our built environment.
- Comply with applicable cultural heritage policy documents

structures, using nontoxic, and renewable materials, and staying mindful and respectful of the cultural heritage of the structure.

Rich added that the process seeks to accommodate coming challenges "both negative and positive." An economic downturn might result in a building being left without occupants or maintenance for years, causing it to deteriorate more quickly. Conversely, an upswing could bring a different use for which the building is also well suited — if it has been designed to last.

In his paper, Rich used the iconic walrus heads that adorn the third floor of Seattle's century-old Arctic Building as a case history, commenting on past rehabilitation efforts and suggesting 10 basic principles of future-proofing for historic buildings.

The building was constructed in 1917 as the headquarters of the Arctic Club, used for offices in subsequent decades and sold to the City of Seattle in 1988. Twenty-seven impressive terra cotta walrus heads with descending tusks grace the outside along the third floor, held in place with steel reinforcements. That steel began corroding by the late 1970s, and the tusks started failing.

Repairs in the early 1980s included anchoring new tusks into place with stainless steel rods drilled into place from the top of the heads, and a gypsum/Portland cement grout mix — but "cracks began appearing almost immediately," Rich said. A 1995 investigation found that the gypsum had expanded in reaction to water that had seeped in from above. About a dozen of the walrus heads needed to be replaced.

Rich doesn't lay blame, especially since research on the expansive properties of gypsum was still new when the repairs were made.

But it got him thinking: "How can we have a process — a checklist or some criteria to help us think through the issues involved, so interventions don't damage buildings in the future.

"That's all I'm espousing here," he said. "People may shoot arrows at me, but that means they're thinking about it, and that's good. With the article I'm hoping to start a conversation."

###

For more information, contact Rich at 206-616-1404 or richaven@uw.edu.

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Tagged with: Capital Projects, College of Built Environments, Department of Architecture

Comments for this thread are now closed.

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Editorial correspondence, including manuscripts for submission, should be emailed to Jeremy Wells at jwells@rwu.edu and Rebecca Sheppard at rjshep@udel.edu. Electronic submissions are encouraged, but physical materials can be mailed to Jeremy Wells, SAAHP, Roger Williams University, One Old Ferry Road, Bristol, RI 02809, USA. Articles should be in the range of 4,500 to 6,000 words and not be under consideration for publication or previously published elsewhere. Refer to the back of this volume for manuscript guidelines.

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The Principles of Future-Proofing: A Broader Understanding of Resiliency in the Historic Built Environment

BRIAN D. RICH

ABSTRACT—The principles of future-proofing are derived through a literature review of the use of the terms "future-proofing" and "resiliency" in the architecture, engineering, and construction (AEC) industry and other industries such as electronics and environmental design. The principles are focused on application to the preservation of historic buildings and are demonstrated through a case study of the 1980-2000 walrus head and tusk repairs at the Arctic Building in Seattle, Washington. The principles assist in consideration of the best practices for the treatment of an historic building by establishing a baseline series of criteria by which to evaluate interventions in historic buildings.

As architects and preservationists, we always strive to make the best designs within the constraints of our projects and our understanding of building technology. Sometimes the results are spectacular successes; at other times the results are less successful. The myriad decisions that contribute to the design and construction process inevitably impact the long-term success of a project. Future-proofing, the process of anticipating the future and developing methods of minimizing the effects of shocks and stresses due to future events, can help guide the rehabilitation process to optimum results. This essay brings together the many ideas of resiliency, future-proofing, historic preservation, and heritage conservation into a coherent set of principles and reveals patterns in a variety of lines of thinking that may remain hidden due to the variety of their sources.

This essay explores the concepts of future-proofing and resiliency present in the architecture, engineering, and construction (AEC) industry and other industries both within the United States and around the globe. Many of the concepts of future-proofing are also present in historic preservation and heritage conservation theory and practice, though not in a cohesive form. Through an analysis of the concepts of future-proofing and resilience, a set of principles is developed to guide the process of rehabilitation of historic buildings. Consideration of interventions in historic buildings in light of these principles may inform the rehabilitation process and prevent flawed rehabilitation efforts.

A case study of the interventions completed in the late twentieth century on the Arctic Building in Seattle, Washington, demonstrates two interventions to rehabilitate deteriorating terra cotta walrus head ornamentation. The first repair, while undoubtedly designed and executed to the best of the architects' and contractors' knowledge and ability, caused further damage. The second future-proof rehabilitation effort successfully remedied the problems of the original design as well as the first rehabilitation efforts.

How can these two interventions inform the rehabilitation process? How can we make more reliably successful designs and reduce the possibility of flaws that cause deterioration of either new, or, more important, historic building fabric? These questions are discussed and answered through analysis of the rehabilitations at the Arctic Building. Study of the 1982 rehabilitation of the walrus tusks at the Arctic Building demonstrates one manner in which rehabilitation efforts did not anticipate future stresses. Study of the 1996 rehabilitation of the walrus heads and tusks illustrates how the concepts of future-proofing may support the rehabilitation process.

THE CONCEPTS OF FUTURE-PROOFING AND RESILIENCE

Due to the complexity of buildings and the design and construction process, it is difficult, if not impossible, to know that our solutions will always be successful. The concepts of future-proofing and resiliency, two closely related subjects, provide guidance to the rehabilitation process. These concepts inform our ideas of how to achieve enduring and sustainable built environments. Whereas future-proofing is a concept found largely outside the United States, "resiliency" is a term increasingly used within the United States, though both are found in a variety of industries. There are also several related concepts already contained within architectural historic preservation and heritage conservation theory and practice.

The Concept of Future-Proofing

The concept of future-proofing is the process of anticipating the future and developing methods of minimizing the negative effects while taking advantage of the positive effects of shocks and stresses due to future events. While the connotations of the term "future-proofing" may be considered negative if the future is thought of in a negative light, similar to bullets and bullet-proofing, future-proofing can also be taken in a positive light. Buildings may also be able to take advantage of the changing attributes of a continually evolving environment, such as the restoration of blighted neighborhoods. If the term "future-proofing" is unpalatable to preservationists, one could also argue for a wider definition of "resiliency" since they both promote very similar concepts.

Future-proofing is a concept that is found in multiple different industries, though use of the term was uncommon in the architecture, engineering, and construction (AEC) industry until the past fifteen to twenty years. Future-proofing is a concept that has been developed largely outside the United States and outside the AEC industry. The industries where future-proofing is used include electronics, data storage, utilities systems, industrial design, environmental and ecological design, and energy conservation. Within the AEC industry, the term "future-proofing" is found most often in the sustainable design field. The concepts of future-proofing are more widespread in the AEC industry, but have not been brought together as a coherent approach to projects.

In the electronics industry, future-proofing references data and image storage and computer electronics. In future-proof electrical systems, buildings should have "flexible distribution systems to allow communication technologies to expand," says Raul Barreneche (1995, 123). Thomas and other designers at Bell Laboratories, Lucent Technologies Australia, focus heavily on the ability of a system to be reused and to be flexible in order to continue competing in the marketplace (Thomas et al. 2003, 150).

In one region of New Zealand, Hawke's Bay, a 2012 study by the consulting firm Page Bloomer Associates specifically sought to understand the existing and potential water demand in the region as well as how this potential demand might evolve with climate change and more intense land use. This information was used to develop demand estimates that would inform the improvements to the regional water system. Future-proofing thus includes forward planning for future development and increased demands on resources (Bloomer and Page 2012, i-vi).

In industrial design, future-proofing strives to encourage people to acquire fewer products by creating objects that hold more value for the purchaser (Kerr 2011, 7). Kerr goes on to state that future-proof products should have a degree of atemporality. As a product wears and ages, its overall desirability is maintained (Blanco-Lion, Pelsmakers, and Taylor 2011). Ideally, desirability exemplifies a positive change; the product can fit into society's paradigm of "progress" while simultaneously changing that paradigm (Kerr 2011, 9).

In the realm of sustainable and environmental issues, future-proof is used to describe the ability of a design to resist the impact of potential climate change due to global warming, based on research by faculty at University of Bristol and the University of Moratuwa in Sri Lanka. Two characteristics describe this impact. First, dependency on fossil fuels will be more or less completely eliminated and replaced by renewable energy sources. Second, society, infrastructure, and the economy will be well adapted to the residual impacts of climate change (Godfrey, Agarwal, and Dias 2010, 180). In the design of high-performance dwellings, "buildings of the future should be sustainable, low-energy and able to accommodate social, technological, economic and regulatory changes, thus maximizing life cycle value." Georgiadou, Hacking, and Guthrie (2013, 9) believe that the goal is to reduce the likelihood of a prematurely obsolete building design.

The concept of future-proofing also comes up in some literature with specific regards to sustainable preservation strategies. Initial studies on climate change and historic structures were carried out by English Heritage in 2004, and scientific research such as *Engineering Historic Futures* and the European Union's *Noah's Ark Project* have been completed (Cassar 2009). Cassar, for example, suggests interest in sustainable rating systems if durability is incorporated as a metric for evaluating buildings. Cassar also argues that historic buildings must fully engage in the process of "adaptation to climate change," lest they become redundant and succumb to "environmental obsolescence" (Cassar 2009, 7). Cassar also recommends a "'long life, loose fit' strategy to managing historic buildings" (Cassar 2009, 8), meaning that sustainable design protocols must be able to be adapted to the particular circumstances of each building rather than applied to the entire built environment with broad brush strokes. Most important, Cassar highlights one of the underlying values of future-proofing— the "historic built environment is a finite and non-renewable resource"—and concludes that "heritage must adapt to changes, physical and intellectual, within its environment" (Cassar 2009, 10). Because embodied energy comprises a significant percentage of energy consumed over a building's service life, the preservation and adaptation of buildings plays a "central role in conserving the past and the future" (Holland 2012, 5).

The hygrothermal performance of the original building materials at the Hudson Bay Department Store in Victoria, British Columbia, was carefully analyzed to ensure that improvements would not reduce the "building's time-proven durability" (Dam 2011, 47). In reference to the Marquette Railroad Depot in Bay City, Michigan, Tyler and Dilcher note that "the use of durable, long-lasting materials was cost effective 100 years ago, and restoring those materials today extends their service into the next century" (Tyler and Dilcher 2010, 24). All of these articles on sustainable preservation strategies discuss various concepts of future-proofing, including durability, doing no harm, extension of service life, adaptability, and avoiding obsolescence.

As mentioned above, a future-proof building is also one that does not become obsolete. Reed and Warren-Myers state that in the valuation of real estate, there are three traditional forms of obsolescence: physical, functional, and aesthetic. Physical obsolescence occurs when the physical material of the property deteriorates and needs to be replaced. Functional obsolescence occurs when the property is no longer capable of serving the intended use or function. Aesthetic obsolescence occurs when fashions change or when something is no longer in style. A potential fourth form, sustainable obsolescence, occurs when a property no longer meets one or more sustainable design goals (Reed and Warren-Myers 2012, 1). Obsolescence is an important characteristic of future-proofing a property because it emphasizes the need for the property to continue to be viable.

In Australia, research commissioned by Health Infrastructure New South Wales explored "practical, cost-effective, design-related strategies for 'future-proofing' the buildings of a major Australian health department" (Carthey et al. 2011, 89). This study, conducted by several faculty and staff at the University of New South Wales, concluded that a focus on a whole lifecycle approach to the design and operation of health facilities would have clear benefits (Carthey et al. 2011, 106). By designing flexible and adaptable structures, one may defer the obsolescence and consequent need for demolition and replacement of many health facilities, thereby reducing overall demand for building materials and energy (Carthey et al. 2011, 106).

In 1997, the MAFF laboratories at York, England, were described by Lawson as "future-proof" by being flexible enough to adapt to developing rather than static scientific research (Lawson 1997). In 2012, a New Zealand–based organization promoting future-proofing outlined eight principles of future-proof buildings: smart energy use, increased health and safety, increased lifecycle duration, increased quality of materials and installation, increased security, increased sound control for noise pollution, adaptable spatial design, and reduced carbon footprint (CMS 2012).

Future-proofing, as evidenced in the above industries, offers several concepts that may guide enduring interventions in our built environment as well. These concepts include obsolescence, durability, adaptability, sustainability, local materials and labor, atemporality, forward planning, and re-use. In the AEC industry and many other industries in the United States, the closely related concept of resilience has gained a significant following and offers several key concepts as well, as we will see in the discussion that follows.

The Concept of Resilience

"Resilience" is a current buzzword used to describe architecture and environments that can withstand external shocks to a system. While commonly used in the popular media, the term "resilient" has also received significant attention in recent scholarly articles. Not only has the term become common in reference to the built environment, but it is also widely used in reference to computing and networking systems, environmental and biological studies, and individual people.

As Jill Fehrenbacher notes, "In November 2012, 'Resilient Design' was a trending search term in Google, moving from near obscurity in the months before the devastating super storm to a popular catchphrase post-Sandy" (Fehrenbacher 2014). The Resilient Design Institute (2013) offers a succinct summary of the principles of resilient design. Intended to be broadly interpreted and applied, they are not specifically focused on the built environment. They do, however, offer some vital clues about resilience that can be applied to the built environment.

- Resilience transcends scales.
- Resilient systems provide for basic human needs.
- Diverse and redundant systems are inherently more resilient.
- Simple, passive, and flexible systems are more resilient.
- Durability strengthens resilience.
- Locally available, renewable, or reclaimed resources are more resilient.
- Resilience anticipates interruptions and a dynamic future.
- Find and promote resilience in nature.
- Social equity and community contribute to resilience.
- Resilience is not absolute.

Very few scholarly articles specifically discuss "resilient architecture," though resiliency is a common topic of discussion in many areas of our lives today. Many of the articles that do discuss "resilient architecture" focus on networks and technology systems. For example, Shi and Khan use resiliency to describe shared-memory multicores for computing and communication networks (Shi and Khan 2013). Another article discusses resiliency in off-shore wind farm communication networks, suggesting that a resilient communication network "can be achieved through a combination of redundancy and Quality of Service" (Gajrani, Gopal Sharma, and Bhargava 2013, 023139-1).

According to Applegath et al. (2010), the principles of a resilient built environment include:

- local materials, parts, and labor
- low energy input
- high capacity for future flexibility and adaptability of use
- high durability and redundancy of building systems
- environmentally responsive design
- sensitivity and responsiveness to changes in constituent parts and environment
- high level of diversity in component systems and features

One approach to resilient cities is an integrated multidisciplinary combination of mitigation and adaptation to raise the level of resilience of the city. In the context of urban environments, resilience is less dependent on an exact understanding of the future than on tolerance of uncertainty and broad programs to absorb the stresses that the urban environment might face. The scale of the context is important: events are viewed as regional stresses rather than local. The intent for a resilient urban environment is to keep many options open, emphasize diversity in the environment, and perform long-range planning that accounts for external systemic shocks (Thornbush, Golubchikov, and Bouzarovski 2013). Options and diversity are strategies similar to ecological resilience, discussed below. This approach again points out the importance of flexibility, adaptability, and diversity to future-proofing urban environments.

Personal resiliency is a common theme in the discussion of recovery from the Boston Marathon bombing (Time 2014) and other natural disasters such as Hurricane Sandy (Bernstein 2012). Important in these stories of personal resilience is the ability of people to persevere in spite of severe physical and mental injuries, "shattered bones, severe burns, and shrapnel wounds" (Sanchez 2014). Resilience in the workforce in China is the subject of another paper. Increasing performance pressure is requiring employees to be more resilient. The paper notes that there is an "increasing overlap between the key attributes in resilience and soft skills. This overlap of resilience and soft skills is identified in 9 dimensions: vision, determination, interaction, relationships, problem-solving, organization, self-confidence, flexibility & adaptability, and pro-activeness" (Wang, Cooke, and Huang 2014, 135).

In its common usage, "resilience" describes the ability to recoil or spring back into shape after bending, stretching, or being compressed. In ecology, the term "resilience" describes the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state (Applegath et al. 2010). Resilience in the natural environment is a subject of current research as humans take more interest in the impacts human activity has on our planet. In an article about the development of urban social-ecological systems, Schewenius, McPherson, and Elmqvist argue that "urban futures that are more resilient and sustainable require an integrated social-ecological system approach to urban policymaking, planning, management, and governance" (2014, 434).

Biological resilience is commonly discussed in research focused on the ability of a living organism to resist and even thrive despite changes to its natural environment. In biological studies off the coast of Italy, oceanic sediment bacteria are described by Kerfahi et al. as resilient in the face of rising levels of carbon monoxide in the ocean waters. Here, resilient is taken to mean that the bacteria are resistant to the corrosive waters (Kerfahi et al. 2014). In an environmental study by Hoggart, "coastal habitats surveyed are relatively resilient to flooding due to their species rich nature and their ability to adapt to flooding. However, specific groups of plants such as grasses are more affected by flooding and less able to recover" (Hoggart et al. 2014, 170). This suggests that adaptability and the ability to recover from flooding are important attributes of resilience.

Through this sampling of recent articles on resilient design and resiliency in computer networks, personal resiliency, and resiliency in urban, ecological, and biological systems, it is clear that the term has been widely used. From these articles, it is also clear that there are several characteristics of resiliency that are similar to the concepts of future-proofing. These characteristics include redundancy, diversity, flexibility, durability, adaptability, and local resources such as materials and labor, to anticipate systematic shocks in a changing future.

Resilience and Climate Change in Heritage Resources

Resiliency and future-proofing are also at the core of the discussion of the impacts of climate change on cultural heritage. The Getty Conservation Institute (GCI), the Association for Preservation Technology (APT), the National Trust for Historic Preservation, UNESCO, and English Heritage all have focused on this issue in recent years. The Spring 2011 issue of *Conservation Perspectives*, the GCI newsletter, is dedicated to the intersection of the impacts of climate change and our heritage. In this edition of the newsletter, Cassar states that climate change "poses significant challenges for cultural heritage" (Cassar 2011, 11). Much of what Cassar discusses in her article describes the need to understand the impacts of climate change on our heritage and developing policies to address these impacts. The policies Cassar promotes deal with how to respond to climate change in a way that will help our heritage endure. The concepts of future-proofing are an essential component in responding to climate change by providing the framework for implementing the policy Cassar promotes developing. In the same issue of *Conservation Perspectives*, Jean Caroon states in an interview that "there's no way to make a building that doesn't have an environmental impact," but that "you can lessen the environmental impact by taking existing objects and extending their service life" (Caroon 2011, 19). Decreasing environmental impacts and extension of service life are two very important concepts in future-proofing. This edition of *Conservation Perspectives* concludes with a list of several other sources that discuss the impacts of climate change on cultural heritage and the need to respond to these impacts.

One of these other sources, APT, has dedicated a symposium to the subject. In 2004, the APT formed a Technical Committee on Sustainable Preservation and a subcommittee on climate change. The following year, the Halifax Symposium was held at the 2005 APT Annual Conference. At this symposium, several concepts were found in common between sustainability and the mission of APT. The principal concepts, summarized by Lesak (2005), include:

- understanding the importance of stewardship and planning for the future
- building to last, including material selection and treatment, craft, and traditional building techniques

- durability and service life of materials and assemblies and their implications for lifecycle assessment
- understanding extending buildings' service lives and systems renewal

The concepts also included a system of evaluation of existing buildings that included "creating sustainable building stock…by assessing material value and energy value" (Lesak 2005, 4). The last level of evaluation included a "product rating system to establish, test, and/or confirm effectiveness, durability, life cycle impacts, [and] renewability" of building materials and products (Lesak 2005, 4). One of the latest developments at APT is a planned special issue of the APT bulletin that focuses on climate change and preservation technology (Rankin 2014). From these statements, several concepts of future-proofing are highlighted, including forward planning, durability, extension of service life, including building systems, and lifecycle assessment.

UNESCO has published several documents that address climate change and heritage conservation, most notably World Heritage Report 22 titled *Climate Change and World Heritage* (UNESCO 2007). This report discusses predicting and managing the impacts of climate change and offers strategies for implementing responses. Much of Report 22 discusses developing a better understanding of the impacts of climate change through modeling, monitoring, and research and appropriate dissemination of the information (UNESCO 2007). However, the report also discusses the need for "adaptive design" in several places as well as identification and promotion of "synergies between adaptation and mitigation" (UNESCO 2007, 41). The report also recommends "increasing resilience of a site by reducing non-climactic sources of stress" and "adapting to the adverse consequences" of climate change (UNESCO 2007, 11). These statements in Report 22 demonstrate the characteristics of adaptation and increased fortification of heritage sites, both of which are important concepts in future-proofing and resiliency.

English Heritage's Conservation Bulletin dedicated its Spring 2008 issue to climate change as well, titling it "Adapting to a Changing Climate." In this issue, Cassar identifies several key research outputs that are necessary to address climate change that are similar to the approach to resilient cities discussed above. These include "adaptations to climate change" and "damage mitigation strategies for materials and assemblies" (Cassar 2008, 11). These outputs reflect the need for heritage to be reinforced and made more durable to resist the future impacts of climate change. These research outputs, thus, reflect the goals of future-proofing and resilience.

Clearly, resilience and climate change have been at the center of discussions on cultural heritage both within the United States and internationally. These discussions often focus on key aspects of future-proofing and resilience, including adaptation to climate change, extension of service life, and mitigation of the effects of climate change.

ATTRIBUTES OF FUTURE-PROOFING IN HISTORIC PRESERVATION AND HERITAGE CONSERVATION

There are many attributes of future-proofing that are inherent in aspects of historic preservation and heritage conservation theory and philosophy. Here, cultural heritage, while including the built environment referred to by the term "historic preservation," is also understood to include a broader realm of artifacts and intangible characteristics of a society, including artwork, sculptures, dance, clothing, and other expressions of our unique identities. In the context of historic buildings, the writings of Georg Morsch, James Marston Fitch, and Bernard Feilden are examples of how the concepts of future-proofing are embedded in preservation theory. The writings of Cesare Brandi, Paul Philippot, and Ernst Van de Wetering also address aspects of future-proofing and resilience in cultural heritage, advocating careful consideration of our heritage that is the goal of future-proofing. Each of these more nuanced approaches to conservation demonstrates some of the characteristics of future-proofing, but these characteristics have not been brought together as a single system of principles until now.

Georg Morsch's concept of conservation, outlined in 1980, includes two major goals: "first, that historical evidence and vestiges must be decipherable; and, second, that evidence and vestiges must be decipherable by a broad public which requests flexible approaches on certain conservation concepts" (Burman 1997, 278). This concept of interventions in historic buildings points out the need for flexibility while retaining a clear understanding of the historic fabric of the building.

James Marston Fitch argues that obsolescence of buildings is often determined on the basis of "superficial examination and inadequate data" (Fitch 1990, 63). Fitch goes on to suggest that there are important new techniques available that make the rehabilitation of historic buildings much more feasible, alluding to extending the service life, fortifying, and increasing the durability and redundancy of historic buildings. Modern preservation technologies make it possible to "reclaim even seriously damaged building fabrics and extend their effective life for decades into the future" (Fitch 1990, 105). Fitch also argues that "interventions for adaptive use will ordinarily be more conservative externally than internally," allowing for flexibility and adaptability to accommodate the new uses within the building (Fitch 1990, 169). Last, Fitch argues that the "reworking of extant structures to adapt them to new uses is as old as civilization itself" and has significant lifecycle benefits as the "characteristic mode of energy conservation" (Fitch 1990, 165).

Bernard Feilden calls conservation "primarily a process that leads to the prolongation of the life of cultural property for its utilization now and in the future" (Feilden 2003, x). Feilden advocates evaluation of all practical alternatives in a rehabilitation "to find the 'least bad' solution" (Feilden 2003, xi). Despite the awkward phrasing, the intent is derived from the Hippocratic approach of "do no harm," which he obliquely references and which is the basis of the future-proof concept of preventing decay. Feilden also advocates rehabilitation by keeping buildings "in use—a practice which may involve what the French call *'mise en valeur,'* or modernization with or without adaptive alteration" (Feilden 2003, 10), another goal of future-proofing.

The concept of different approaches to conservation and rehabilitation is captured in the variety of heritage conservation policy documents used across the globe. From the four different Standards developed by the National Park Service in the United States to the multitude of documents available to members of the World Heritage Convention, general and specialized guidelines are available. Flexibility and adaptability of treatment and use, maintaining authenticity, differentiation of additions, and implied support for the extension of the service life of historic buildings are all characteristics of these documents. In the words of Burman, we should "treat a historic monument in such a way that it could serve as an example for other cases, not as a straightjacket" (Burman 1997, 286).

The goal of heritage conservation is to preserve for all eternity the objects thought of as the world's patrimony (Appelbaum 2007). In this process, there are a myriad of different possibilities for the goals of the conservation treatment as well as the actual treatment methods and materials. Just as architectural historic preservation theory has evolved, so has conservation theory. Today, many of the key attributes of heritage conservation are similar to the concepts of future-proofing and resiliency.

By the middle of the twentieth century, the understanding of restoration evolved to include the functional restoration of a work of art and architecture as well as painting and sculpture. Cesare Brandi writes about art and architecture as equally valid works of art. However, the functional properties are still held secondary to the "primary or fundamental aspect that respects a work of art as a work of art" (Brandi 1996a, 230). In contrast to Viollet Le Duc's definition of restoration, Brandi holds that "restoration is the methodological moment in which the work of art is appreciated in its material form and in its historic and aesthetic duality, with a view to transmitting it to the future" (Brandi 1996a, 231). Brandi suggests that for buildings, the exterior appearance is primary, but that, in line with modern preservation requirements and designation of significant features, interior walls and structures may be altered to improve the building. This is important to the understanding of future-proofing and resiliency because it allows for flexibility and adaptability as well as the extension of service life, reduction of obsolescence, fortification, and increased durability and redundancy.

Brandi goes on to say that while "patina documents the passage through time of the work of art and thus needs to be preserved," the patina should be an "imperceptible muting" of the original materials and must be brought into equilibrium with the original materials (Brandi 1996b, 378). Brandi's intent is that the patina should not overwhelm and disguise the original, nor should patina be completely removed, but rather a balance must be sought between the two. This approach promotes the understanding not only of the original material but also the aging and interventions that it has been subjected to over its history.

For Philippot, it is the authentic relationship between the past and the present that must be integrated "into the actualization of the work produced by the intervention" (Philippot 1996c, 225). This is also very similar to the concept of promoting understanding of the historic structure both before and after rehabilitation. Most important here is recognition and respect for the *Gesamkunstwerk*, or "unity resulting from the cooperation and collaboration of the various arts and crafts" that made the historic building (Philippot 1996a, 271). A natural consequence of this approach then becomes evident when considering lacunae, or missing pieces, and new interventions. These interventions should be made in such a way as to "reestablish continuity … while being easily identified on closer inspection" (Philippot 1996b, 359). This again underscores the importance of understanding the evolution of an historic structure.

Conservation theory has evolved to understand that "each treatment, or even non-treatment, nevertheless involves an interpretation of the object" (Van de Wetering 1996, 193). "Restoration has a certain autonomy independent, to some extent, from the artist's intentions" (Van de Wetering 1996, 196). However, like Ruskin's philosophy, Van de Wetering also holds that there is a "growing awareness that we will never understand the artist's intentions to their full extent and that consequently our interpretations … never entirely cover the truth" (Van de Wetering 1996, 196). The restoration approach will thus vary; depending on the subject of the rehabilitation, different approaches may be appropriate. One approach, that of the collector, "prefers no restoration over authentic appearance," or, alternatively, one recognizes that "interventions are often inevitable" and are the "concrete manifestation of an interpretation" of the historic object (Van de Wetering 1996, 197). Like Brandi and Philippot, Van de Wetering argues for the ability to understand the original aged object as well as its history, and, further, that this be conveyed to future observers.

Appelbaum suggests that there are potential differences between the "ideal state for the object" and the "realistic goal of the treatment" (2007, xx) The goal of conservation is to protect the object, extend its service life, and reduce its obsolescence by making the object desirable to keep (Appelbaum 2007, xxvii). As noted by Van de Wetering, a treatment involves an interpretation. A treatment, then, is "an interpretation chosen to enhance the meanings for which the object is valued and to accommodate its intended future" (Appelbaum 2007, xxi). "Treatments that improve aesthetics, usability, or lifespan of an object all increase its utility" (Appelbaum 2007, xxvi). Appelbaum goes on to say that "slowing an object's deterioration also increases utility," "an object that cannot be used … provides no benefit," and "treatment is supposed to provide the physical strength to make those improvements last" (Appelbaum 2007, xxvii). Appelbaum's statements contain many references to future-proof concepts, including preventing deterioration and decay, reduced obsolescence, and extension of service life, among others.

Implicit in the dozens of cultural heritage policy documents that address both heritage conservation and historic preservation are the doctrines of minimal intervention, reversibility, and differentiation. The concepts of reversibility are embedded in the Secretary's Standards, the Venice Charter, and multiple other documents. Yet, as Muñoz Viñas points out, true reversibility is not possible and the concept is thus evolving to that of "removability" or "retreatability" (Muñoz Viñas 2005). Indeed, the phrasing of Rehabilitation Standard 10 already softens the relentless intent of reversibility by allowing for the "essential form and integrity" of an historic property to be returned (Weeks 2000). Minimal interventions are typically recommended to prevent loss of original historic fabric. Article 13 of the Venice Charter requires that additions do not "detract" from the historic building or its context (ICOMOS 1964). Similarly, the Secretary's Rehabilitation Standard 7 requires that treatments use the "gentlest means possible" (Weeks 2000). Differentiation is explicitly included in the Secretary's Rehabilitation Standard 9: "the new work shall be differentiated from the old" (Weeks 2000). Articles 9 and 12 of the Venice Charter speak to differentiation as well, requiring that "work which is indispensable must be distinct" and "distinguishable" from the original historic fabric (ICOMOS 1964). In the discussion of the concepts of future-proofing and resilience, the doctrines of minimal intervention, reversibility, and differentiation may be incorporated through inclusion of cultural heritage policy documents.

The fields of historic preservation and heritage conservation have evolved since the nineteenth century to offer many of the same concepts as future-proofing and resilience. However, historic preservation and heritage conservation have not developed a coherent theory or set of principles around these concepts. Future-proofing and resilience have developed clearer definitions in different industries, as discussed above, and these may be analyzed to determine common characteristics. This analysis of the concepts of future-proofing and resiliency and their applications in a multitude of industries, including historic preservation and heritage conservation, may be brought together to develop a rubric or tool to support the rehabilitation process and avoid unsuccessful designs. To do this, one may develop a single set of principles that can guide the rehabilitation process.

THE PROPOSED PRINCIPLES OF FUTURE-PROOFING HISTORIC BUILDINGS

The concepts of future-proofing and resiliency both offer significant and compelling ideas that can be beneficial to the development of design solutions in the built environment and, more specifically, historic buildings. I propose that, when the concepts of future-proofing and resiliency are brought together, the following set of guiding principles may be developed.

1. **Prevent decay.**
   Promote building materials, methods, maintenance, and inspections that prevent premature deterioration of our built environment. It is natural for all building materials to deteriorate. Maintenance and interventions in historic structures should mitigate the deterioration of the existing building fabric rather than accelerate deterioration. I propose the following oath, with acknowledgment of the Hippocratic Oath and Cervat Erder's proposal (Erder 1977):

   > *The procedures and materials selected will be for the benefit and respect of our cultural heritage. We will give no harmful treatment, nor counsel such, nor aid in the deterioration or demolition of any monument. As stewards of our heritage and for the benefit of society, we will spurn harmful practices and document all steps taken.*

2. **Promote understanding.**
   Allow for understanding of the built environment and its place in our built heritage. Minimal interventions in existing structures allow future students of history to understand and appreciate the original historic building and *Gesamkunstwerk*, or unity of craft, as well as the patina. Interventions that have kept it viable should remain distinguishable from the original structure.
3. **Stimulate flexibility and adaptability through diversity.**
   Flexibility and adaptability of our built environment and our attitudes toward it are essential to retention of our built environment in a disposable society. The interventions in an existing structure should not just allow flexibility and adaptability, but also stimulate it while minimally impacting the historic building fabric. Adaptability to the environment, uses, occupant needs, and future technologies by keeping a diverse array of options open is critical to the long service life of a historic building..
4. **Extend service life.**
   Extend the service life of our built environment so it may continue to contribute to our economy, culture, and sustainable society. Regular maintenance and appropriate interventions in existing buildings help to make the buildings useable for the long-term future rather than shorten their service life.
5. **Fortify!**
   Fortify our built environment against climate change, extreme weather, and shortages of materials and energy. Interventions should prepare buildings for the impacts of climate change by reducing energy consumption; reducing consumption of materials; and helping them to withstand extreme natural events, such as hurricanes, floods, and tornadoes.
6. **Increase durability and redundancy.**
   Interventions in existing buildings should use equally durable building materials. Don't mix short-term materials with long-term materials. Materials that deteriorate more quickly than the original building fabric require further interventions and decrease the service life of a building. Building designs should either include components with similarly long service lives or be designed for disassembly for replacement of the shorter life components. Redundant systems provide backup in the event that a primary system fails and allow a building to continue to function.
7. **Reduce obsolescence.**
   Don't accept planned obsolescence. The built environment should be able to continue to be used for centuries into the future. Take an active approach to preventing physical, functional, aesthetic, and sustainable obsolescence. Regularly evaluate and review current status in terms of future service capacity. Find the most appropriate uses for the building, even if that means it has to be unused for a short period of time.
8. **Consider lifecycle benefits.**
   Consider the long-term lifecycle benefits of interventions in our built environment. The embodied energy and material resources in existing structures should be incorporated in environmental, economic, social, and cultural costs for any project.
9. **Be local and healthy.**
   Incorporate non-toxic, renewable, local materials, parts, and labor into our built environment. The parts and materials used in designing and implementing building interventions should be available locally and installed by local labor. This

means that the materials and manufacturing capabilities will be readily available in the future for efficient repairs.

10. **Take advantage of cultural heritage policy documents.** Cultural heritage policy documents provide excellent guidance for the long-term retention of an historic building. From the Secretary's Standards to the World Heritage Convention's charters, documents, and declarations, these documents offer invaluable guidance, including the concepts of minimal intervention, reversibility, and differentiation, when working with historic buildings as well as other existing buildings. Above all, in striving to meet the above principles, respect the historic building as a work of art, including its past interventions.

Having analyzed the characteristics of future-proofing and resilience and developed a set of principles to guide the design of interventions, it is instructive to see how the principles of future-proofing may be applied in a case study. The case study that follows describes two rehabilitation efforts involving the walrus heads on the Arctic Building in Seattle, Washington. These rehabilitations are an example of an initial non-future-proof rehabilitation in the 1980s and a subsequent future-proof rehabilitation in the late 1990s. The author was not involved in these two rehabilitation projects.

THE ARCTIC BUILDING: A CASE STUDY

The 1980s rehabilitation of the walrus heads demonstrates the potential for well-intentioned rehabilitations and repairs of problems in historic buildings to create further problems and cause further damage to the building. The contribution of the successful 1990s rehabilitation of the walrus heads to preservation and future-proofing of the Arctic Building led to the successful conversion to a boutique hotel. While this particular case study addresses decorative terra cotta elements, the consequences and the application of the principles of future-proofing are relevant in all types of interventions in historic buildings wherever a cultural heritage policy document such as the Secretary of the Interior's Standards (Weeks 2000) is applied, as will be discussed later.

Background—History of the Arctic Club Building

After the Alaska Club merged with the Arctic Club in 1908, the Arctic Club launched efforts to "construct a Class A fireproof building especially designed for the club" (Davis 1981, 10 2003). In 1917, A. Warren Gould, architect for the owner, pioneered the use of lightweight

Fig. 1. The double walrus heads at the southwest corner of the Arctic Building in Seattle, Washington. Note the highly decorative terra cotta, bright colorful palette, and the tusks that hang from the walrus heads. (Credit: Brian Rich, 2013.)

glazed molded terra cotta over a reinforced concrete frame to create the ornament on the exterior of the building and to resist fires like the Seattle fire of 1889. The Arctic Building was recognized as one of the finest examples of multicolored matte-glazed terra cotta in the Northwest (Figures 1, 2, and 3). It had "been well received by the public, and [had] won much commendation, which after all is the true measure of success," according to Gould in a *Pacific Builder and Engineer* article of February 23, 1917 (Davis 1981, 13; DeCoster 2010).

The Arctic Club Building remained the home of the club until 1971. From 1971 until 1988, the privately man-

Fig. 2. Aerial photo of the Arctic Building from the southwest. (Credit: City of Seattle Archives, SPU Fleets and Facilities Department. Imagebank Collection. Item No: 120399.)

Fig. 3. View of the exterior of the Arctic Building from the intersection of Third Avenue and Cherry Street. The walrus heads adorn the third floor. (Credit: Brian Rich, 2013.)

aged building was leased to the city of Seattle. In 1988, it was sold to the city of Seattle and used for city offices and public events (DeCoster 2010). Throughout this period of time, there were several interventions in the building as it was transformed fully to city office use. In 2005, a new private owner rehabilitated the building, converting it into a boutique hotel. The Arctic Club Building was listed on the Washington and National Registers of Historic Places in November 1978. The building was also designated a City of Seattle Landmark on April 4, 1985.

Intervention and Deterioration: The 1982 Walrus Tusk Intervention

Several exterior interventions were made to the Arctic Building during the 1980s and 1990s, though this case study focuses on the twenty-seven walrus heads. Though the walrus tusks are said to have been removed after the 1949 earthquake, some tusks must have remained in place until 1982 (Woodbridge, Montgomery, and

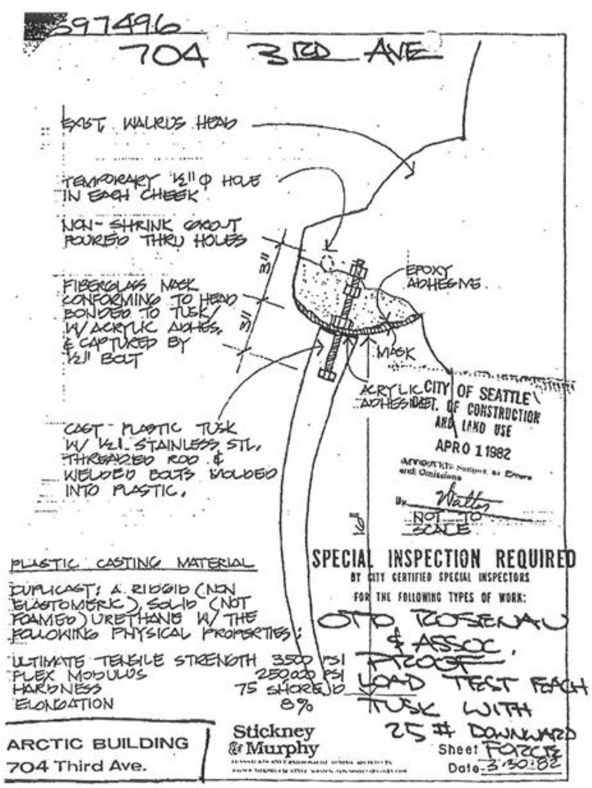

Fig. 4. Section detail of 1982 walrus tusk replacement detail by Stickney Murphy Architects. (Credit: Image courtesy of the Seattle Landmarks Preservation Board. Original detail by Stickney & Murphy Architects, 3/30/1982.)

Streatfield 1980, 123). In 1982, all of the walrus tusks were replaced by cast urethane plastic replicas. It was reported in 1996 that the original tusk failure had occurred due to "corrosion of the mild steel used to anchor the tusks into the terra cotta heads," but there are no records to corroborate this information (Morden and Slaton 1996, 2).

Details developed for the 1982 tusk restoration called for four major items to be installed (Figure 4). These items included new cast urethane plastic tusks, stainless steel threaded rods, a fiberglass mask to reconstruct the walrus face, and non-shrink grout. To anchor the new tusks, the cavities of the terra cotta walrus heads were filled with a combination of gypsum and Portland cement grout. The details called for holes on the front of the walrus snout to inject the grout. According to the 1982 design detail, the grout not only anchored the tusk, but held a fiberglass mask in place as well. The original mild steel rods supporting the

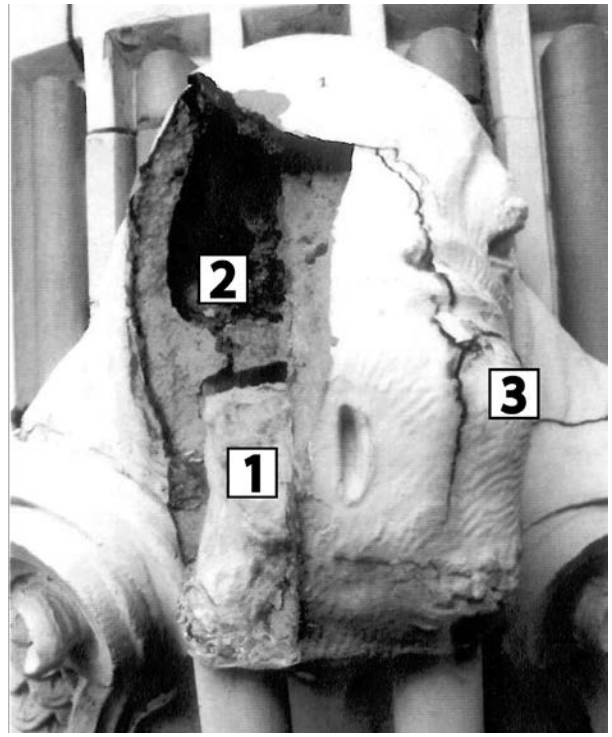

Fig. 6. 1996 inspection photo of walrus head S-1. Note the white grout sections filling the sinus cavity area of the walrus head (1). This meant there was no space left for the grout to expand into when the gypsum got wet. Note also the crack in the internal webbing (2). The damage to the internal structure of the head was so severe that this head had to be replaced. Note the cracks radiating from the dot on the top right of the walrus snout (3). This dot is the injection point for the 1982 grout installation and created a weak point in the terra cotta. (Credit: Morden & Slaton, WJE.)

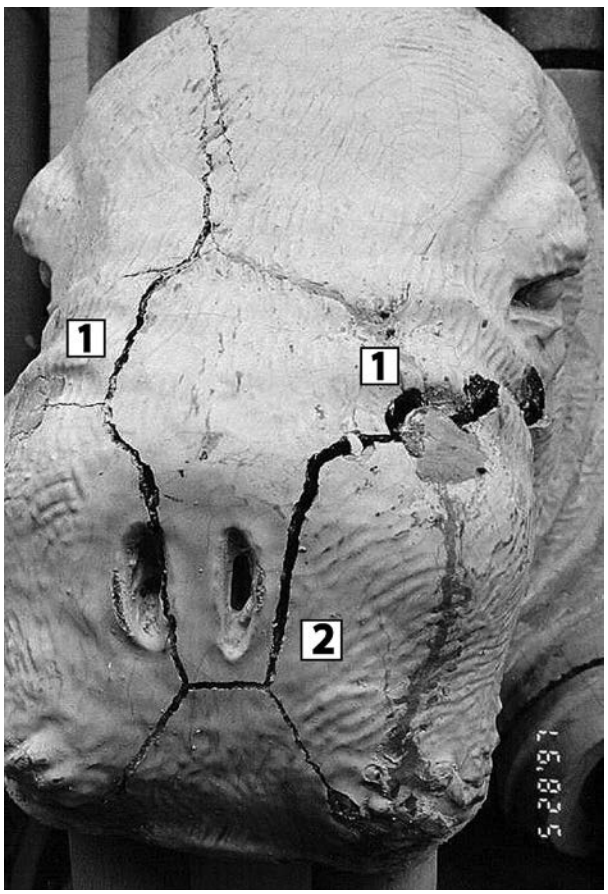

Fig. 5. Existing conditions in late 1995. Note the dark spots above the nostrils to the right and left (1). These are the holes grout was filled through. Note that they are on top of the walrus head. Also note the cracking of the snout (2). (Credit: Wiss, Janney, Elstner Associates, Inc.)

Fig. 7. 1996 walrus head rehabilitation. Note the drilled hole (1) for insertion of a helical anchor to pin sections of the walrus snout that had fractured due to expansive grout in the cavities of the terra cotta unit. The white dot (2) on top of the nostril is where the expansive grout was injected in the 1982 repair. (Credit: Wiss, Janney, Elstner Associates, Inc.)

original terra cotta tusks were removed in the 1982 restoration (Morden and Slaton 1996, 6). Within one to two years after the 1982 tusk replacement, minor repairs of new cracks observed in the walrus heads were performed.

Investigation: The 1995 Condition Survey

In late 1995, a condition survey and investigation of the walrus heads was performed by Wiss Janney Elstner (Morden and Slaton 1996). Overall, the building was determined to be in "good condition," but the walrus heads were a different story. The degradation of the walrus heads had progressed to the point where the ornamental terra cotta units were wrapped with chicken wire and duct tape to hold the pieces together until repairs could be made (Morden and Slaton 1996, 1). A field survey of the walrus heads found many modes of deterioration present. Fractures, spalling, cracks, crazing, and rust jacking (expansive corrosion of ferrous metals) were observed. The investigation discovered that the holes for the 1982 grout injection were located at the top surfaces of the walrus heads rather than on the vertical surfaces as detailed in the repair plan (Figures 5, 6, and 7). The 1995 investigations also discovered that the fiberglass masks had not been installed (Morden 2013).

On-site observations of the locations of the cracks in the walrus heads provided important clues about the deterioration. The cracks were located around the grout injection holes and the voids in the terra cotta where the grout had been injected (Morden 2013; Morden and Slaton 1996, 6).

Analysis—Causes of Deterioration

There are several potential deterioration mechanisms in glazed terra cotta cladding systems. These include crazing of the glazed face of the terra cotta; spalling; deterioration of the anchors or mortar; and unrelieved stresses due to settlement, movement, or rust jacking (Tiller 2004, 67-69). Many of these were observed in the 1996 investigation and repaired in the subsequent rehabilitation work. Although several of these factors contributed to the deterioration of the walrus heads and tusks, the key causes of the deterioration were (1) the original mild steel anchor rods for the tusks, (2) the grout injection hole location for the 1982 rehabilitation, and (3) the gypsum-Portland cement grout that was used in the 1982 tusk replacement.

In the 1982 tusk replacement, stainless steel anchors were used for the new tusk anchors to avoid rust jacking. The force of rust jacking can split stone and other masonry materials over time (Tiller 2004, 68). Because stainless steel anchors were used, rust jacking was precluded as the cause of the cracking of the walrus heads.

The location of the grout injection holes is a likely contributor to the deterioration of the walrus heads. Water likely penetrated the terra cotta units and the grout infill within the walrus heads through the grout injection holes in addition to existing mortar joints, cracks, and spalls in the glazing (Morden and Slaton 1996, 6). The location of the grout injection holes may have made this water infiltration worse because they were located on top of the walrus heads. In addition, however, the hole location also allowed the grout to fill the entire terra cotta cavity, leaving the grout no place to expand.

Gypsum and Portland cement are usually used together to combine the benefits of the rapid hardening of gypsum with the long-term strength and durability of Portland cement. Typically, gypsum quantities in such grout mixes are strictly limited by ASTM C150 to balance gypsum expansion and shrinkage of the grout during curing (Hime 1993). Conditions where there is excessive gypsum can lead to sulfate attack. Sulfate attack is the chemical reaction of gypsum to water, resulting in ettringite. Delayed ettringite formation (months or years after initial curing) causes heterogenous expansion (equal in all directions) and pressure on the surrounding terra cotta, resulting in cracking or spalling of the terra cotta (Collepardi 2001, 1-2). Eventually the chemical reaction between the gypsum and water would convert all of the gypsum to sulfate compounds and stop, but it is impossible to tell when that process would be complete (Morden 2013; Morden and Slaton 1996, 6).

Material samples of the grout that held the walrus tusks were taken and confirmed a high percentage of gypsum in the grout. A material analysis found that the grout consisted of 32 percent deleterious sulfate compounds. These compounds were in the form of gypsum (calcium sulfate hydrate) and ettringite (calcium sulfoaluminate hydrate) (Backus 1996). In this instance, because of the full cavities, there was no place to relieve the pressure from the ettringite formation.

Repair and Restoration: The 1996 Walrus Head and Tusk Intervention

The initial 1996 restoration plans included replicating ten walrus heads in terra cotta to match the originals where structural integrity was completely compromised

Fig. 8. 1996 replica walrus head. The joints between terra cotta pieces are filled with mortar after the epoxy sets around the threaded rod anchors. (Credit: Wiss, Janney, Elstner Associates, Inc.)

and replacement pieces were recommended. A total of twelve walrus heads were replaced after two were later found to be too severely damaged to be repaired. Alternative materials for replication were considered, but since the cost was approximately the same, terra cotta was preferred in accordance with the Secretary of the Interior's Standards for Rehabilitation (Morden 2013). All of the urethane tusks had been salvaged and were reinstalled in the new heads by bolting them through the new terra cotta. No grout was used to install the tusks (Morden 2013).

A variety of repairs were planned for the remaining fifteen of the twenty-seven walrus heads. Where structural integrity was believed to be acceptable, the walrus heads were repaired. Additional helical anchors were provided for seven walrus heads where sections of terra cotta were beginning to delaminate. Where possible, cracks were cut out to a width and depth suitable for grout infill (Figure 8). The 1982 gypsum-Portland cement grout was removed to the extent possible (Morden 2013). Repairs of the other modes of deterioration were also performed.

Current Condition of the Walrus Heads

The condition of the walrus heads has been monitored in multiple ways since the 1996 rehabilitation in order to ascertain whether there has been any further deterioration of the remaining walrus heads. Follow-up review of the walrus heads has been performed by Wiss, Janney, Elstner as well as by the building maintenance personnel through the late 1990s and no additional issues were observed (Morden 2013).

The 2005 Certificate of Approval application for rehabilitation of the Arctic Building as a boutique hotel does not note that any work on the terra cotta facade would be required other than cleaning (Day 2005). The terra cotta facade elements are noted as being "intact and in fair to good condition" (Day 2005). However, it is reported that minor repairs have been undertaken to the terra cotta focusing primarily on stabilization of the parapets. No further rehabilitation of the walrus heads was required at the time of the rehabilitation according to the architects (Weaver 2013). Photos of the current conditions taken in November 2013 by me were reviewed and discussed with Mark Morden during a 2013 interview regarding the project due to concerns about further deterioration. Based on the limited information in the photographs, Morden concluded that there had been no further deterioration (Morden 2013).

Case Study Conclusions

The case study of the interventions on the walrus heads at the Arctic Building is an example of two repairs, one of which in 1982 caused further damage to the historic building, and a second one in 1996 that resolved all of the issues in the original walrus head design as well as the 1982 restoration.

It is difficult if not impossible to be certain that any design, original or an intervention in an existing building, will be a long-term solution. The two rehabilitations of the walrus heads, while chronologically close to each other and addressing the same portion of the Arctic Building, raise questions about how we can know that our designs are going to endure. What can we learn from these two interventions? How can we improve our rehabilitation process and prevent ourselves from unwittingly incorporating flaws in our designs? How can we make our designs more reliably successful?

These interventions serve as an example of how the concepts of future-proofing and resiliency could have supported the rehabilitation process. Consideration of the concepts of future-proofing and resiliency in both the AEC and other industries led to the development of a set of principles of future-proofing that may be used as a tool or rubric in support of the rehabilitation process when working with historic buildings. In the instance of the walrus head rehabilitations, we can retrospectively apply the principles of future-proofing to demonstrate how they would have affected the 1982 rehabilitation and how the 1996 rehabilitation is future-proof.

SUPPORTING THE REHABILITATION PROCESS—THE PRINCIPLES IN ACTION

How do the principles of future-proofing help to solve the problem of the interventions in the Arctic Building? Was the Arctic Building a future-proof building even before the interventions? Consideration of the principles of future-proofing help to prevent the problems of the Arctic Building by preventing the inclusion of flaws in the design in the first place. This may be demonstrated through the application of the principles to each of the designs.

There is an argument to be made that the Arctic Building, as a whole, is a future-proof building. The existing glazed terra cotta shell of the building can last for centuries if it is well maintained. Terra cotta is a durable material that endures the moderate Pacific Northwest weather well. The flaws in early twentieth-century terra cotta building systems are well known today and can be overcome with thoughtful consideration (principle 1). The building is also easily understood as an historic building in its exterior appearance and significant interior spaces that have been renovated and converted to new uses over time. These uses included the original Arctic Club headquarters, with leasable spaces for their tenants, adaptive reuse as offices and public event spaces for the city of Seattle, and adaptive reuse as a boutique hotel. Attitudes toward this building have been clearly flexible in finding ways to accommodate different uses and tenants (principles 2 and 3).

The Arctic Building continues to demonstrate its future-proof nature through adaptation to the new uses without losing its historic character, even including additional floors being added to the building (principle 3). With careful rehabilitations, the building's service life has been extended into the foreseeable future (principle 4). The building has been fortified against the most significant danger in Seattle, earthquakes, through a complete seismic retrofit. The most recent rehabilitation takes advantage of sustainable features such as the high level of daylight exposure of the rooms and the operable windows. This will support the building through environmental changes (principles 5 and 6).

With the complete rehabilitation in 2005, all of the building systems have a reduced potential for physical, functional, and aesthetic obsolescence. The exterior shell of the building has been rehabilitated, including the walrus heads, and the interior has also been rehabilitated for ongoing use, preventing physical obsolescence. The multiple uses of the building over its history demonstrate that the building is unlikely to be functionally obsolete. While aesthetics are in the eye of the beholder, it is clear that the Arctic Building holds broad appeal since that is one of the bases of its designation as a landmark (principle 7).

The lifecycle benefits of retaining a masonry and steel structure are clear. Significant resources were used to create the building. The Arctic Building's rehabilitation has contributed to the local economy through jobs completing the rehabilitation and by revitalizing a portion of downtown Seattle and bringing more jobs and more tourism to the area (principle 8). While the Arctic Building's materials are most likely not locally manufactured, and the building may not be considered future-proof in this way, many rehabilitation materials are local and certainly the labor to perform the rehabilitations was local (principle 9). Last, it is clear that the cultural heritage policy documents relevant to this building have been followed as a consequence of its designation as a landmark and the stewardship of its owners and architects (principle 10).

Another valid question is whether the rehabilitation of the walrus heads was future-proof. Arguably, the 1982 rehabilitation was not, but the 1996 rehabilitation is future-proof. At the time of the design of the Arctic Building, it would have been well known through observation that ferrous metals expand as they corrode. How then would the application of the principles of future-proofing have prevented this problem? Starting with principle 1, if one is aware that ferrous metals deteriorate in an expansive manner and that terra cotta is brittle, one might not believe it appropriate to combine the two materials. Designers combining steel and terra cotta likely would have considered their designs to meet principle 5 as well, believing that the terra cotta cladding protected the ferrous metals from corrosion, especially where glazed terra cotta is used. This exposes one of the challenges of future-proofing and design in general: that we design to the best of our ability. It also underscores the importance of flexibility and adaptability, durability and redundancy. The simultaneous consideration of principles 1 and 8 may arrive at the conclusion that ferrous metals and terra cotta should not be combined. By considering both the concepts of preventing deterioration and long-term lifecycles for buildings at the same time, one may choose to take a different design path.

Similar principle-based considerations may be made for the use of the gypsum grout in the 1982 repairs, though the time scale is much smaller since the properties of gypsum were being published in the late 1970s and the repairs were completed in the early 1980s. Certainly a better understanding of the chemical reaction of gypsum and water and the use of lower quantities of gypsum in the grout mixture would have made the 1982 rehabilitation more future-proof. If one were to bear in mind the principles of preventing deterioration, extending the service life, and increasing durability, the problem of the expansive nature of the ettringite formation could have been avoided.

Closely related to the grout mixture is the amount of grout injected into the walrus heads. Thoughtful consideration of the same principles would have led a contractor to understand that completely filling the terra cotta cavities and giving the gypsum-Portland cement grout no place to expand into was not advisable. Similarly, an understanding of the nature of ettringite formation by the contractor would have led the contractor to place the holes in a less exposed location. The holes may have also been filled with a different material to prevent water infiltration.

Regardless of the nature of the 1982 rehabilitation of the walrus heads, what is clear is that the future-proof rehabilitation in 1996 led to preservation of the Arctic Building and its continued viability. In 2005, a new owner rehabilitated the building, converting it into a boutique hotel, giving it a new lease on life and an ongoing role in the heart of Seattle.

CONCLUSION

One may take issue with the term "future-proofing" when it is applied to the historic preservation field. However, the concepts of future-proofing and resiliency as embodied in other industries are applicable to the AEC industry as well. Whether conceived as future-proofing or as a wider understanding of resiliency, the concepts advocated here are focused on the long-term endurance of our built environment and reducing material consumption in a resource-limited world.

At the time of the 1982 interventions in the Arctic Building walrus tusks, it may not have been possible to consider the design through the lens of the principles of future-proofing. The 1982 rehabilitation serves as an example of a non-future-proof intervention in an historic building. There are three major points to examine in the consideration of the future-proof nature of the repairs to the walrus heads, including the original design of the terra cotta tusks, the gypsum grout used in the 1982 repairs, and the location of the grout injection holes.

Ideally, future-proof designs incorporate all of the principles discussed above. Realistically, however, future-proof designs may never accommodate all of the proposed principles. Rather, they may be very strong in some principles and less so in others. The nature of a design, the circumstances of its creation, and the preferences of the designer will likely determine the ways in which a project is future-proof.

The potential for future deterioration raises a question not addressed here about long service life for buildings. What exactly is meant by a building's long service life? Is it one hundred years? Two hundred? Four hundred? More? For many, twenty to thirty years seems quite reasonable. Regardless of the threshold, buildings will deteriorate over time. Perhaps an appropriate perspective is that we should not cause the premature deterioration of our built environment through insensitive interventions in existing structures.

Architects and preservationists generally understand and accept that no project is going to be perfect. Our designs are limited by the knowledge we possess and consider at the time of design. One does not have the ability or time to understand in minute detail all the aspects of a building material that is proposed in our designs. Perhaps by keeping the principles of future-proofing and resiliency in mind, we can do better.

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An Interview with Brian Rich about Future-Proofing and Historic Structures

Posted on: April 13th, 2015 *by* Jeana Wiser | No Comments

University of Washington, Guggenheim Hall. Rehabilitation of 1920's brick and cast stone building to serve the current and future needs of the Aeronautical and Astronautical Engineering Departments. Project completed by Brian Rich for Bassetti Architects in 2006.|Credit: Richaven PLLC, 2014.

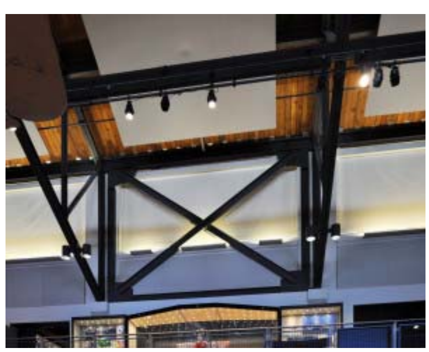
If Brian Rich, a preservation architect in Seattle, had motto to guide his work, it would be "first do no harm." His second motto would be "take the long view." Together these two maxims have led him to his current interest: future-proofing our historic buildings. Future proofing, according to Rich, is the process of anticipating the future and developing methods of minimizing the negative effects while taking advantage of the positive effects of shocks, stresses, and changes due to future events, such as increased severe weather events and rising sea levels.

Recently, I had the opportunity to sit down with Rich to talk about his work and the role of future-proofing in protecting historic resources.

Rich has been working in the field of architectural preservation for 22 years. He started his career in Chicago rehabilitating 1920s vaudeville theaters for modern Broadway productions. He returned to his hometown of Seattle in 2000, and, inspired by Seattle's old building stock, he became increasingly interested in the adaptive use of old buildings. He opened his own firm, Richaven Sustainable Preservation Architecture, where he pursues preservation projects in the Pacific Northwest.

Rich explains that he has always been interested in how to make old buildings perform again with a different use. He says, "In addition, I also became very interested in technical design and implementation. I began to ask, how can you design an intervention in a building that allows it to continue to perform in the future without creating more problems than you are solving?"

He tells the story of 1930s brick and terra cotta school that was recently rehabilitated. When he went up on the roof, he says, he saw that some of the terra cotta glazing had spalled off in dozens of different places, most likely from water vapor getting inside the tiles and freezing and expanding. Exposing the soft clay core of the terra cotta would lead to further frost cycle deterioration, he explains, and he began to wonder why we make changes to buildings that do more damage to them. The school building was severely harmed by the renovation. He says, "I couldn't believe someone else hadn't thought of it before—and I began to see things like this everywhere. Problems with older buildings and materials that could have been prevented with improved thought processes during design."



South Lake Union Naval Reserve Armory. Section 106 review completed on seismic upgrades. Project completed

The term future-proofing has traditionally been used with reference to technology, such as computers and utilities. It meant designing systems that were flexible enough to be reused in the future and not become obsolete in a marketplace that focuses on innovation. But Rich notes that up until recently, no one has used that language to talk about the built environment. He says: "If we want our buildings to be able to adapt in a future world, we have to talk about materials and performance in addition to flexibility and adaptability. How can we rehabilitate our

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by Brian Rich for URS Corporation in 2005.| Credit: Richaven PLLC, 2014.

To answer this question Rich has developed what he calls the "Principals of Future Proofing." Some of these principals include, preventing decay, fortifying existing structures, and reducing obsolescence, which means finding the most appropriate use for a building and continually evaluating the built environment in terms of future capacity to accommodate different uses. Rich encourages preservationists to take active steps in assuring that the built environment is durable and continues to perform. "A big part of this is understanding change over time—not only with regard to building use and demand, but also in terms of materials and design. Often developers will approach a reuse project in terms of what is trendy—lofts, etc.—but in doing so, they are not listening to the building. One of the Principles calls for finding the best use of the structure, even if that means allowing it to sit vacant for a few years."

Lakota Middle School, Federal Way, WA. The original 1950's gym was retained and the rest of the school demolished. With additions and rehabilitations, the old gym to serves all the current athletic facility needs for the school. Project completed by Brian Rich for Bassetti Architects in 2011.| Credit: Richaven PLLC, 2014.

Future proofing will require some changes in current thinking about rehabilitating older buildings. Rich says that as a society, we aren't particularly good at taking the long view. He explains that developers have inherently short timelines because of financing models, and that a typical development project could have a timeline of just seven years, which encourages the developer to get in and get out without thinking of creating something adaptable for future uses. He also notes, "We have a culture of technological innovation—looking for the next big thing—which can lead to a misunderstanding of older materials and an inability to integrate the old with the new in a way that doesn't cause deterioration of the historic building fabric. If we can do more projects that highlight this integration and continue to educate about adaptability and reuse, I think we can shift the perspective toward a longer-term view."

The Evergreen School, Shoreline, WA. Preliminary designs for rehabilitation of a neighboring house ultimately found that the house would not be a future-proof solution for the school's space or curriculum needs. Project completed by Richaven PLLC in 2012. | Credit: Richaven PLLC, 2014.

Rich suggests that we look to Europe for inspiration. "European countries have had a much older building fabric and have traditionally done a better job of taking care of it," he explains. "There are many examples in France and Italy of centuries-old structures that have been continuously used. The European culture requires human adaptability to the built environment instead of asking the buildings to change to meet human-imposed requirements. This is something we should look at as we hope to shift our culture away from an attitude of disposability."

Going forward Rich encourages preservationists to promote the fact that building reuse is a key strategy in planning for a resilient future and be prepared to talk about adaptability. "We have to incorporate more flexibility in our approach," he says, "but stand behind the fact that old buildings are irreplaceable with respect to their materials, their character, and their contribution to our communities."

About Jeana Wiser

Jeana Wiser is an associate project manager at the National Trust for Historic Preservation's Preservation Green Lab.

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Future-Proof Building Materials: A Life Cycle Analysis

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Abstract

Future-proofing of existing and historic structures is dependent on the durability of the construction materials. Where several recent studies have explored the short term impacts of renovating existing buildings, this research compares the initial construction, periodic renovation, and regular maintenance impacts over a 200 year time span to determine which building systems have the least environmental impact. Maintenance of existing brick, stone, and concrete structures is shown to have similar impacts as multiple iterations of wood structures, metal structures are shown to have significantly larger impacts. The concept of "First Impacts," the environmental impacts of converting raw materials into installed building components, is introduced.

Introduction

It is widely acknowledged that Carl Elefante coined the phrase "the greenest building is the one that is already built".1 As a result, several recent studies on the environmental impacts of buildings and building construction have explored the short term impacts of renovating existing buildings. Examples include the 2012 study by the Preservation Green Lab titled "The Greenest Building: Quantifying the Environmental Value of Building Reuse"2, and studies by Larry Strain of Siegel and Strain3. These studies often focused on the immediate goal of carbon reduction and the resulting global warming impacts. However, because these studies have been limited to time scales of approximately 20 years, the true long term impacts of future-proofing our built environment are not well developed.

Future-proofing is the process of anticipating the future and developing methods of minimizing the negative effects while taking advantage of the positive effects of shocks and stresses due to future events. Future-Proofing Principle 8, Increase durability and redundancy, recommends that "interventions in existing buildings should use equally durable building materials. Don't mix short-term materials with long-term materials. Materials that deteriorate more quickly than the original building fabric require further interventions and decrease the service life of a building. Building designs should either include components with similarly long service lives or be designed for disassembly for replacement of the shorter life components. Redundant systems provide backup in the event that a primary system fails and allow a building to continue to function."[4]

This research intends to begin to quantify the impacts of initial construction, periodic renovation, and regular maintenance impacts for reuse of a building over a 200 year time span.

While this Life Cycle Analysis (LCA) has not been reviewed by a critical review panel, it is intended to comply with the requirements of ISO 14040, and would be ISO compliant pending the completion of critical review.

Goal and Scope

The goal of this research is to compare the long term impacts of resilient construction with low cost, short service life construction observed in contemporary educational facilities. This study is based on the Lakota Middle School Gymnasium in Federal Way, WA, built in 1960 and renovated in 2009. See Figure 1 of the renovated gym at Lakota. At the time of the project design, there was considerable discussion over the retention of the existing gym structure versus building a new gymnasium structure. The discussion was resolved based on the estimated cost of renovation versus new construction. However, there was the belief that retention of the existing building was a sustainable practice.

This research could have been used by the Owner and Design Team to assist in the decision of which option to choose. This Life Cycle Analysis is intended for the internal use of the project team and is not intended to be used in comparative assertions. There are several sub-goals for this research:

1. This author proposes the concept of "first impacts." Similar to the concept of first cost in construction, "first impacts" are the environmental impacts of

construction from extraction of raw materials to initial occupancy of the building. This research investigates “first impacts” versus long term environmental impacts of different building materials and techniques.

2. While wood materials have significantly less environmental impacts in the short term (20 to 40 years), how does this compare to more durable materials over the long term (200 to 1000 years)? And how does this compare to wood structures when biogenic carbon is not taken into account due to the long time period to be studied?

3. Depending on material quality, design and maintenance, wood and light gauge metal building materials are anticipated to have shorter service lives compared to brick, steel, and concrete due to the more rapid deterioration of the material. What are the environmental impacts of shorter life span materials (and thus anticipated higher frequency of replacement) compared to longer life span materials?

4. Do buildings that are typically considered to be more future-proof (or resilient), such as steel and concrete construction, have more or less environmental impact on the Earth than ones considered to be less resilient?

5. What might these conclusions suggest with regards to the existing built environment in general and historic buildings in particular?

Functional or Declared Unit

The declared unit in this LCA is one 12,150 square foot Middle School gymnasium including a main gym and an auxiliary gym. The gym building consists only of the athletic spaces (a main gym and an auxiliary gym) and excludes the locker rooms, offices, storage, lobby, and other related spaces. The study will also exclude mechanical, electrical, plumbing, fire sprinkler, alarm systems, and exterior site features. The above features are not included in the models to maximize similarity and simplicity of the models.

Scope of the Study

This study proposes to begin with new construction for each of the four gymnasiums and track the impacts of a 200 year period of time, though the buildings may last longer. Extrapolation of the results is possible, though circumstances around material extraction and fabrication would likely significantly change and render the data invalid. The study utilizes the Athena Impact Estimator for Buildings, version 4.5.0102 to model the buildings. The proposed wood gym is also analyzed using Athena Impact Estimator version 4.2 which did not include biogenic carbon in the calculations to understand the impacts of biogenic carbon sequestration in wood construction better. This gym is referred to as Gym A1. Athena Impact Estimator is a whole building, life cycle based environmental assessment tool that lets building designers, product specifiers and policy analysts compare the relative environmental effects or trade-offs across alternative building design solutions at the conceptual design stage. Athena evaluates whole buildings and assemblies based on internationally recognized life cycle assessment (LCA) methodology.

It includes maintenance and replacement cycles for each building appropriate to their planned service lives and material selections. Both minor and major renovations are anticipated by the Athena calculator and are planned to double the actual service life. Further, only the total impacts for the service lives calculated are considered in this analysis. Impacts of individual phases of the life cycle are not included in this analysis.

The literature describing the Athena Software indicates that the following life cycle phases are accounted for in this model: material manufacturing, including resource extraction and recycled content; related transportation; on-site construction; regional variation in energy use, transportation and other factors; building type and assumed lifespan; maintenance, repair and replacement effects; demolition and end-of-life disposition; and operating energy emissions and pre-combustion effects (requires input from another model).

In order to accurately model “first impacts” (as opposed to “first costs”), data is extracted from each model with a 1 (one) year service life, intended to represent initial construction. Since Athena includes maintenance, repair, and replacement impacts for the systems involved, the buildings are modeled again with their anticipated service life (20, 50, and 100 years), and a third time with double service life (40, 100, and 200 years). These service lives are then extrapolated to determine the impacts for 200 years.

It is not clear whether Athena incorporates major renovations at intervals within the service life of the buildings or whether buildings are simply demolished at the end of their service lives. For the purposes of this study, limited service lives are anticipated based on the authors experience as an architect. New buildings are anticipated to be built at the end of the 200% service life anticipated. Building impact data can be modeled at 50%, 100%, and 200% of anticipated service life and the data extrapolated to determine if the “maintenance, repair, and replacement effects” are linear. This data is then evaluated for the impacts of major renovations assumed to occur at the end of the anticipated service life.

LCA Phases, Outputs and Allocation

The use of Athena for the analysis is intended to include all phases of the life cycle from cradle to grave for raw material extraction, manufacturing, building construction, occupancy, and end of life. This LCA study uses the 7 summary environmental impacts as output from Athena as the basis of comparison. Raw impacts are not used in this analysis. The summary environmental impacts include: Fossil Fuel Consumption (MJ), Global Warming Potential (kg CO2 eq), Acidification Potential (kg SO2 eq), Human Health Particulate (kg PM2.5 eq), Eutrophication Potential (kg N eq), Ozone Depletion Potential (kg CFC-11 eq), and Smog Potential (kg O3 eq).

Default allocations for environmental impacts from Athena are accepted as baseline criteria for this LCA study and are not altered. Two default allocation techniques are worthy of note in this analysis. First, Athena does account for end of life recycling of steel building components (structural and reinforcing steel). Similar end of life allocations to recycling for other building materials are not applied despite potential recycling rates over 95% for some projects.

The second allocation technique worthy of note in this analysis is for biogenic carbon. Biogenic carbon is the carbon that is sequestered in a wood product as the natural material grows in the forest and a tree converts CO2 through the photosynthesis process. As noted elsewhere, a comparison of Gym A and Gym A1 endeavored to determine the effects of biogenic carbon sequestration in wood materials for the life of the wood. While this does not affect the data in most environmental impacts, Global Warming Potential (GWP) is higher when biogenic carbon is not taken into account. This result is noteworthy to this analysis because of the time span analyzed for the buildings. A 200 year service life is a sufficiently long time that the vast majority of wood products have completed their life cycle and released the carbon that was sequestered in the material.[5] Thus the beneficial effects of the carbon sequestration are negated.

Life Cycle Analysis - Inventory

The building inventory was developed by modeling the four gymnasiums in Athena Impact Estimator. The scope of the research is a comparison of the long term impacts of four gymnasiums of differing construction types and anticipated service lives. All three gymnasiums are the same configurations: 135’x90’x30’ high. The gym is divided into two parts by a bearing wall such that there is a 90’x90’ Main gym and a 90’x45’ Auxiliary gym. Foundations were kept identical between the three models due to limitations in the software. A summary table of the building systems follows at the end of this section. However, briefly, the design of the four gymnasiums may be described as follows:

Figure 1: The interior of the Main Gym at Lakota Middle School in Federal Way, WA. Credit: Brian Rich, 2013.

Gym A is intended to represent a low first cost gym with a 20 year service life. It is designed with wood structure and siding, vinyl windows and a 20 year asphalt roof. Gym A1 is modeled the same as Gym A, except that the data was run through Athena version 4.2, rather than version 4.5. The distinction is that Athena version 4.2 does not account for biogenic carbon. The gym at Lakota Middle School is an excellent example of the roof framing for Gym A and A1. See Figure 1 above.

Gym B is also anticipated to have a low first cost with a 20 year life span. It is designed with a structural steel columns and beams and open web joists, metal stud framing, light gauge metal siding, PVC windows, and an EPDM roof membrane. See Figure 2.

Figure 2: The gym at Skyline High School in Issaquah, WA, is an example of the metal framed roof structure in Gym B and C. Credit: Brian Rich, 2013.

Figure 3: The Gym at Shorewood High school in Shoreline, WA is an example of Gym C construction. The main volume of the gym has CMU exterior walls and metal roof structure. Credit: Brian Rich, 2013.

Gym C is typical of contemporary gym construction representing a mid-level first cost with a 50 year service life. It is designed with structural steel columns and beams, furred out CMU exterior walls, triple glazed aluminum windows and steel doors, and an EPDM roofing membrane. The gymnasiums at Shorewood High School in Shoreline, WA, and Skyline High School in Issaquah, WA are examples of this type of design. See Figure 2 and 3.

Gym D is intended to be a resilient/future-proof structure representing upper level first cost and a 100 year service life. This gym is constructed of a reinforced concrete frame, brick facing over furred 8" thick concrete walls, aluminum windows and steel doors, and a modified bitumen roofing system.

Maintenance and Replacement Cycles

Athena was also used to model the individual impacts of building components that would need to be replaced on a regular cycle so as to simulate the ongoing maintenance and renovations over the lifespan of the building. The results of this study subtracted first impacts from total 200 year impacts to discover the maintenance and replacement impacts over the 200 year service life that was assumed for the buildings.

Building components often included in regular maintenance cycles include roofing systems, insulation systems, interior and exterior paint finish systems, flooring materials, exterior wall cladding systems, windows, and interior wall materials.

Not surprisingly, the top replacement contributors are roofing, siding, and windows, as exemplified in Figure 10. This is a relatively consistent result regardless of the gym construction type or material quantity versus mass value, with the exception of Gym D. In Gym D, the brick facing is not considered required to be replaced over a 200 year life span. One might also conclude that the higher mass materials are also more durable and thus have a lower replacement frequency.

However, the maintenance regime in Athena is not transparent and thus it is unclear what materials are considered to require maintenance versus replacement at the end of the component's life cycle. Nor is it clear what impacts maintenance has on the overall life cycle of the structure. Further, it is not clear what impacts removal of a material that has reached the end of its service life has on the remainder of the building. For instance, does removal of wood siding have an impact upon the weather barrier that may wrap the building?

In addition, Athena assumes that building systems include certain components which are not clearly delineated in the system descriptions. For example, built-up roofing systems include ballast rock, as discovered in this analysis. The ballast rock was discovered when it rose to the top of the material replacement list during the maintenance analysis. The roofing system was revised to provide a more common modified bitumen roofing system.

This analysis also found that maintenance cycles included in Athena are for a specific use of a material. For example, since wood flooring was not available as a material for the interior gym floors, gyms C and D were modeled with tongue and groove wood siding as a flooring component. While this material was not an exact match to the sprung maple flooring systems typically used, this was believed to be an approximate match. However, no warnings were displayed that this was an inappropriate material or use of material in this application. Data extracted from the model was thus severely distorted and required recalculation.

The maintenance and replacement calculations revealed that interior finish materials rarely appeared in the maintenance cycle calculations. The most common materials found to be replaced were siding, roofing, and windows. These were closely followed by wood siding materials. The 200 year comparison of replacement materials in Gym A1 is typical of the results. It is clear that the wood siding of the gym was the dominant material replaced by material quantity. While the figure is not adjusted to accommodate different units for material quantities, it is indicative of the types of materials that commonly appeared on the material replacement lists.

Environmental Impacts

Environmental impacts may be studied under several different scenarios to develop appropriate responses to specific situation within the built environment. Four scenarios are envisioned in this analysis. Figure 4 diagrams the four different scenarios.

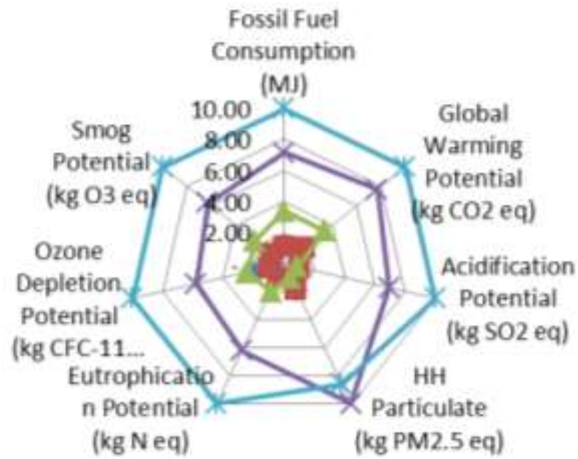

Figure 4: Life Cycle Analysis phases are diagrammed here for each of the four different scenarios analyzed in this LCA study. Credit: Brian Rich, 2014.

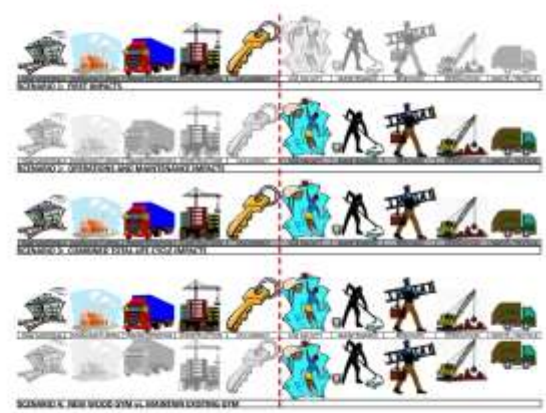

Figure 5: Scenario 1, a comparison of First Impacts, normalized on a scale of 10. Note that the buildings involving masonry and concrete (Gym C and D, blue and purple) have the most significant first impacts and wood (A and A1, red and dark blue) the least. Credit: Brian Rich, 2014.

Scenario 1: First Impacts of New Construction

The first scenario analyzes the environmental impacts of the construction of a new gym from raw materials to completion of construction. This analysis focuses on the first impacts of new construction and does not include any operation or maintenance impacts.

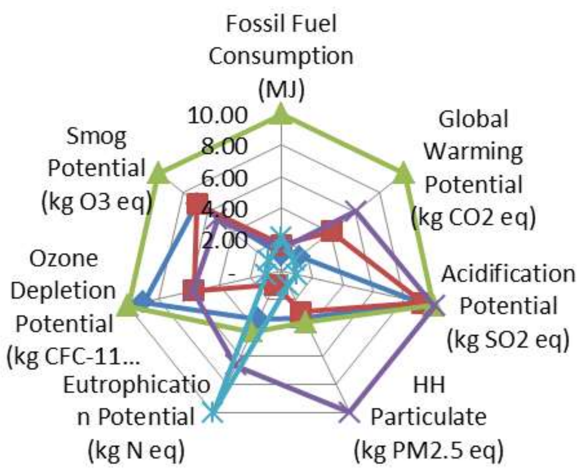

Figure 6: Scenario 2, a 200 year comparison of maintenance requirements, not including first impacts, normalized on a scale of 10. Gym D (light blue) has the least maintenance impact in most categories and Gym B (green) has the largest impacts in most categories. Credit: Brian Rich, 2014.

Scenario 2: Operations and Maintenance Impacts

The second scenario analyzes maintaining and operating an existing gym for 200 years. In this scenario, all five gym designs are to be maintained and operated. The first impacts are considered sunk impacts that cannot be recovered or avoided. The intent of this scenario is to compare the operating impacts of the different gyms and their respective environmental impacts. The graph below characterizes the impacts of the gym designs.

Scenario 3: Combined Total Impacts (First Impacts and Maintenance Impacts)

The third scenario analyzes the total environmental impacts of constructing a new middle school gymnasium on an undeveloped site, including all new materials and site work, and operating and maintaining it for 200 years. This analysis includes first impacts as well as maintenance and replacement impacts. Further, this scenario assumes that Gym A, A1 and B have a 40 year life, including regular maintenance and material replacement, and then is demolished and a new gymnasium is built. Similarly, this scenario assumes that Gym C has a 100 year life including regular maintenance and material replacement, and then is demolished and a new

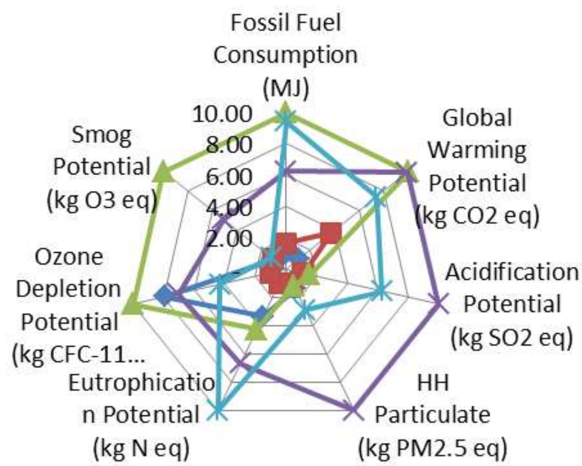

Figure 7: Scenario 3, a 200 year comparison of total environmental impacts, normalized on a scale of 10. Gym B and C (purple, green) typically have the largest impacts while Gym D (light blue) has mixed total impacts and Gym A and A1 (red and dark blue) the least total impacts. Credit: Brian Rich, 2014.

gymnasium is built. Last, this scenario assumes that Gym D has a 200 year life and is not replaced. The intent in scenario one is to compare the environmental impacts of shorter service life structures to those of more durable longer service life materials.

One hazard with this scenario is that the building is only as good as the weakest portion of the design. Often this weak link in modern construction is sealant or roofing systems. These elements can deteriorate and cause more rapid deterioration of even more durable building material products and systems.

Scenario 4: Total Impacts – New Wood vs. Maintenance of Metal, Masonry, or Concrete

The fourth scenario includes replacement of an existing gym versus ongoing operation of the existing facility. Further it supposes that Gym A or A1 are proposed for the replacement due the low first cost of construction and that they will be maintained and operated for 200 years rather than being replaced every 40 years. Gym B, C, and D are assumed to be maintained and operated for another 200 years. The first impacts are considered sunk impacts that cannot be recovered or avoided. Environmental impacts are then evaluated for a period of 200 years.

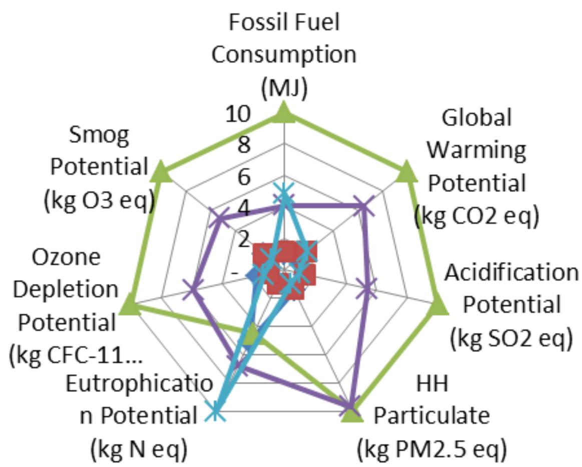

Figure 8: Scenario 4, a 200 year comparison of total environmental impacts, normalized on a scale of 10. This answers the question: If I am considering a new Gym, should I build a new wood gym or continue to maintain my existing concrete or masonry one? Note that there are many respects in which Gym A and A1 have lower impacts, Gym D has moderate impacts, and Gym B and C have the largest impacts. Credit: Brian Rich, 2014.

Interpretation

In this section, the results of the data provided by the Athena models are interpreted. However, there are a few appropriate notes about the data that was extracted that are important.

First, each of the three gyms was consistently modeled in terms of size and functions within the building, therefore the data should also be consistent. The one intentional exception to this is Gym A1 which was modeled in Athena 4.2 rather than Athena 4.5 in order to assess the impacts of biogenic carbon.

Second, the models varied in terms of the materials used. This is a deliberate variation in order to study the environmental impacts of different building systems.

Third, this study makes certain assumptions about the predicted service life for the entire building. Due to assumptions within Athena, this may lead to errors since the assumptions made in the spreadsheet calculations were based on author defined service lives for each building rather than the service lives included by Athena. The data produced by Athena should also be timely as the most recent update to the software was less than 1 year prior to the analysis.

Last, Athena is a good tool for use for projects in the Seattle area because of the location specific data available in its calculations. What could be better explained are the effects of data location on the model. For example, does location affect the energy mix used in the analysis?

The major contributors to the environmental impacts of the buildings modeled are readily split into two categories: first impacts versus maintenance and replacement impacts. As predicted prior to the study, building materials with higher levels of durability also have significantly higher first impacts. For example, the environmental impacts of making and installing concrete, steel, and CMU materials are higher than that of wood materials. See Figure 5. In Figure 5, the normalized data for First Impacts clearly indicates that Gym D has the highest environmental impacts in most categories. Gym A and A1, the wood structures, have the lowest first impacts.

Conversely, the maintenance and operations impacts of lower durability materials, such as metal siding and wood, are higher than the impacts of high durability materials, such as concrete, brick, and structural steel. See Figure 6. It is interesting to note that while Gym D, built of concrete and brick, has the least impact; the highest impact is actually that of Gym B with metal siding and an EPDM roof. Wood structures, with or without biogenic carbon, have varying impacts.

When the environmental impacts of maintenance and replacement are considered with first impacts for each gymnasium, a complete picture of the 200 year environmental impacts are formed. See Figure 7. This figure demonstrates the significant variability in the overall environmental impacts of each gym type. While gym A and A1 (wood) continue to demonstrate the lowest overall impacts, the other gym designs show mixed results.

The results of the LCA analysis are more favorable for buildings of higher durability materials, such as Gym D, when one is considering replacement of an existing gym with a new wood framed structure. Here, the impacts of the higher durability materials are shown to pay off. See Figure 8.

Conclusions

1. The concept of "First Impacts" is introduced in this research and reflects the environmental impacts of new construction from raw material extraction to occupancy of the building. As anticipated, "first impacts" are greater for steel, concrete, and masonry structures than for wood structures.

2. Prima facie evidence suggests that wood structures are a more sustainable building alternative when considering new construction. This is true in both the 20 year term and the 1000 year term when starting with new construction, regardless of how biogenic carbon is counted. The effects of a shift to a wood-based construction economy are unknown, though, and may outweigh the benefits of this building system.

3. When considering existing buildings, first impacts are "sunk costs" and may be disregarded. The evidence suggests that ongoing maintenance and operation of existing structures with higher durability and quality have comparable environmental impact to new wood construction. With the potential for durable construction to last up to several hundred years, the impacts may be lower than wood construction.

4. Biogenic Carbon affects only one environmental impact criteria: Global Warming Potential (GWP). When the benefits of the sequestration of carbon in wood materials are not included due to the relatively short life span of wood materials, wood materials still have less environmental impacts than steel and concrete materials (Gym A1).

5. Durability of all components of a building system should have equivalent service lives or allow for disassembly in order to maintain the shorter service life materials. This allows retention of materials that have longer service lives rather than disposing of them when removed to perform maintenance.

6. Though not clearly indicated in this study, proper maintenance of a building is critical to long term service life. Maintenance prevents deterioration of less durable materials and can significantly affect the service life of a building.[6]

7. Historic buildings have value above and beyond the environmental impacts of their materials and construction. The data in this analysis should be noted as a strictly numerical analysis. There are significant aspects of existing and historical buildings that have value beyond the environmental impacts, including the social, cultural, economic, and aesthetic value. Enduring buildings form the core identity of many places and provide stability and increased personal and community resilience because of the way people identify with their "homes."

8. Further research is needed into the design details, materials, and workmanship aspects which make buildings more future-proof. In addition, research is needed to validate the Principles of Future-Proofing and better understand the methods of calculating life cycle impacts in Athena.

Further information and the full research report, including the raw data, is available at www.principlesoffutureproofing.com.

Notes:

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Future-Proofing Critical Water Infrastructure from an Economic and Hazard Resilience Perspective

This paper examines different future-proofing options for increasing both the resilience and capabilities of Tijuana's critical infrastructure, using San Diego as a comparative control. It also examines the problems in effectively pricing water as a commodity, and the productivity impact of non-potable piped water on Tijuana's GDP. The system improvements being pursued by San Diego demonstrate the application of the Principles of Future-Proofing as guidance for infrastructure projects yielding a high ROI and offsetting potential economic losses.

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INTRODUCTION

Tijuana and San Diego are two cities, separated by a border, but share critical components of their built environment. They share water sources, water infrastructure, and the same climate. They have similar populations and population growth patterns, yet their plans for dealing with water scarcity issues, and their planning for potential natural hazards vary widely. Tijuana's critical water infrastructure has much room for improvement, as well as a strong need for improvement.

This paper examines different future-proofing options for increasing both the resilience and capabilities of Tijuana's critical infrastructure, using San Diego as a comparative control. It also examines the problems in effectively pricing water as a commodity, and the productivity impact of non-potable piped water on Tijuana's GDP. High costs of water serve as an economic rationale and incentive for investing in Tijuana's critical water infrastructure system. Common vulnerabilities of water infrastructure systems are explored. The system improvements being pursued by San Diego demonstrate the application of the Principles of Future-Proofing as guidance for infrastructure projects yielding a high ROI and offsetting potential economic losses. Future-proofing is applicable to infrastructure systems as well as not only to existing and historic buildings.

PROBLEMS IN EFFICIENTLY AND EFFECTIVELY PRICING POTABLE WATER

The pricing of water is a complex question, taking into account infrastructure, social, economic and security factors. The issue of social equity is central to potable water supply: no matter the scarcity, potable water should be priced so as to be affordable for vulnerable, impoverished populations. The World Bank defines household potable water as affordable if it costs less than 5% of household expenditures (Wang, 2008).

Water Quality as a Basis of Cost

However, water for manufacturing and irrigation are not held to the same social equity standards. One of the main difficulties in the Continental Southwest region of North America is that water is considered and treated as a singular variety and quality - potable water. In reality, water, as a commodity, is much more complex and includes potable water, treated and reclaimed water as well as many grades of industrial water and wastewater. Potable water is considered a high value and increasingly scarce. Treated water can often be used for agriculture and energy resources, and reclaimed water can be used for recharging aquifers and rivers, along with commercial uses.

Hummels (2002) examined the importance of the extensive, intensive and quality margins in trade using the highly detailed 1995 United Nations data on traditional exported goods. If one considers water a traditional good, the extensive margin (variety and quality) should be the optimal way to consider water. However, water is not often considered a traditional good, and is not differentiated by quality or variety on the North American commodity market. Because the difference in water quality and variety levels can be substantial, there are different price points due to their supply side costs. The type of water a supplying nation must provide is often not mandated or specified in international water agreements.

As water scarcity has become a widespread issue, many different methodologies and pricing structures for efficiently valuing water have been tried and discarded. Many countries have been testing using different types of water tariffs. Mexico uses block tariffs in many regions for water to encourage water conservation within the population. By contrast, The World Bank often establishes the value of water by using Willing-To-Pay (WTP), an economic measurement that determines the value of a commodity based on the demand for the commodity.

WTP uses the contingent valuation method (CVM), a method that bases the value and price of a commodity on the consumer demand for the commodity, and is usually accompanied by a regression variation. In essence, WTP is a measure of how much a household is willing to pay for that commodity. The weakness of CVM is in incomplete information on the part of the consumer. In reality, potable water is an inelastic good, meaning that WTP for potable water would be contingent on scarcity issues. CVM is actually questioning the WTP for the convenience of 24-hour potable water infrastructure. In a study by Van Houtven, et al, in 2006, the WTP for centralized piped water connections was examined and found to be connected to several factors: the consumer's access to other water sources, whether they were already connected to the government's critical water infrastructure, and, most importantly, how safe the consumers viewed their current water source.

This is but one direct connection to our built environment where the degree of resilience is important. Architects should strive to provide universally accessible potable water sources that are secure, reliable, and trustworthy. The facilities and infrastructure that architects design can help to ensure these goals are met by demanding infrastructure improvements, supporting minimum code requirements for water quality and quantity and legislation that secure water sources for the long term future, and by designing buildings that can purify contaminated water sources that may contaminate potable water systems.

Economic Considerations for Potable Water in Tijuana

Tijuana's water supply is considered by locals to be unsafe to drink. The local government does not perform spatial analysis of water-borne diseases (Calva 2012). Therefore the disease burden of water is a pervasive problem, though not included in public discourse. CESPT, the water utilities organization of Tijuana, is responsible for water services within Tijuana, and their only inter-governmental liaison is with the United States Department of Environmental Health. Tijuana is one of the largest consumers of private water in Mexico - more specifically, privately bottled water. The privately run water industry is not well regulated for quality on the local level, despite regulations. Often, the water trucks used by private companies unintentionally provide contaminated water, when contaminated, unsterile, and unclean equipment and practices are used (Calva 2012).

Economic Rationale for Future-Proofing Water Infrastructure

To develop an economic rationale for the infrastructure improvements, a basic Ordinary Least Squares (OLS) regression could be run, incorporating the age, condition, and location of infrastructure, the incidence of waterborne illness in terms of its effect on productivity. Equating productivity with lost wages, we can use the minimum wage for Mexico, 70 pesos per day, as a quantitative measure of lost productivity (Harrup 2014). Assuming that obtaining clean water and water-borne illnesses cause lost productivity, we can assess the lost productivity, and thus, lost Gross Domestic Product (GDP) of Tijuana based on poorly maintained critical infrastructure.

The case in San Diego is similarly based in economics, but with less emphasis on health and welfare. The primary reason to future-proof the water infrastructure in San Diego is because of the economic loss that might be incurred due to reduced business volume. Water shortages or interruptions due to natural or man-made disasters can impact the region's economy severely. In addition, maintaining a ready supply of water is important to the long term economic health of the region. If there is not enough water available to sustain the population at an affordable price, people and businesses will leave the region for more affordable areas. These threats to water security in San Diego can be managed by future-proofing the infrastructure. This includes development of quantities of water that meet generously predicted growth in the region, strengthening water processing facilities and pipelines to resist natural hazards, and even providing private water treatment on our sites. Architects can further influence the situation by designing buildings for low water consumption, rainwater capture, and wastewater recycling. These methods of managing the threats to water security are based upon the Principles of Future-Proofing, as we shall see later.

Clearly, we can establish the economic value of potable water, though the exact value is not relevant in this context and is researched elsewhere. The Return on Investment (ROI) for future-proof improvements to water infrastructure systems can, therefore, also be established. How, then, can that value be used to improve the resilience of water infrastructure systems? The first step is to understand the vulnerabilities of water infrastructure system. Following that, the Principles of Future-Proofing can be applied to guide capital investments in the system for the greatest effect. The rest of this paper will further explore

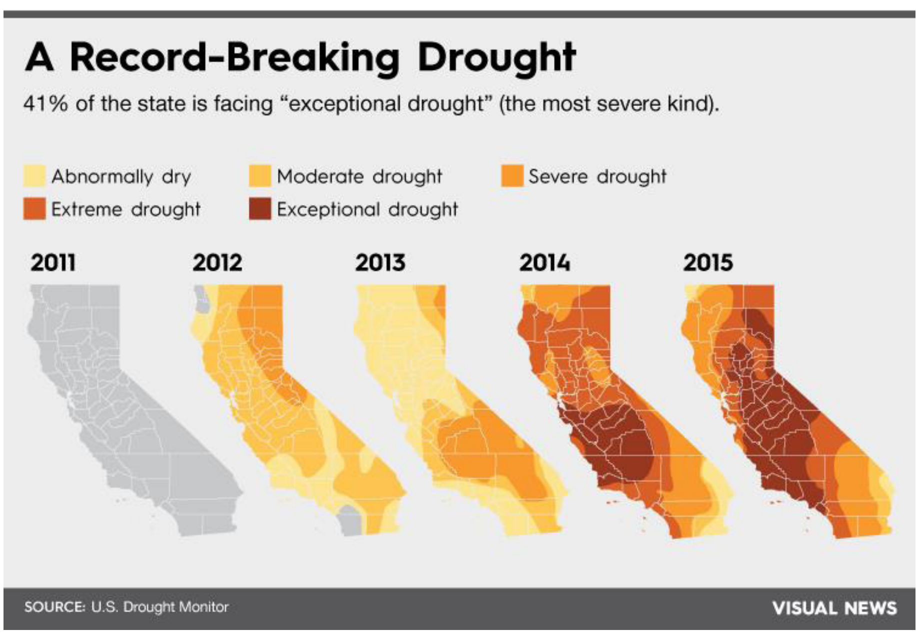


Figure 1: Map of the expanding drought area in California. Credit: US Drought Monitor, National Drought Mitigation Center, 2015.

2

Figure 2: A map of the aqueducts in California. Credit: Shannon1 / Wikimedia Commons /CC-BY-SA-3.0.

region-specific vulnerabilities of the infrastructure system and different future-proofing options that can be utilized to increase resilience not only in infrastructure systems, but other aspects of the built environment as well.

FUTURE-PROOFING: A NEW METHODOLOGY TO ADDRESS VULNERABILITIES

To increase resilience to vulnerabilities, there are four aspects related to critical water infrastructure resiliency that need to be addressed. As stated by John Matthews, the key aspects of underground water infrastructure resiliency include:

> (1) redundancy in the water distribution system, (2) storage capacity in the wastewater collection system, (3) structural integrity in the water distribution and wastewater collection systems, and (4) backup power to and structural stability of drinking water and wastewater treatment and pumping facilities (Matthews, 2015).

Vulnerabilities of Regional Water Systems

There are numerous potential vulnerabilities to the critical infrastructure systems for potable water. The San Diego and Tijuana regional water systems are an excellent example of these vulnerabilities as well as potential methods for future-proofing those systems. Potential vulnerabilities include levee failures, material deterioration, and climate change (CDWR, 2009, 2). With changes in the hydrologic conditions due to climate change (see Figure 1, below), there will be increased emphasis on ensuring that the water infrastructure systems continue to function after a natural hazard event where specific components or facilities in the system are compromised (RWMG, 2013). In addition to the aqueducts and pipelines, local or regional infrastructure such as reservoirs, dams, local pipeline systems, pump stations, water treatment, and desalination facilities could be impacted by any of several potential natural hazards.

Imported water via aqueducts and pipelines stands as the most significant vulnerability due to the high volumes required, the length of travel, and the nature of the delivery system. See Figure 2, above. "A seismic event is the single greatest risk to levee integrity in the Delta Region," a region in central California that is the "hub of California's water supply system" (CDWR, 2009, 2). Examining the combination of the vulnerabilities of water infrastructure and seismic events demonstrates the potential impacts in San Diego and Tijuana.

Conventional piping infrastructure is at risk for damage in a seismic event as the materials do not generally react well to the shear stresses brought upon by earthquakes. A 2012 article in the American International Journal of Contemporary Research by Robert Brears outlines the effect of a 6.3 earthquake that occurred 5 km below the surface on water systems in Christchurch, New Zealand (Brears, 2012). The city relied heavily on piped water from aqueducts, using 1500 km (932 miles) of pipe which were heavily damaged in the earthquake. It was estimated that the damage totaled $17 million and consisted of 150 km (10%) of pipe being damaged ($12 million), reservoirs cracked, and wells collapsed.

The City of San Diego has 3,250 miles of pipeline compared to 932 miles in Christchurch (City of San Diego, 2015b). Based upon the damage in Christchurch and the proportional differences in amount of pipeline supplying water to San Diego, the damage due to a seismic event would be more than three times larger.

By contrast, Tijuana has a shorter amount of pipeline than San Diego and approximately the same amount of reservoirs and wells as Christchurch (CDM, 2010). With twice as much pipe and approximately the same amount of reservoirs and wells as Christchurch, the damage could be about twice that in Christchurch (CDM, 2010).

RESPONSE TO VULNERABILITIES AND SEISMIC IMPACTS

New Potable Water Technologies

There are a multitude of different technologies being pursued which will provide different options for new sources of potable water. There are two basic options: natural filtration or human filtration.

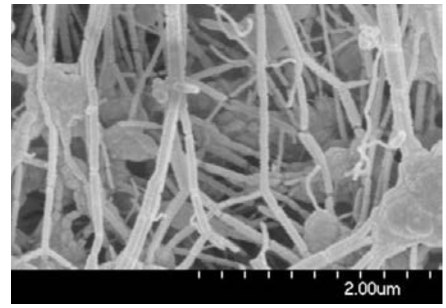
Natural filtration of water has been through the latter part of the 20th century by humans to provide safe sources of water. Typically, natural water is filtered through the ground to purify it. Only in the last century has ground water been treated by additional processes to comply with EPA and WHO potable water standards. Such naturally filtered water ends up in streams or rivers and underground aquifer systems and is often accessed through wells. Naturally filtered water sources are no longer sufficient to support our population and the natural eco-systems for a variety of reasons – overuse, pollution, climate changes.

Due to the ready availability of wastewater, however, there are several man-made water filtration systems that have been developed in search of the most efficient ways to create drinking water from contaminated wastewater. These include desalination, physical treatment, chemical treatment, and biological treatment systems.

Desalination, the direct conversion of salt water to potable water, is achieved through reverse osmosis technology, eliminating salt and resulting in pure water that requires little additional treatment. Physical treatment includes different types of filtration of the contaminated water. Filtration media include sand or soil, and membrane filtration. Membrane filtration technologies include micro- or ultrafiltration and membrane bioreactor filtration (MBR) which uses combined biological treatment and membrane filtration to meet non-potable water use standards (Li, 2009). Chemical treatment can include "coagulation, photocatalytic oxidation, ion exchange, and granular activated carbon treatments" (Li, 2009). Biological treatment can include rotating biological contactor (RBC), sequencing batch reactor (SBR), anaerobic sludge blanket, and constructed wetland processes (Li, 2009).

These options are often used in combination since one particular treatment does not remove all contaminants. For instance, physical filtration systems are not adequate to remove all organics, nutrients or surfactants and chemical processes don't work well for highly contaminated greywater. In addition, anaerobic processes don't treat organic substances or surfactants, contrasting with aerobic biological processes will treat organics and surfactants, but still require filtration and ultraviolet light treatment (Li, 2009).

In the end, there are many technologies available for treatment of contaminated water, but there are few that are reasonable to pursue from the point of view of economics or energy consumption. Reasonable processes include a combination of aerobic processes, filtration, and disinfection or filtration membrane technologies. For example, the California Groundwater Replenishment System (GWRS) takes wastewater that has already been highly treated and further purifies it using microfiltration, reverse osmosis, and ultraviolet treatments to meet US and California drinking water standards (Bennett, 2011). In the San Diego and Tijuana region, additional potable water sources are being implemented to future-proof their water infrastructure system.



3

SAN DIEGO AND TIJUANA INFRASTRUCTURE VULNERABILITY RESPONSE

The San Diego Regional Water System has sought to ensure water sources for many decades into the future, assuring the region of secure water supplies and distribution. For emergencies, the Regional Water Management Group (RWMG) has developed an emergency storage program aimed at providing a 75% service level and includes several key elements of the regional water system (RWMG, 2013). The regional water authority is also in the middle of a multi-decade long project to reline the existing pipeline system to increase their service life

Figure 3: An electron microscope image of a membrane filter for water. Credit: Joachim Koschikowski / Wikimedia Commons /CC-BY-SA-3.0.

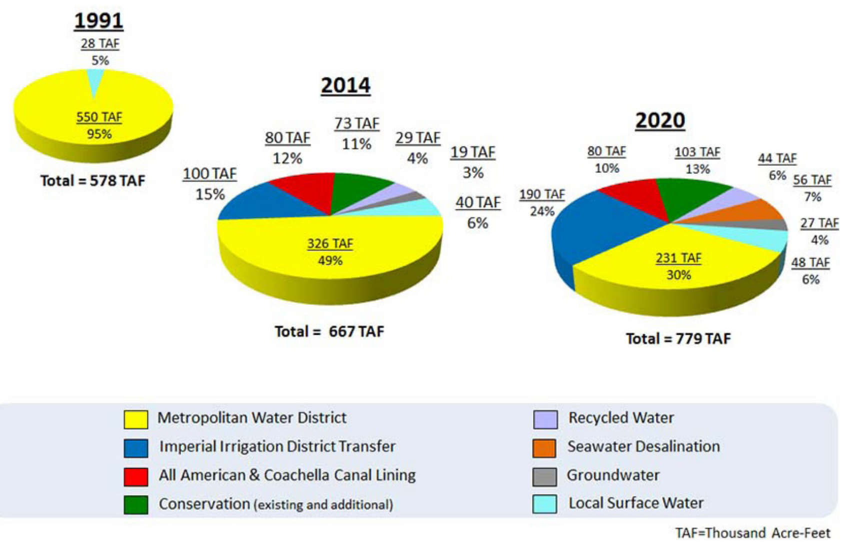


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Figure 4: Diversification of the water sources for the San Diego County area shows increased diversification of metropolitan water district sources. Credit: San Diego County Water Authority (SDCWA), 2015.

(Water-technology.net, 2012). In the Delta Region of Central California, the source of much of the water supplying San Diego, "state water representatives… …say they need to build the [water] tunnels to guard the water supply against" the impacts of catastrophic earthquakes (Madrigal, 2014). While these efforts continue, the region also seeks to supplement the water supply through diversification of sources of water which will support continued growth of the regional population. This diversification of water sources is illustrated in Figure 4 (below).

To address the critical shortfalls in the water supply for Tijuana and Playa de Rosarito, the Mexican government and US government have pursued several water infrastructure projects. Priorities for development of new water sources (in order of preference) are seawater desalination, indirect potable reuse (wastewater recycling), and additional water from the Colorado River (CDM, 2010). Alternative sources of water in the region are limited to optimization of the Colorado River supply, indirect potable use of effluent (wastewater recycling), and seawater desalination (CDM 2010). Capital improvement projects totaling more than $1 billion seek to construct a desalination plant, wastewater treatment plants, update the water and wastewater piping system, advanced treatment of wastewater, aquifer recharge, and aggressive industrial pretreatment programs (Calva, 2012). In 2012, 3 wastewater treatment plants generated a total of 55 million gallons per day (mgd) of potable and indirect potable water for the area (Calva, 2012).

The projects and improvements above are all examples of ways in which a water infrastructure system may be developed in a future-proof way while also addressing hazard mitigation concerns and the long term adaptive cycles of panarchy. Diversification of the water sources future-proofs the system by increasing ecological resiliency allowing for multiple states of equilibrium should one source fails. The bi-national support for wastewater treatment plants in the region helps to ensure that water sources are not polluted and easier to convert into potable water sources. Relining pipes is a clear effort to maintain and strengthen the pipeline infrastructure. Installation of additional wastewater treatment plants and other facilities helps to ensure not only an adequate volume of water will be available for current needs but also for future needs. Last, multiple facilities of each type create redundancy in the system so that at least partial service is more likely in the event of a natural disaster.

THE PRINCIPLES OF FUTURE-PROOFING

The interventions in the water systems in San Diego and Tijuana above are examples of future-proofing the infrastructure and water sources to ensure that the region continues

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to be a viable location to live. The Principles of Future-Proofing established by Rich were originally written with a focus on historic buildings (2014). However, they are also excellent guidelines for increasing resilience in infrastructure systems with the addition of two principles that address the long timeline required to design and implement major infrastructure projects: Plan Ahead and Diversify. With these, the Principles of Future-Proofing are:

1. **Prevent decay.** Promote building materials, methods, maintenance, and inspections that prevent premature deterioration of our built environment rather than accelerate deterioration.

2. **Promote understanding.** Allow for understanding of the built environment and its place in our built heritage through minimal interventions that remain distinguishable from the original structure.

3. **Stimulate flexibility and adaptability.** Flexibility and adaptability of our built environment and our attitudes toward it are essential to retention of our built environment in a disposable society.

4. **Extend service life.** Extend the service life of our built environment through regular maintenance so it may continue to contribute to our economy, culture, and sustainable society.

5. **Fortify!** Fortify our built environment against climate change, extreme weather and natural hazards, and shortages of materials and energy.

6. **Increase durability and redundancy.** Interventions should use building materials of equal or greater durability than existing building fabric or design for disassembly and replacement. Redundant systems provide backup in the event that a primary system fails and allow a building to continue to function.

7. **Reduce obsolescence.** Don't accept planned obsolescence. Take a proactive approach to preventing physical, functional, aesthetic, and sustainable obsolescence.

8. **Consider life cycle benefits.** Consider the long-term life cycle benefits of interventions in our built environment as opposed to demolition and disposal of existing historic building fabric.

9. **Be local and healthy.** Incorporate non-toxic, renewable, local materials, parts, and labor into our built environment to ensure materials and manufacturing capabilities will be readily available in the future for efficient repairs.

10. **Take advantage of cultural heritage policy documents.** Cultural heritage policy documents provide excellent guidance for the long-term retention of an historic building.

11. **Plan Ahead** Plan for optimum materials, construction phasing, and maintenance to prevent the need of major interventions.

12. **Diversify** Ecologically resilient systems allow for multiple stable states, including different sources, uses, capabilities, and economic models rather than on one dominant trait.

Analysis

It is immediately evident that many of the strategies being employed in San Diego and Tijuana are future-proofing their potable water infrastructure systems, in line with John Matthews' key aspects previously discussed. Architects, Urban Designers, and Planners are regularly involved with the design and implementation of infrastructure systems, including water systems. Even on a site by site basis, we can learn to design in future-proof measures such as seismic loops and flexible over-sized systems to prevent damage in seismic events as well as accommodate future changes in use and population growth.

Diversification of the water sources and processing facilities most closely relates to Principle 12, but also increases redundancy (Principle 6). In San Diego, the long term plan includes several water sources including metropolitan water district sources, irrigation water transfer, canal lining to prevent leakage, conservation or reduced consumption, recycled wastewater, desalination, groundwater sources, and surface water sources.

The City of San Diego projects to reline water mains, branches, and canals demonstrates the implementation of Principle 4 to extend service life, Principle 5 to fortify and increase durability, and Principle 7 to reduce physical and functional obsolescence. Relining the water pipes is an example of Principle 1 preventing further deterioration of the infrastructure system and preventing obsolescence. Relining is also a result of life cycle analysis that includes cost and community impact considerations - Principle 8.

Recycling of wastewater sources, including industrial and greywater is a sustainable practice advocated by Principle 9 and also increases the diversity of water sources and building redundancy into the infrastructure system - Principles 9, 12, and 6 respectively. Developing use agreements with adjacent users such as Tijuana and the agricultural communities in central California demonstrate long term planning and diversification of water sources, exemplifying Principles 11 and 12.

New water tunnels are being built from northern California to the San Diego region, thus fortifying water supply systems against natural hazards, increasing capacity, and demonstrating long term planning, diversification of sources. The implementation of new water tunnels are examples of Principle 5 and 11. The emergency storage program under development for San Diego is an example of developing redundancy (Principle 6) and planning ahead (Principle 11).

The efforts that San Diego Regional Water management group are pursuing in relation to their local and regional water infrastructure exemplify nine of the twelve Principles of Future-Proofing. This suggests that when all of these projects are complete that they will have a far more future-proof water system than ever before. However, the current efforts should not be the end of the process. Ongoing maintenance, diversification efforts, capacity development, and planning for future requirements are necessary to ensure an ongoing future-proof supply of water for the region.

CONCLUSION

Water infrastructure, a component of our built environment, has important economic, social and health benefits. Application of the Principles of Future-Proofing to water infrastructure systems is critical in regions that are vulnerable to water scarcity, flooding, drought and earthquake hazards. The return on investment of future-proofing water infrastructure include productivity increases due to health and welfare benefits, effective water pricing, and a higher WTP price point for potable water. This will allow utility infrastructure managers to effectively create a portfolio of water infrastructure resilience options that fit their budget and needs.

Architects are involved on a regular basis to design secure water treatment facilities, secure water supply sources, and infrastructure systems for all scales of built environment from individual sites to regions of the country. Future-proofing infrastructure systems means durable and redundant systems that are flexible and adaptable to anticipate future needs and prevent obsolescence. Stringent maintenance regimens coupled with diversification of water sources extend the service life of infrastructure systems. These and other techniques founded on future-proof principles will help to develop a sustainable resilient built environment.

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Appendix 2: Case Study Information

Appendix 2: Case Study Information
University of Washington
Clark Hall

Clark Hall

List of Figures

Collections Division.

20. Clark Hall interior showing kitchen and staff, University of Washington, ca. 1900. Credit: Anders Beer Wilse. UW Negative Number 6261. Courtesy University of Washington Libraries. Special Collections Division.
21. Clark Hall interior showing reception room, University of Washington, ca. 1900. UW Negative Number UW6264. Courtesy University of Washington Libraries. Special Collections Division.
22. Suite of Rooms in Clark Hall. 1905. Document Number 008-CP-7, Identifier 3062021. Credit: Webster & Stevens. Courtesy UW Facilities Records.
23. Suite of Rooms in Clark Hall. 1905. Document Number 008-CP-8, Identifier 3062022. Credit: Webster & Stevens. Courtesy UW Facilities Records.
24. Room - Women's Dormitory (Clark). 1900. Document Number 008-CP-2, Identifier 3046661. Photographer unknown. Courtesy UW Facilities Records.

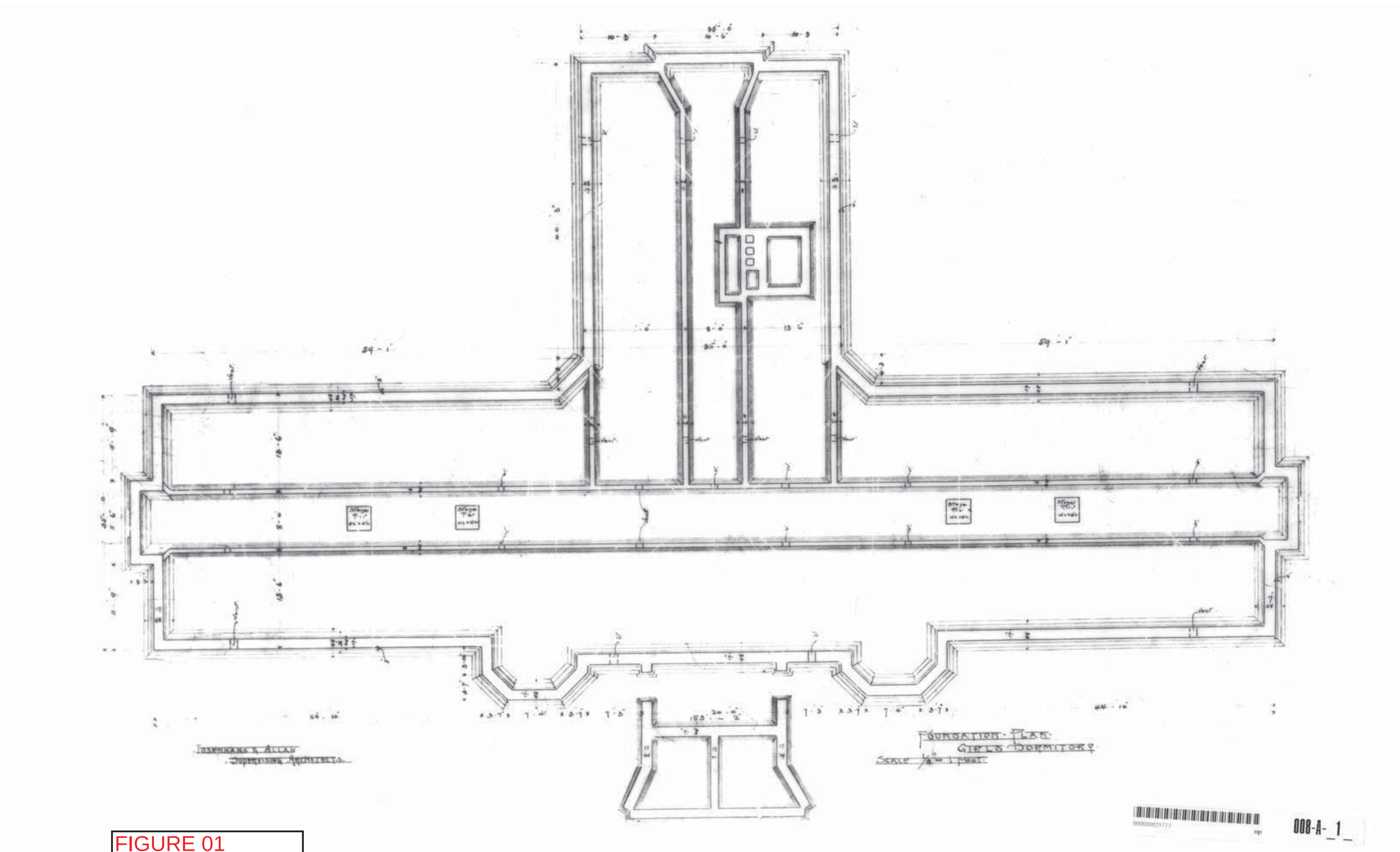
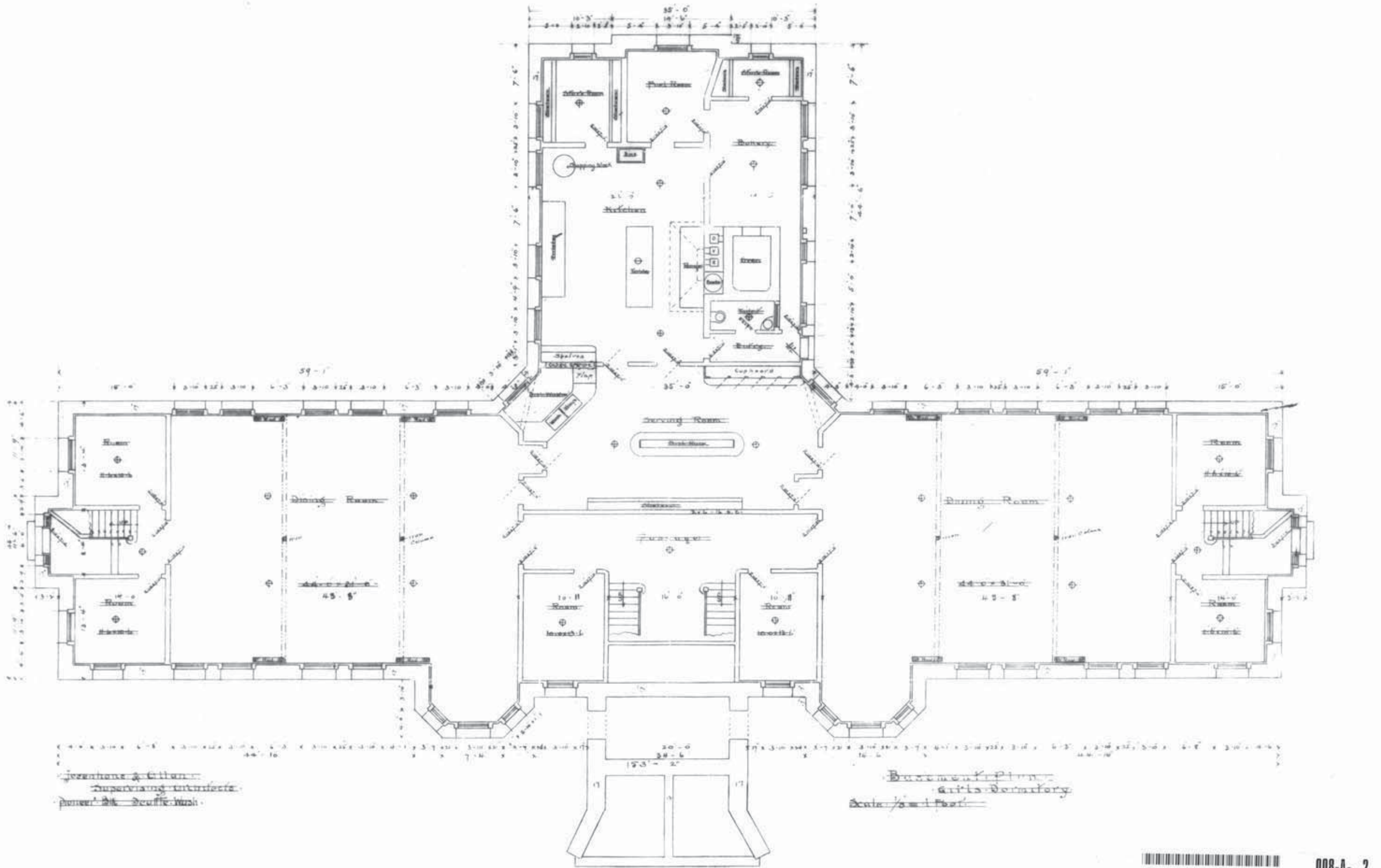

FOUNDATION · PLAN ·
GIRLS · DORMITORY ·
SCALE 1/8" = 1 FOOT ·
SUPERVISING ARCHITECTS
008-A-_1_

FIGURE 01



Dining Room
Dining Room
45'-8"
59'-1"
59'-1"
35'-0"
153'-2"
Basement Plan
Girls Dormitory
Scale 1/8 = 1 Foot
008-A-2

FIGURE 02

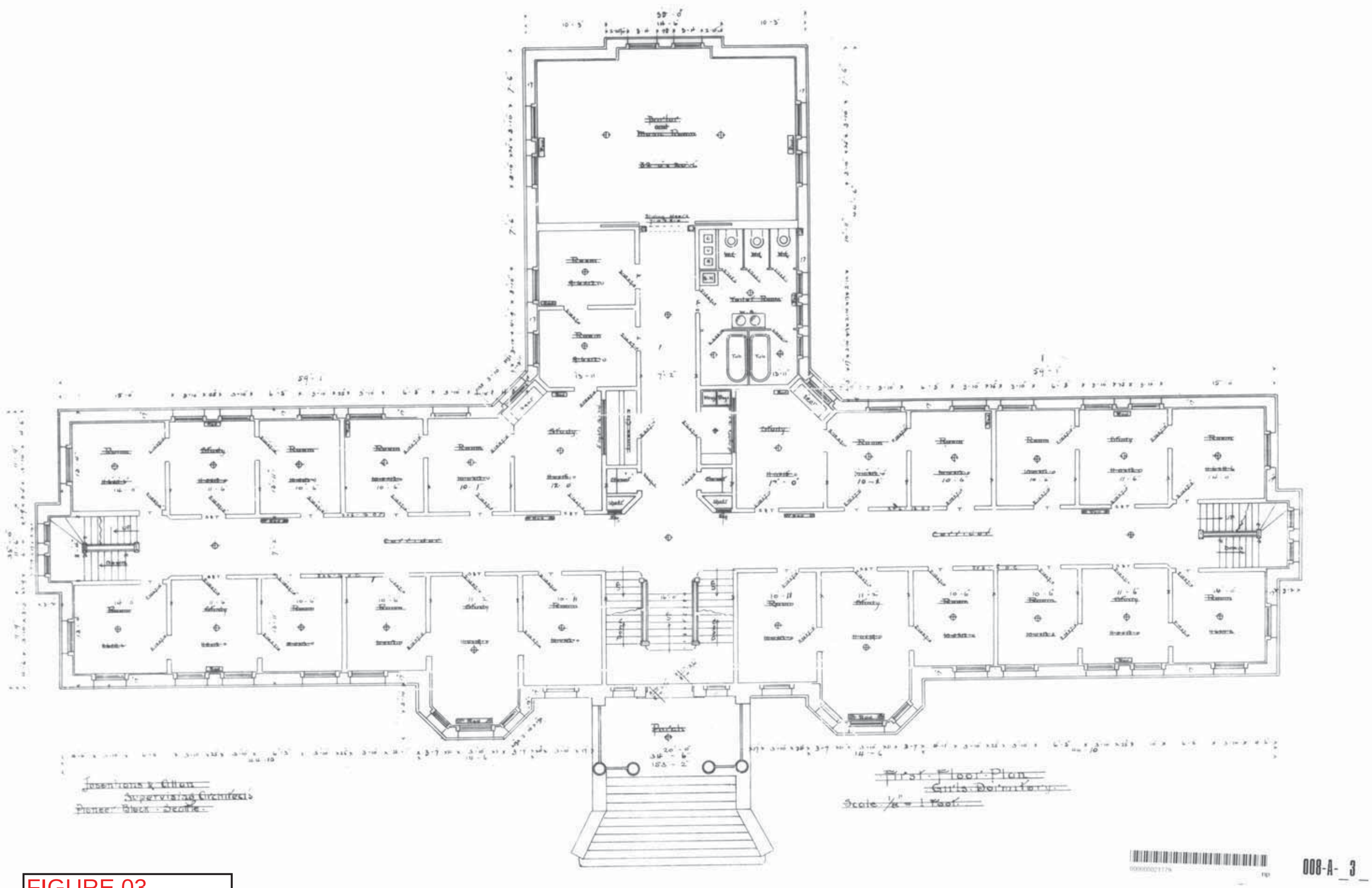

Josenhans & Allan
Supervising Architects
Pioneer Block · Seattle
First · Floor · Plan
Girls Dormitory
Scale 1/8" = 1 Foot
008-A-_3_

FIGURE 03

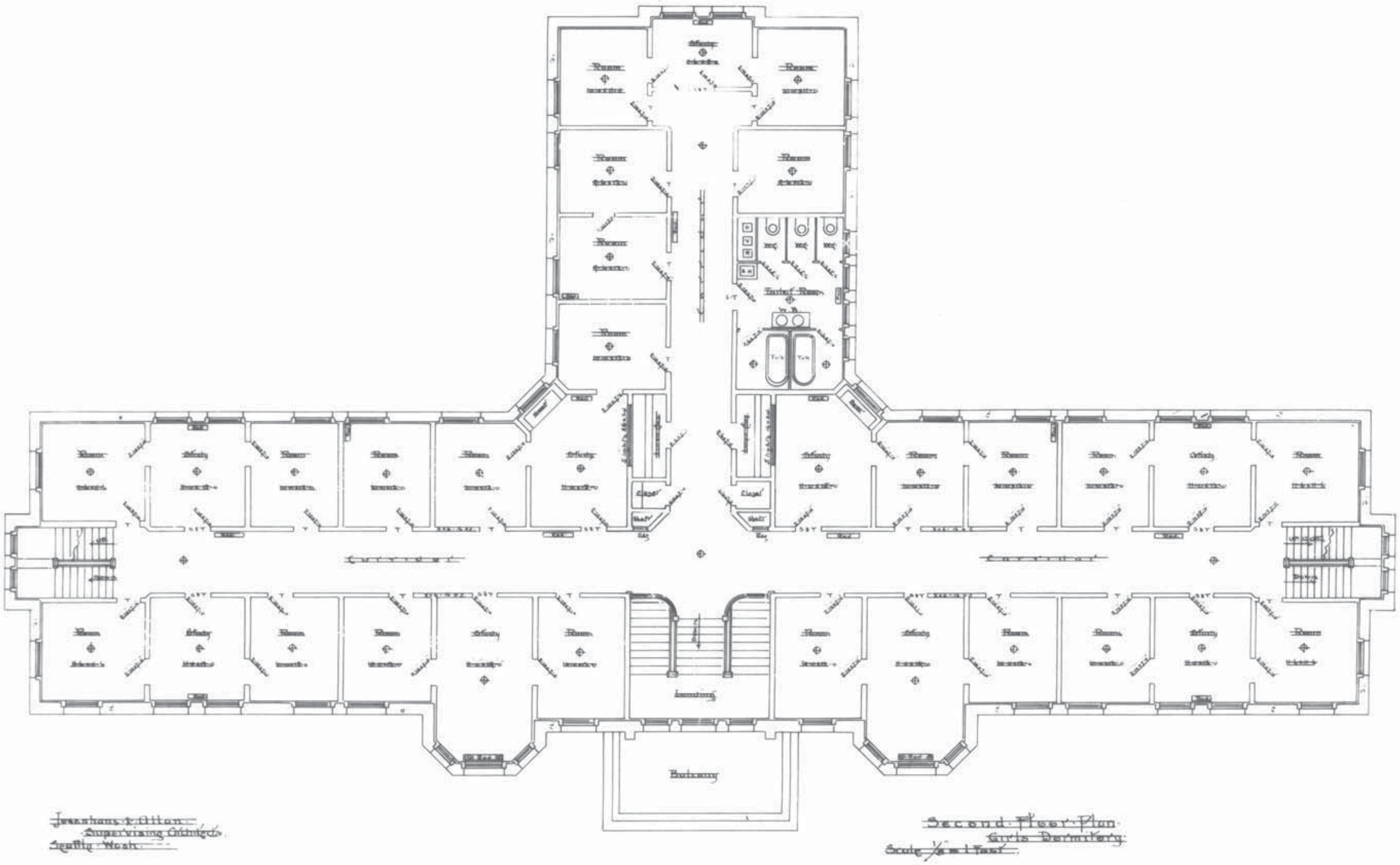


FIGURE 04

008-A-_4_

Josenhans & Allan
Supervising Architects
Seattle Wash.

Front Elevation
Girls Dormitory
Scale 1/8" = 1 foot

FIGURE 05

008-A-5

FIGURE 06

008-A-_6_

FIGURE 07

008-A-_7_

FIGURE 08

008-A-_8_

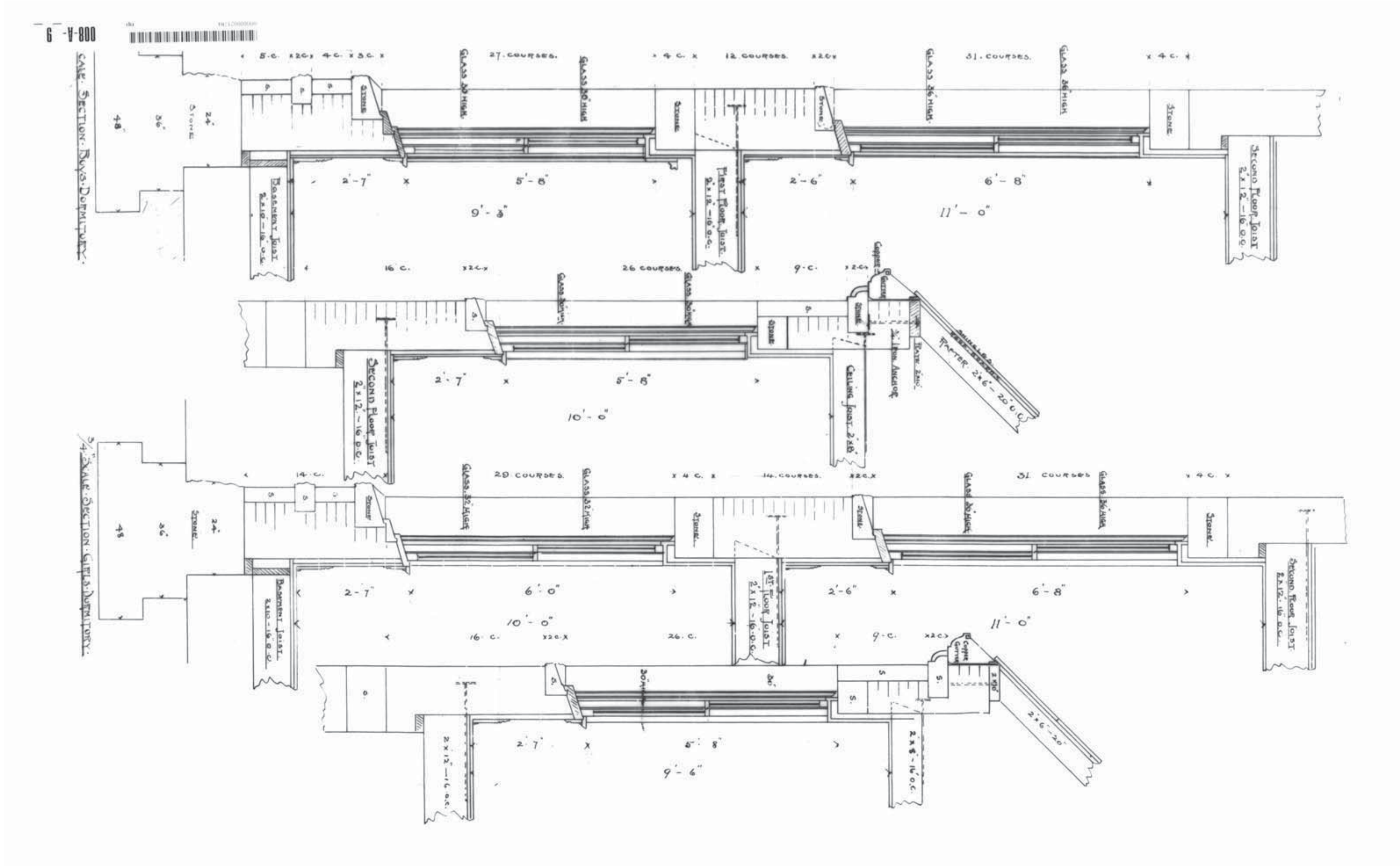
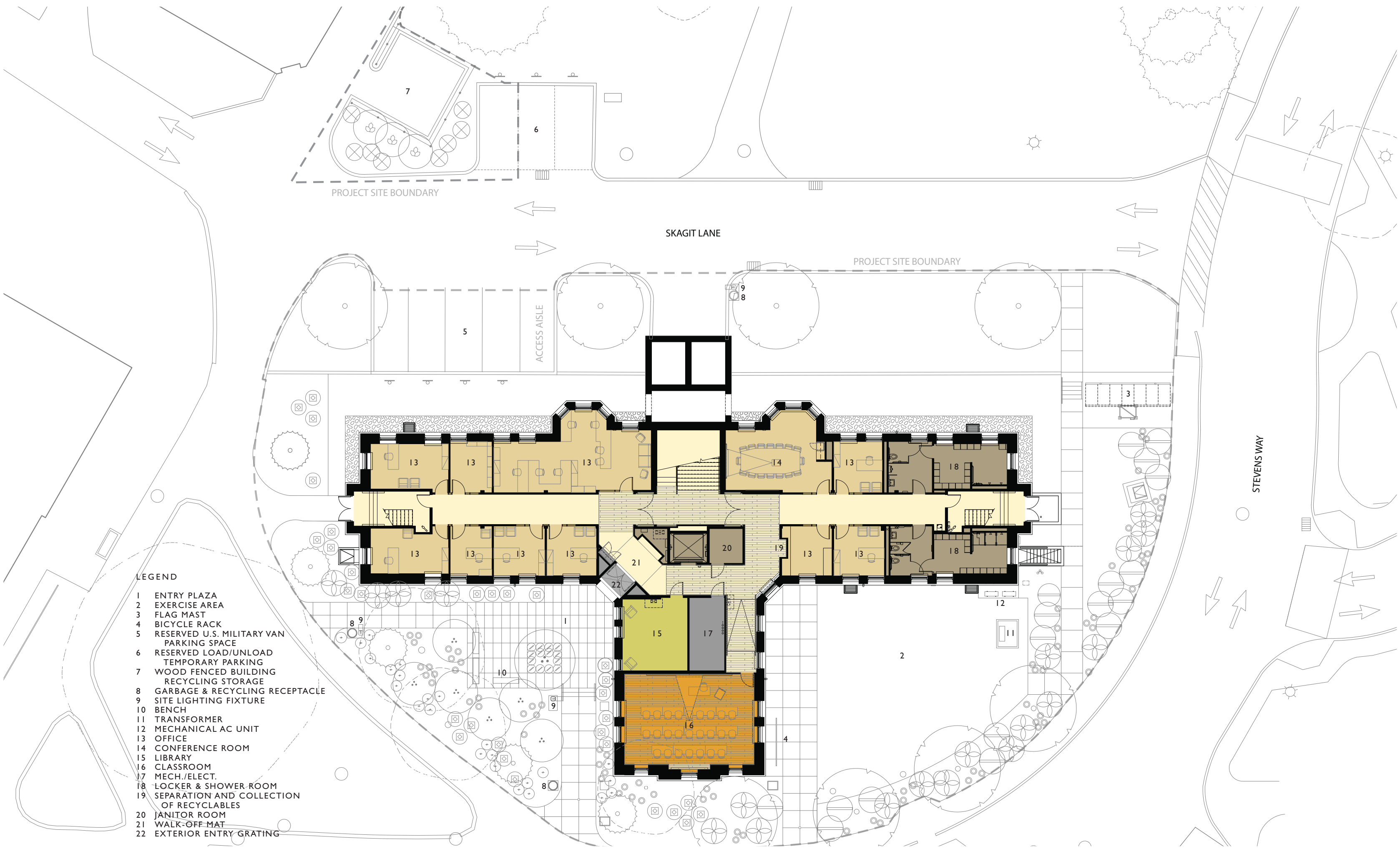

27 COURSES.
12 COURSES.
31 COURSES.
2'-7"
5'-8"
9'-3"
2'-6"
6'-8"
11'-0"
26 COURSES
10'-0"
29 COURSES.
14 COURSES.
6'-0"
9'-6"

FIGURE 09



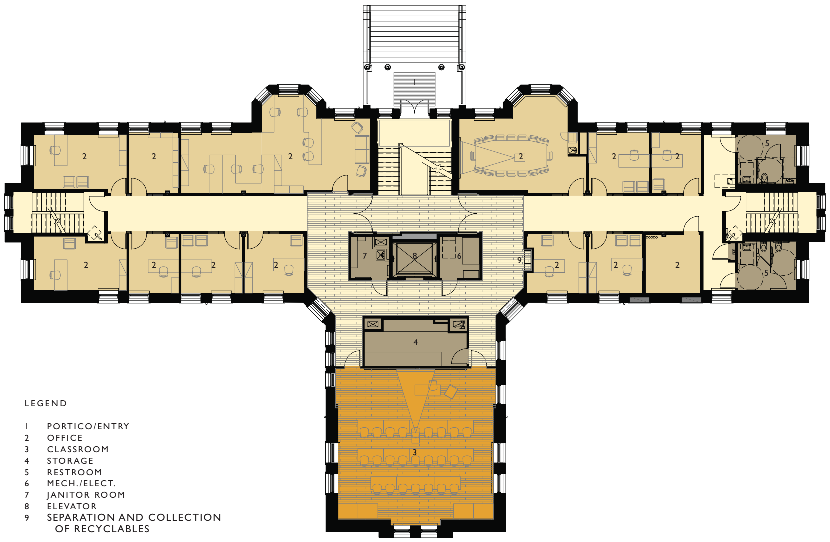
MAHLUM architects

SITE PLAN & LEVEL 01 FLOOR PLAN
CLARK HALL RENOVATION
UNIVERSITY OF WASHINGTON

NORTH
SCALE: 1" = 20'-0"

UW PROJECT NO: 200910
DATE: 03/31/2008

FIGURE 10



LEGEND

1 PORTICO/ENTRY
2 OFFICE
3 CLASSROOM
4 STORAGE
5 RESTROOM
6 MECH./ELECT.
7 JANITOR ROOM
8 ELEVATOR
9 SEPARATION AND COLLECTION OF RECYCLABLES

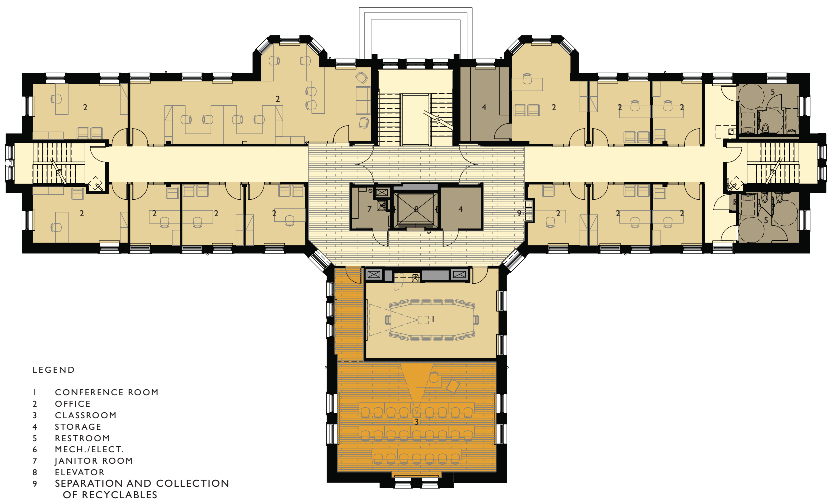
MAHLUM architects

LEVEL 02 FLOOR PLAN
CLARK HALL RENOVATION
UNIVERSITY OF WASHINGTON

NORTH
SCALE: 1" = 20'-0"

UW PROJECT NO: 200910
DATE: 03/31/2008

FIGURE 11



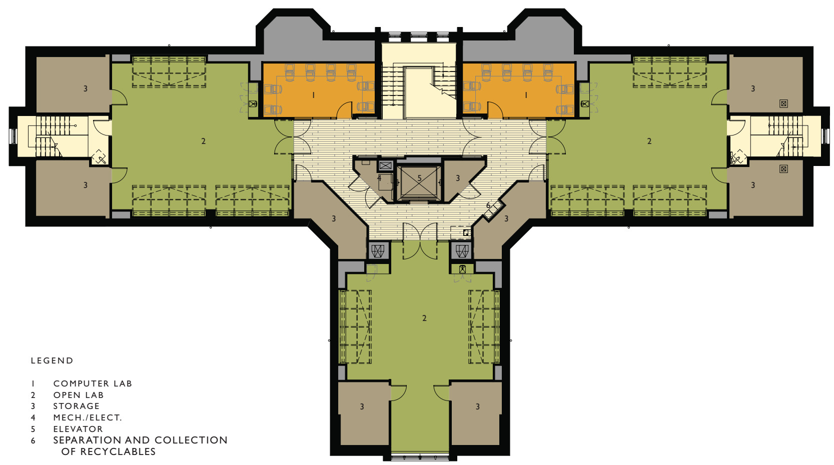
MAHLUM architects

LEVEL 03 FLOOR PLAN
CLARK HALL RENOVATION
UNIVERSITY OF WASHINGTON

NORTH
SCALE: 1" = 20'-0"

UW PROJECT NO: 200910
DATE: 03/31/2008

FIGURE 12



MAHLUM architects

LEVEL 04 FLOOR PLAN
CLARK HALL RENOVATION
UNIVERSITY OF WASHINGTON

SCALE: 1" = 20'-0"

UW PROJECT NO: 200910
DATE: 03/31/2008

FIGURE 13

MAHLUM architects

FIGURE 14

NORTH ELEVATION
CLARK HALL RENOVATION
UNIVERSITY OF WASHINGTON

SCALE: N.T.S.

MAHLUM
architects

FIGURE 15

WEST ELEVATION
CLARK HALL RENOVATION
UNIVERSITY OF WASHINGTON

SCALE: N.T.S.

MAHLUM architects

TYPICAL BUILDING SECTION
CLARK HALL RENOVATION
UNIVERSITY OF WASHINGTON

SCALE: N.T.S.

FIGURE 16

FIGURE 17

FIGURE 18

Dining Hall, Clark Hall 1907

CP-1905-47

OLD NUMBER

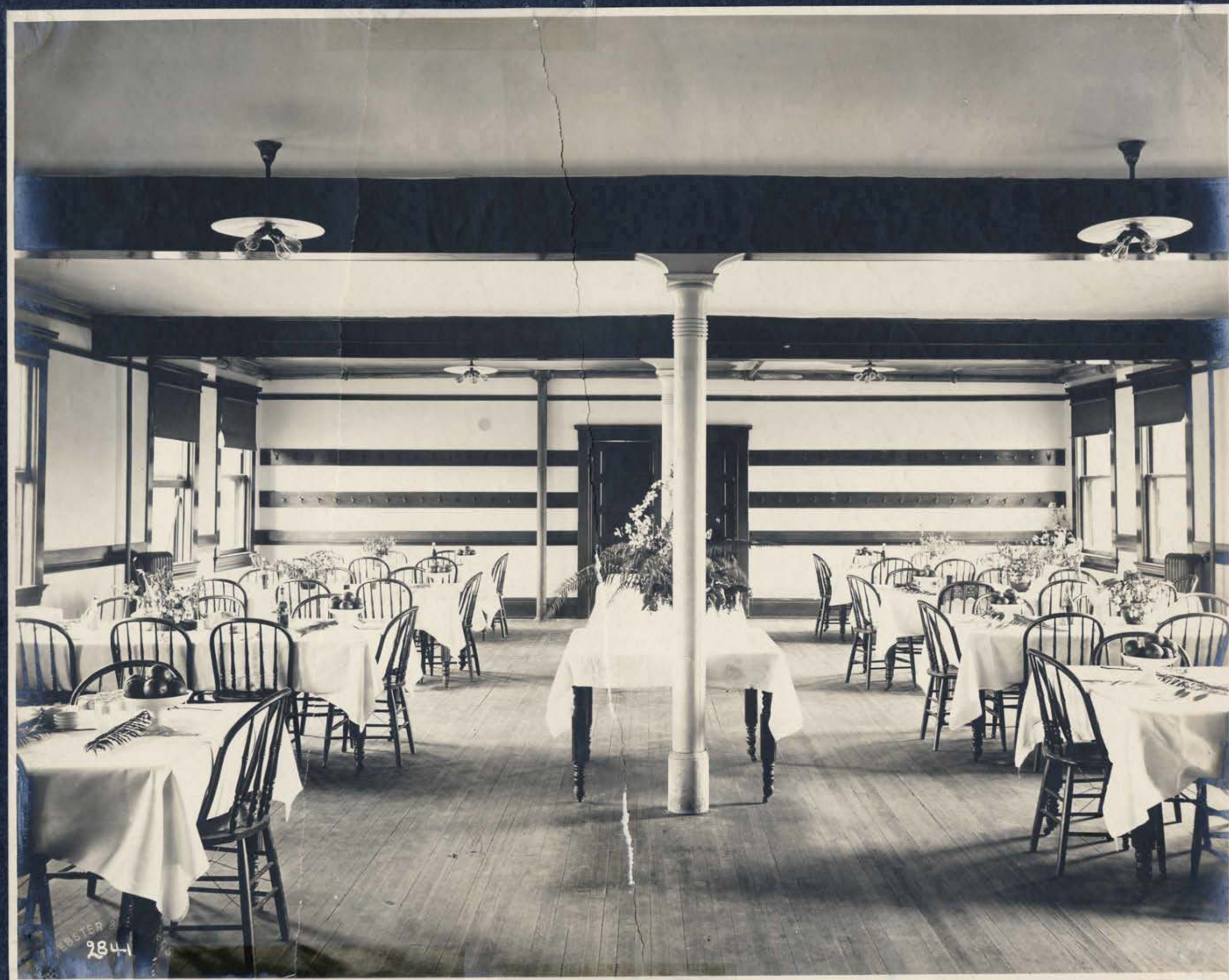


FIGURE 19

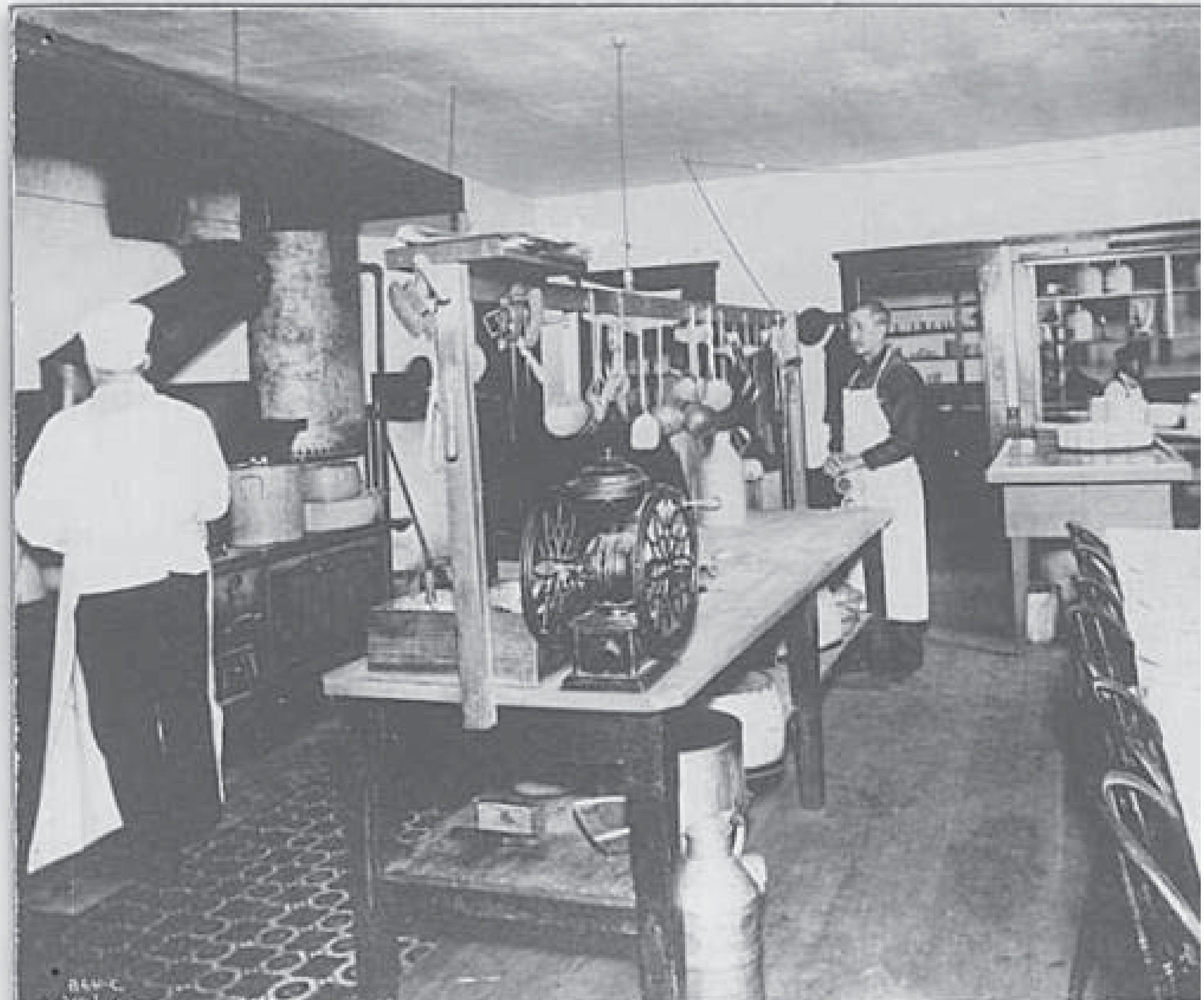


FIGURE 20 Property of MSCUA, University of Washington Libraries. Photo Coll 700

Parlor, Clark Hall, 1907

CP-1905-46

OLD NUMBER

62017

008-CP-_5_

np CP – 1905 – 46

FIGURE 21

FIGURE 22

FIGURE 23

(11)

Room ~ Women's Dormitory

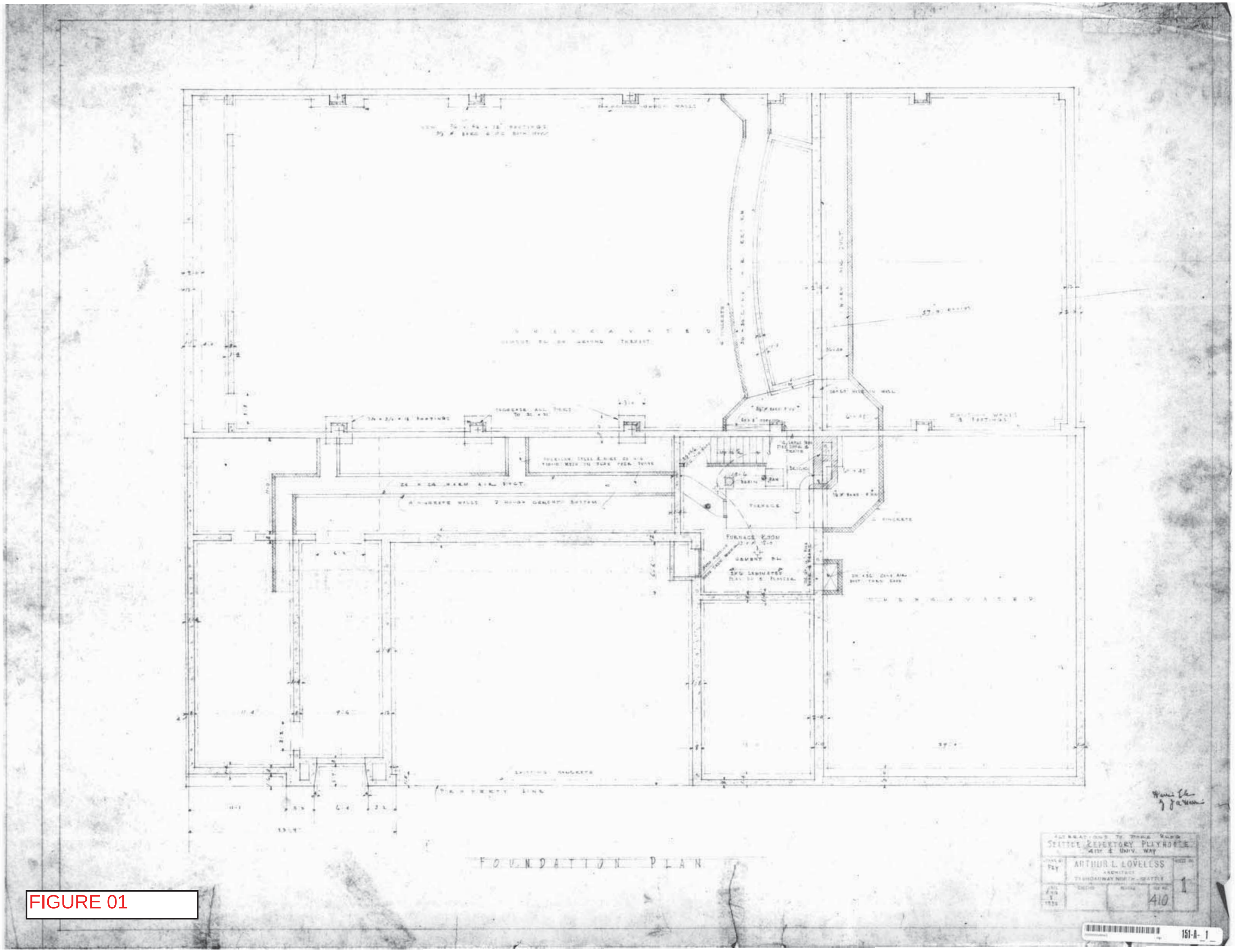
FIGURE 24

Appendix 2: Case Study Information
University of Washington
Playhouse Theater

Floyd and Dolores Jones Playhouse Theater

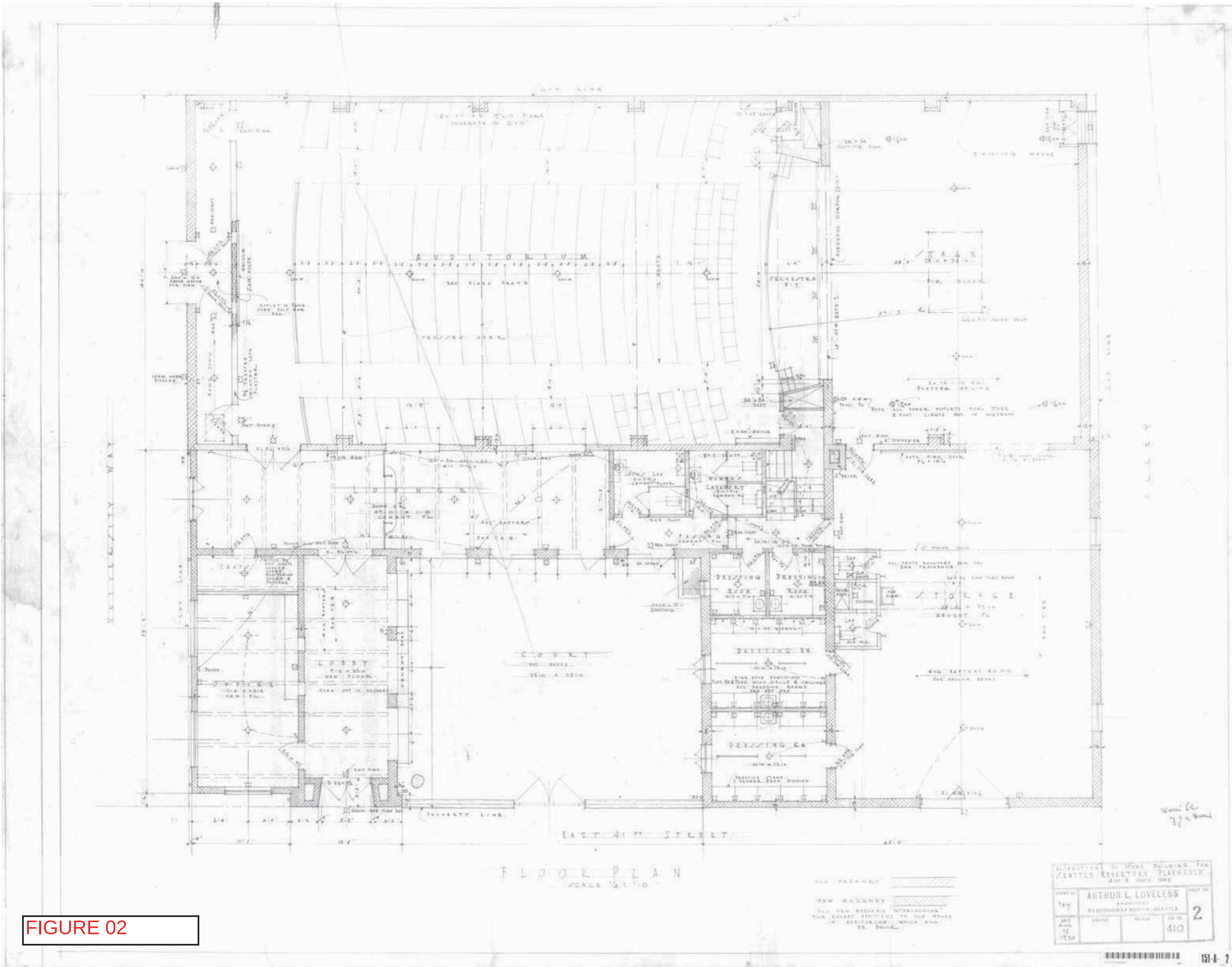
List of Figures

15. Floyd & Dolores Jones Playhouse. Wall Sections. 2007. Credit: LMN Architects. Document Number 151-A-62. Courtesy UW Facilities Records.
16. Floyd & Dolores Jones Playhouse. Wall Sections. 2007. Credit: LMN Architects. Document Number 151-A-63. Courtesy UW Facilities Records.
17. Floyd & Dolores Jones Playhouse. Exterior view looking southwest and Panoramic view from Stage Right. 2007. Credit: John Stamets. Courtesy UW Capital Planning & Development.
18. Floyd & Dolores Jones Playhouse. South wall of the stage block under construction. 2008. Courtesy UW Capital Planning & Development.
19. Floyd & Dolores Jones Playhouse. Northwest entry during construction. 2008. Courtesy UW Capital Planning & Development.
20. Floyd & Dolores Jones Playhouse. New lobby space under construction (interior view). 2008. Courtesy UW Capital Planning & Development.
21. Floyd & Dolores Jones Playhouse. New lobby space under construction (exterior view). 2008. Courtesy UW Capital Planning & Development.
22. Floyd & Dolores Jones Playhouse. Exterior view of the main entrance and courtyard prior to construction. ca. 2007. Courtesy UW Capital Planning & Development.



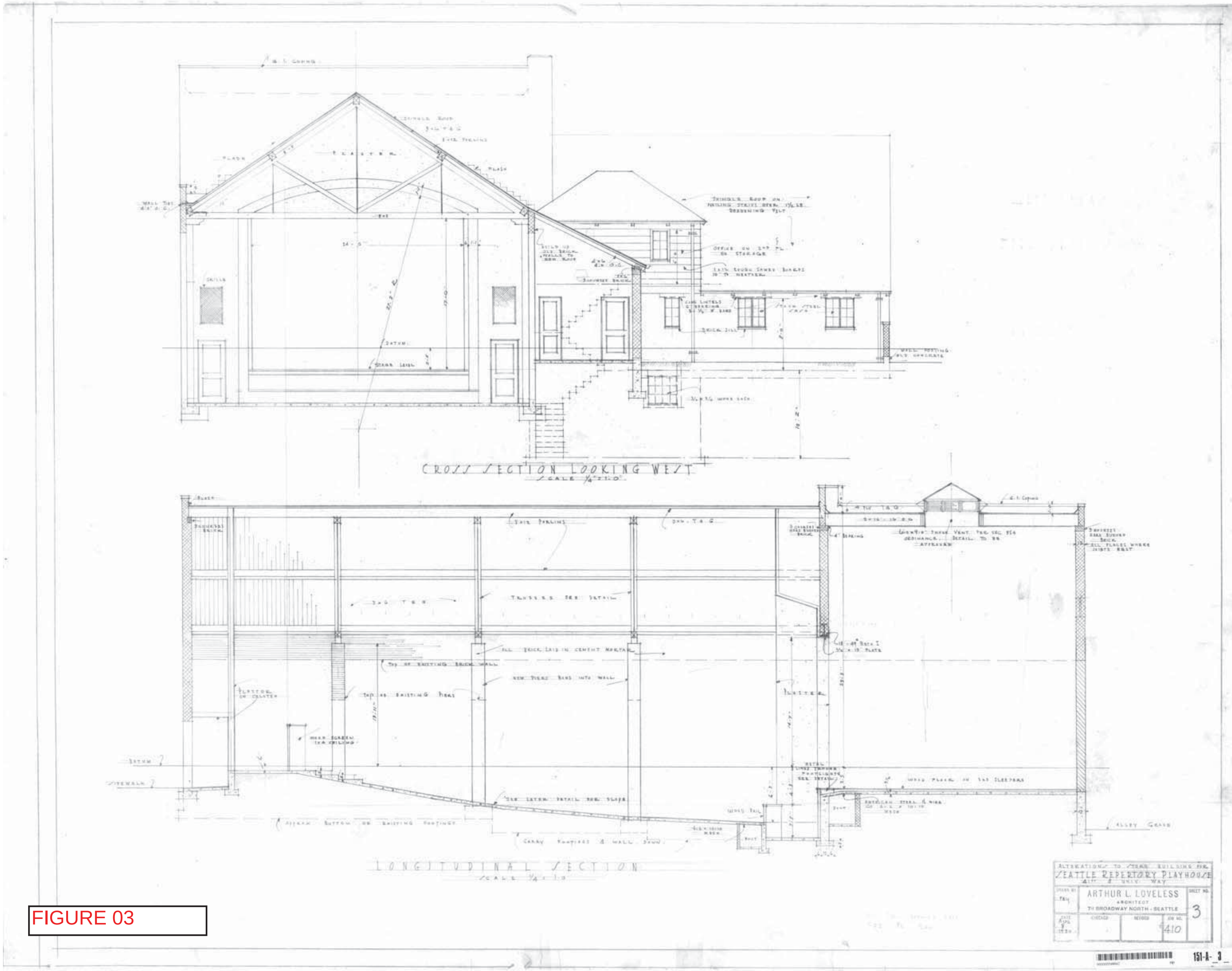
FURNACE ROOM
PROPERTY LINE
FOUNDATION PLAN
SEATTLE REPERTORY PLAYHOUSE
UNIV. WAY
ARTHUR L. LOVELESS
410
1
151-A- 1

FIGURE 01



AUDITORIUM
STAGE
ORCHESTRA PIT
COURT
LOBBY
OFFICE
DRESSING ROOM
STORAGE
EAST 41ST STREET
FLOOR PLAN
ARTHUR L. LOVELESS
ARCHITECT
410
2
151-A- 2

FIGURE 02



CROSS SECTION LOOKING WEST
LONGITUDINAL SECTION
ALLEY GRADE
ALTERATIONS TO STORE BUILDING FOR
SEATTLE REPERTORY PLAYHOUSE
ARTHUR L. LOVELESS
ARCHITECT
711 BROADWAY NORTH - SEATTLE
SHEET NO.
3
JOB NO.
410
151-A- 3

FIGURE 03


EAST ELEVATION
NORTH ELEVATION
SEATTLE REPERTORY PLAYHOUSE
ARTHUR L. LOVELESS
ARCHITECT
BROADWAY NORTH - SEATTLE
410
4
151-A- 4

FIGURE 04

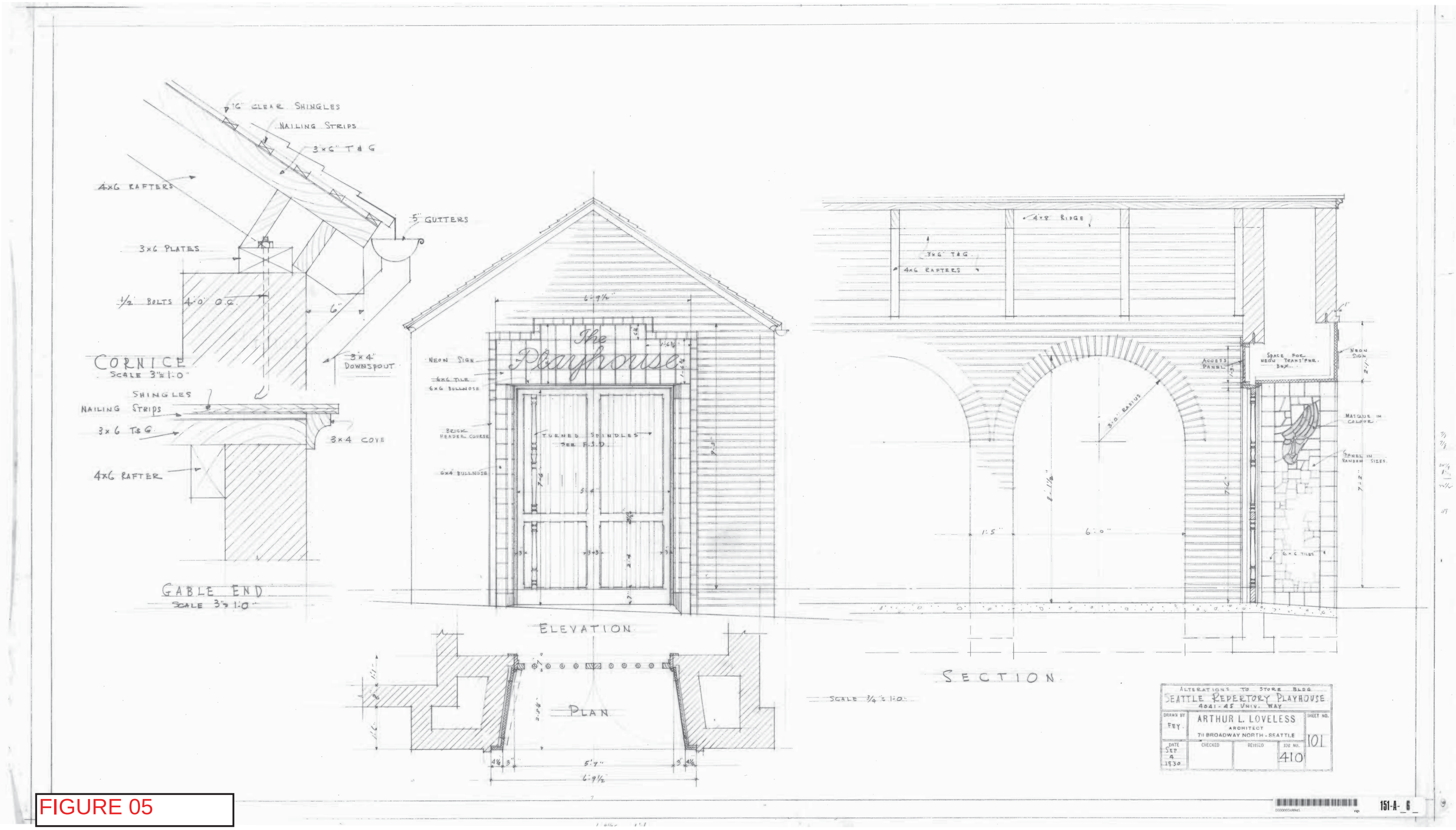

16" CLEAR SHINGLES
NAILING STRIPS
3×6" T&G
4×6 RAFTERS
5" GUTTERS
3×6 PLATES
½ BOLTS 4'0" O.C.
3×4" DOWNSPOUT
CORNICE
SCALE 3"=1'-0"
SHINGLES
NAILING STRIPS
3×6 T&G
3×4 COVE
4×6 RAFTER
GABLE END
SCALE 3"=1'-0"
The Playhouse
NEON SIGN
TURNED SPINDLES
ELEVATION
PLAN
4×8 RIDGE
3×6 T&G
4×6 RAFTERS
SECTION
SCALE ¼"=1'-0"
ALTERATIONS TO STORE BLDG
SEATTLE REPERTORY PLAYHOUSE
4041-45 UNIV. WAY
DRAWN BY
FEY
ARTHUR L. LOVELESS
ARCHITECT
711 BROADWAY NORTH - SEATTLE
SHEET NO.
101
DATE
SEP 4 1930
CHECKED
REVISED
JOB NO.
410
151-A-6

FIGURE 05

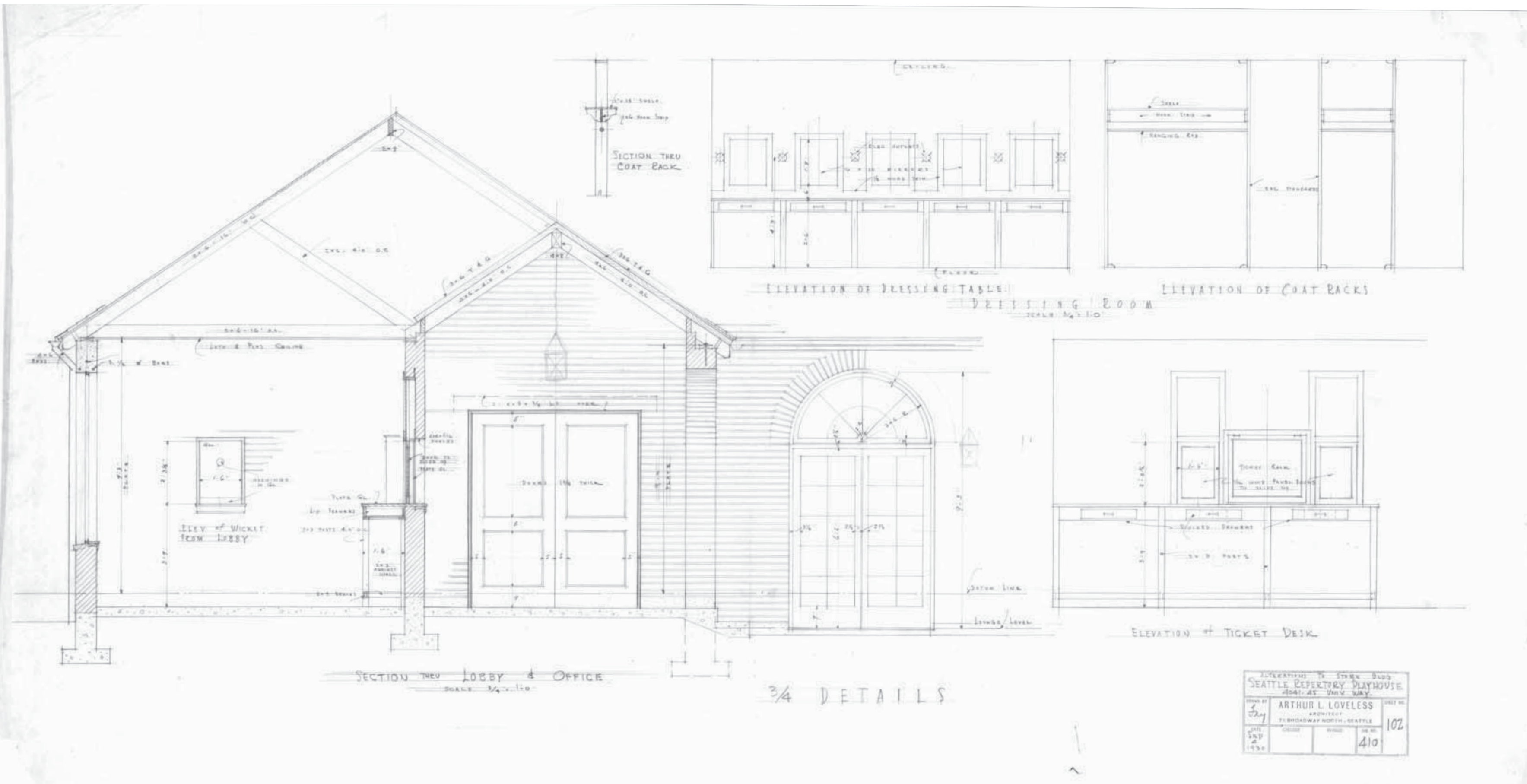
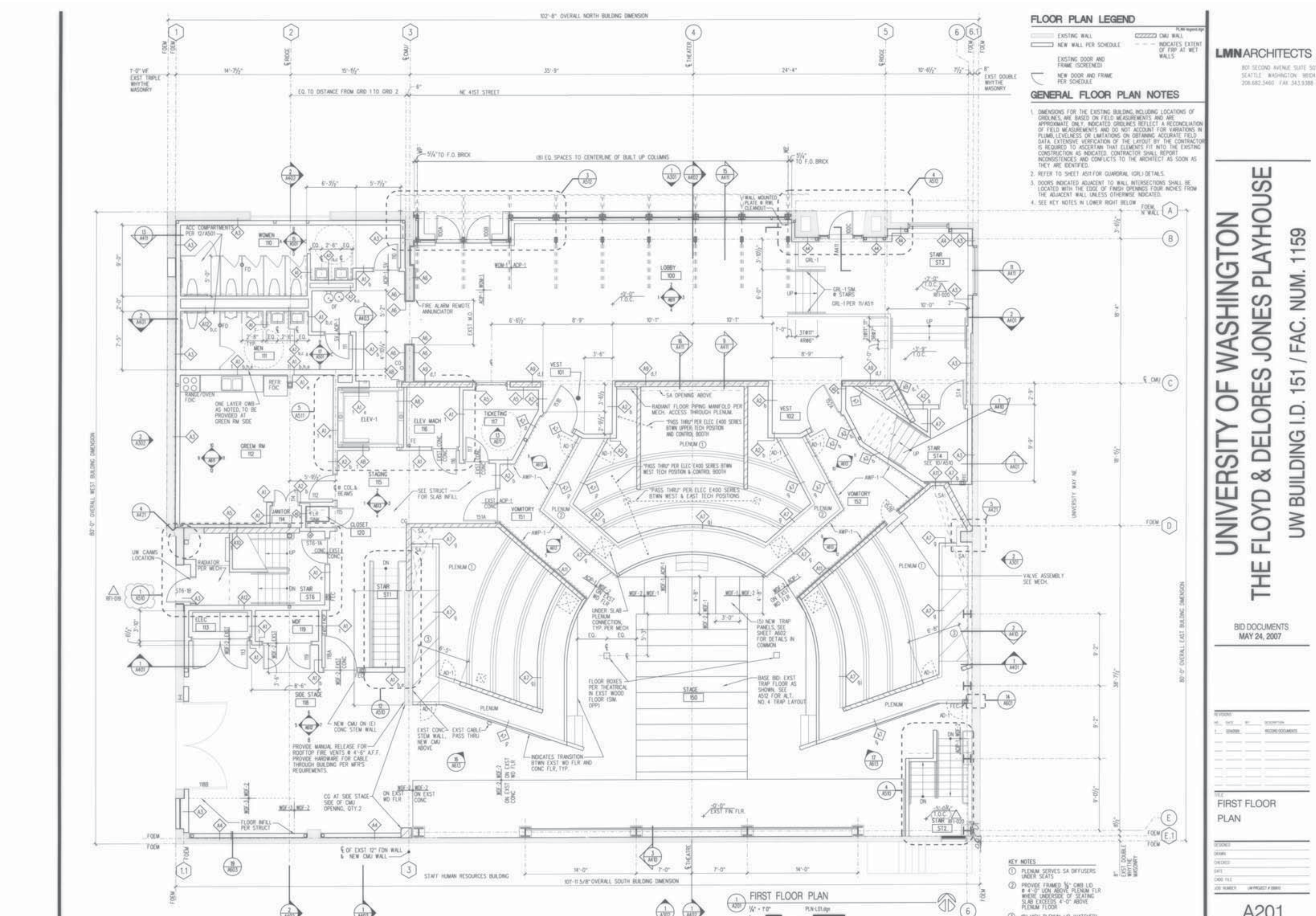

SECTION THRU COAT RACK
ELEVATION OF DRESSING TABLE
DRESSING ROOM
ELEVATION OF COAT RACKS
ELEVATION OF TICKET DESK
SECTION THRU LOBBY & OFFICE
3/4 DETAILS
SEATTLE REPERTORY PLAYHOUSE
ARTHUR L. LOVELESS
ARCHITECT
102
410

FIGURE 06



FLOOR PLAN LEGEND
GENERAL FLOOR PLAN NOTES
LMNARCHITECTS
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
FIRST FLOOR PLAN
A201
LOBBY
STAGE
KEY NOTES

FIGURE 07

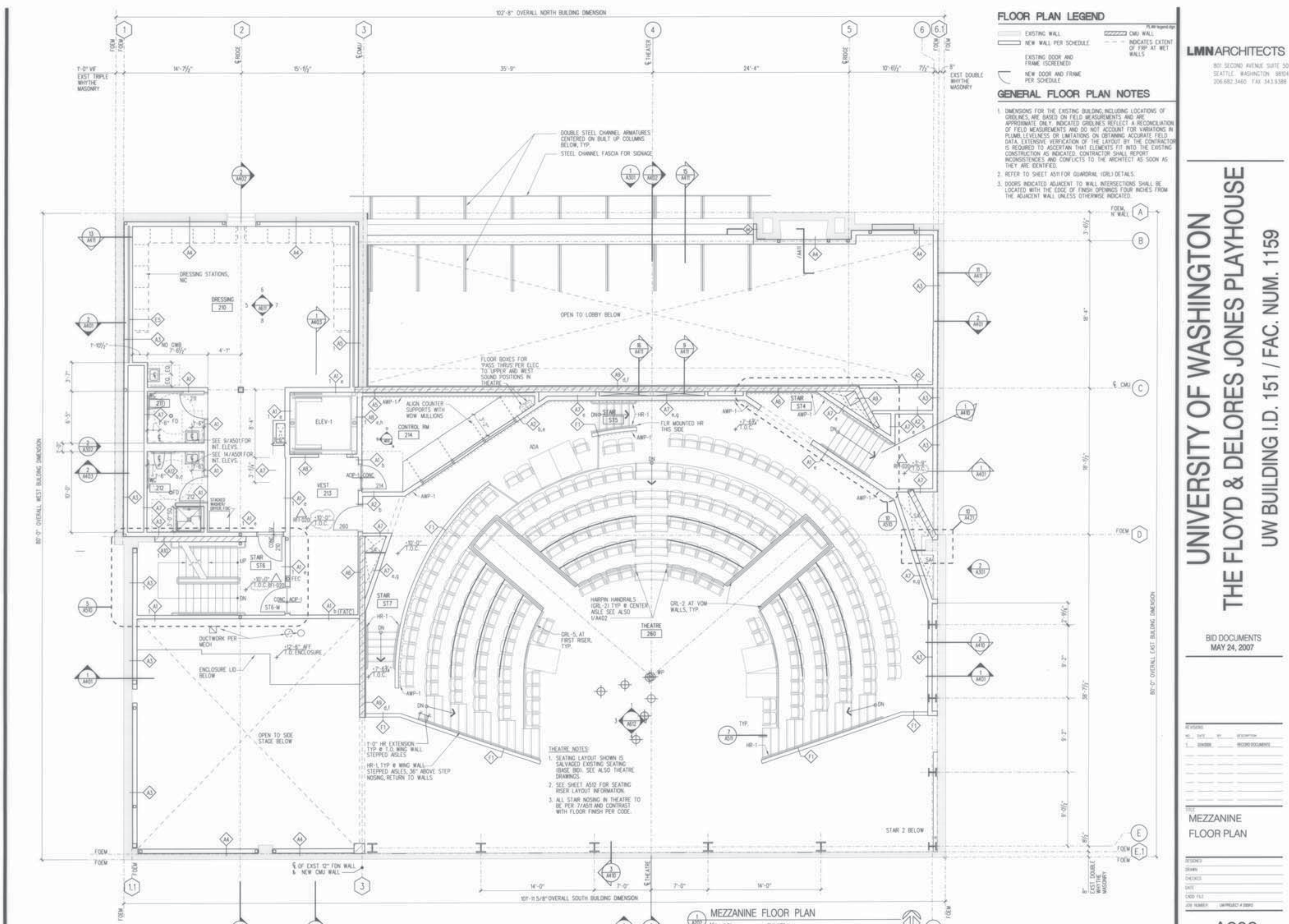

FLOOR PLAN LEGEND
GENERAL FLOOR PLAN NOTES
LMNARCHITECTS
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
MEZZANINE
FLOOR PLAN
A202
MEZZANINE FLOOR PLAN
OPEN TO LOBBY BELOW
THEATRE NOTES

FIGURE 08

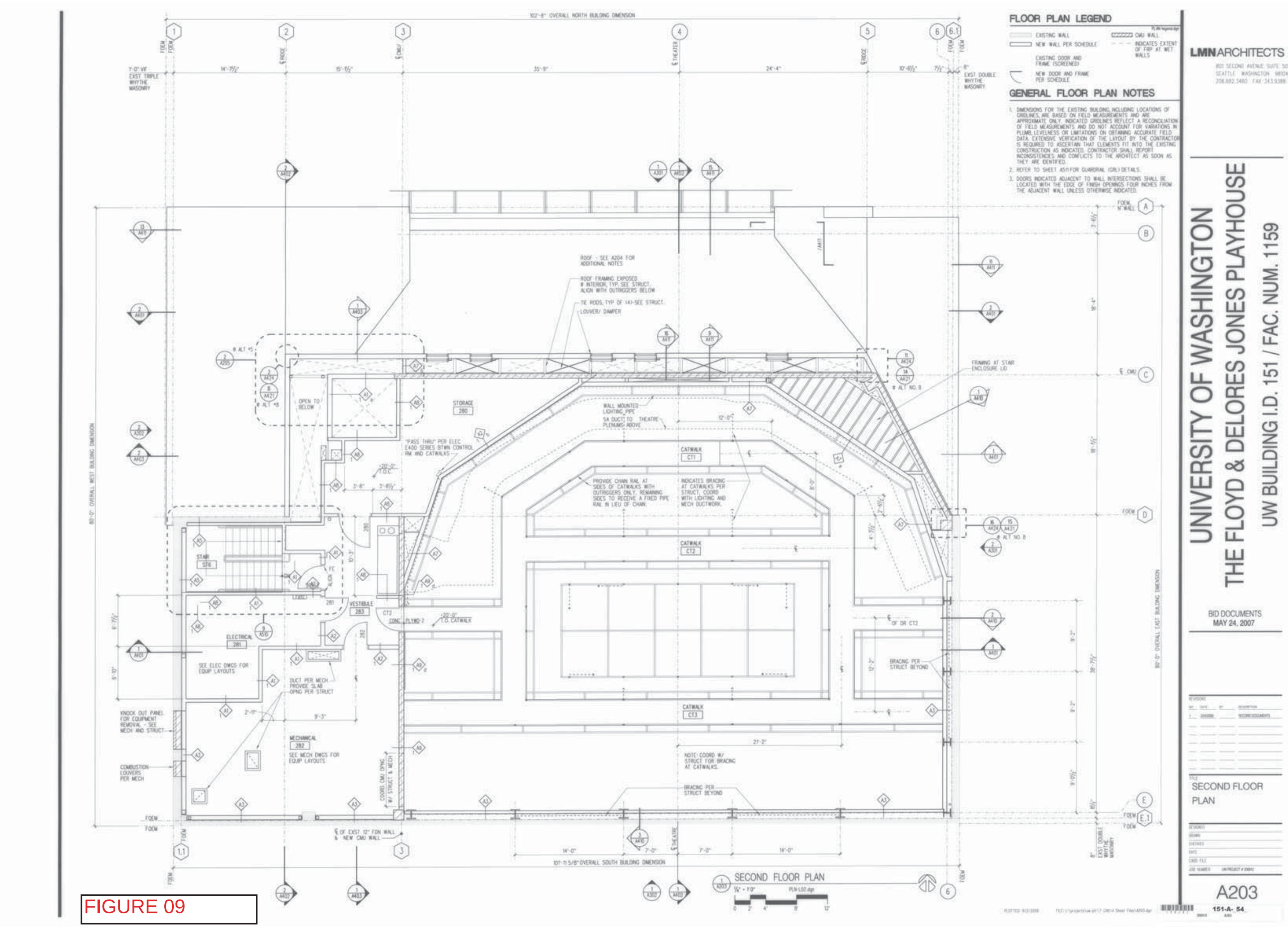

FLOOR PLAN LEGEND
GENERAL FLOOR PLAN NOTES
LMNARCHITECTS
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
SECOND FLOOR PLAN
A203
SECOND FLOOR PLAN
STORAGE
280
CATWALK
CT1
CATWALK
CT2
CATWALK
CT3
STAIR
ST6
VESTIBULE
283
ELECTRICAL
281
MECHANICAL
282
102'-8" OVERALL NORTH BUILDING DIMENSION
101'-11 5/8" OVERALL SOUTH BUILDING DIMENSION

FIGURE 09

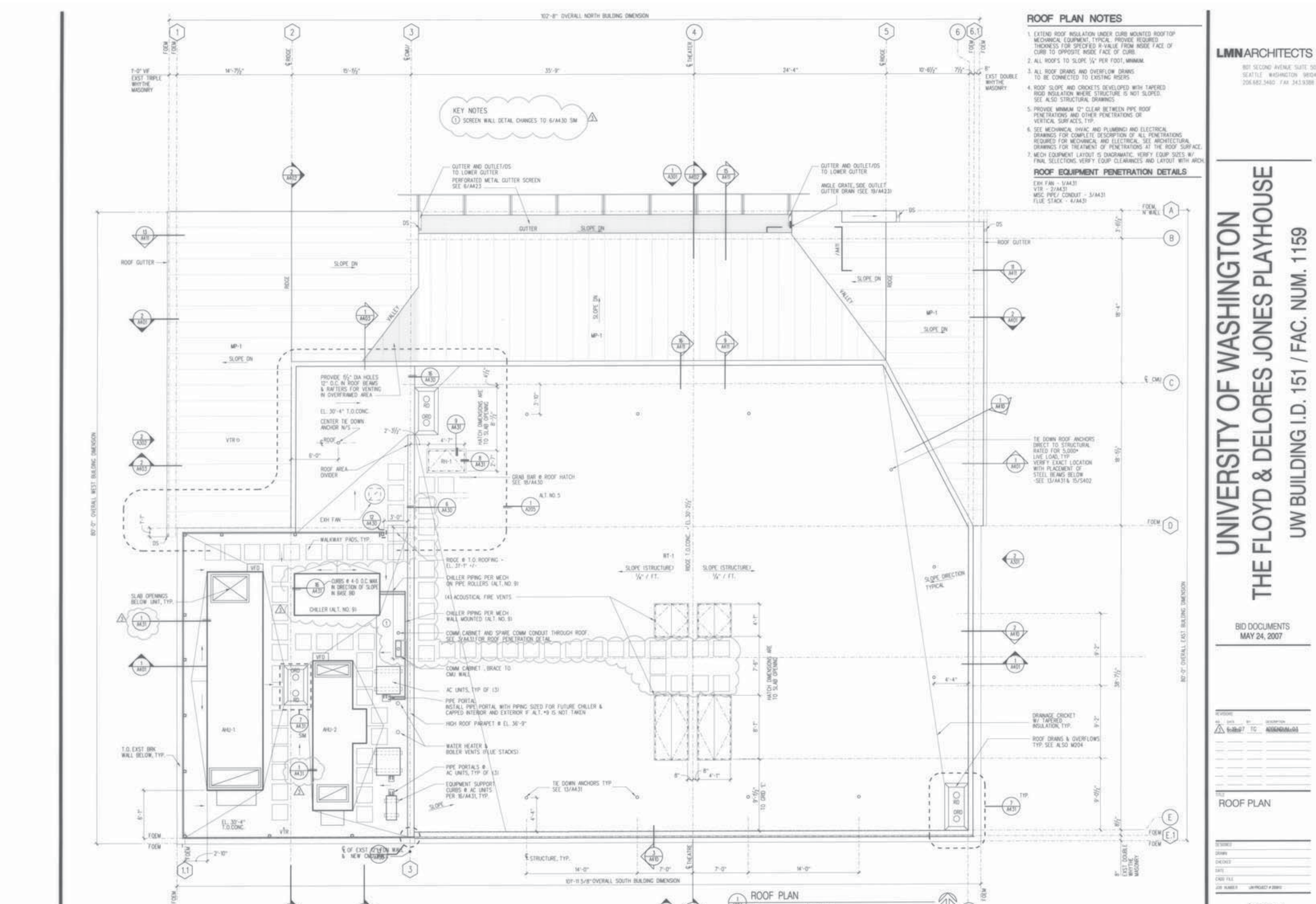

ROOF PLAN NOTES
1. EXTEND ROOF INSULATION UNDER CURB MOUNTED ROOFTOP MECHANICAL EQUIPMENT, TYPICAL. PROVIDE REQUIRED THICKNESS FOR SPECIFIED R-VALUE FROM INSIDE FACE OF CURB TO OPPOSITE INSIDE FACE OF CURB.
2. ALL ROOFS TO SLOPE 1/4" PER FOOT, MINIMUM.
3. ALL ROOF DRAINS AND OVERFLOW DRAINS TO BE CONNECTED TO EXISTING RISERS.
4. ROOF SLOPE AND CRICKETS DEVELOPED WITH TAPERED RIGID INSULATION WHERE STRUCTURE IS NOT SLOPED. SEE ALSO STRUCTURAL DRAWINGS.
5. PROVIDE MINIMUM 12" CLEAR BETWEEN PIPE ROOF PENETRATIONS AND OTHER PENETRATIONS OR VERTICAL SURFACES, TYP.
6. SEE MECHANICAL (HVAC AND PLUMBING) AND ELECTRICAL DRAWINGS FOR COMPLETE DESCRIPTION OF ALL PENETRATIONS REQUIRED FOR MECHANICAL AND ELECTRICAL. SEE ARCHITECTURAL DRAWINGS FOR TREATMENT OF PENETRATIONS AT THE ROOF SURFACE.
7. MECH EQUIPMENT LAYOUT IS DIAGRAMATIC. VERIFY EQUIP SIZES W/ FINAL SELECTIONS. VERIFY EQUIP CLEARANCES AND LAYOUT WITH ARCH.
ROOF EQUIPMENT PENETRATION DETAILS
EXH FAN - 1/A431
VTR - 2/A431
MISC PIPE/ CONDUIT - 3/A431
FLUE STACK - 4/A431
KEY NOTES
1 SCREEN WALL DETAIL CHANGES TO 6/A430 SIM
102'-8" OVERALL NORTH BUILDING DIMENSION
107'-11 5/8" OVERALL SOUTH BUILDING DIMENSION
80'-0" OVERALL WEST BUILDING DIMENSION
80'-0" OVERALL EAST BUILDING DIMENSION
GUTTER AND OUTLET/DS TO LOWER GUTTER
PERFORATED METAL GUTTER SCREEN SEE 6/A423
ANGLE GRATE, SIDE OUTLET GUTTER DRAIN (SEE 19/A423)
SLOPE DN
ROOF GUTTER
VALLEY
RIDGE
MP-1
AHU-1
AHU-2
CHILLER (ALT. NO. 9)
WALKWAY PADS, TYP.
EXH FAN
SLAB OPENINGS BELOW UNIT, TYP.
T.O. EXST BRK WALL BELOW, TYP.
TIE DOWN ROOF ANCHORS DIRECT TO STRUCTURAL RATED FOR 5,000# LIVE LOAD, TYP.
DRAINAGE CRICKET W/ TAPERED INSULATION, TYP.
ROOF DRAINS & OVERFLOWS TYP. SEE ALSO M204
TIE DOWN ANCHORS TYP SEE 13/A431
HATCH DIMENSIONS ARE TO SLAB OPENING
SLOPE DIRECTION TYPICAL
ROOF PLAN
1/4" = 1'-0"
LMNARCHITECTS
801 SECOND AVENUE SUITE 501
SEATTLE WASHINGTON 98104
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
ROOF PLAN
A204
151-A- 55

FIGURE 10

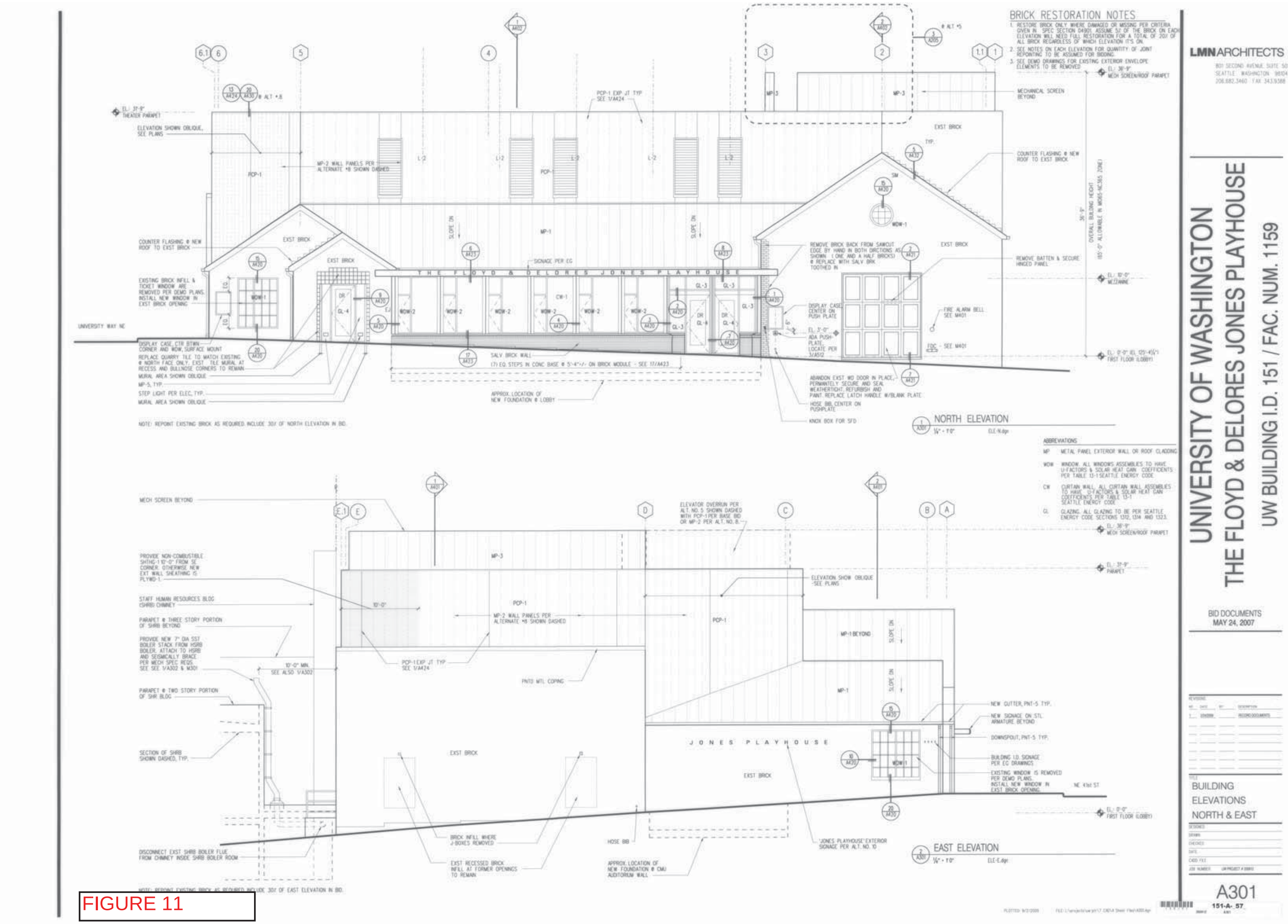

BRICK RESTORATION NOTES
NORTH ELEVATION
1/8" = 1'0"
EAST ELEVATION
1/8" = 1'0"
ABBREVIATIONS
THE FLOYD & DELORES JONES PLAYHOUSE
JONES PLAYHOUSE
UNIVERSITY WAY NE
NE 41st ST
LMNARCHITECTS
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
BUILDING
ELEVATIONS
NORTH & EAST
A301
151-A- 57

FIGURE 11

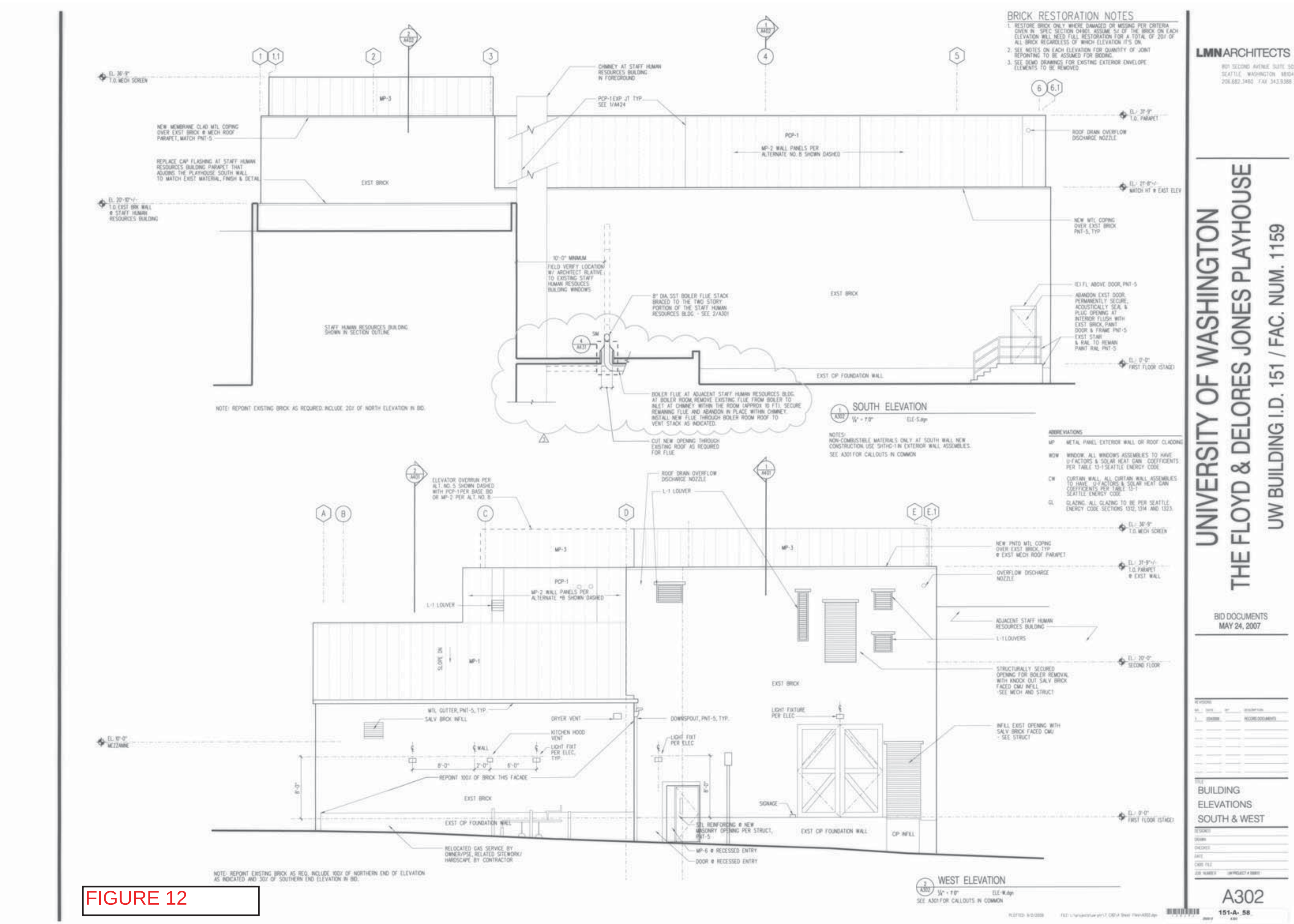

BRICK RESTORATION NOTES
SOUTH ELEVATION
WEST ELEVATION
LMNARCHITECTS
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
BUILDING
ELEVATIONS
SOUTH & WEST
A302
151-A-58

FIGURE 12

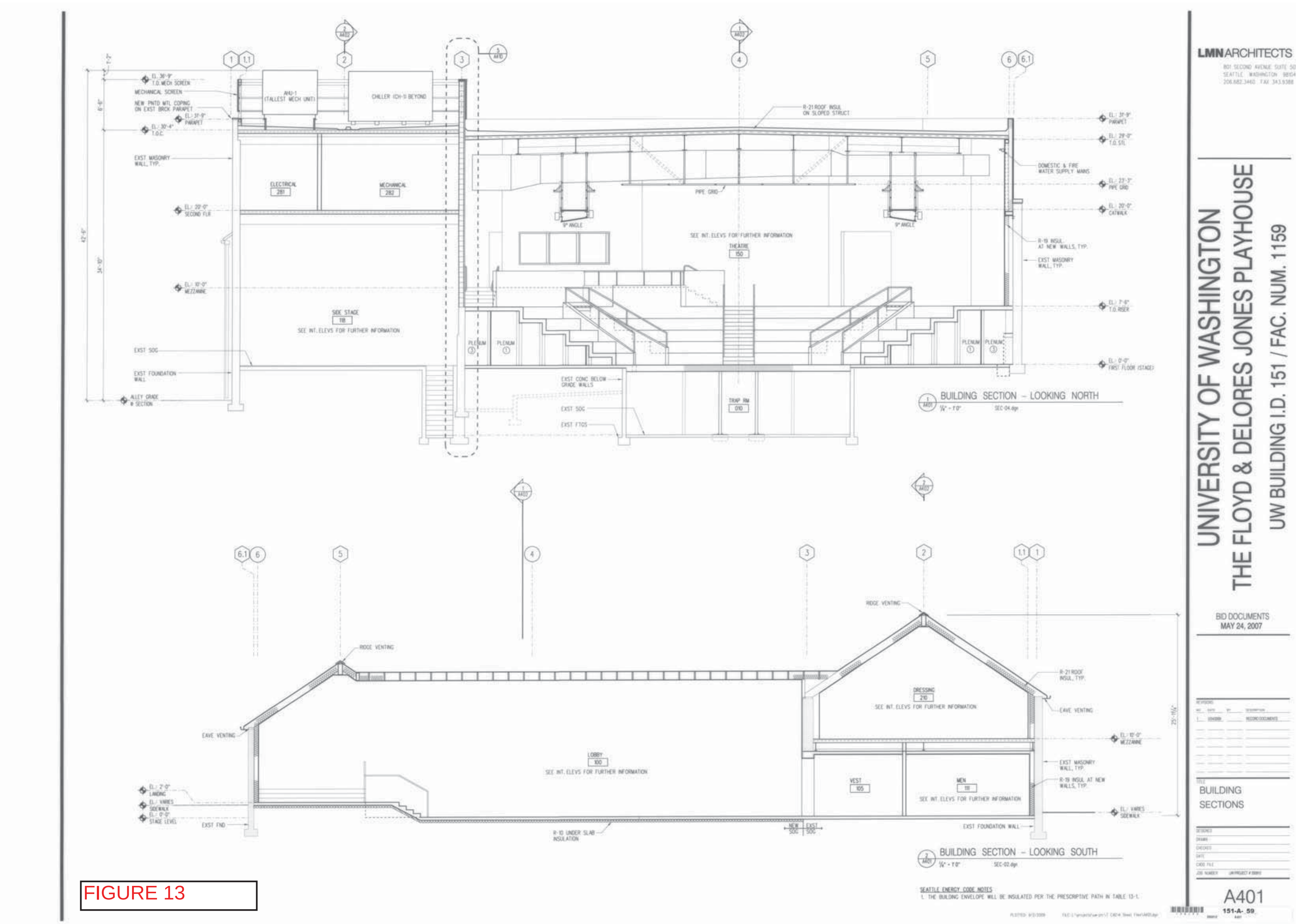

LMNARCHITECTS
801 SECOND AVENUE SUITE 501
SEATTLE WASHINGTON 98104
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
BUILDING
SECTIONS
A401
151-A-59
BUILDING SECTION - LOOKING NORTH
BUILDING SECTION - LOOKING SOUTH
AHU-1 (TALLEST MECH UNIT)
CHILLER (CH-1) BEYOND
R-21 ROOF INSUL ON SLOPED STRUCT
ELECTRICAL 281
MECHANICAL 282
THEATRE 150
SEE INT. ELEVS FOR FURTHER INFORMATION
SIDE STAGE 118
PIPE GRID
PLENUM
TRAP RM 010
DOMESTIC & FIRE WATER SUPPLY MAINS
R-19 INSUL AT NEW WALLS, TYP.
EXST MASONRY WALL, TYP.
EXST SOG
EXST FOUNDATION WALL
EXST FTGS
RIDGE VENTING
EAVE VENTING
R-21 ROOF INSUL, TYP.
DRESSING 210
LOBBY 100
VEST 105
MEN 111
R-10 UNDER SLAB INSULATION
EXST FND
SEATTLE ENERGY CODE NOTES
1. THE BUILDING ENVELOPE WILL BE INSULATED PER THE PRESCRIPTIVE PATH IN TABLE 13-1.

FIGURE 13

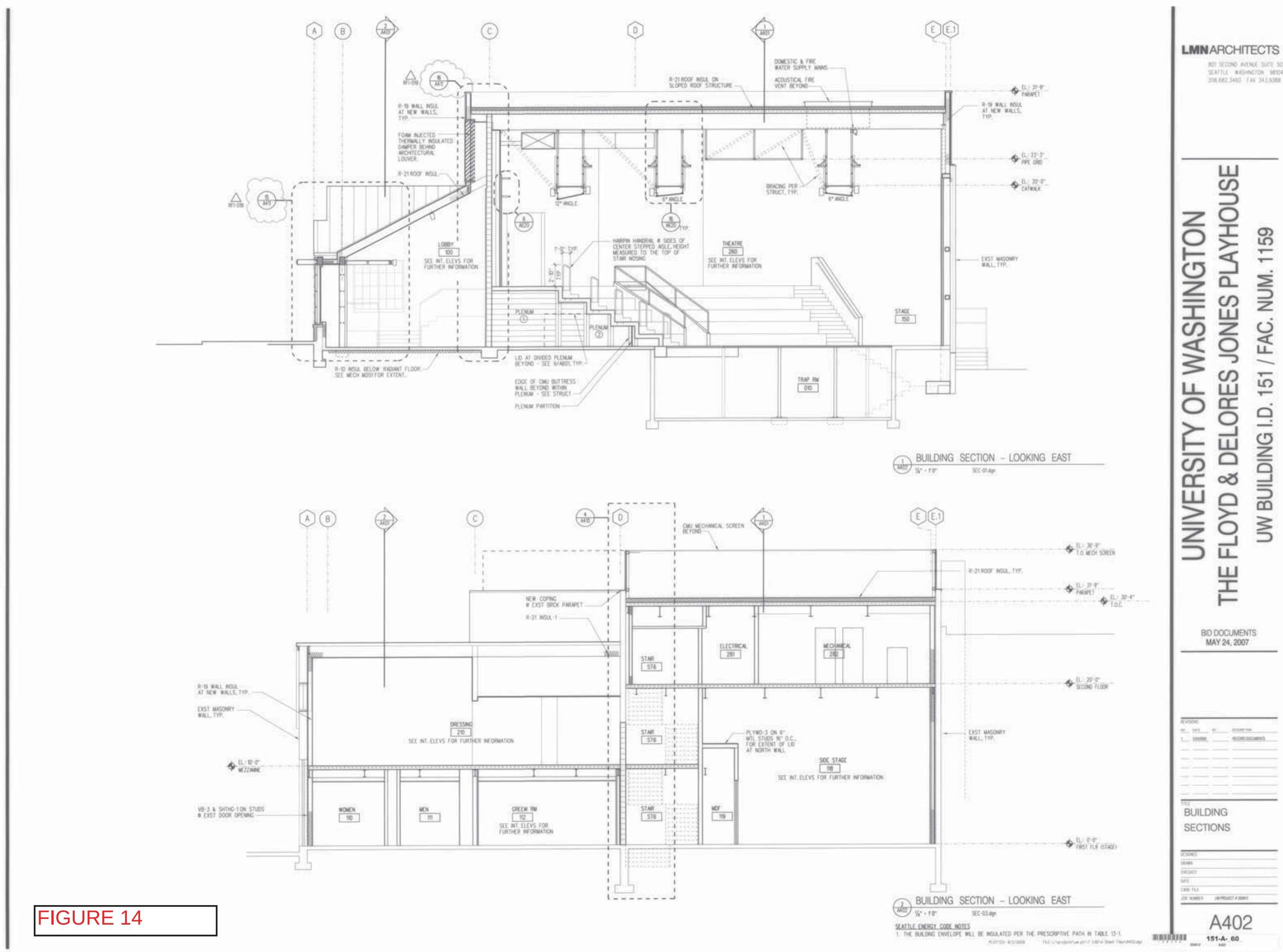

LMNARCHITECTS
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
BUILDING
SECTIONS
A402
BUILDING SECTION - LOOKING EAST
BUILDING SECTION - LOOKING EAST
LOBBY
100
THEATRE
260
STAGE
150
TRAP RM
010
DRESSING
210
ELECTRICAL
281
MECHANICAL
282
SIDE STAGE
118
WOMEN
110
MEN
111
GREEN RM
112
SEATTLE ENERGY CODE NOTES
1. THE BUILDING ENVELOPE WILL BE INSULATED PER THE PRESCRIPTIVE PATH IN TABLE 13-1.

FIGURE 14

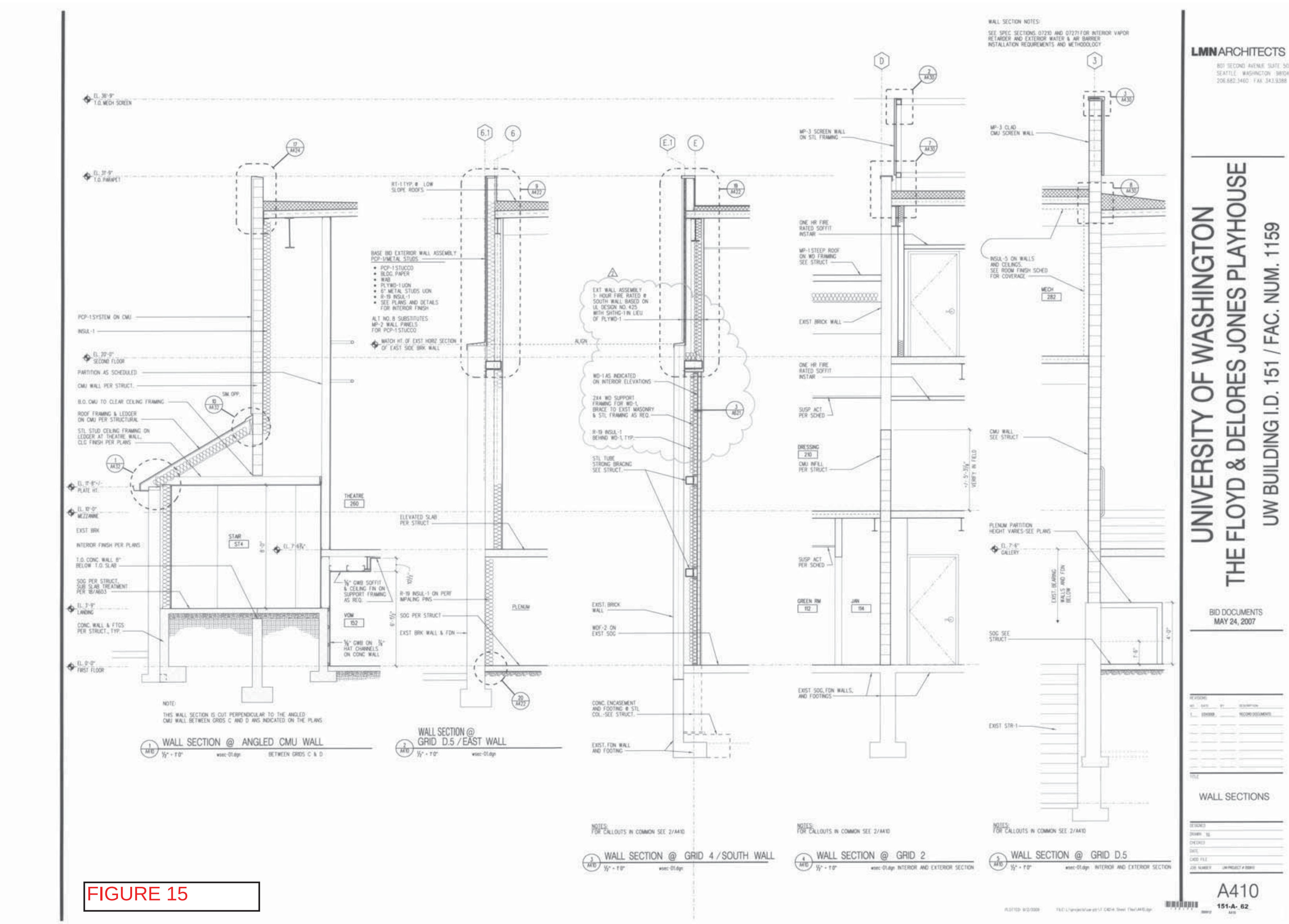

WALL SECTION @ ANGLED CMU WALL
WALL SECTION @ GRID D.5 / EAST WALL
WALL SECTION @ GRID 4 / SOUTH WALL
WALL SECTION @ GRID 2
WALL SECTION @ GRID D.5
LMNARCHITECTS
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
WALL SECTIONS
A410

FIGURE 15

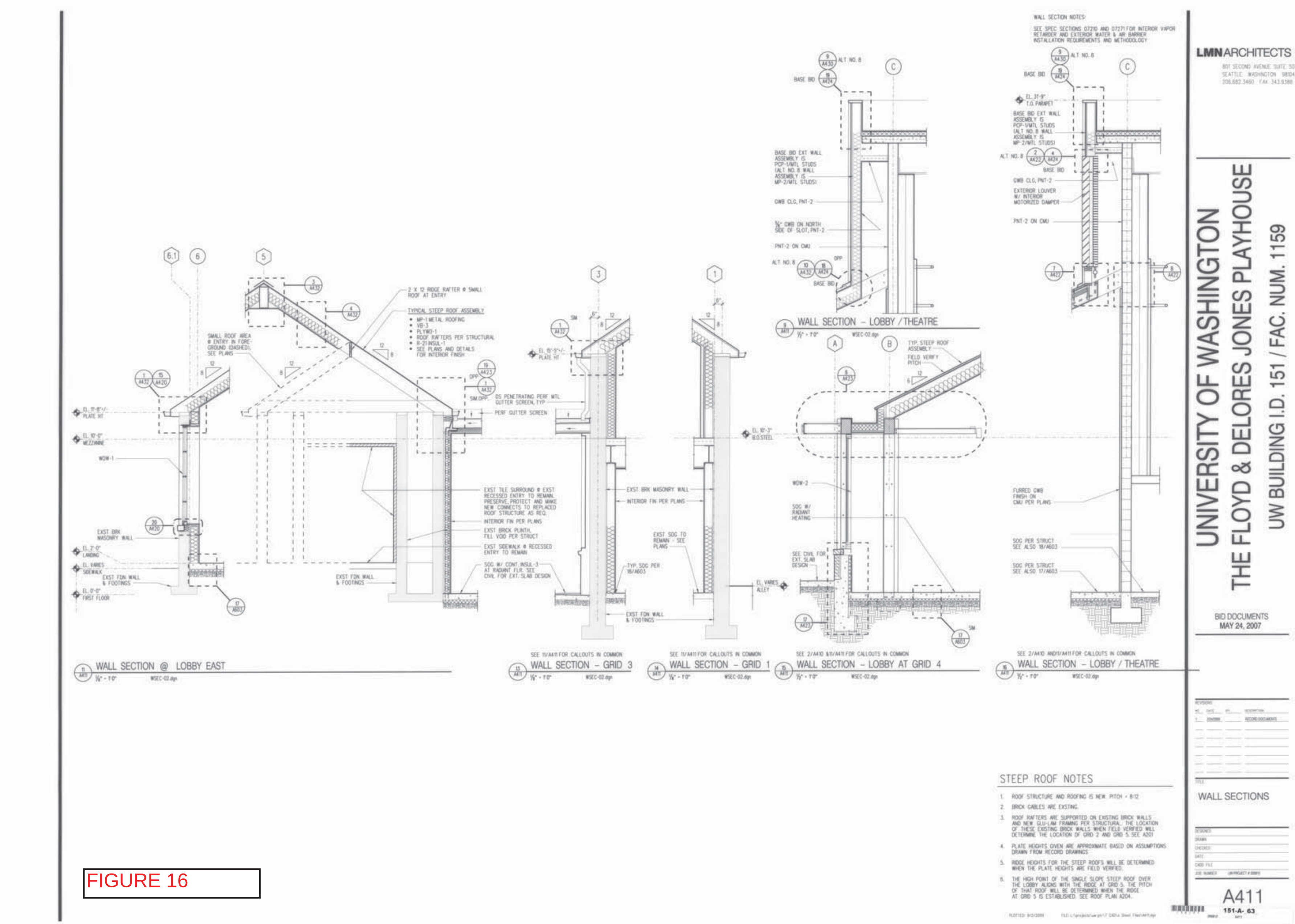

WALL SECTION NOTES:
SEE SPEC SECTIONS 07210 AND 07271 FOR INTERIOR VAPOR RETARDER AND EXTERIOR WATER & AIR BARRIER INSTALLATION REQUIREMENTS AND METHODOLOGY
LMNARCHITECTS
801 SECOND AVENUE SUITE 501
SEATTLE WASHINGTON 98104
206.682.3460 FAX 343.9388
UNIVERSITY OF WASHINGTON
THE FLOYD & DELORES JONES PLAYHOUSE
UW BUILDING I.D. 151 / FAC. NUM. 1159
BID DOCUMENTS
MAY 24, 2007
WALL SECTION @ LOBBY EAST
WALL SECTION - GRID 3
WALL SECTION - GRID 1
WALL SECTION - LOBBY AT GRID 4
WALL SECTION - LOBBY / THEATRE
WALL SECTION - LOBBY / THEATRE
TYPICAL STEEP ROOF ASSEMBLY
STEEP ROOF NOTES
1. ROOF STRUCTURE AND ROOFING IS NEW. PITCH = 8:12
2. BRICK GABLES ARE EXISTING.
3. ROOF RAFTERS ARE SUPPORTED ON EXISTING BRICK WALLS AND NEW GLU-LAM FRAMING PER STRUCTURAL. THE LOCATION OF THESE EXISTING BRICK WALLS WHEN FIELD VERIFIED WILL DETERMINE THE LOCATION OF GRID 2 AND GRID 5. SEE A201
4. PLATE HEIGHTS GIVEN ARE APPROXIMATE BASED ON ASSUMPTIONS DRAWN FROM RECORD DRAWINGS
5. RIDGE HEIGHTS FOR THE STEEP ROOFS WILL BE DETERMINED WHEN THE PLATE HEIGHTS ARE FIELD VERIFIED.
6. THE HIGH POINT OF THE SINGLE SLOPE STEEP ROOF OVER THE LOBBY ALIGNS WITH THE RIDGE AT GRID 5. THE PITCH OF THAT ROOF WILL BE DETERMINED WHEN THE RIDGE AT GRID 5 IS ESTABLISHED. SEE ROOF PLAN A204.
WALL SECTIONS
A411
151-A- 63

FIGURE 16

4045 University Way NE | PLAYHOUSE THEATER | August 2007

Panoramic View from Stage Right

photos by John Stamets

FIGURE 17


SNELL CRANE SERVICE
SNELL
CRANE SERVICE
24 HR
"SAFETY FIRST"
THE FOLLOWING ARE REQUIRED NOT OPTIONAL
SAFETY GLASS 100%
HARDHATS 100%
REFLECTIVE VEST 100%
Thank You
Wick Constructors

FIGURE 18


FIGURE 19

FIGURE 20

FIGURE 21

FIGURE 22

Appendix 2: Case Study Information
University of Washington
Savery Hall

Savery Hall

List of Figures

Development.

18. Savery Hall. Savery Hall and Raitt Hall taken from south, University of Washington, n.d. Negative Number UW19898z. Credit: Webster and Stevens. Courtesy University of Washington Libraries. Special Collections Division.
19. Savery Hall. Savery Hall entrance, University of Washington, n.d. Negative Number UW6860. Credit: A. A. Peterson. Courtesy University of Washington Libraries. Special Collections Division.
20. Savery Hall. Savery Hall showing southwest side, University of Washington, 1958. Negative Number UW19898z. Credit: E.F. Martin. Courtesy University of Washington Libraries. Special Collections Division.
21. Savery Hall. Savery Hall south entrance, University of Washington, n.d. Negative Number UW19899z. Courtesy University of Washington Libraries. Special Collections Division.
22. Savery Hall. South end of Savery Hall under construction, University of Washington, February 24, 1920. Negative Number UW19903z. Courtesy University of Washington Libraries. Special Collections Division.
23. Savery Hall. South end of Savery Hall under construction, University of Washington, 1920. Negative Number UW19901z. Courtesy University of Washington Libraries. Special Collections Division.
24. Savery Hall. South end of Savery Hall under construction, University of Washington, 1920. Negative Number UW19897z. Courtesy University of Washington Libraries. Special Collections Division.
25. Savery Hall. Aerial View from southeast. 2008. Credit: Sky-Pix Aerial Photography. Courtesy of UW Capital Planning & Development..
26. Savery Hall. Interior view of Mezzanine. 2009. Credit: Lara Swimmer Photography.
27. Savery Hall. Exterior view looking west. 2009. Credit: Masonry Contractors Association of America.

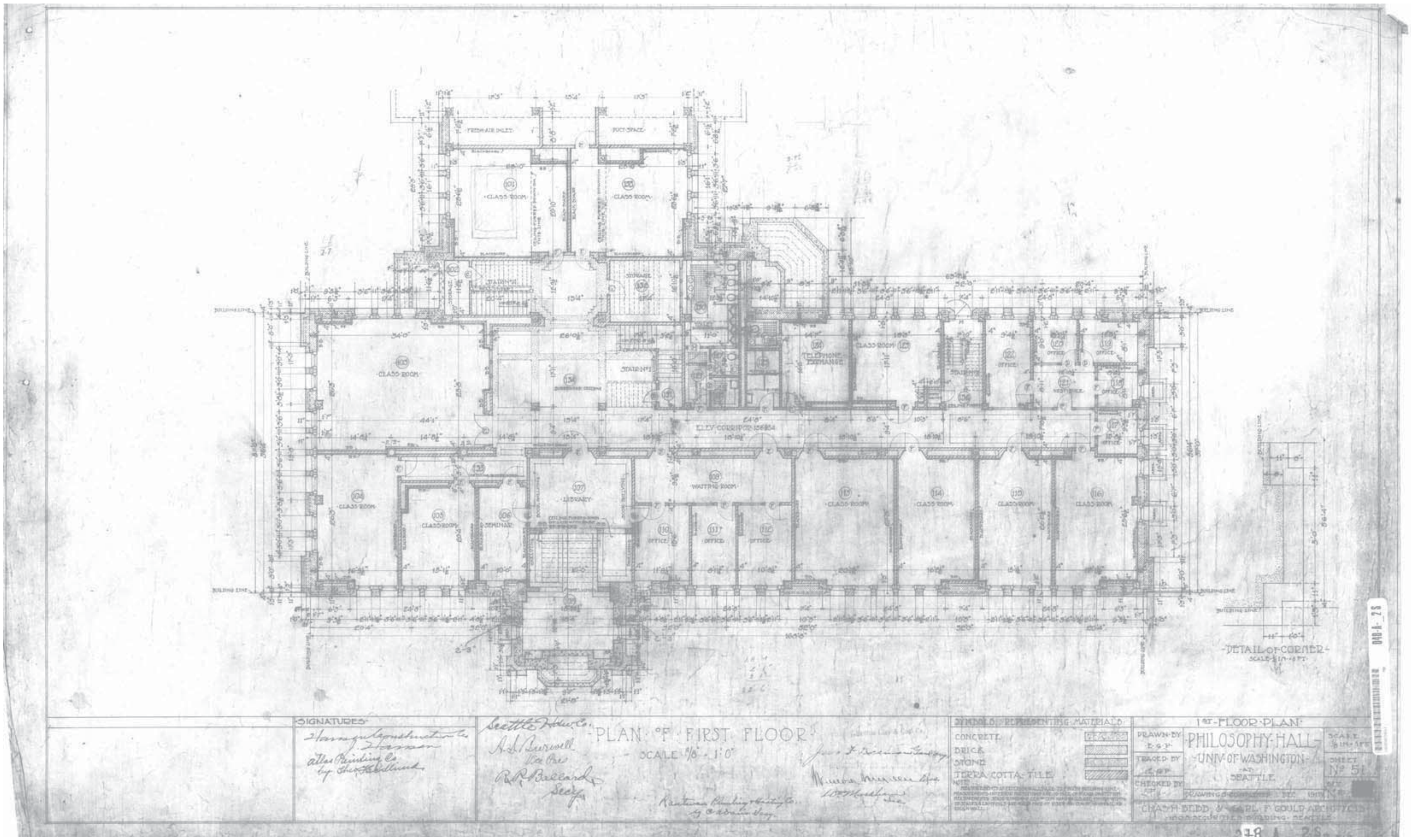

PLAN OF FIRST FLOOR
SCALE 1/8" - 1'0"
1ST FLOOR PLAN
PHILOSOPHY HALL
UNIV OF WASHINGTON
SEATTLE
DETAIL OF CORNER
SIGNATURES
SYMBOLS REPRESENTING MATERIALS
CONCRETE
BRICK
STONE
TERRA COTTA TILE
DRAWN BY
TRACED BY
CHECKED BY
SHEET
Nº 51
CLASS ROOM
LIBRARY
WAITING ROOM
OFFICE
SEMINAR
TELEPHONE EXCHANGE
FRESH AIR INLET
DUCT SPACE
STAIR NO 1
ELEV CORRIDOR

FIGURE 01

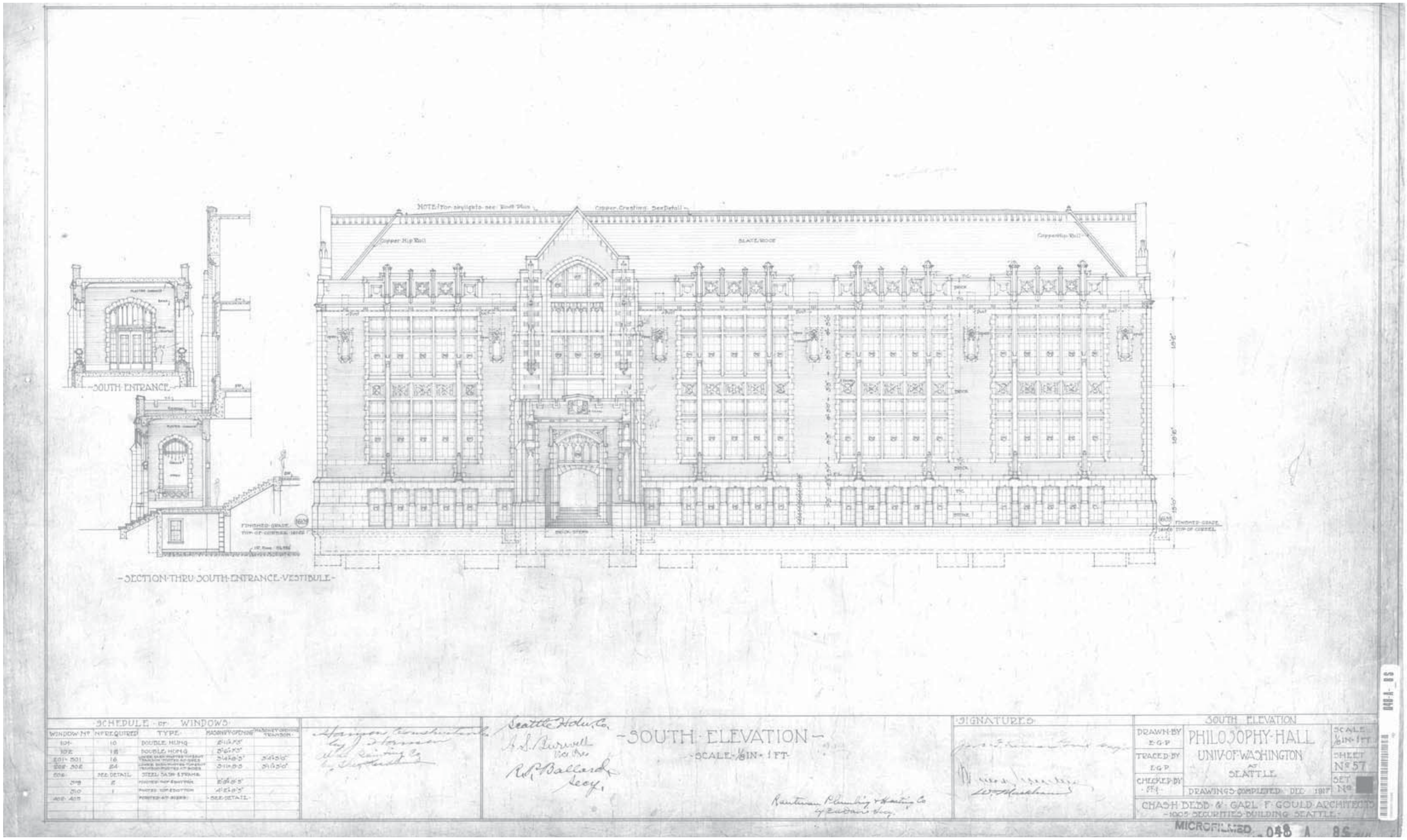

SOUTH ENTRANCE
SECTION THRU SOUTH ENTRANCE VESTIBULE
NOTE: For skylights see Roof Plan
Copper Cresting See Detail
Copper Hip Roll
SLATE ROOF
FINISHED GRADE
TOP OF CORBEL
SCHEDULE OF WINDOWS
SOUTH ELEVATION
SCALE 1/8 IN = 1 FT
SIGNATURES
Seattle Hdw. Co.
SOUTH ELEVATION
DRAWN BY E.G.P.
TRACED BY E.G.P.
CHECKED BY
PHILOSOPHY HALL
UNIV OF WASHINGTON AT SEATTLE
SCALE 1/8 IN = 1 FT
SHEET Nº 57
SET Nº
DRAWINGS COMPLETED DEC 1917
CHAS H BEBB & CARL F GOULD ARCHITECTS
1005 SECURITIES BUILDING SEATTLE
MICROFILMED

FIGURE 02

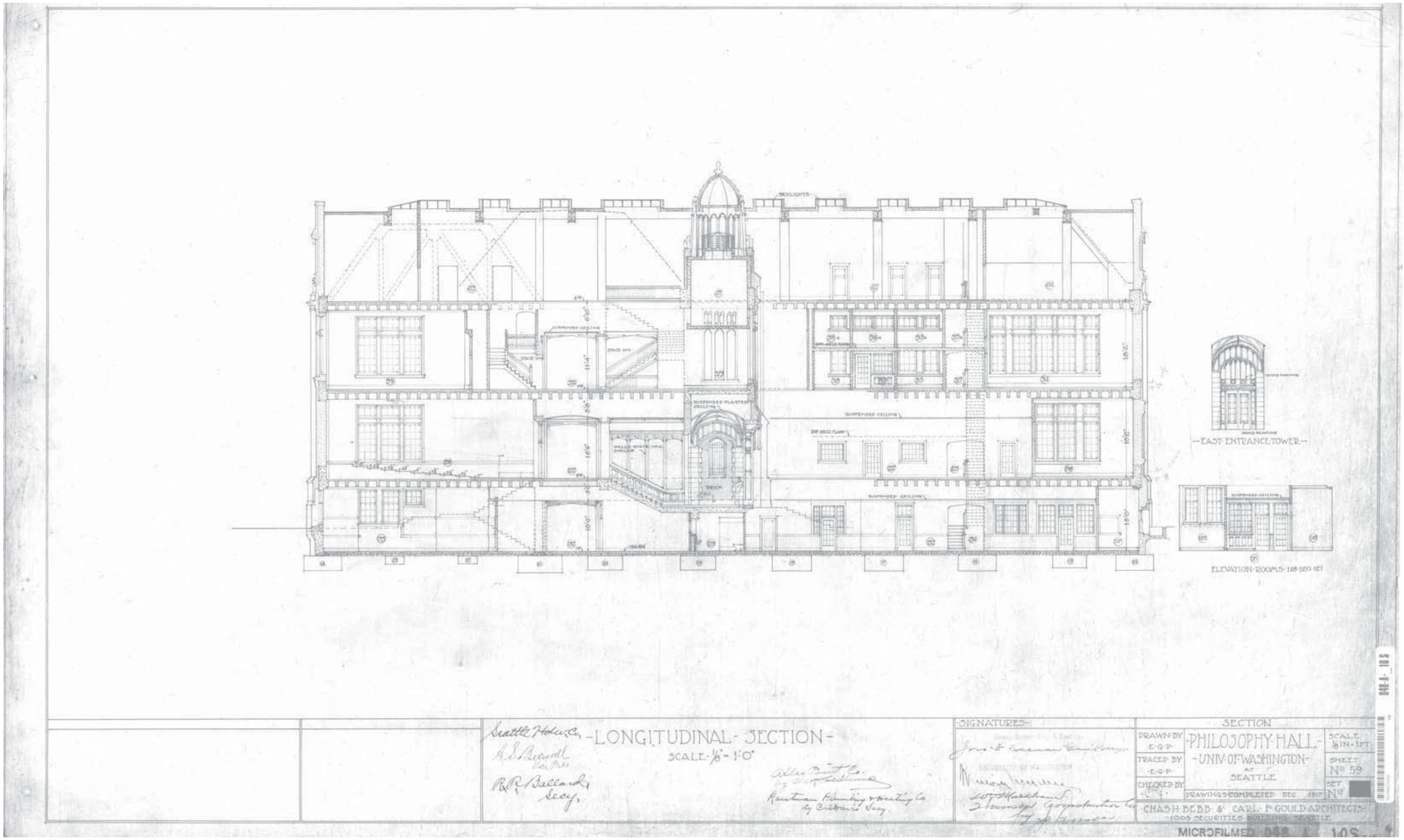

SKYLIGHTS
EAST ENTRANCE TOWER
-LONGITUDINAL-SECTION-
SCALE-1/8"-1'0"
SIGNATURES
SECTION
DRAWN BY E.G.P.
TRACED BY E.G.P.
CHECKED BY
-PHILOSOPHY HALL-
-UNIV OF WASHINGTON-
AT
SEATTLE
SCALE 1/8 IN-1FT
SHEET No 59
SET No
DRAWINGS COMPLETED DEC 1917
CHAS H BEBB & CARL F GOULD ARCHITECTS
1005 SECURITIES BUILDING SEATTLE
MICROFILMED

FIGURE 03

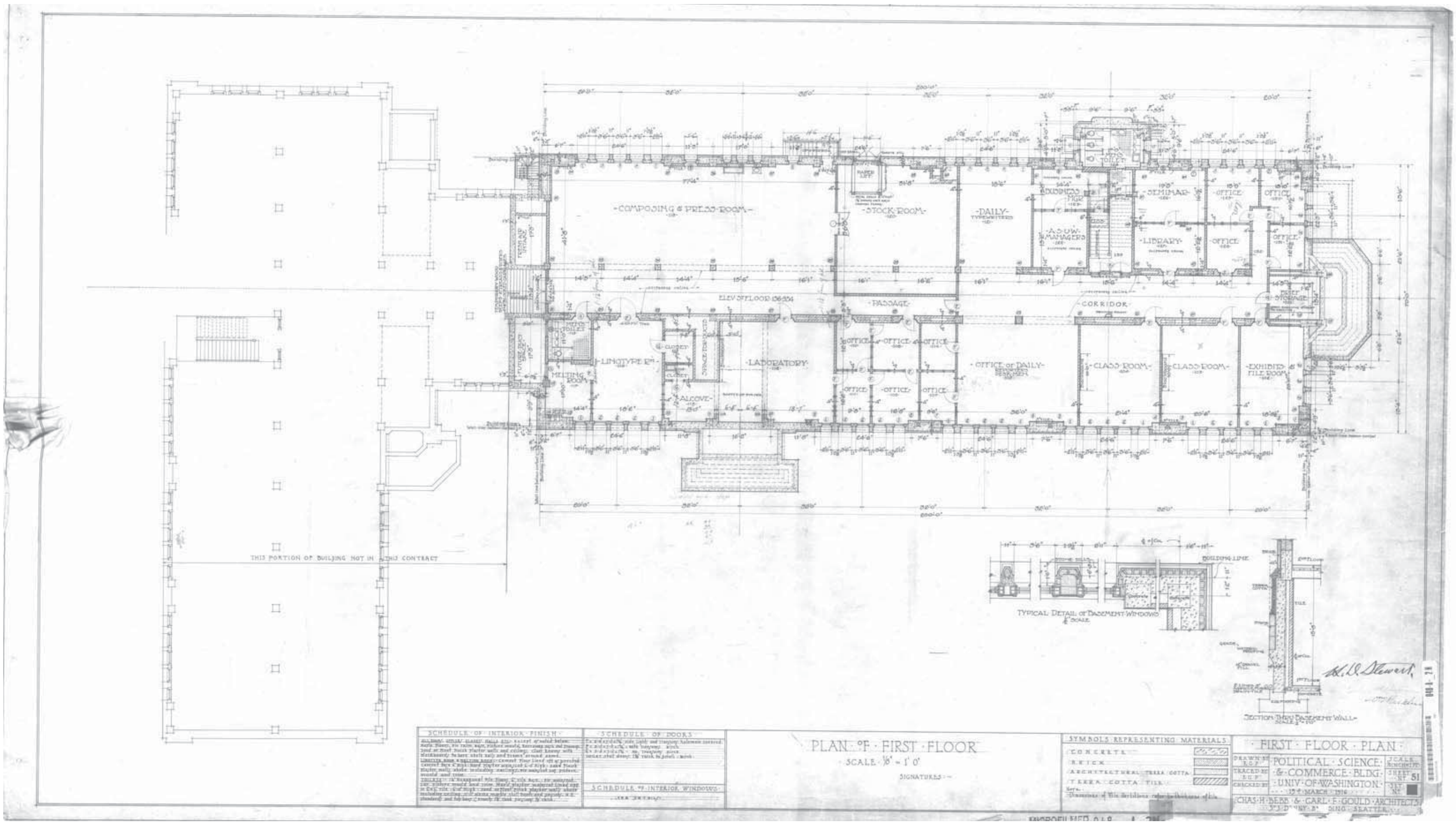

COMPOSING & PRESS ROOM
STOCK ROOM
DAILY
BUSINESS
SEMINAR
OFFICE
A.S.U.W. MANAGERS
LIBRARY
PASSAGE
CORRIDOR
LINOTYPE RM
MELTING ROOM
ALCOVE
LABORATORY
OFFICE OF DAILY
CLASS ROOM
EXHIBIT FILE ROOM
THIS PORTION OF BUILDING NOT IN THIS CONTRACT
TYPICAL DETAIL OF BASEMENT WINDOWS
SECTION THRU BASEMENT WALL
SCHEDULE OF INTERIOR FINISH
SCHEDULE OF DOORS
SCHEDULE OF INTERIOR WINDOWS
PLAN OF FIRST FLOOR
SCALE 1/8" = 1'0"
SIGNATURES
SYMBOLS REPRESENTING MATERIALS
CONCRETE
BRICK
ARCHITECTURAL TERRA COTTA
TERRA COTTA TILE
FIRST FLOOR PLAN
POLITICAL SCIENCE & COMMERCE BLDG.
UNIV. OF WASHINGTON
CHAS. H. BEBB & CARL F. GOULD ARCHITECTS

FIGURE 04

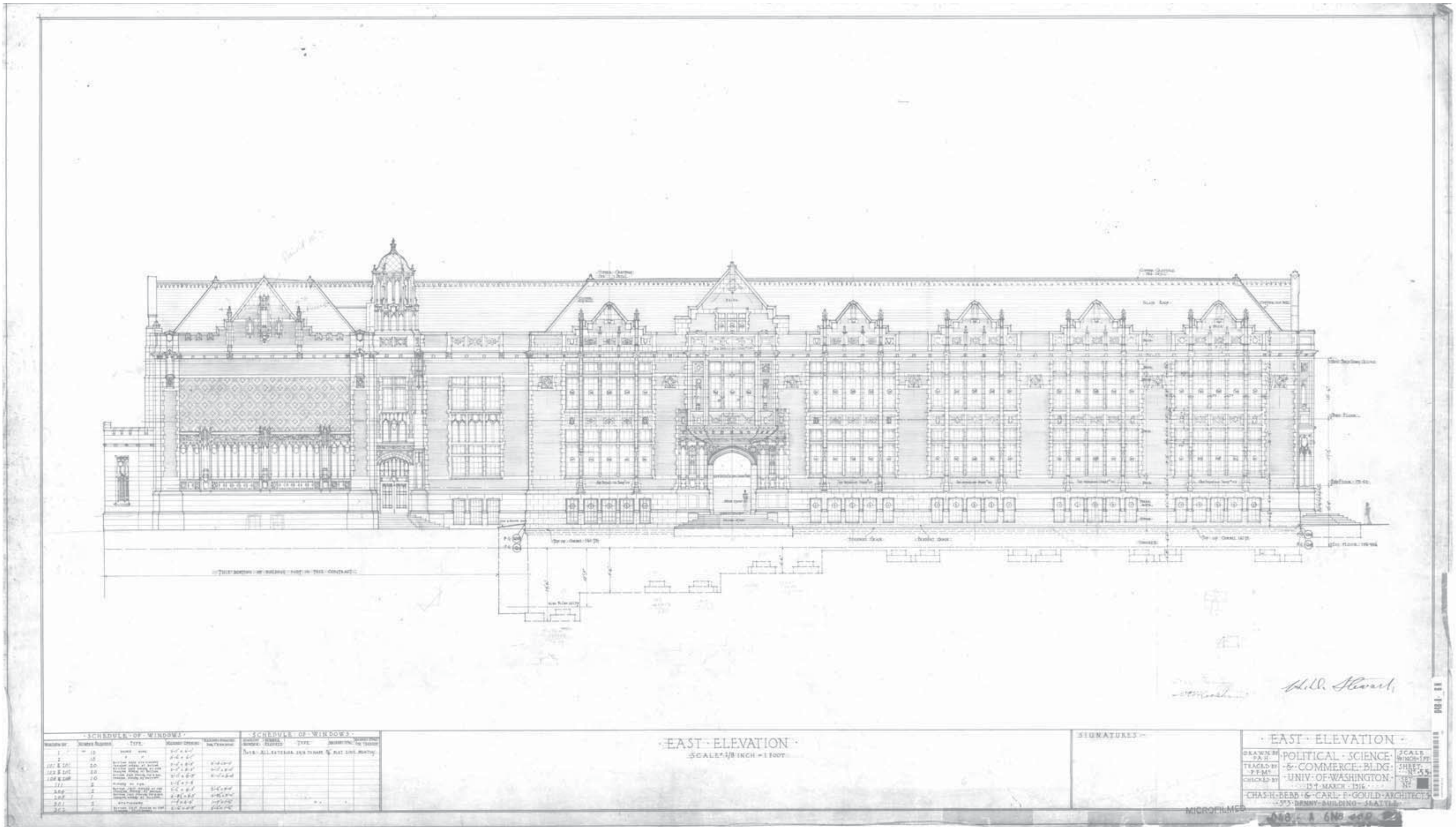

· EAST · ELEVATION ·
SCALE 1/8 INCH = 1 FOOT
SCHEDULE · OF · WINDOWS
SIGNATURES
· EAST · ELEVATION ·
DRAWN BY P.A.H.
TRACED BY P.F.M.
CHECKED BY
· POLITICAL · SCIENCE ·
· & · COMMERCE · BLDG ·
· UNIV · OF · WASHINGTON ·
13 · MARCH · 1916
SCALE
SHEET Nº 55
SET Nº
CHAS · H · BEBB · & · CARL · F · GOULD · ARCHITECTS
5th · DENNY · BUILDING · SEATTLE
MICROFILMED

FIGURE 05

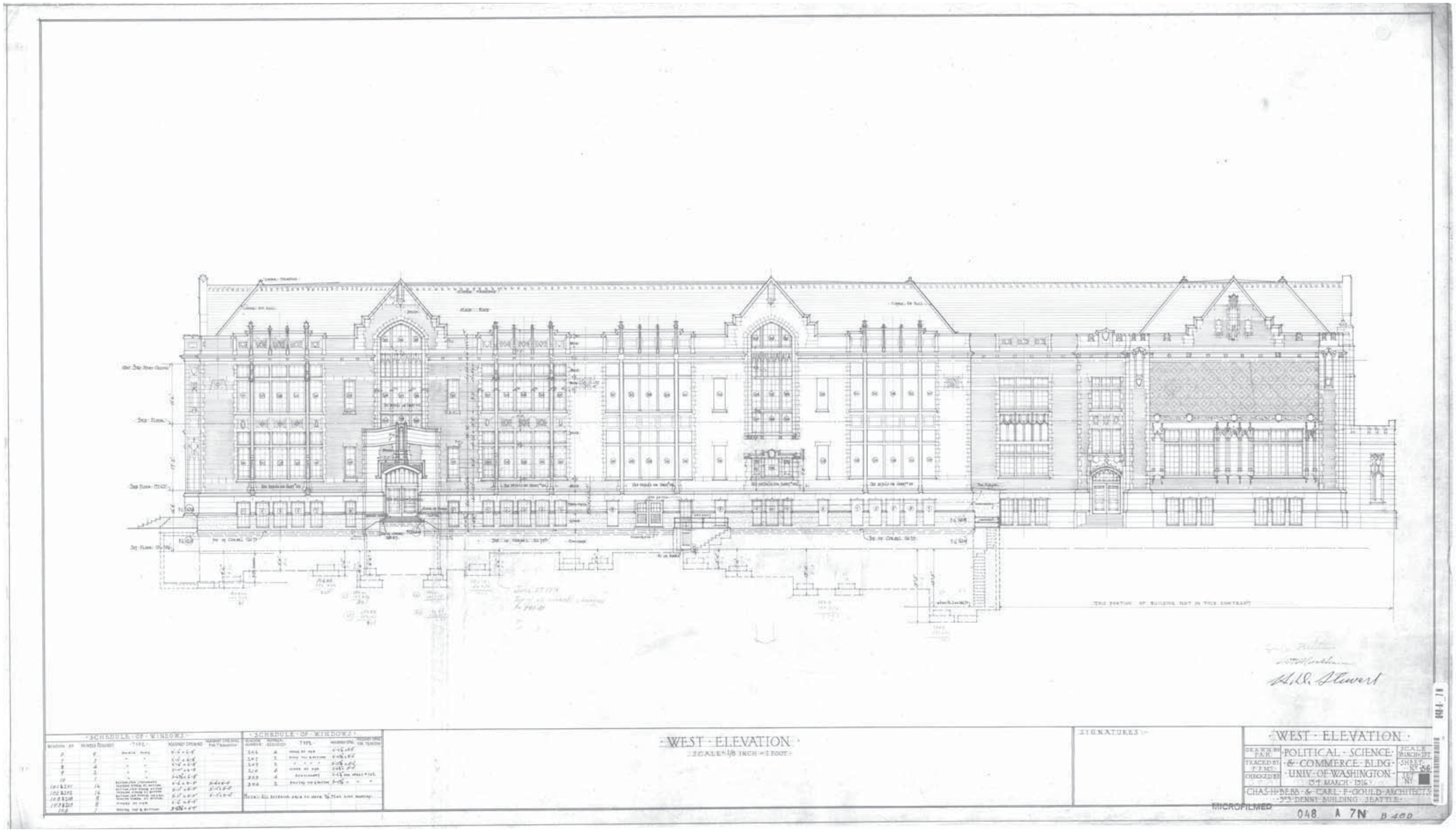
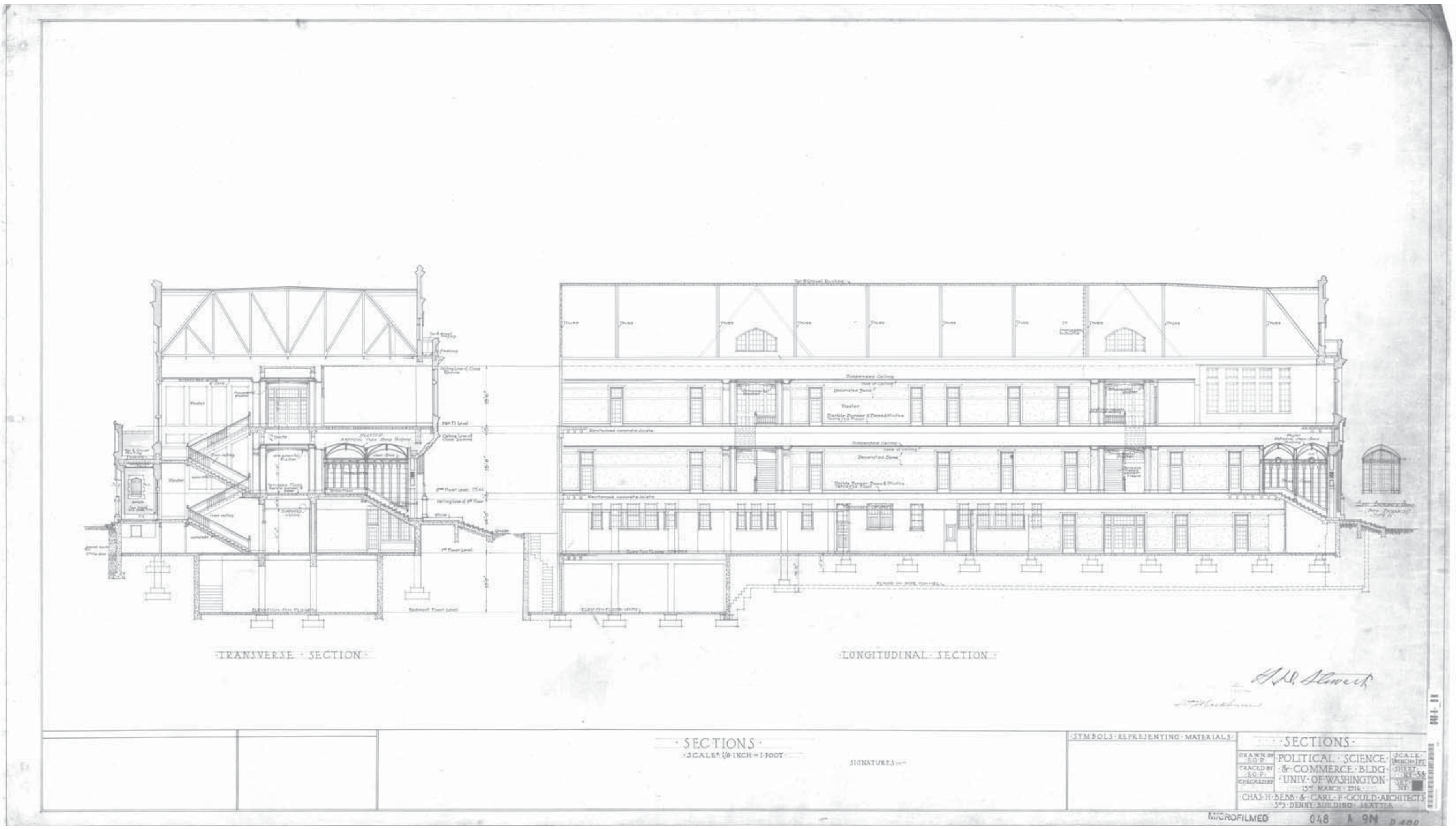
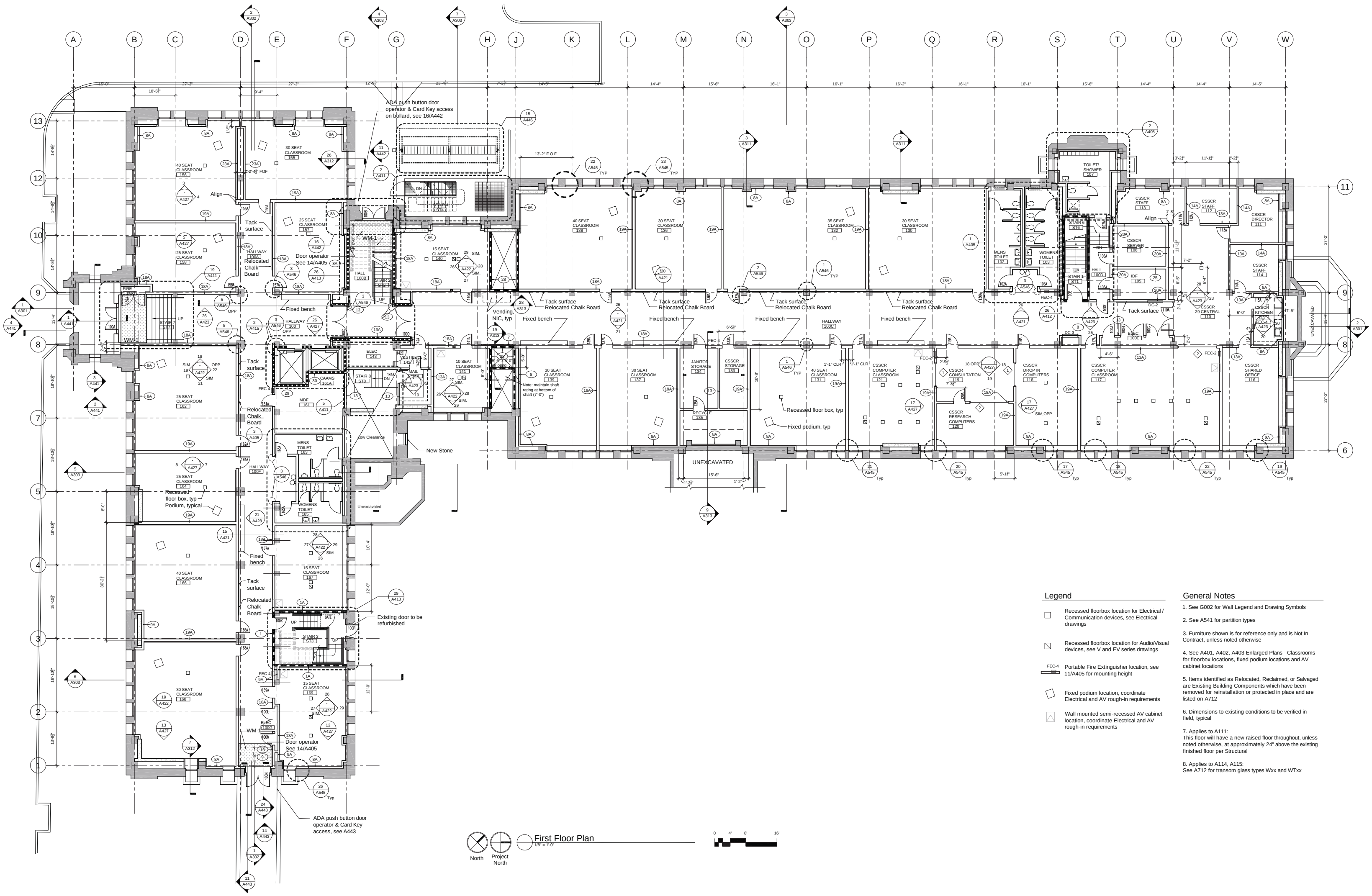

WEST · ELEVATION
SIGNATURES
WEST · ELEVATION
DRAWN BY P.A.K.
TRACED BY F.F.MC.
CHECKED BY
POLITICAL · SCIENCE
& COMMERCE · BLDG
UNIV · OF · WASHINGTON
15th MARCH · 1916
SCALE 1/8 INCH = 1 FT
SHEET No 56
SET No
CHAS · H · BEBB · & · CARL · F · GOULD · ARCHITECTS
3rd DENNY · BUILDING · SEATTLE
MICROFILMED
048 A 7N B 400

FIGURE 06



·TRANSVERSE · SECTION·
·LONGITUDINAL · SECTION·
· SECTIONS ·
· SCALE: 1/8 INCH = 1 FOOT ·
SIGNATURES
SYMBOLS · REPRESENTING · MATERIALS
· SECTIONS ·
DRAWN BY E.O.P.
TRACED BY E.O.P.
CHECKED BY
· POLITICAL · SCIENCE ·
· & · COMMERCE · BLDG ·
· UNIV · OF · WASHINGTON ·
15th MARCH 1916
CHAS · H · BEBB · & · CARL · F · GOULD · ARCHITECTS
503 · DENNY · BUILDING · SEATTLE
MICROFILMED
048 A 9N

FIGURE 07



Legend

- Recessed floorbox location for Electrical / Communication devices, see Electrical drawings
- Recessed floorbox location for Audio/Visual devices, see V and EV series drawings
- FEC-4 — Portable Fire Extinguisher location, see 11/A405 for mounting height
- Fixed podium location, coordinate Electrical and AV rough-in requirements
- Wall mounted semi-recessed AV cabinet location, coordinate Electrical and AV rough-in requirements

General Notes

1. See G002 for Wall Legend and Drawing Symbols
2. See A541 for partition types
3. Furniture shown is for reference only and is Not In Contract, unless noted otherwise
4. See A401, A402, A403 Enlarged Plans - Classrooms for floorbox locations, fixed podium locations and AV cabinet locations
5. Items identified as Relocated, Reclaimed, or Salvaged are Existing Building Components which have been removed for reinstallation or protected in place and are listed on A712
6. Dimensions to existing conditions to be verified in field, typical
7. Applies to A111:
This floor will have a new raised floor throughout, unless noted otherwise, at approximately 24" above the existing finished floor per Structural
8. Applies to A114, A115:
See A712 for transom glass types Wxx and WTxx

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Seattle, Washington 98104
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SRG PARTNERSHIP INC

UNIVERSITY OF WASHINGTON

Savery Hall Renovation

Construction Documents

Construction Documents

Drawing Title

First Floor Plan

Revisions

0	Construction Set	8/31/07
1	ASI #2	9/17/07
2	ASI #3	9/27/07
3	ASI #7	11/02/07
4	ASI #17	7/11/08
5	RFI #247	7/17/08
6	As-Built Set	12/10/09

Drawn by **SRG**

Checked by **GJH**

Date **August 31, 2007**

Project No **2518S**

Consultant Project No

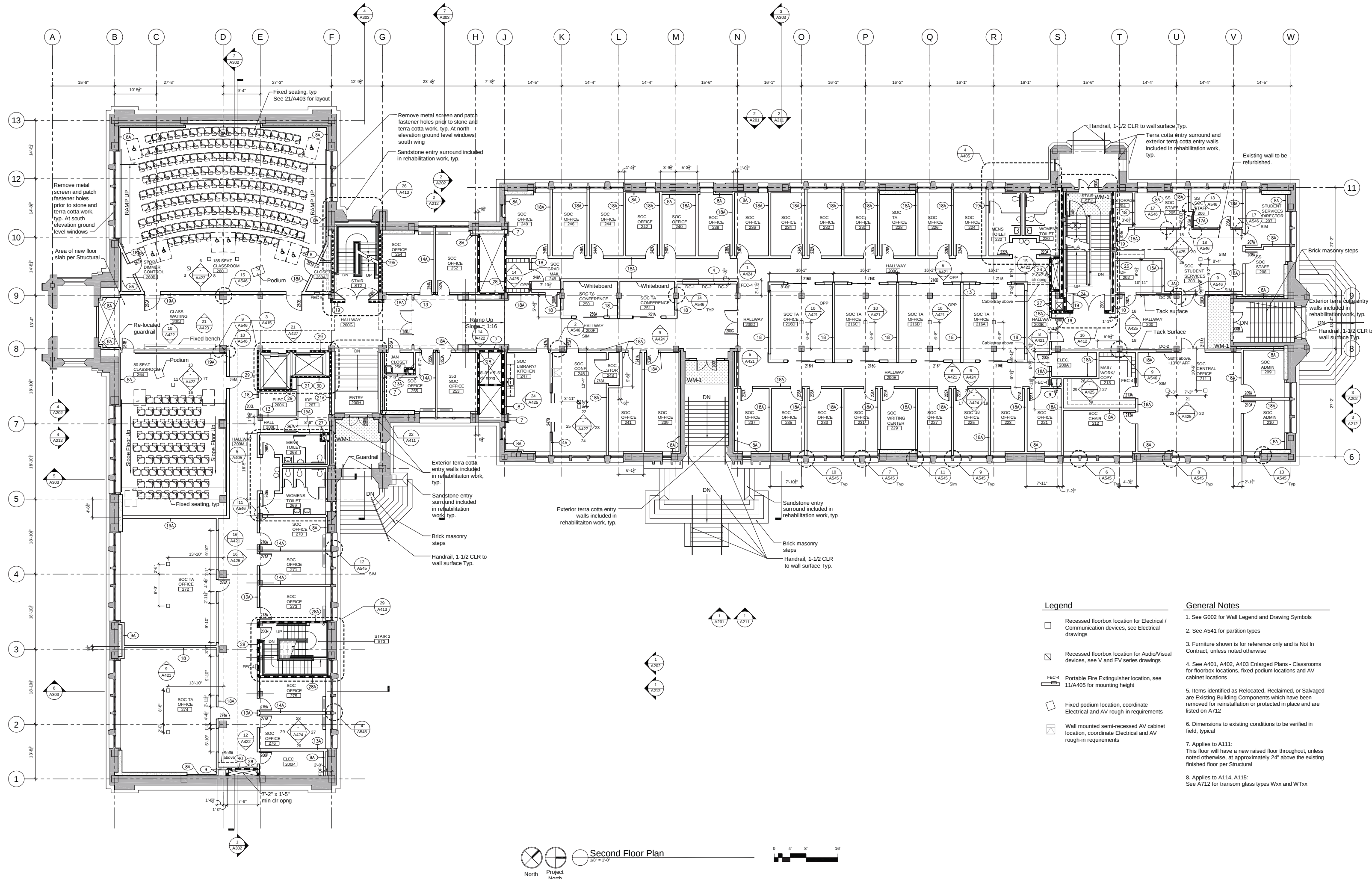
Owner Project No 200911

Drawing No

A111

Drawing Name:

FIGURE 08



Second Floor Plan

1/8" = 1'-0"

Legend

- Recessed floorbox location for Electrical / Communication devices, see Electrical drawings
- Recessed floorbox location for Audio/Visual devices, see V and EV series drawings
- FEC-4 Portable Fire Extinguisher location, see 11/A405 for mounting height
- Fixed podium location, coordinate Electrical and AV rough-in requirements
- Wall mounted semi-recessed AV cabinet location, coordinate Electrical and AV rough-in requirements

General Notes

1. See G002 for Wall Legend and Drawing Symbols
2. See A541 for partition types
3. Furniture shown is for reference only and is Not In Contract, unless noted otherwise
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5. Items identified as Relocated, Reclaimed, or Salvaged are Existing Building Components which have been removed for reinstallation or protected in place and are listed on A712
6. Dimensions to existing conditions to be verified in field, typical
7. Applies to A111:
This floor will have a new raised floor throughout, unless noted otherwise, at approximately 24" above the existing finished floor per Structural
8. Applies to A114, A115:
See A712 for transom glass types Wxx and WTxx

FIGURE 09

Drawing Name:

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SRG PARTNERSHIP INC

Revisions (Continued)

UNIVERSITY OF WASHINGTON

Savery Hall Renovation
Construction Documents

Construction Documents

Drawing Title
Second Floor Plan

Revisions		
0	Construction Set	8/31/07
1	ASI #2	9/17/07
2	ASI #3	9/27/07
3	ASI #7	11/02/07
4	RFI #107	4/2/08
5	RFI #125	4/21/08
6	ASI #17	7/11/08
7	As-Built Set	12/10/09

Drawn by
SRG
Checked by
GJH
Date
August 31, 2007
Project No
2518S
Consultant Project No

Owner Project No
200911
Drawing No
A112

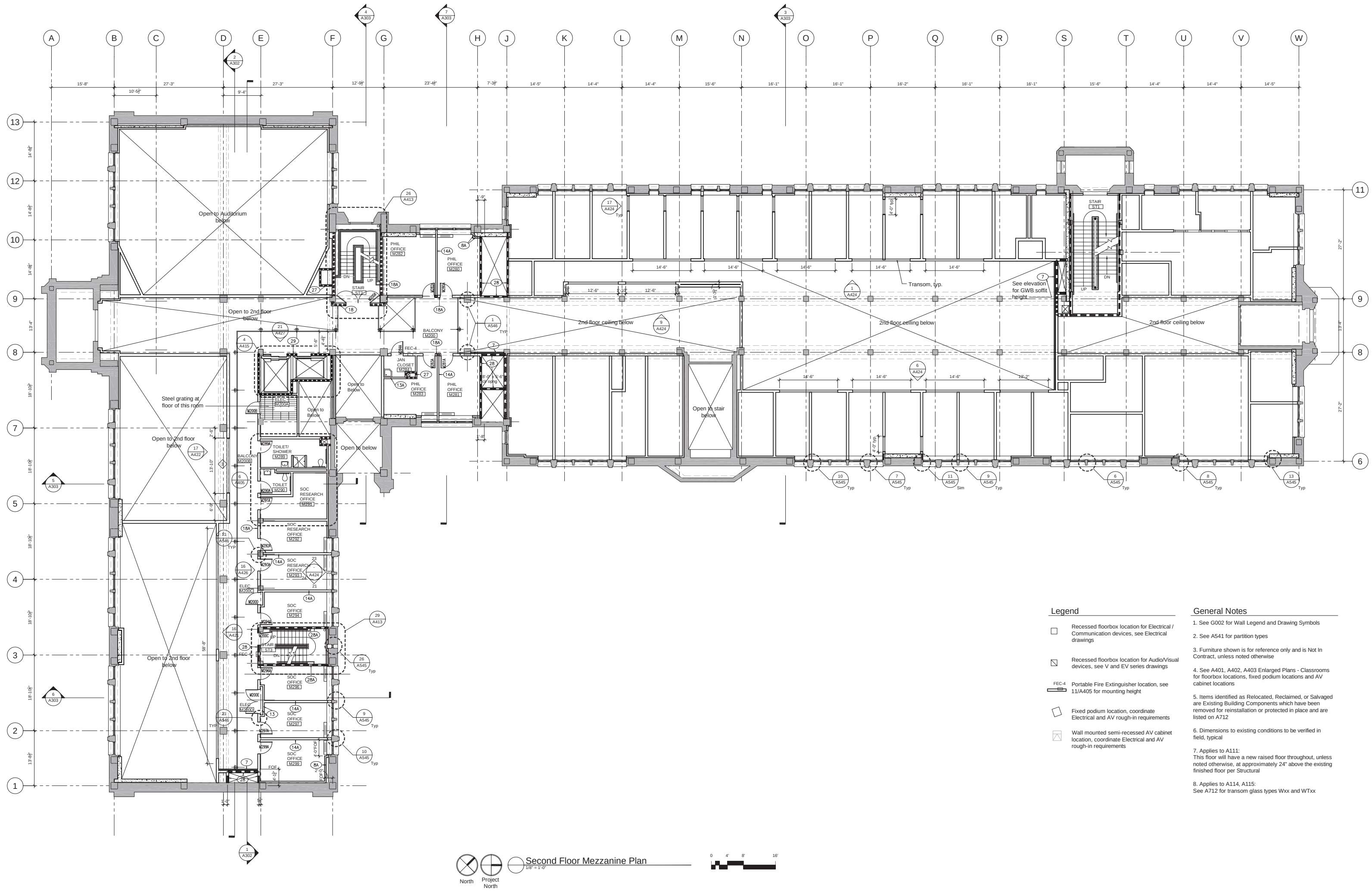

FIGURE 10

Legend

- Recessed floorbox location for Electrical / Communication devices, see Electrical drawings
- Recessed floorbox location for Audio/Visual devices, see V and EV series drawings
- FEC-4 — Portable Fire Extinguisher location, see 11/A405 for mounting height
- Fixed podium location, coordinate Electrical and AV rough-in requirements
- Wall mounted semi-recessed AV cabinet location, coordinate Electrical and AV rough-in requirements

General Notes

1. See G002 for Wall Legend and Drawing Symbols
2. See A541 for partition types
3. Furniture shown is for reference only and is Not In Contract, unless noted otherwise
4. See A401, A402, A403 Enlarged Plans - Classrooms for floorbox locations, fixed podium locations and AV cabinet locations
5. Items identified as Relocated, Reclaimed, or Salvaged are Existing Building Components which have been removed for reinstallation or protected in place and are listed on A712
6. Dimensions to existing conditions to be verified in field, typical
7. Applies to A111:
This floor will have a new raised floor throughout, unless noted otherwise, at approximately 24" above the existing finished floor per Structural
8. Applies to A114, A115:
See A712 for transom glass types Wxx and WTxx

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Revisions (Continued)

UNIVERSITY OF WASHINGTON
Savery Hall Renovation
Construction Documents

Construction Documents

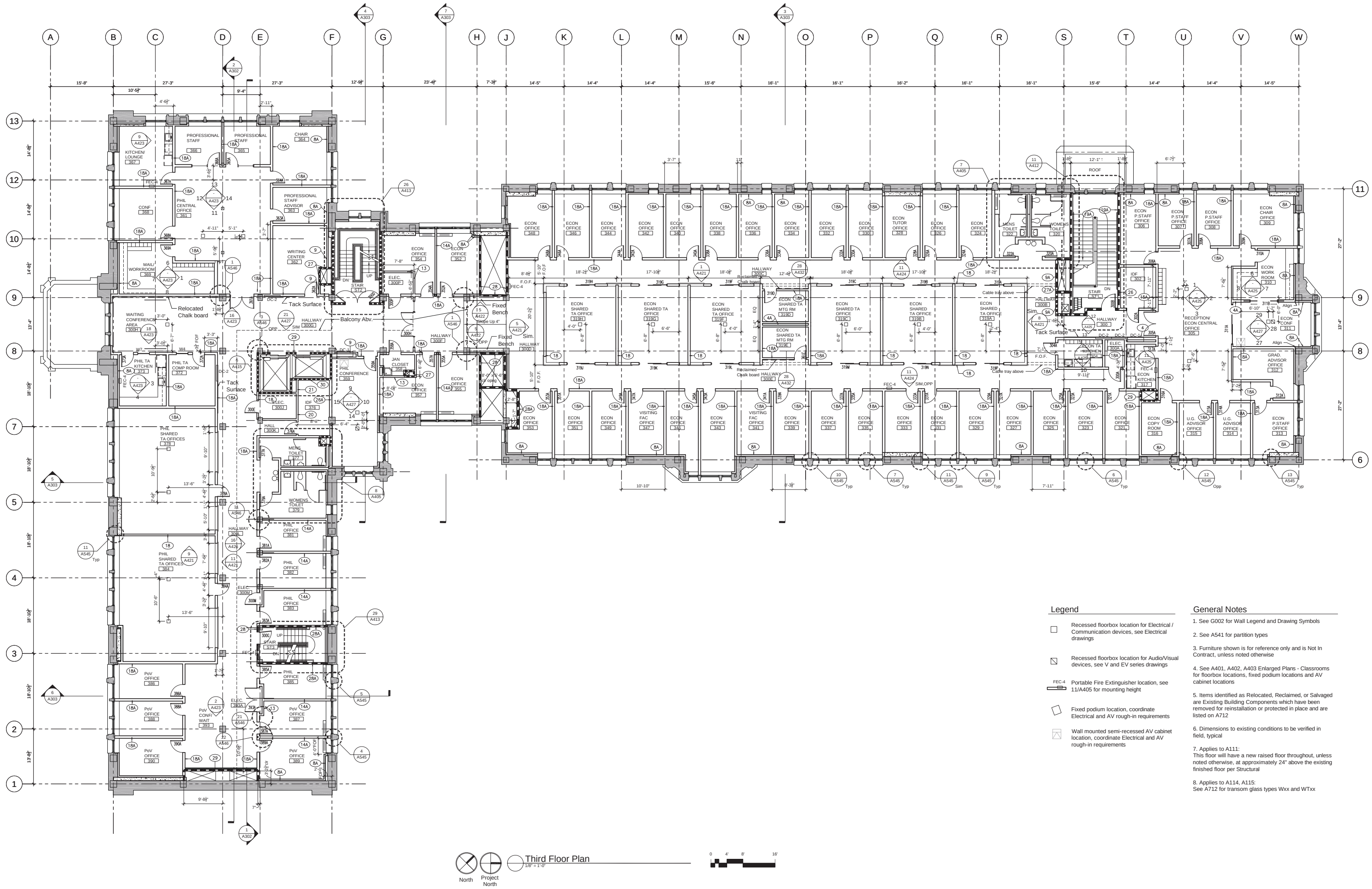
Drawing Title
Second Floor Mezzanine Plan

Revisions

0	Construction Set	8/31/07
1	ASI #2	9/17/07
2	ASI #7	11/02/07
3	RFI #107	4/2/08
4	ASI #17	7/11/08
5	As-Built Set	12/10/09

Drawn by
SRG
Checked by
GJH
Date
August 31, 2007
Project No
25185
Consultant Project No
Owner Project No
200911
Drawing No
A113

Drawing Name:



Third Floor Plan
1/8" = 1'-0"

North | Project North

Legend

- Recessed floorbox location for Electrical / Communication devices, see Electrical drawings
- Recessed floorbox location for Audio/Visual devices, see V and EV series drawings
- FEC-4 Portable Fire Extinguisher location, see 11/A405 for mounting height
- Fixed podium location, coordinate Electrical and AV rough-in requirements
- Wall mounted semi-recessed AV cabinet location, coordinate Electrical and AV rough-in requirements

General Notes

1. See G002 for Wall Legend and Drawing Symbols
2. See A541 for partition types
3. Furniture shown is for reference only and is Not In Contract, unless noted otherwise
4. See A401, A402, A403 Enlarged Plans - Classrooms for floorbox locations, fixed podium locations and AV cabinet locations
5. Items identified as Relocated, Reclaimed, or Salvaged are Existing Building Components which have been removed for reinstallation or protected in place and are listed on A712
6. Dimensions to existing conditions to be verified in field, typical
7. Applies to A111:
This floor will have a new raised floor throughout, unless noted otherwise, at approximately 24" above the existing finished floor per Structural
8. Applies to A114, A115:
See A712 for transom glass types Wxx and WTxx

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Savery Hall Renovation
Construction Documents

Construction Documents

Drawing Title
Third Floor Plan

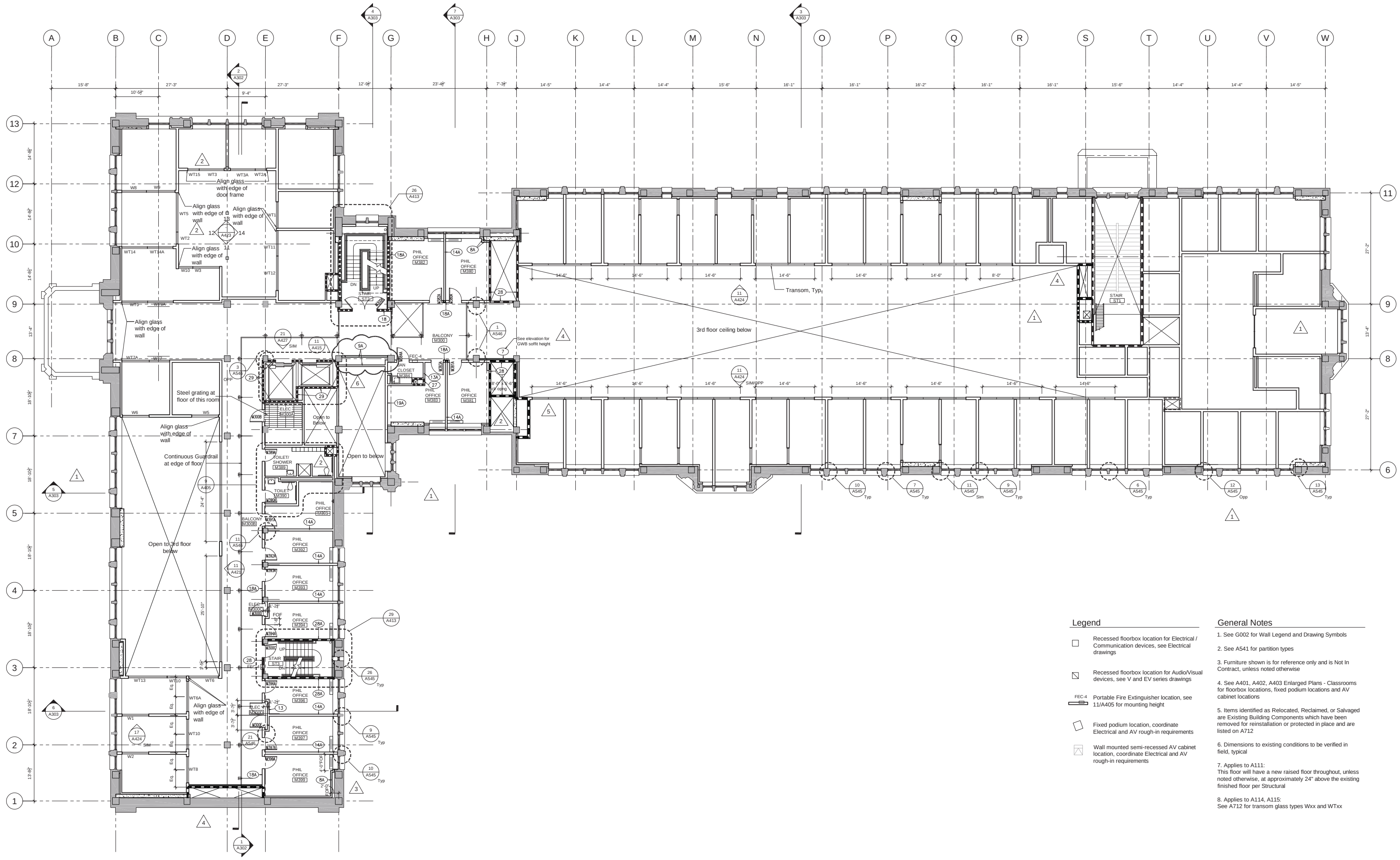
Revisions

0	Construction Set	8/31/07
1	ASI #2	9/17/07
2	ASI #3	9/27/07
3	ASI #7	11/02/07
4	RFI #107	4/2/08
5	ASI #17	7/11/08
6	RFI #298	8/11/08
7	As-Built Set	12/10/09

Drawn by
SRG
Checked by
GJH
Date
August 31, 2007
Project No
25188
Consultant Project No
Owner Project No
200911
Drawing No
A114

Drawing Name:

FIGURE 11



North

Project North

Third Floor Mezzanine Plan

1/8" = 1'-0"

Legend

- Recessed floorbox location for Electrical / Communication devices, see Electrical drawings
- Recessed floorbox location for Audio/Visual devices, see V and EV series drawings
- FEC-4 Portable Fire Extinguisher location, see 11/A405 for mounting height
- Fixed podium location, coordinate Electrical and AV rough-in requirements
- Wall mounted semi-recessed AV cabinet location, coordinate Electrical and AV rough-in requirements

General Notes

1. See G002 for Wall Legend and Drawing Symbols
2. See A541 for partition types
3. Furniture shown is for reference only and is Not In Contract, unless noted otherwise
4. See A401, A402, A403 Enlarged Plans - Classrooms for floorbox locations, fixed podium locations and AV cabinet locations
5. Items identified as Relocated, Reclaimed, or Salvaged are Existing Building Components which have been removed for reinstallation or protected in place and are listed on A712
6. Dimensions to existing conditions to be verified in field, typical
7. Applies to A111:
This floor will have a new raised floor throughout, unless noted otherwise, at approximately 24" above the existing finished floor per Structural
8. Applies to A114, A115:
See A712 for transom glass types Wxx and WTxx

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Revisions (Continued)

UNIVERSITY OF WASHINGTON

Savery Hall Renovation

Construction Documents

Construction Documents

Drawing Title

Third Floor

Mezzanine Plan

Revisions		
0	Construction Set	8/31/07
1	ASI #2	9/17/07
2	ASI #7	11/02/07
3	RFI #107	4/2/08
4	ASI #17	7/11/08
5	RFI #298	8/11/08
6	RFI #512	11/3/08
7	As-Built Set	12/10/09

Drawn by
SRG

Checked by
GJH

Date
August 31, 2007

Project No
2518S

Consultant Project No

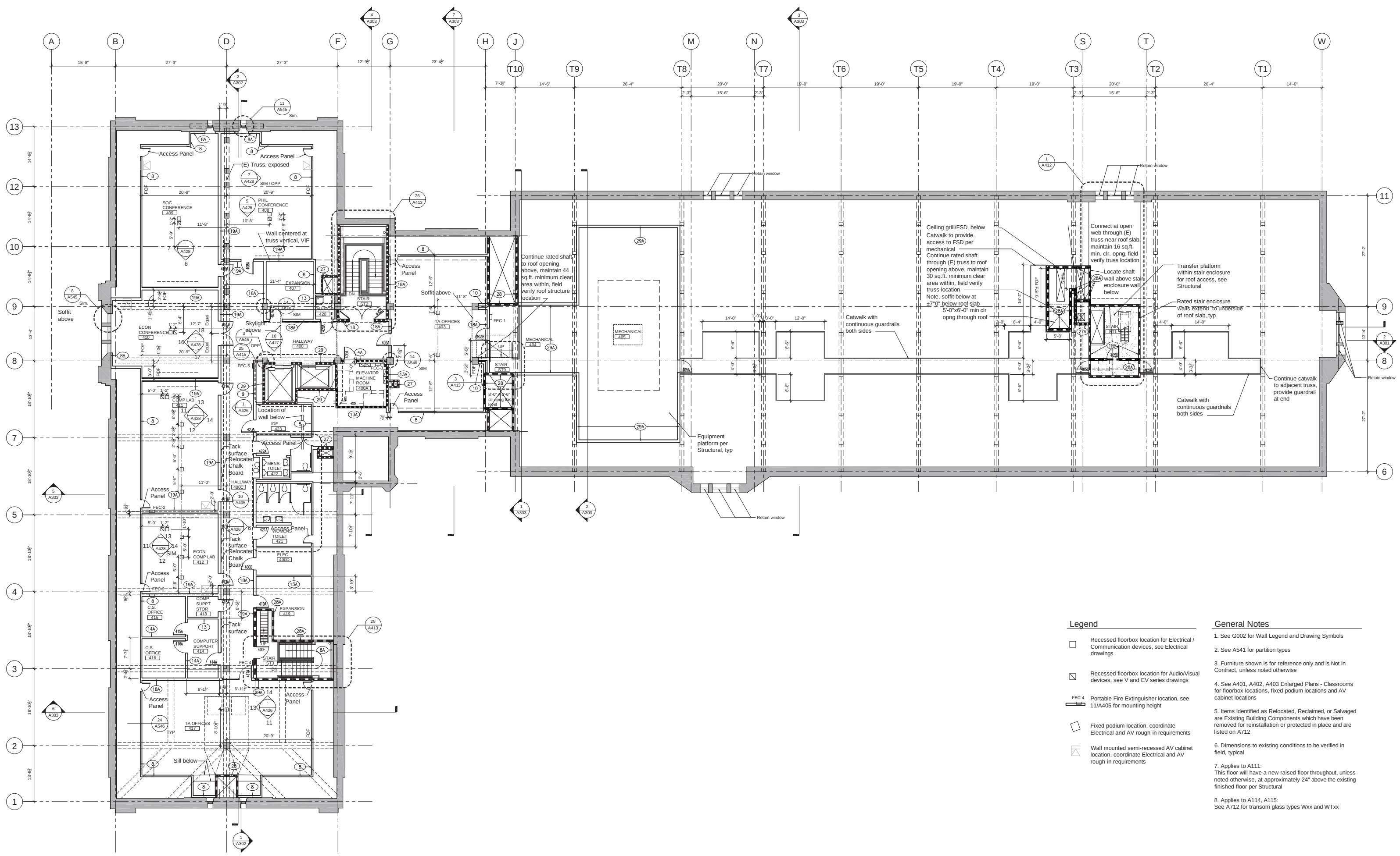
Owner Project No
200911

Drawing No

A115

Drawing Name:

FIGURE 12



Fourth Floor Attic Plan

1/8" = 1'-0"

North

Project North

FIGURE 13

Legend

- Recessed floorbox location for Electrical / Communication devices, see Electrical drawings
- Recessed floorbox location for Audio/Visual devices, see V and EV series drawings
- FEC-4 — Portable Fire Extinguisher location, see 11/A405 for mounting height
- Fixed podium location, coordinate Electrical and AV rough-in requirements
- Wall mounted semi-recessed AV cabinet location, coordinate Electrical and AV rough-in requirements

General Notes

1. See G002 for Wall Legend and Drawing Symbols
2. See A541 for partition types
3. Furniture shown is for reference only and is Not In Contract, unless noted otherwise
4. See A401, A402, A403 Enlarged Plans - Classrooms for floorbox locations, fixed podium locations and AV cabinet locations
5. Items identified as Relocated, Reclaimed, or Salvaged are Existing Building Components which have been removed for reinstallation or protected in place and are listed on A712
6. Dimensions to existing conditions to be verified in field, typical
7. Applies to A111:
This floor will have a new raised floor throughout, unless noted otherwise, at approximately 24" above the existing finished floor per Structural
8. Applies to A114, A115:
See A712 for transom glass types Wxx and WTxx

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ARCHITECTURE PLANNING INTERIORS
Seattle, Washington

University of Washington
Savery Hall Renovation
Construction Documents

Revisions (Continued)

Construction Documents

Drawing Title
Fourth Floor Attic Plan

Revisions

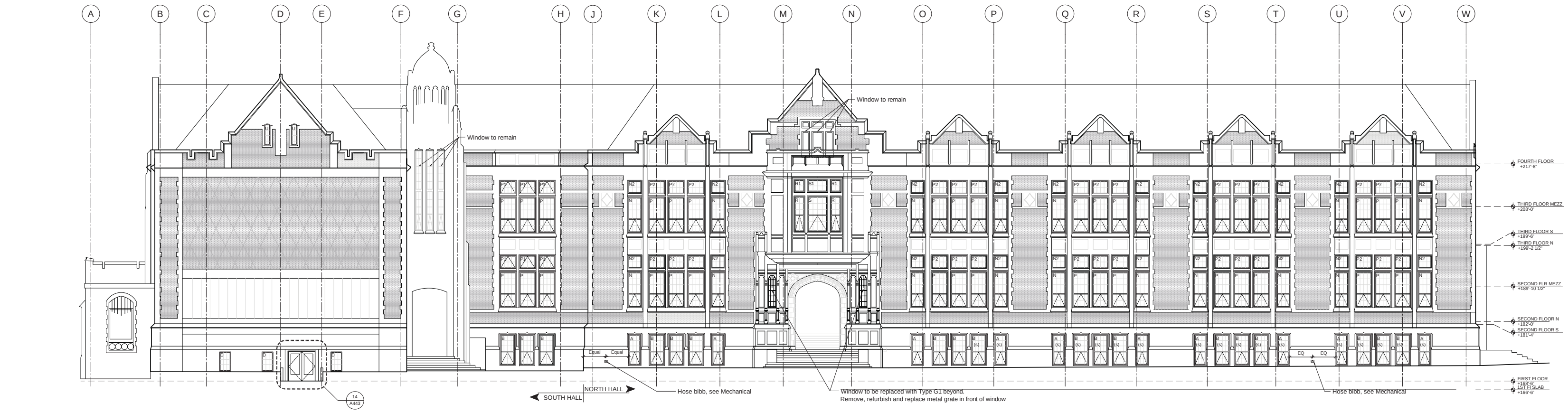
0	Construction Set	8/31/07
1	ASI #2	9/17/07
2	ASI #3	9/27/07
3	ASI #7	11/2/07
4	ASI #13	4/18/08
5	RFI #159	5/14/08
6	ASI #17	7/11/08
7	RFI #409	9/15/08
8	RFI #581	12/12/08
9	As-Built Set	12/10/09

Drawn by
SRG
Checked by
GJH
Date
August 31, 2007
Project No
25185
Consultant Project No
Owner Project No
200911
Drawing No
A116

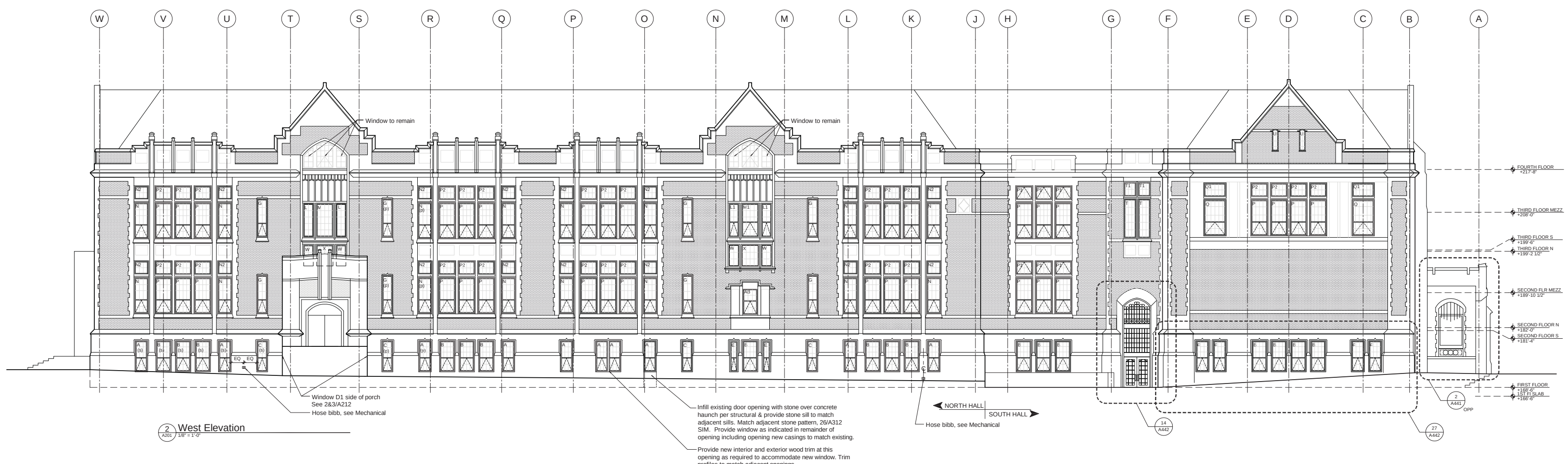
Drawing Name:

Glazing key:

Window Type, See A571 for detail information
Window notes
(p) Privacy glass
(s) Security screen, See A572 for details
Operable portion



1 A201 East Elevation 1/8" = 1'-0"



2 A201 West Elevation 1/8" = 1'-0"

FIGURE 14

Drawing Name:

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Revisions (Continued)

UNIVERSITY OF WASHINGTON
Savery Hall Renovation
Construction Documents

Construction Documents

Drawing Title
Exterior Elevations

Revisions

0	Construction Set	8/31/07
1	As-Built Set	12/10/09

Drawn by
NRP

Checked by
GJH

Date
August 31, 2007

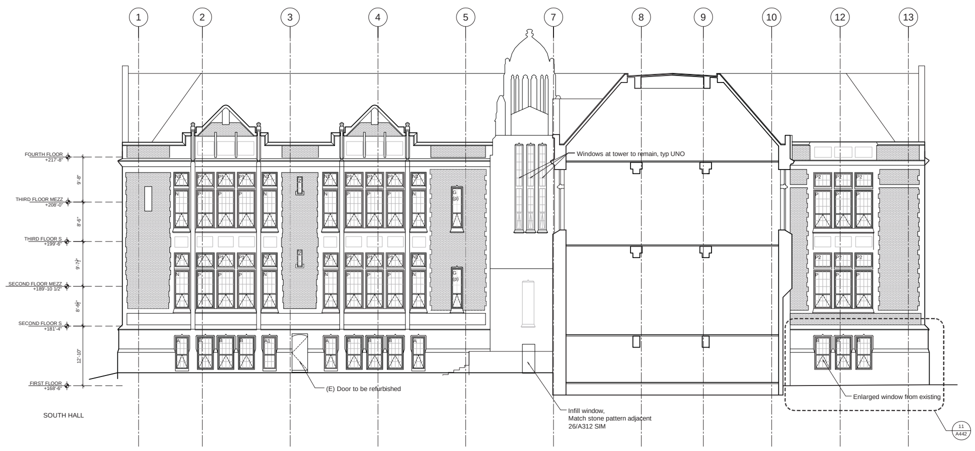
Project No
2518S

Consultant Project No

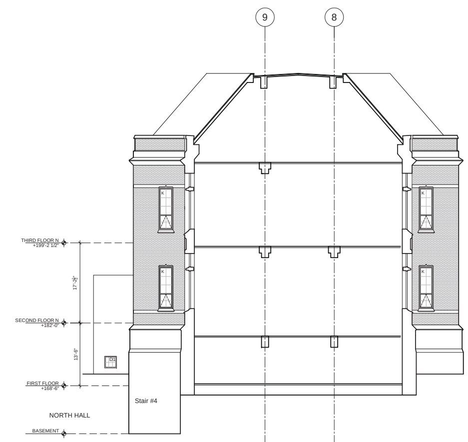
Owner Project No
200911

Drawing No
A211

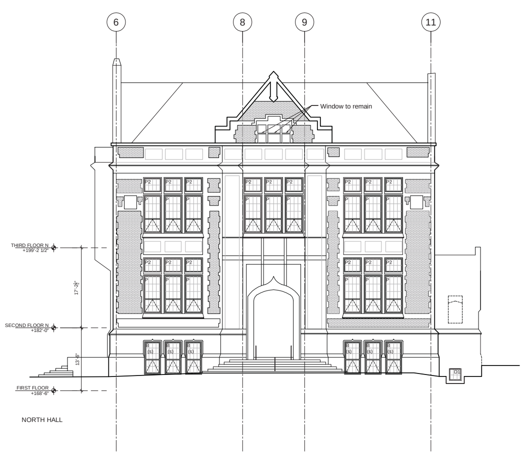
Glazing key:
Window Type, See A571 for detail information
Window notes
(p) Privacy glass
(s) Security screen, See A572 for details
Operable portion



1 NORTH ELEVATION AT SOUTH WING
A212 1/8" = 1'-0"



2 SOUTH ELEVATION AT NORTH WING
A212 1/8" = 1'-0"



3 NORTH ELEVATION
A212 1/8" = 1'-0"

4 SOUTH ELEVATION
A212 1/8" = 1'-0"

FIGURE 15

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Revisions (Continued)

UNIVERSITY OF WASHINGTON
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Construction Documents

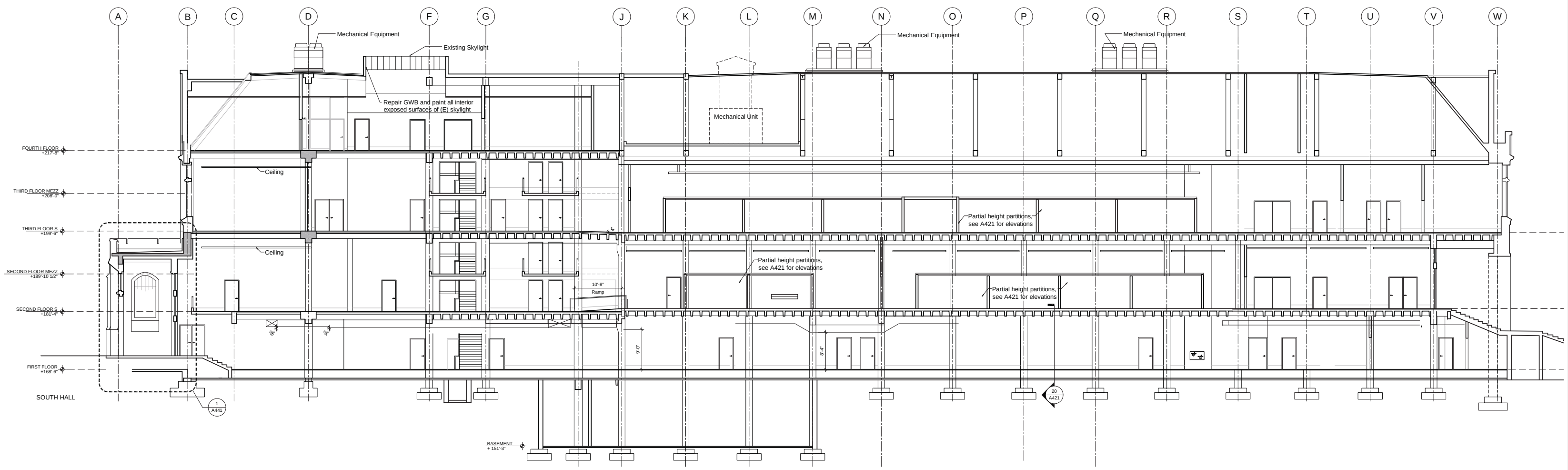
Construction Documents

Drawing Title
Exterior Elevations

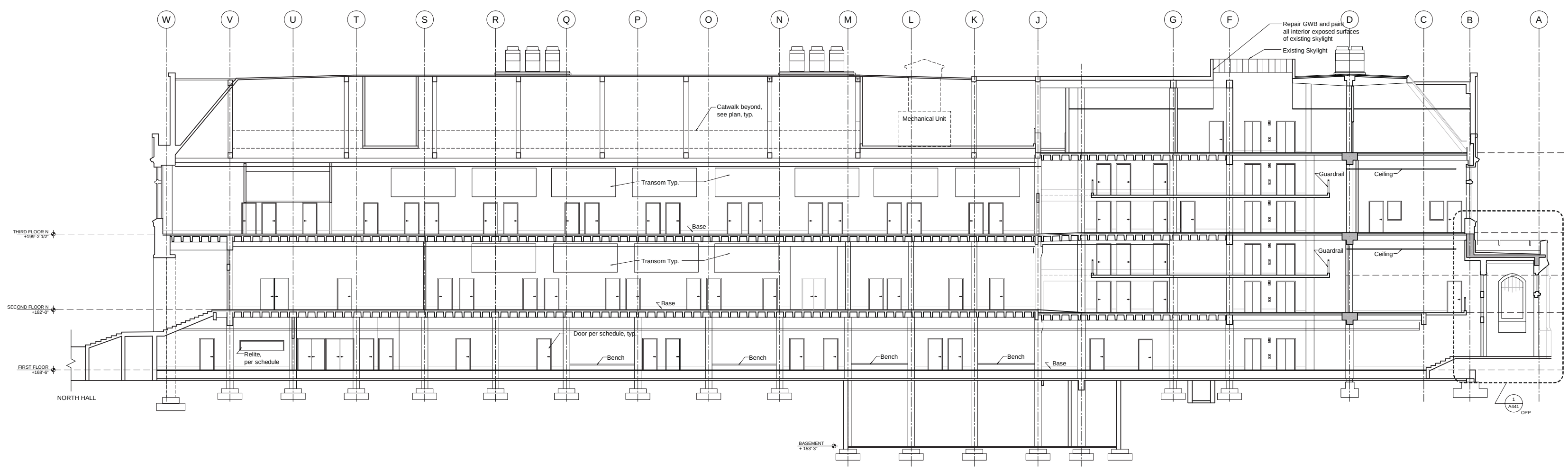
Revisions
0 Construction Set 8/31/07
1 ASI #2 9/17/07
2 As-Built Set 12/10/09

Drawn by
NRP
Checked by
GJH
Date
August 31, 2007
Project No
2518S
Consultant Project No
Owner Project No
200911
Drawing No
A212

Drawing Name:



Longitudinal Building Section - North Wing looking West



Longitudinal Building Section - North Wing looking East

FIGURE 16

ARCHITECTURE PLANNING INTERIORS
SRG PARTNERSHIP INC

UNIVERSITY OF WASHINGTON
Savery Hall Renovation
Construction Documents

Revisions (Continued)

Construction Documents

Drawing Title
Building Sections

Revisions
0 Construction Set 8/31/07
1 ASI #2 9/17/07
2 ASI #7 11/2/07
3 As-Built Set 12/10/09

Drawn by
AP, KMJ
Checked by
GJH
Date
Project No
Consultant Project No
Owner Project No
Drawing No
A301

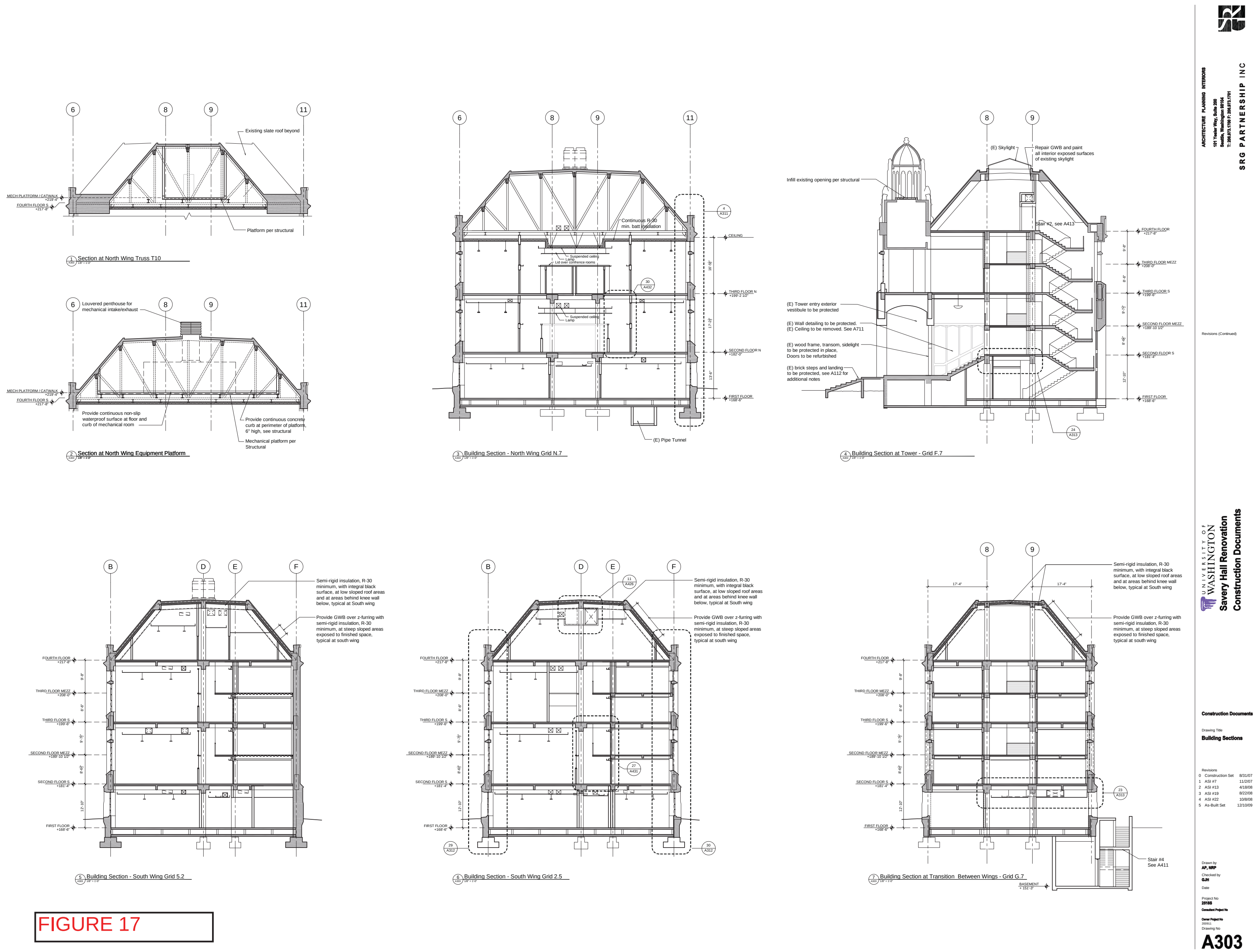

Section at North Wing Truss T10
Section at North Wing Equipment Platform
Building Section - North Wing Grid N.7
Building Section at Tower - Grid F.7
Building Section - South Wing Grid 5.2
Building Section - South Wing Grid 2.5
Building Section at Transition Between Wings - Grid G.7
Existing slate roof beyond
Platform per structural
Louvered penthouse for mechanical intake/exhaust
Provide continuous non-slip waterproof surface at floor and curb of mechanical room
Provide continuous concrete curb at perimeter of platform, 6" high, see structural
Mechanical platform per Structural
Continuous R-30 min. batt insulation
(E) Pipe Tunnel
(E) Skylight
Repair GWB and paint all interior exposed surfaces of existing skylight
Infill existing opening per structural
Stair #2, see A413
(E) Tower entry exterior vestibule to be protected
(E) Wall detailing to be protected. (E) Ceiling to be removed. See A711
(E) wood frame, transom, sidelight to be protected in place, Doors to be refurbished
(E) brick steps and landing to be protected, see A112 for additional notes
Semi-rigid insulation, R-30 minimum, with integral black surface, at low sloped roof areas and at areas behind knee wall below, typical at South wing
Provide GWB over z-furring with semi-rigid insulation, R-30 minimum, at steep sloped areas exposed to finished space, typical at south wing
Stair #4 See A411
FOURTH FLOOR
THIRD FLOOR MEZZ
THIRD FLOOR S
SECOND FLOOR MEZZ
SECOND FLOOR S
FIRST FLOOR
BASEMENT
SRG PARTNERSHIP INC
ARCHITECTURE PLANNING INTERIORS
UNIVERSITY OF WASHINGTON
Savery Hall Renovation
Construction Documents
Drawing Title
Building Sections
Revisions
0 Construction Set 8/31/07
1 ASI #7 11/2/07
2 ASI #13 4/18/08
3 ASI #19 8/22/08
4 ASI #22 10/8/08
5 As-Built Set 12/10/09
Drawn by
AP, NRP
Checked by
GJH
Date
Project No
Drawing No
A303

FIGURE 17

FIGURE 18 Property of MSCUA, University of Washington Libraries. Photo Coll 700

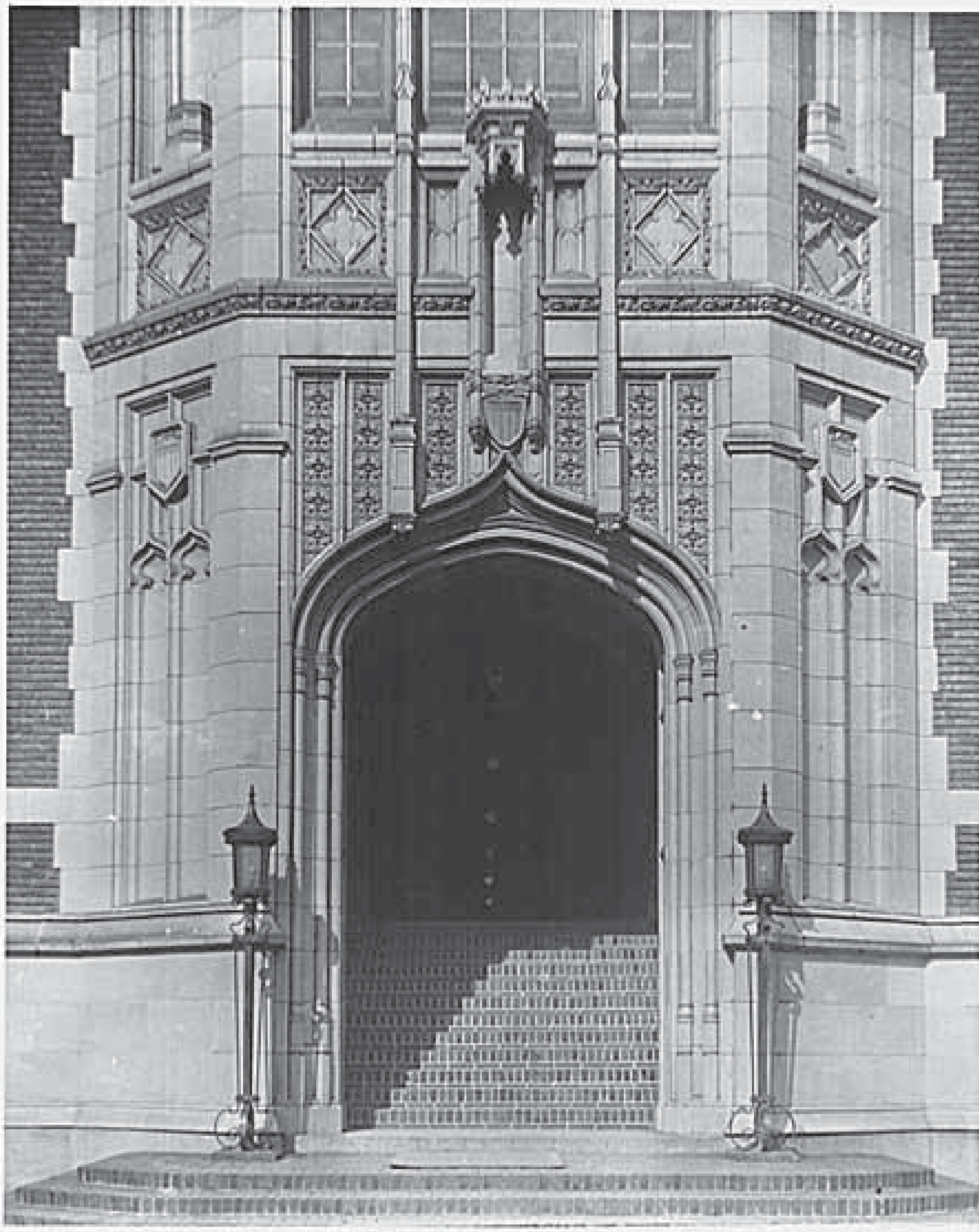


FIGURE 19

FIGURE 20 Property of MSCUA, University of Washington Libraries. Photo Coll 700

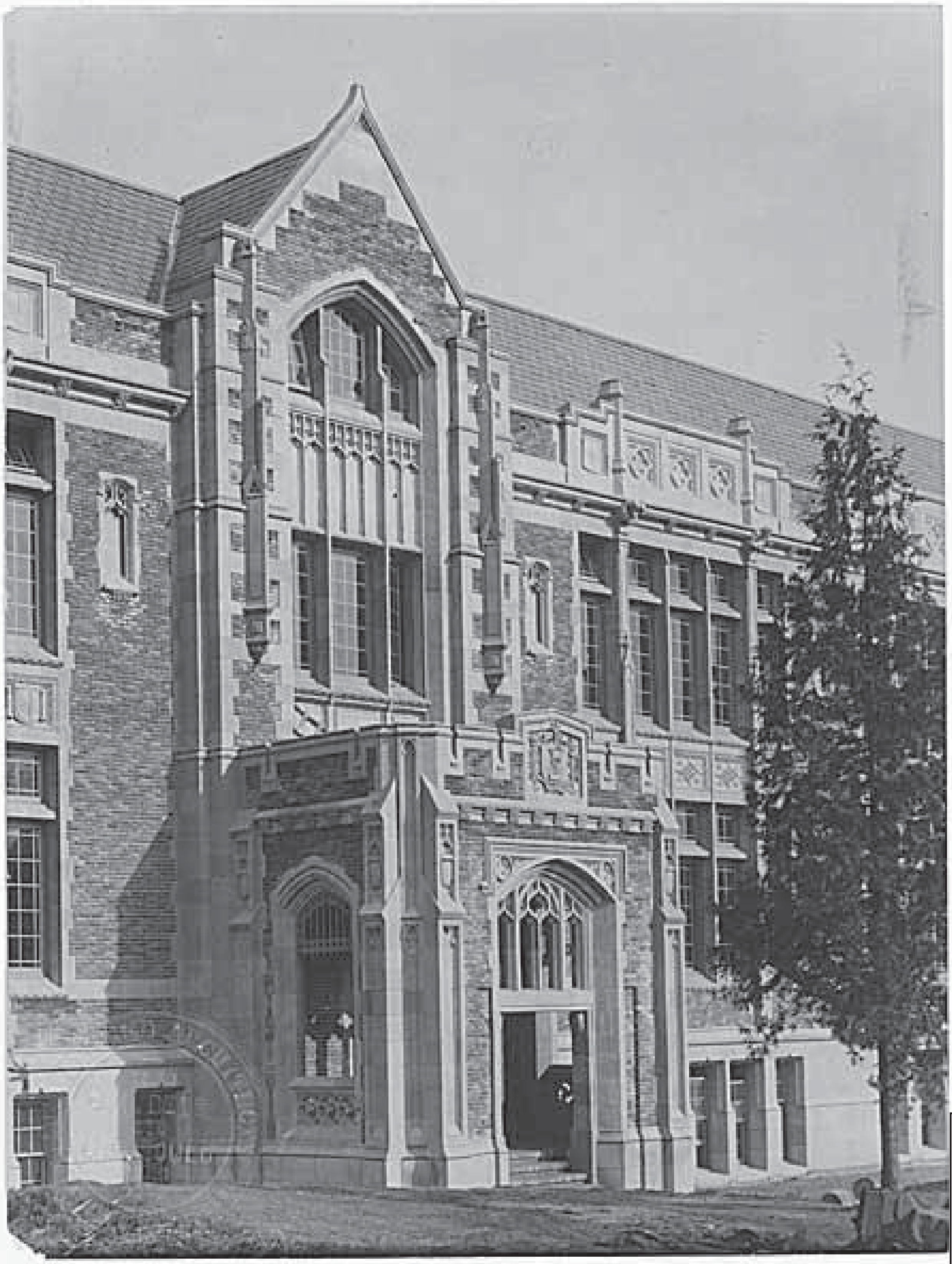


FIGURE 21

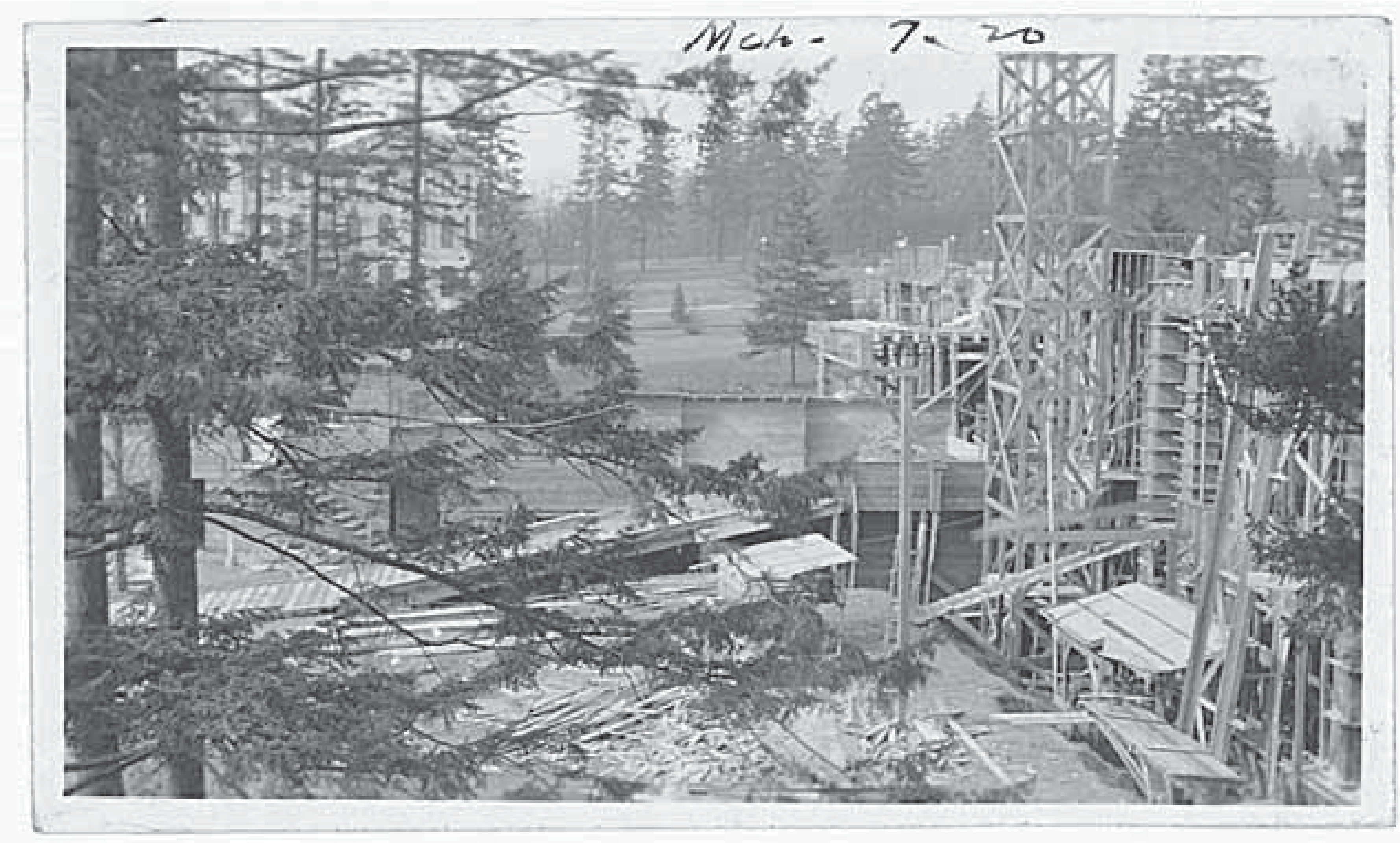


FIGURE 22 Property of MSCUA, University of Washington Libraries. Photo Coll 700

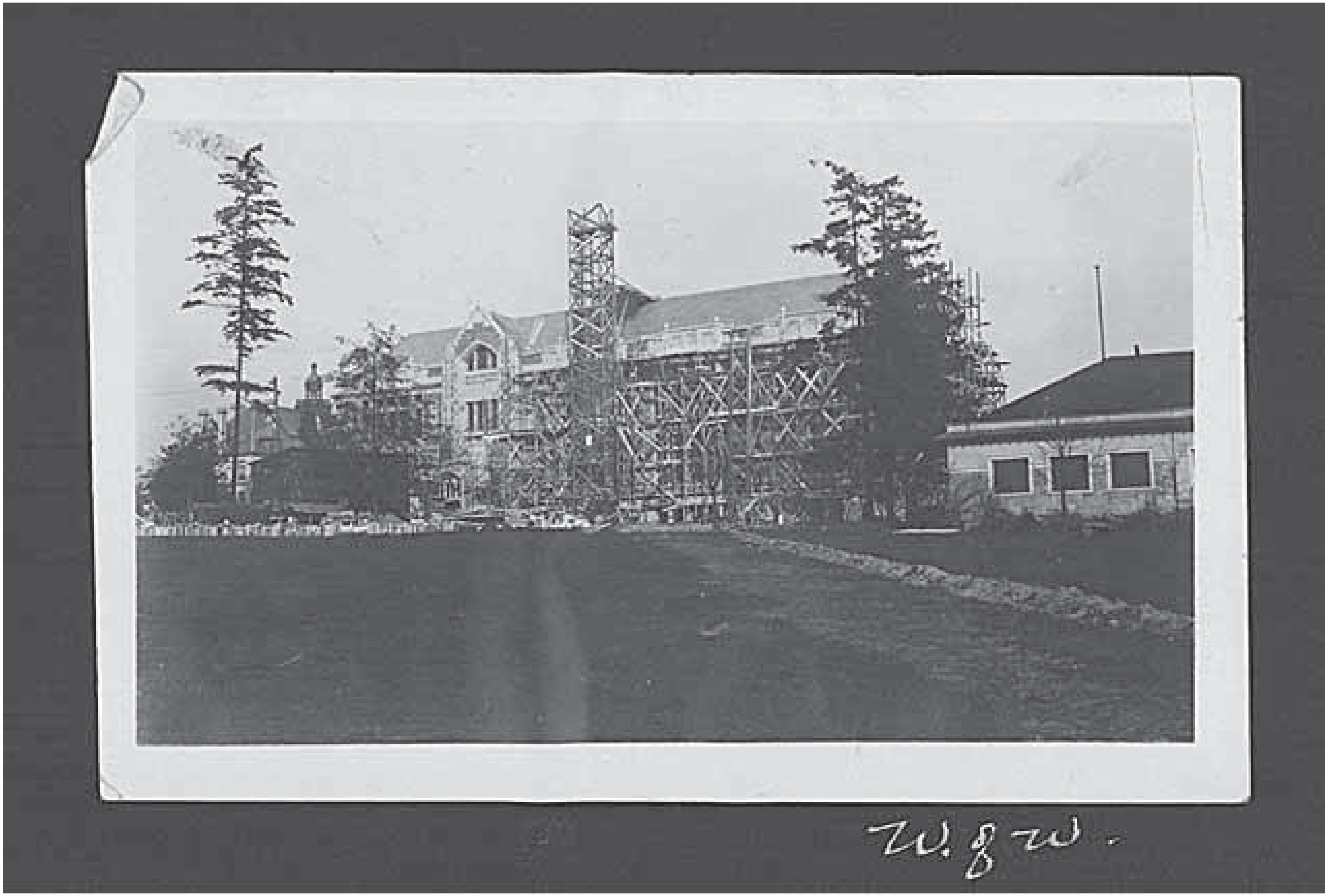


FIGURE 23 Property of MSCUA, University of Washington Libraries. Photo Coll 700

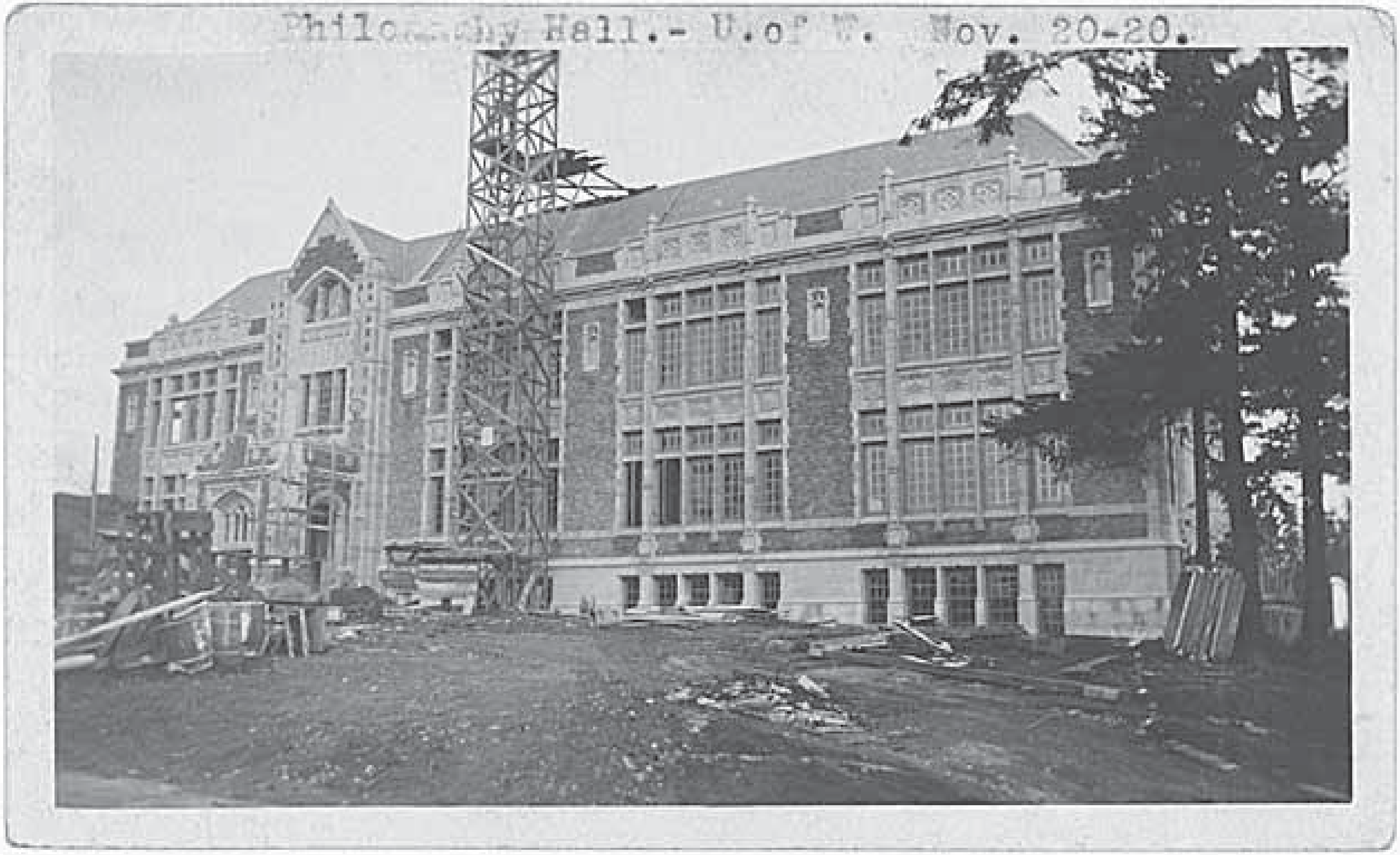


FIGURE 24

Property of MSCUA, University of Washington Libraries. Photo Coll 700

FIGURE 25

FIGURE 26

FIGURE 27

Appendix 2: Case Study Information

The SIERR Building at McKinstry Station

The SIERR Building at McKinstry Station

List of Figures

Used with permission of McKinstry Company.

15. The SIERR Building. Interior view of main entry. 2012. Credit: Dean Davis. Courtesy of McKinstry Corporation. Used with permission of McKinstry Company.
16. The SIERR Building. Interior view of McKinstry Reception area. 2012. Credit: Dean Davis. Courtesy of McKinstry Corporation. Used with permission of McKinstry Company.
17. The SIERR Building. Interior view of common kitchen and dining area. 2012. Credit: Dean Davis. Courtesy of McKinstry Corporation. Used with permission of McKinstry Company.
18. The SIERR Building. Interior view of elevator and catwalks near Main Entry. 2012. Credit: Dean Davis. Courtesy of McKinstry Corporation. Used with permission of McKinstry Company.
19. The SIERR Building. Interior view of McKinstry office space. 2012. Credit: Dean Davis. Courtesy of McKinstry Corporation. Used with permission of McKinstry Company.
20. The SIERR Building. Exterior view looking northeast. 2012. Credit: Dean Davis. Courtesy of McKinstry Corporation. Used with permission of McKinstry Company.
21. The SIERR Building. Exterior view of car barn doors. 2012. Credit: Dean Davis. Courtesy of McKinstry Corporation. Used with permission of McKinstry Company.
22. The SIERR Building. Exterior view looking southeast at dawn. 2012. Credit: Dean Davis. Courtesy of McKinstry Corporation. Used with permission of McKinstry Company.

Appendix 2 - Case Study Info - SIERR Building.pdf 1

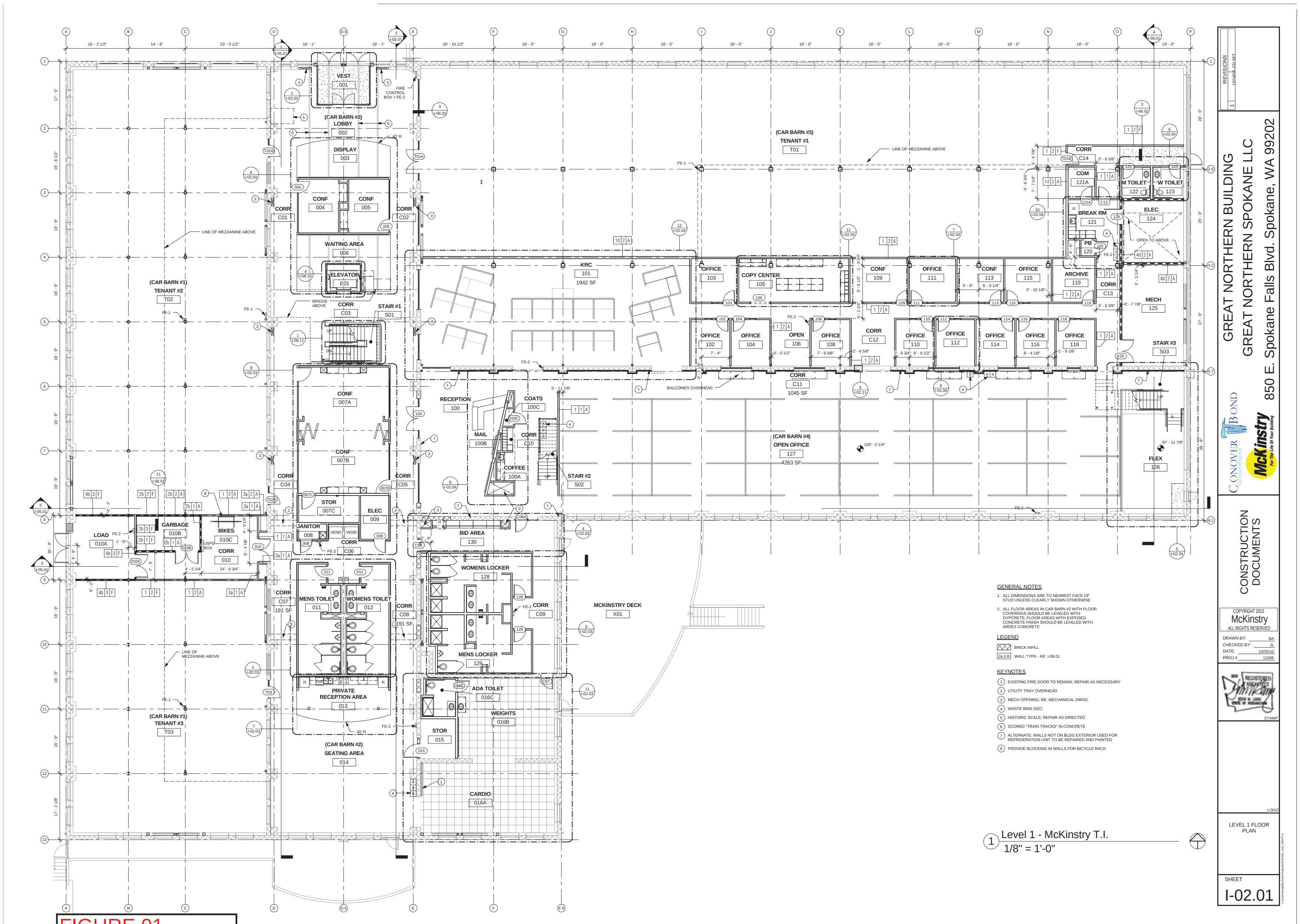


FIGURE 01

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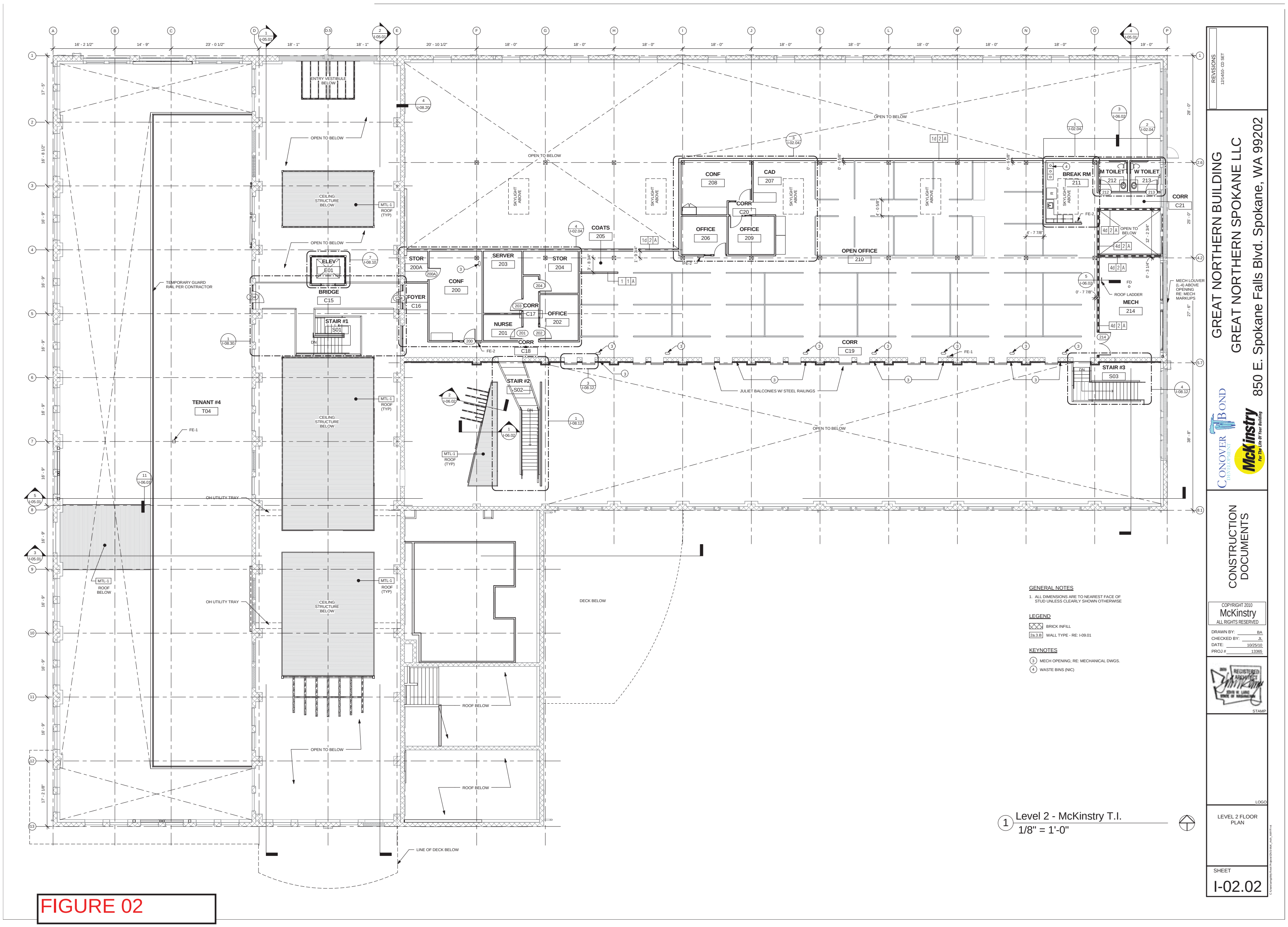
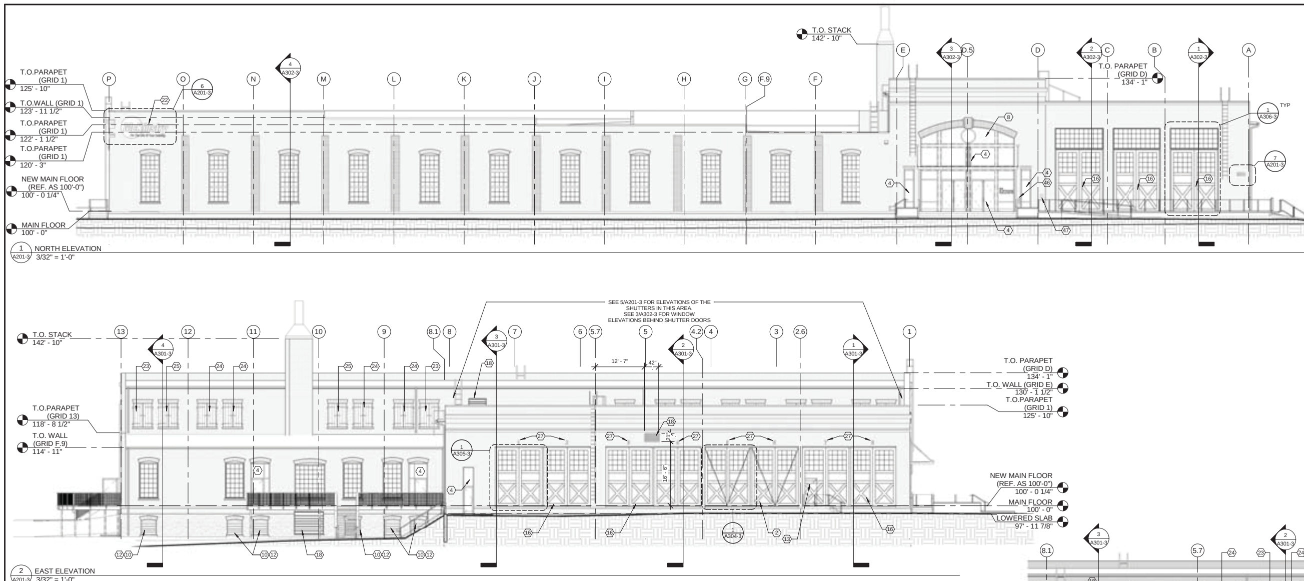

GREAT NORTHERN BUILDING
GREAT NORTHERN SPOKANE LLC
850 E. Spokane Falls Blvd. Spokane, WA 99202
CONSTRUCTION DOCUMENTS
McKinstry
ALL RIGHTS RESERVED
LEVEL 2 FLOOR PLAN
SHEET
I-02.02
Level 2 - McKinstry T.I.
1/8" = 1'-0"
GENERAL NOTES
1. ALL DIMENSIONS ARE TO NEAREST FACE OF STUD UNLESS CLEARLY SHOWN OTHERWISE
LEGEND
BRICK INFILL
WALL TYPE - RE: I-09.01
KEYNOTES
MECH OPENING; RE: MECHANICAL DWGS.
WASTE BINS (NIC)
TENANT #4
T04
OPEN TO BELOW
CEILING STRUCTURE BELOW
ELEV E01
BRIDGE C15
STAIR #1 S01
STOR 200A
CONF 200
FOYER C16
SERVER 203
STOR 204
NURSE 201
CORR C17
OFFICE 202
CORR C18
COATS 205
CONF 208
CAD 207
CORR C20
OFFICE 206
OFFICE 209
OPEN OFFICE 210
BREAK RM 211
M TOILET 212
W TOILET 213
CORR C21
MECH 214
CORR C19
STAIR #2 S02
STAIR #3 S03
JULIET BALCONIES W/ STEEL RAILINGS
TEMPORARY GUARD RAIL PER CONTRACTOR
OH UTILITY TRAY
DECK BELOW
ROOF BELOW
LINE OF DECK BELOW
ENTRY VESTIBULE BELOW
SKYLIGHT ABOVE
ROOF LADDER
MECH LOUVER (L-4) ABOVE OPENING RE: MECH MARKUPS

FIGURE 02



DRAWING NOTES

1. PREPARE EXISTING WINDOW OPENING AND INSTALL NEW WINDOW, PER MANUFACTURER'S RECOMMENDATIONS, SEE DETAILS & SEE WINDOW SCHEDULE FOR WINDOW TYPES.
2. REPAIR & SALVAGE EXISTING BARN DOOR. SEE ELEVATIONS & DETAILS FOR MOR INFO. REMOVE & REPLACE ROT, PAINT.
3. NEW H.M. DOUBLE DOOR, SEE DOOR SCHEDULE FOR TYPE.
4. NEW ALUM. STOREFRONT SYSTEM, SEE WINDOW SCHEDULE FOR TYPE. PREPARE WINDOW OPENING FOR INSTALLATION.
5. CANOPY, SEE SECTIONS AND ELEVATIONS FOR MORE DETAIL.
6. DUMMY LOUVER W/ BLANK OFF PANEL.
7. MODIFIED PUNCHED OPENING, REMOVE EXISTING WINDOW FRAME & SILL IF APPLICABLE, REMOVE MASONRY FROM SILL DOWN TO FLOOR IN THIS LOCATION. REPLACE FIXED TRANSOM SASH IN (E) TRIM CASING. SEE WINDOW TYPES, PAINT. SEE TI PLANS FOR DOORS.
8. INSULATED METAL PANEL PROVIDED BY OWNER IN FRAME PROVIDED BY CONTRACTOR.
9. KALWALL SKYLIGHT, SECURE, SEAL & FLASH TO EXISTING CURB PER MFR. RECOMMENDATIONS.
10. FRAME IN HARDIE BOARD. PANEL. SECURE TO (E) CONC. WALL, SEE DETAIL.
11. SECURE METAL CLAD SHUTTERS IN CLOSED POSITION, PAINT.
12. REMOVE WOOD WINDOW JAMB ENTIRELY.
13. NEW WOOD DOOR & CONCEALED FRAME, SEE DOOR SCHEDULE & DETAILS.
14. APPLIED 2X WOOD TRIM.
15. NOT USED.
16. NEW METAL STUD WALL TO BE INSET INTO EXISTING GARAGE DOOR OPENING. EXTERIOR TO MIMIC BARN DOOR. SEE ELEVATIONS & DETAILS FOR MORE INFO.
17. NEW H.M DOOR & FRAME, SEE DOOR SCHEDULE FOR TYPE. FIELD VERIFY OPENING SIZE .
18. MECHANICAL LOUVER SEE MECHANICAL FOR SIZE.
19. (E) COLUMNS, VERIFY WITH STRUCTURAL FOR DEMO OR REPAIR, TYP.
20. NEW T.S. COLUMNS, SEE STRUCT.
21. FUTURE PHOTOVOLTAIC ARRAY.
22. METAL SIGNAGE, ATTACH TO BUILDING. SEE DETAILS
23. NEW SHUTTERS & HARDWARE TO MATCH EXISTING IN MATERIAL, DIMENSION & FINISH. LATCH IN OPEN POSITION.
24. REFURBISH HARDWARE, REPAINT (E) SHUTTERS. REPLACE AND/OR REPAIR COMPONENTS AS NECESSARY. LATCH IN OPEN POSITION.
25. SALVAGE (E) SHUTTER & HARDWARE FOR USE IN REFURBISH OF OTHER (E) SHUTTERS. REPLACE W/ NEW TO MATCH (E) IN MATERIAL, DIMENSION & FINISH. LATCH IN OPEN POSITION.
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27. NUMBERS ABOVE DOORS TO REMAIN, PROTECT.
28. NOT USED
29. NEW OPENING, SEE TI & STRUCTURAL DRAWINGS FOR DEMO & INFILL, UNLESS NOTED OTHERWISE.
30. (E) OPENING TO REMAIN.
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35. REPAIR/REPLACE HISTORIC BRICK TO MATCH (E) & REDEFINE HISTORIC OPENINGS.
36. REPAIR/REPLACE HISTORIC MASONRY SILL TO MATCH.
37. REPAIR/REPLACE METAL SHUTTERS & HARDWARE TO MATCH HISTORICAL, PAINT
38. CONCRETE PAD, SEE SECTION & LANDSCAPE.
39. NEW STRUCT. CONCRETE WALL, SEE STRUCT.
40. BRICK IN HISTORIC OPENING W/ HISTORIC MASONRY SALVAGED ELSEWHERE IN PROJECT. MATCH ADJACENT BRICK PATTERN, GROUT LINES & WALL THICKNESS.
41. ROOF MEMBRANE, INSULATION, DECKING & GUTTERS IN PREVIOUS PACKAGE, NOT IN CONTRACT.
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43. NEW ROOF LADDER, SEE DETAILS, VERIFY DIMENSIONS IN THE FIELD.
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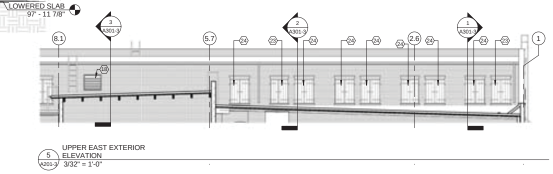
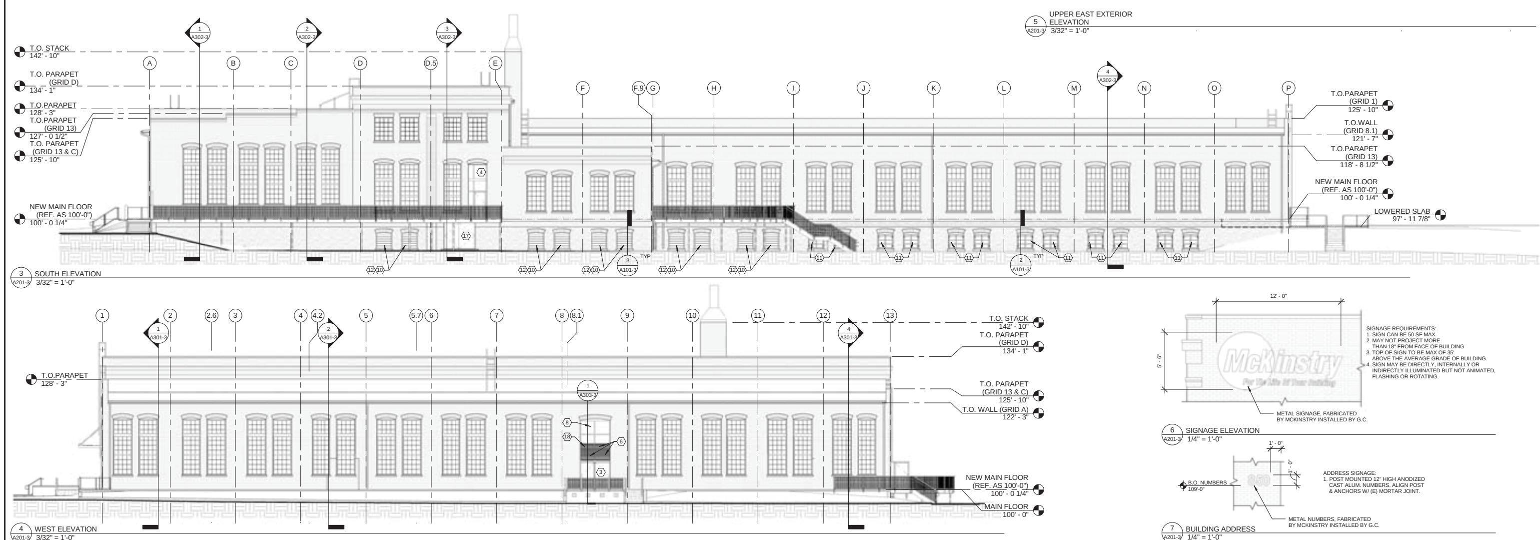
45. CONCRETE SLAB ON GRADE PER STRUCT. DIRECTLY OVER 15MIL. UNDER SLAB VAPOR BARRIER, TYP. SEE SPECS.
46. BOLLARD MOUNTED ADA OPERATOR & CARD READER. SEE SPECS., ELEVATIONS & ELECTRICAL.
47. FIRE DEPARTMENT KNOX BOX RECESSED INTO MASONRY.
48. R-10 RIGID POLYSTRYRENE UNDER CONC. SLAB @ PERIMETER TO 8'-0" INBOARD OF EXTERIOR WALL.
49. R-10 RIGID POLYSTRYRENE UNDER CONC. SLAB @ PERIMETER TO 4'-0" INBOARD OF EXTERIOR WALL.





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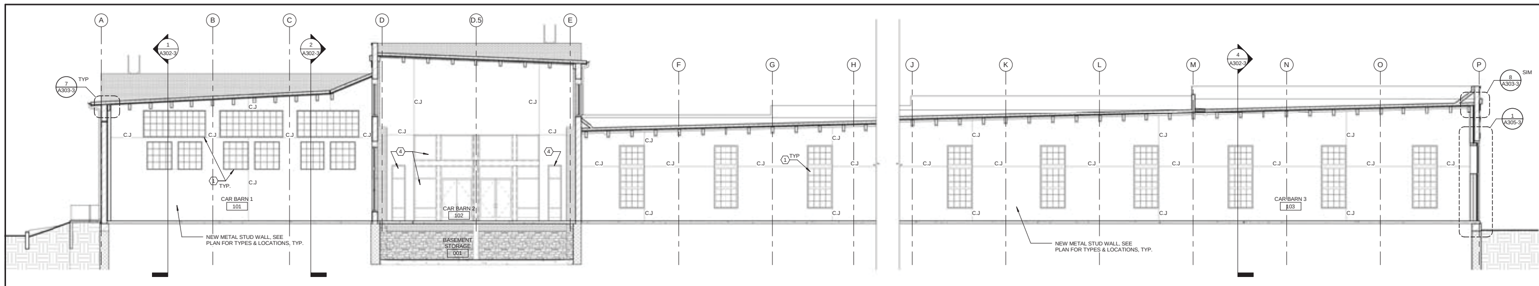
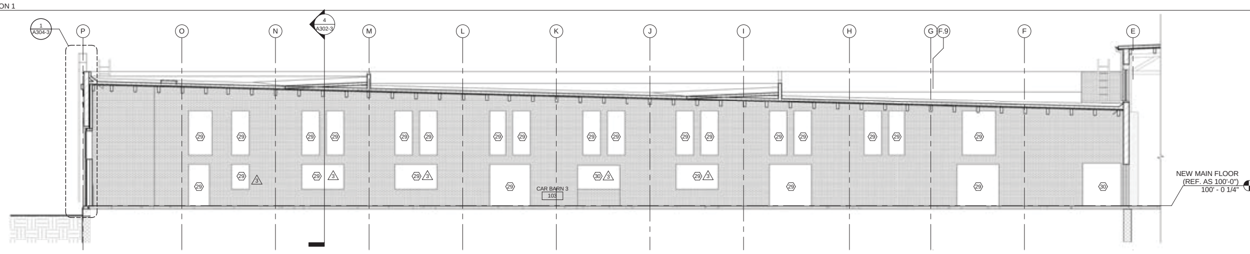
EXTERIOR ELEVATIONS

SHEET
A201-3

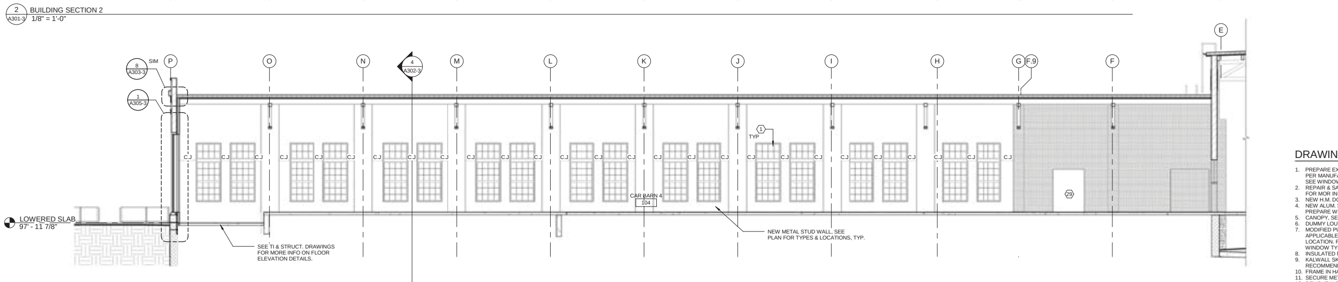
FIGURE 03



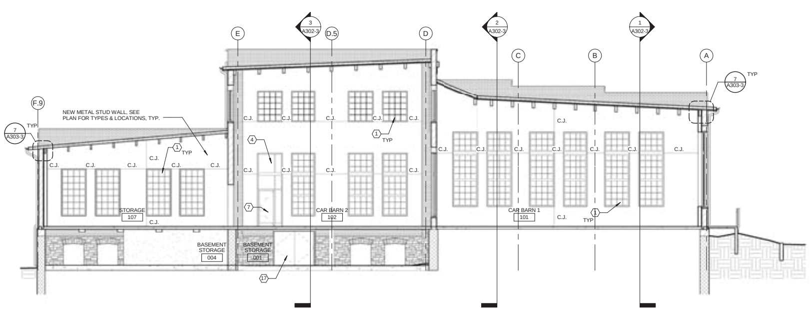
BUILDING SECTION 1
1/8" = 1'-0"



BUILDING SECTION 2
1/8" = 1'-0"



BUILDING SECTION 3
1/8" = 1'-0"



BUILDING SECTION 4
1/8" = 1'-0"

FIGURE 04

DRAWING NOTES

1. PREPARE EXISTING WINDOW OPENING AND INSTALL NEW WINDOW, PER MANUFACTURER'S RECOMMENDATIONS, SEE DETAILS & SEE WINDOW SCHEDULE FOR WINDOW TYPES.
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3 | 12/7/10 | ASI 003

GREAT NORTHERN BUILDING
GREAT NORTHERN SPOKANE LLC
850 E. Spokane Falls Blvd. Spokane, WA. 99202

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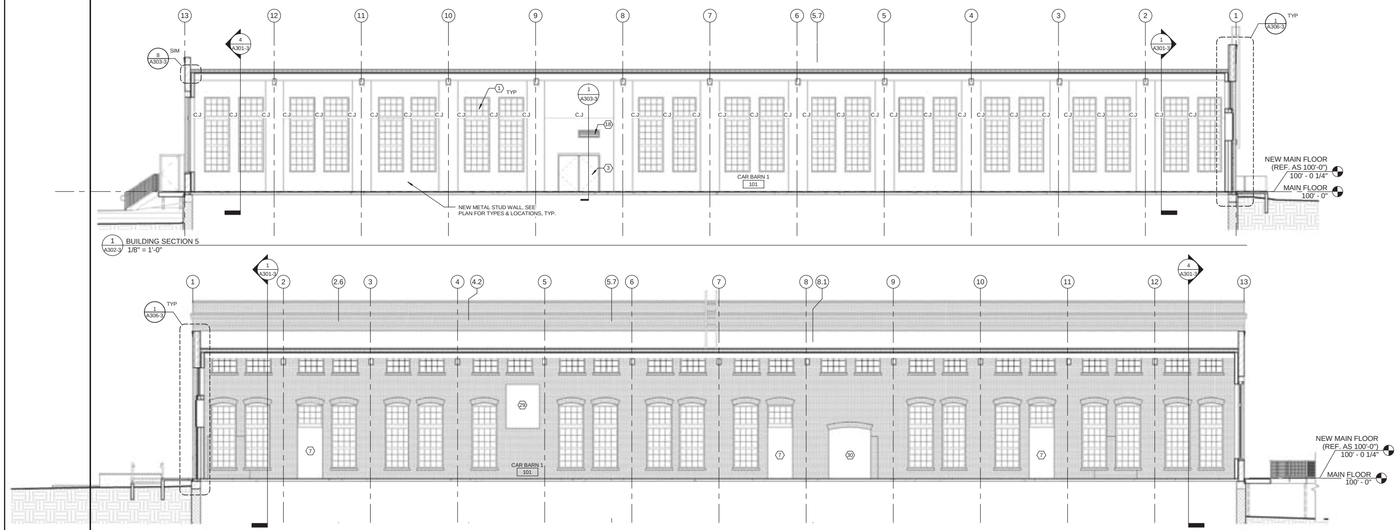
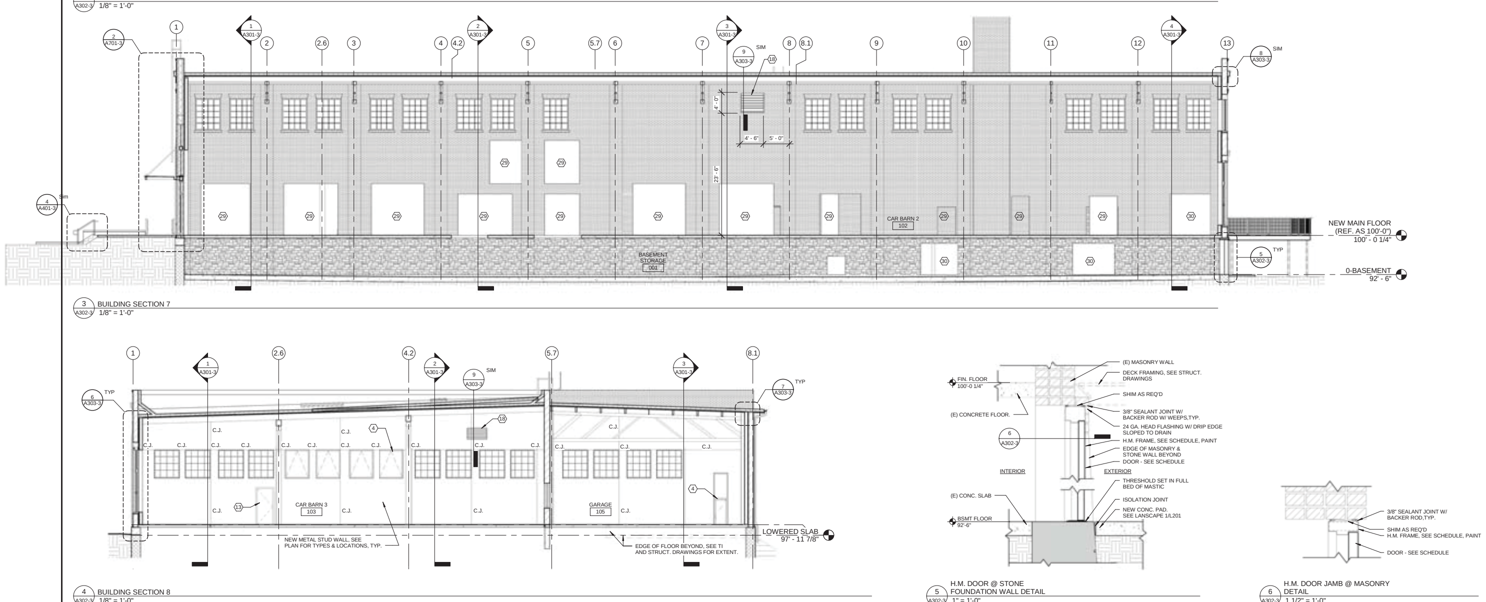
BUILDING SECTIONS

SHEET
A301-3



1 BUILDING SECTION 5
A302-3 1/8" = 1'-0"

2 BUILDING SECTION 6
A302-3 1/8" = 1'-0"



3 BUILDING SECTION 7
A302-3 1/8" = 1'-0"

4 BUILDING SECTION 8
A302-3 1/8" = 1'-0"

5 H.M. DOOR @ STONE FOUNDATION WALL DETAIL
A302-3 1" = 1'-0"

6 H.M. DOOR JAMB @ MASONRY DETAIL
A302-3 1 1/2" = 1'-0"

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CONOVER BOND

McKinstry

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8314 REGISTERED ARCHITECT KENT C. BRAY STATE OF WASHINGTON

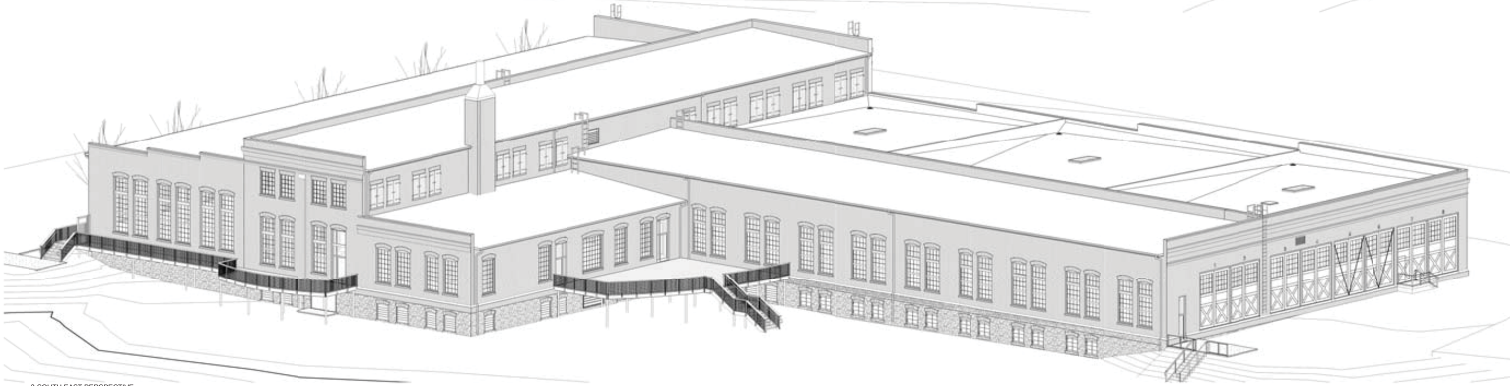
CTA

BUILDING SECTIONS

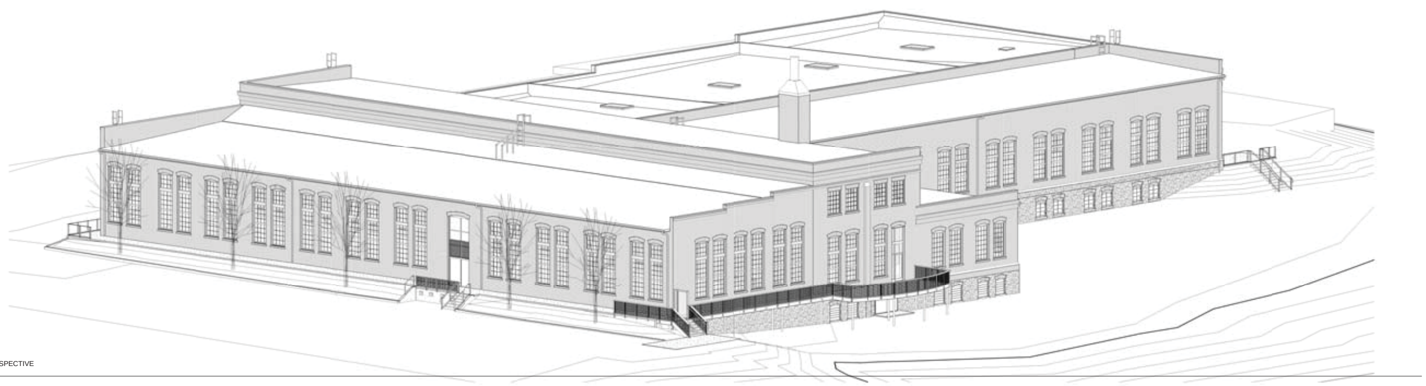
SHEET
A302-3

FIGURE 05

1 A202-3 3-NORTH EAST PERSPECTIVE VIEW 2



2 A202-3 3-SOUTH EAST PERSPECTIVE VIEW 2



3 A202-3 3-SOUTH WEST PERSPECTIVE VIEW 2

FIGURE 06

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GREAT NORTHERN SPOKANE LLC
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DATE: 11/12/10
CTA # GNS

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PERSPECTIVE VIEWS

SHEET A202-3

C:\RevitFiles\GNS\GNSarch_Ryan1.rvt

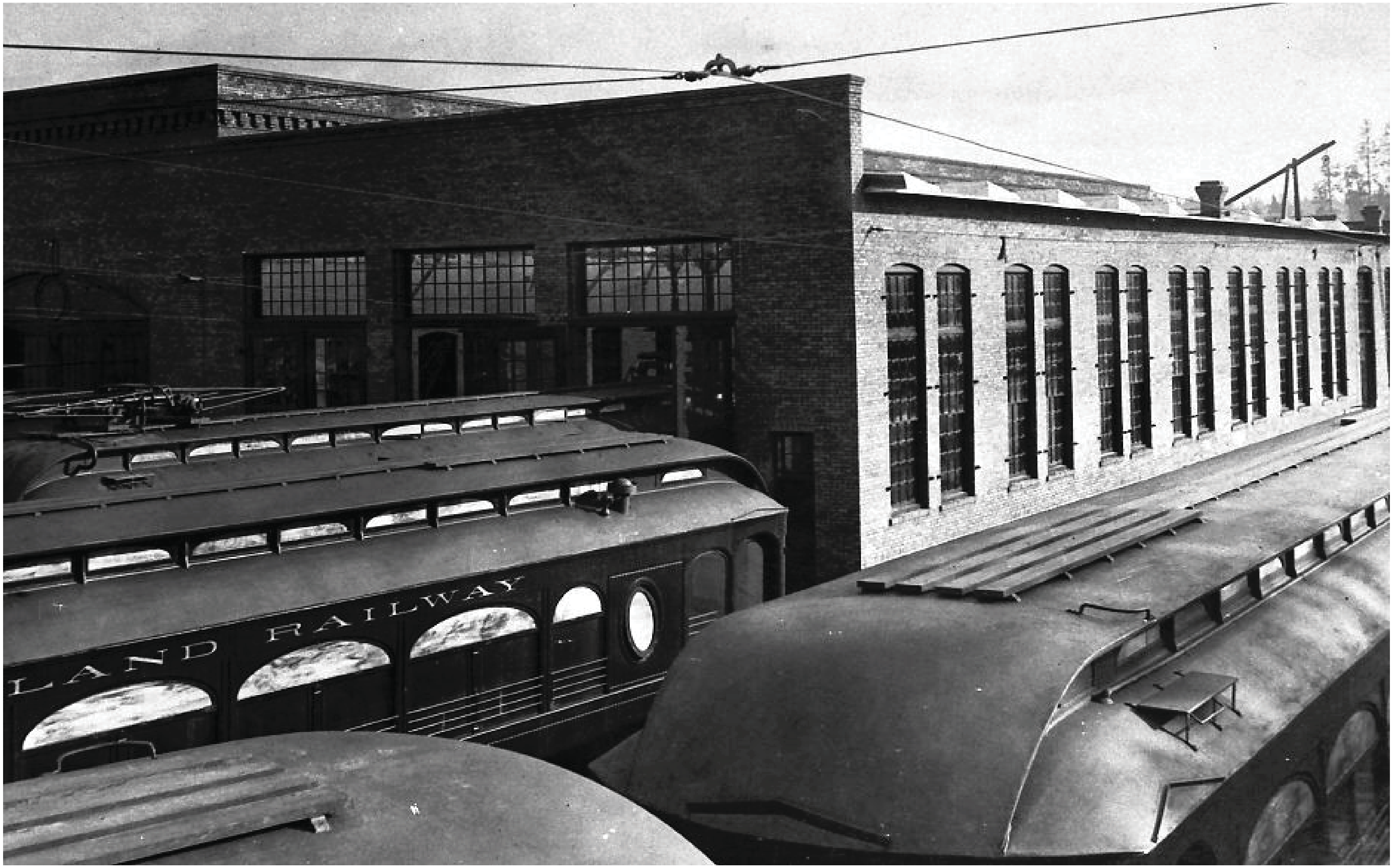

FIGURE 07

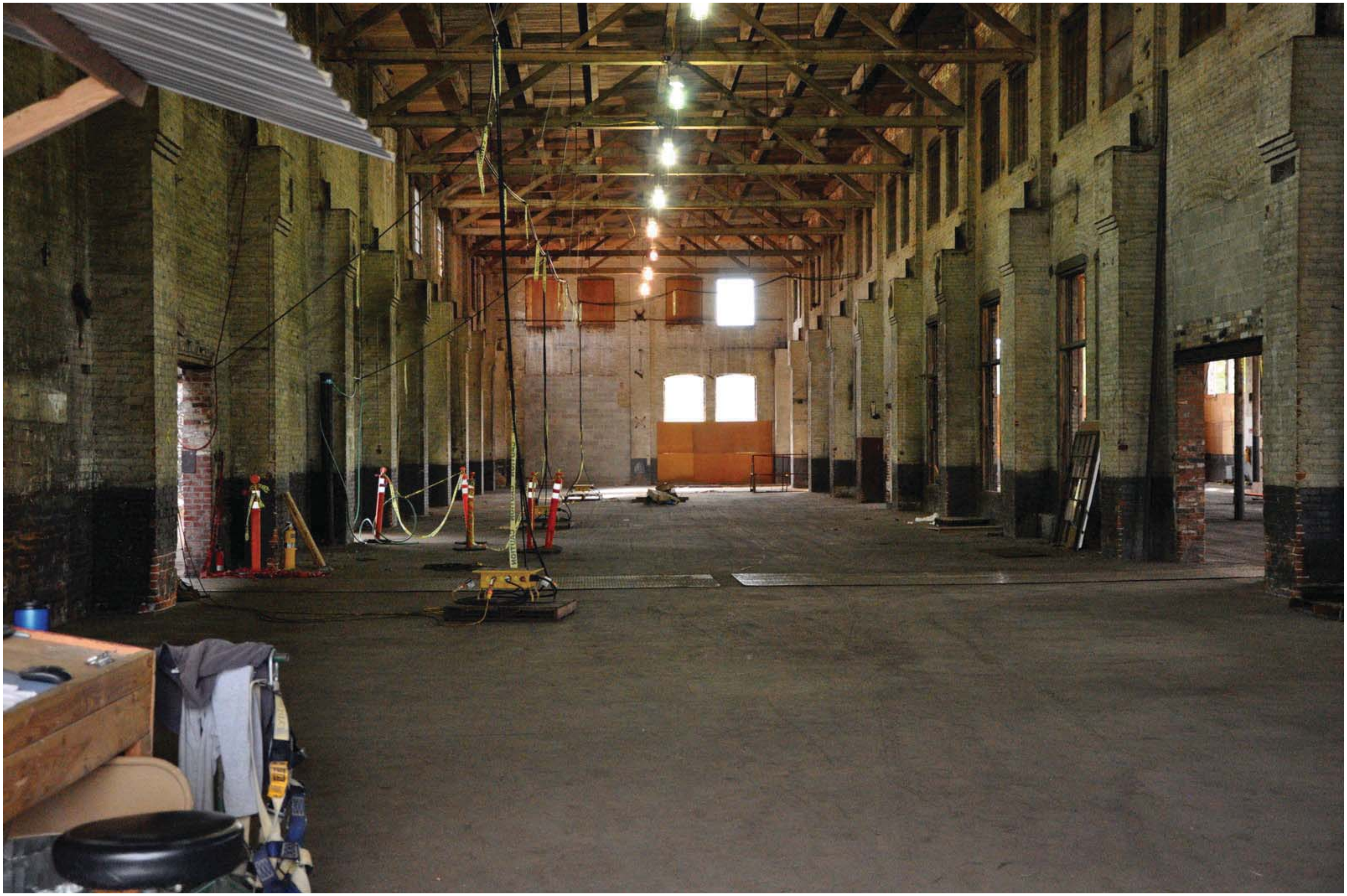

FIGURE 08

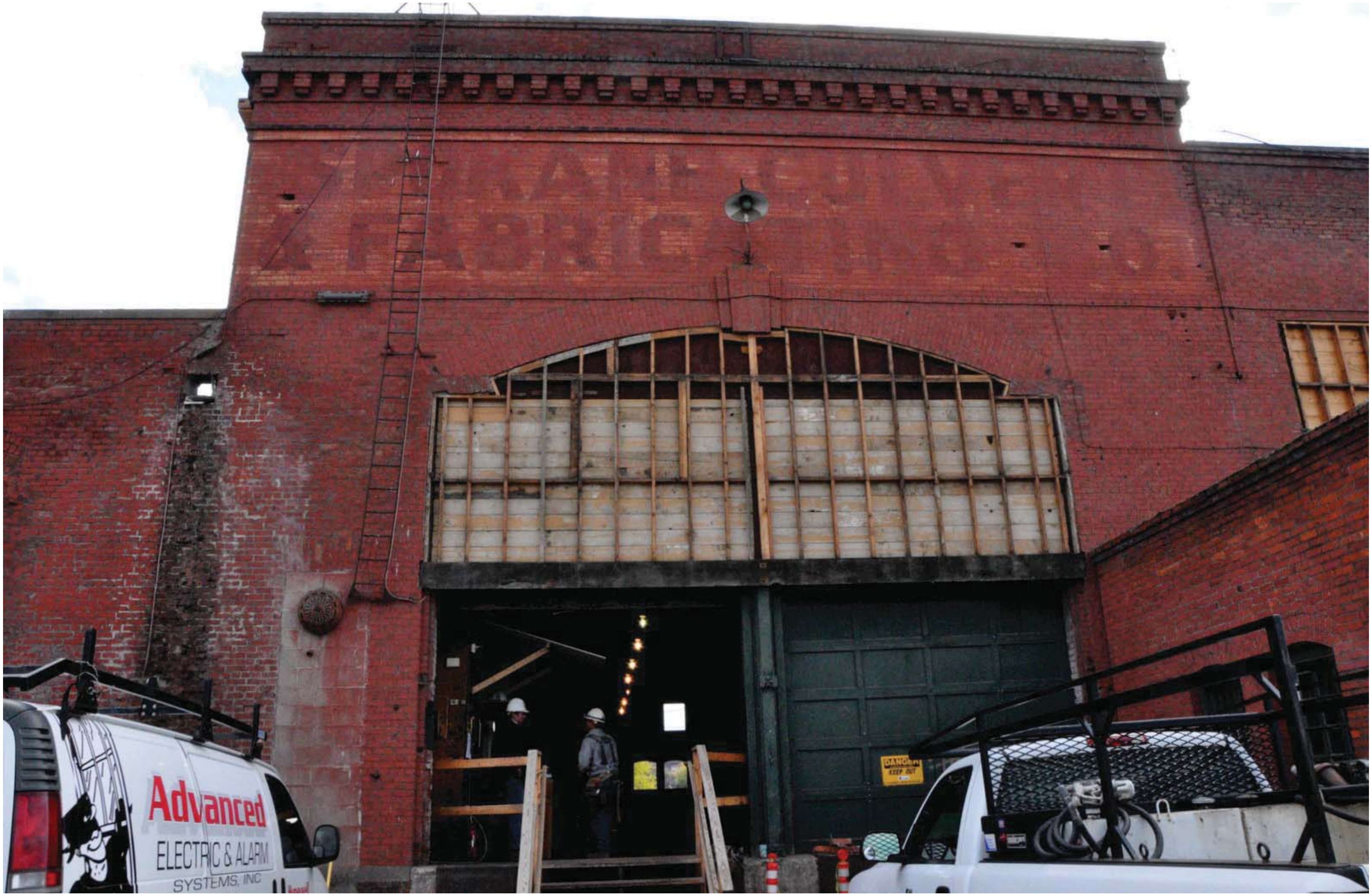

FIGURE 09

FIGURE 10

FIGURE 11

FIGURE 12

FIGURE 13

FIGURE 14

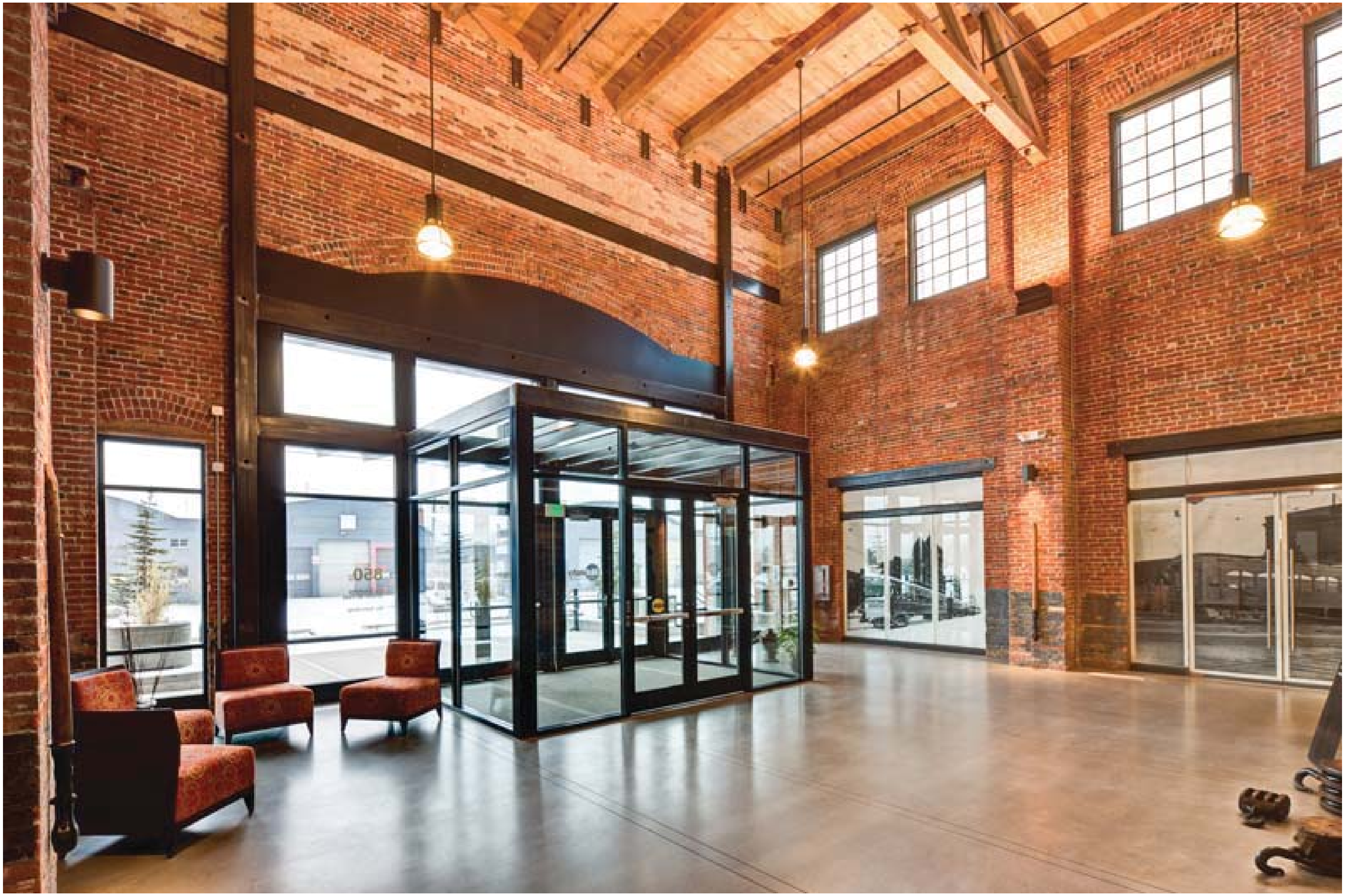

FIGURE 15

FIGURE 16

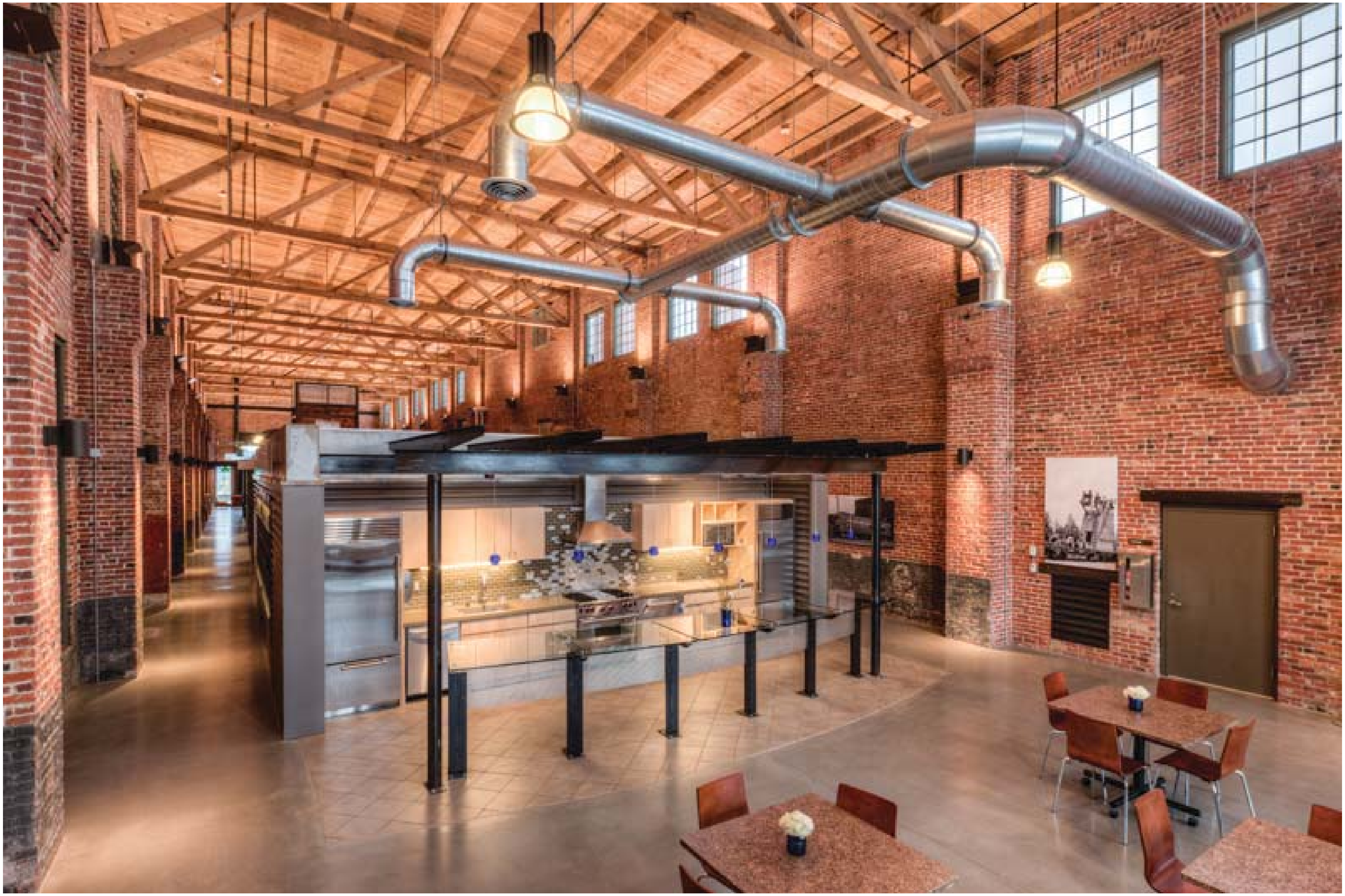

FIGURE 17

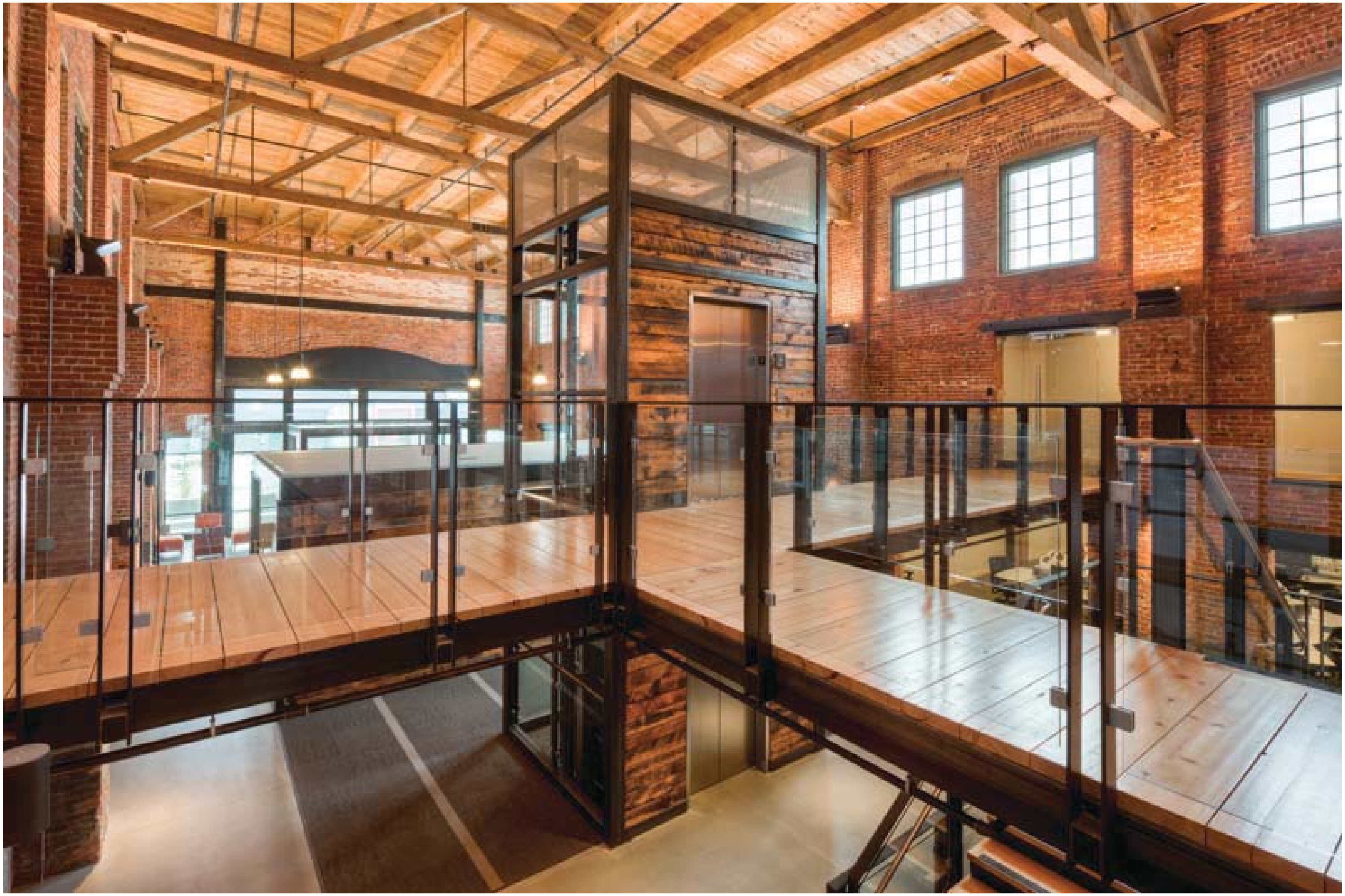

FIGURE 18

FIGURE 19

FIGURE 20

FIGURE 21

FIGURE 22

Appendix 3: RELi Rating System

RELi PROJECT TALLY

RESILIENCY ACTION LIST

For Communities, Buildings, Homes + Infrastructure

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RELi ACTION LIST

BAR SCENARIO LEVELS 1, 2 ,3 | Basic, Advanced, Revolutionary
BIKE RACK | Mark Credits for further consideration
STRUCTURE | Applies to Artifacts, Buildings + Homes
COMMUNITY | Applies to Orgs, Neighborhoods, Districts, Infrastructure, Urban + Campus projects
SCALE JUMPING | The thoughtful mixing of structure + community Reqs. + Credits is encouraged.

PANORAMIC APPROACH

B SCENARIO 1	A SCENARIO 2	R SECNARIO 3	BIKE RACK	STRUCTURES	COMMUNITY	NUMBER		POINTS	DIRECT VALUE	REFERENCE
0	0	0	0			PA	PANORAMIC APPROACH TO PLANNING, DESIGN, MAINTENENCE + OPERATIONS			
				S	C	Req 1	Study: Short-Term Hazard Preparedness + Mitigation	Required	Y	RELi
				S	C	Req 2	Integrative Process, Development + Community Stakeholder Involvement	Required	Y	IP | LEED | Envision
0	0	0	0	S	C	Poly-Req 3	Commissioning + Long-Term Monitoring / Maintenance	Required		LEED | Envision
				S	C	Req 3.1	Fundamental Commissioning		Y	LEED NC V4
				S	C	Req 3.2	Building Level Metering		Y	LEED NC V4
				S	C	Req 3.3	Enhanced Commissioning + Monitor Based (LEED Credit Path 2)		Y	LEED NC V4
				S	C	Req 3.4	Plan for Long-Term Monitoring and Maintenance [Envision 2.0 LD3.1 Conserving Level]		Y	Envision
0	0	0	0	S	C	Poly-Credit 1	Business + Community Case Analysis, Post-Development Evaluation and Reporting	TBD		Varies
				S	C	Credit 1.1 Select One	Business Case	TBD		RELi
				S	C		Comprehensive Business Case	TBD		RELi
				S	C	Credit 1.2	Health Impact Assessment (HIA)	TBD		RELi
						Credit 1.3	Local + Regional Economic and Socio-Economic Equity Study			NEF / JUST
				S	C	Credit 1.4	Post-Development Evaluation + Reporting	TBD		RELi
				S	C	Credit 2	Establish a Sustainability + Resiliency Management System	TBD		Envision
				S	C	Credit 3	Address Conflicting Regulations + Policies	TBD	Y	Envision
							Credits 4-7 below expand the Integrative Process required by requisite 2 above.			
0	0	0	0	S	C	Poly-Credit 4	Study + Design for By-Product + Underutilization Synergies	TBD	Y	Adapted - Envision
				S	C	Credit 4.1	Part 1 - Study: Explore Potential By-Product + Utilization Synergies relevant to the projects	TBD		Adapted: Envision
				S	C	Credit 4.2	Part 2 - Design: Develop and execute strategies from the opportunities studied in Part 1	TBD		Adapted: Envision
0	0	0	0	S	C	Poly-Credit 5	Study + Design for Improved Project Element + Infrastructure Integration	TBD	Y	Adapted - Envision
				S	C	Credit 5.1	Part 1 - Study: Explore Improved Infrastructure + Element Integration relevant to the project	TBD		Adapted: Envision
				S	C	Credit 5.2	Part 2 - Design: Develop and execute strategies from the opportunities studied in Part 1	TBD		Adapted: Envision
0	0	0	0	S	C	Poly-Credit 6	Study + Design for Long-Term Adaptability, Diversity + Redundancy	TBD	Y	RELi
				S	C	Credit 6.1	Part 1 - Study: Explore opportunities for long-term adaptability relevant to the project	TBD		RELi
				S	C	Credit 6.2	Part 2 - Design: Develop and execute strategies from the opportunities studied	TBD		RELi
0	0	0	0	S	C	Poly-Credit 7	Study + Living Design for Advanced Resiliency using a diversity of ecology based perspectives	TBD	Y	RELi
				S	C	Credit 7.1	Part 1 - Study: Explore opportunities for Advanced Resiliency	TBD		RELi
				S	C	Credit 7.2	Part 2 - Design Execution: Develop and execute strategies from the opportunities studied	TBD		RELi
				S	C	Credit 8	Third Party Leadership + Next Generation Certifications and Programs	TBD	Y	RELi

RELI Resilience Rating system information is available online at
http://c3livingdesign.org/?page_id=5110
.
The RELi Credit Catalog is available as an online flipbook at
https://dl.dropboxusercontent.com/u/99195203/RELi_Resiliency_Reference_Briefv71215/RELi_Resiliency_Reference_Briefv2.html

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RISK ADAPTATION + MITIGATION FOR ACUTE EVENTS

0	0	0	0			HP	HAZARD PREPAREDNESS			
				S	C	Req 1	Fundamental Emergency Planning + Preparedness for Common Hazardous Events	Required	Y	RELi
				S	C	Req 2	Fundamental Access To: First Aid, Emergency Supplies, Water, Food, Communications	Required	Y	RELi
0	0	0	0	S	C	Poly-Credit 1	Enhanced Emergency Planning for Common Hazards + Extreme Events	TBD		RELi
				S	C	Credit 1.1	Enhanced Emergency Planning for Common Hazards + Extreme Events.	TBD	Y	RELi
					C	Credit 1.1	Project organization actively participates in or starts a United We Serve Team	TBD	Y	RELi
				S	C	Credit 2	Enhanced Access: Emergency Care + Supplies, Water, Food, Communications	TBD	Y	RELi
0	0	0	0	S	C	Poly-Credit 3	Additional Emergency Provisions For the Community + for Longer Timeframes	TBD		
				S	C	Credit 3.1	4 Days of additional Provisions provided for the Community	TBD		RELi
				S	C	Credit 3.2	4 Days of additional Provisions and Shelter provided for the Community	TBD		RELi
				S	C	Credit 3.3	10 Days of additional Provisions provided for the Community	TBD		RELi
				S	C	Credit 3.4	10 Day of additional Provisions and Shelter provided for the Community	TBD		RELi
				S	C	Credit 3.5	10 Day of additional Provisions provided for the Facility(s) Occupants	TBD	Y	RELi
				S	C	Credit 4	Community Education: Authentic Dialogues on ever-increasing Weather, Safety + Resiliency Risks	TBD		RELi
0	0	0	0			HA	HAZARD ADAPTATION + MITIGATION			
				S	C	Req 1	Sites of Avoidance + Repair: 500 Year Flood Plain, Storm Surge + Sea Rise	Required	Y	RELi
				S	C	Req 2	Fundamental Emergency Operations: Back-up Power + Operations	Required	Y	RELi
				S	C	Req 3	Fundamental Emergency Operations: Thermal Safety During Emergencies	Required	Y	RELi
				S	C	Req 4	Safer Design for Extreme Weather, Wildfire + Seismic Events	Required	Y	Fortified
0	0	0	0	S	C	Poly-Credit 2	Adaptive Design for Extreme Rain, Sea Rise, Storm Surge + Extreme Weather, Events + Hazards	TBD		RELi
				S	C	Credit 2.1	Adaptive Design for Resilient Management of Extreme Rain Events	TBD	Y	RELi
				S	C	Credit 2.2	Adaptive Design for Sea Rise, Storm Surge	TBD	Y	RELi
				S	C	Credit 2.3	Adaptive Design for Extreme Weather, Wildfire, Fire + Seismic Events	TBD		Fortified
				S	C	Credit 2.4	NYC Urban Green Proposals: Conform with the NYC Building Resiliency Task Force Proposals	TBD		RELI + NYC Urban Green
				S	C	Credit 2.5	Avoid Proximity to Hazardous Sites	TBD		RELi
				S	C	Credit 2.6	Conventional + Naturalized Rainwater and Flood Management	TBD		RELi
				S	C	Credit 2.7	Safeguard Toxic + Hazardous Materials in Flood, Surge and Sea Rise Areas	TBD		RELi
0	0	0	0	S	C	Poly-Credit 3	Advanced Emergency Operations: Back-up Power, Operations, Thermal Safety + Operating Water	TBD		RELi
				S	C	Credit 3.1	Advanced Emergency Operations: Back-up Power + Operations: Critical Services, Lighting	TBD	Y	RELi
				S	C	Credit 3.2	Advanced Emergency Operations: Thermal Safety During Emergencies	TBD	Y	RELi
				S	C	Credit 3.3	Advanced Emergency Operations: On-Site Water Storage for Operations	TBD	Y	RELi
				S	C	Credit 3.4	Thermal Safety: Moderate to Large Cooling Center	TBD		RELi
				S	C	Credit 3.5	Thermal Safety: Advanced Cooling Center	TBD		RELi
0	0	0	0	S	C	Poly-Credit 4	Passive Thermal Safety, Thermal Comfort + Lighting Design Strategies	TBD		2030 Palette
				S	C	Credit 4.1	Landscape based Passive Cooling	TBD	Y	2030 Palette
				S	C	Credit 4.2	Passive Lighting	TBD	Y	2030 Palette
				S	C	Credit 4.3	Passive Heating	TBD	Y	2030 Palette
				S	C	Credit 4.4	Passive Cooling	TBD	Y	2030 Palette
0	0	0	0	S	C	Poly-Credit 5	Transit + Transportation System Protection + Continuous Operations	TBD		RELi
0	0	0	0	S	C	Poly-Credit 6	Provide Environmental Protection + Remediation for Parks + Preserves	TBD		RELi
				S	C	Credit 6.1 Select One	Option 1: Develop action plans + stow needed supplies on-site for flood protection	TBD		RELi
				S	C		Option 2: Protect, restore + develop flood protection (including natural systems)	TBD		RELi
				S	C	Credit 6.2	Provide Buffer Zones protecting from development + supporting bio-diversity and biophilia	TBD		RELi
				S	C	Credit 6.3	Provide wildlife corridors between parks + preserves to support bio-diversity and biophilia	TBD		RELi

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COMPREHENSIVE ADAPTATION + MITIGATION FOR A LIVING PRESENT + FUTURE

0	0	0	0			CV	COMMUNITY COHESION, SOCIAL + ECONOMIC VITALITY			
0	0	0	0	S	C	Poly-Req 1	Improve Community Quality of Life	Required	Y	Envision
				S	C	Select One	Option 1: Broad community alignment (Envision QL1.1 Superior Level)	Required	Y	Envision
							Option 2: Holistic assessment and collaboration (Envision QL1.1 Conserving Level)	TBD		Envision
							Option 3: Community Renaissance (Envision QL1.1 Restorative Level)	TBD		Envision
0	0	0	0	S	C	Poly-Credit 1	Incorporate important community views and aspects of local landscape	TBD		Envision
						Credit 1.1	Understanding and balance - (Envision QL3.2 Improved Level / required for this credit)	TBD		Envision
						Credit 1.2	Alignment with community values- (Envision QL3.2 Enhanced Level / required for this credit)	TBD		Envision
				S	C	Credit 1.3 Select One	Option 1: Community preservation and enhancement - (Envision QL3.2 Superior Level)	TBD		Envision
							Option 2: Community connections and collaboration - (Envision QL3.2 Conserving Level)	TBD		Envision
							Option 3: Restoration of community and character - (Envision QL3.2 Restorative Level)	TBD		Envision
0	0	0	0	S	C	Poly-Credit 2	Community Connectivity: Walkability, Public Transit, Non-motorized Transit	TBD		LEED V4
				S		Credit 2.1	Surrounding Density + Diverse Uses (Option 1. Surrounding Density)	TBD		LEED NC V4
				S		Credit 2.2	Access to Quality Transit	TBD		LEED NC V4
				S		Credit 2.3	Bicycle Facilities	TBD		LEED NC V4
				S		Credit 2.4	Reduced Parking Footprint	TBD		LEED NC V4
					C	Credit 2.5	Preferred Location	TBD		LEED NC V4
					C	Credit 2.6	Access to Quality Transit	TBD		LEED NC V4
					C	Credit 2.7	Bicycle Facilities	TBD		LEED NC V4
					C	Credit 2.8	Walkable Streets	TBD		LEED ND V4
					C	Credit 2.9	Compact Development	TBD		LEED ND V4
					C	Credit 2.10	Connected and Open Community: Surrounding Connectivity (Case 1.)	TBD		LEED ND V4
					C	Credit 2.11	Connected and Open Community: Internal Connectivity (Case 2.)	TBD		LEED ND V4
0	0	0	0	S	C	Poly-Credit 3	Community Connectivity: Mixed-Use Commercial, Housing + Public / Community Space	TBD		LEED | RELi
				S	C	Credit 3.1	Surrounding Density + Diverse Uses (LEED NC, Option 2. Diverse Uses)	TBD	Y	LEED BD+C V4
				S	C	Credit 3.2	Surrounding Density + Diverse Uses (RELi Resilient Use Categories)	TBD	Y	RELi
				S		Credit 3.3	Provide Community Access to Useful Space	TBD		RELi
				S		Credit 3.4	Open Space	TBD	Y	LEED BD+C V4
				S	C	Credit 3.5	Joint Use of Facilities	TBD	Y	LEED Schools V4
				S	C	Credit 3.6	Housing and Jobs Proximity	TBD	Y	LEED ND V4
				S	C	Credit 3.7	Mixed-Use Neighborhoods	TBD	Y	LEED ND V4
					C	Credit 3.8 Select One	Option 1: Access to Civic and Public Space	TBD	Y	LEED ND V4
							Option 2: The 2030 Palette - Parks Swatch	TBD	Y	2030 Palette
				S	C	Credit 3.9	Access to Recreation Facilities	TBD	Y	LEED ND v4
				S	C	Credit 3.10	Access to Public Schools + Public Libraries	TBD	Y	RELi
0	0	0	0	S	C	Poly-Credit 4	Expand Citizen Participation: Public Amenities, Councils, Organizations, Communication	TBD		RELi
				S	C	Credit 4.1	Public Amenities: Manage + Operate a Community Space + Resource	TBD		RELi
				S	C	Credit 4.2	Actively Participate in Local Disaster Recovery Programs	TBD		RELi
				S	C	Credit 4.3	Actively Participate in a Local, Regional or National Groups + Organizations	TBD		RELi
				S	C	Credit 4.4	Organize and Develop a Community Communication Tool	TBD		RELi
0	0	0	0	S	C	Poly-Credit 5	Resilient Organizations: Cooperative + B-Corporation(s), Non-Profits + Social Equity Measures	TBD		RELi
				S	C	Credit 5.1	Develop a Resilient Organization: Producer / Consumer / Worker Cooperative, B-Corp., Non-Profit	TBD		RELi
				S	C	Credit 5.2	Human PHD: Social Equity Within the Community	TBD		LEED V4 Pilot Credit
				S	C	Credit 5.3	Human PHD: Social Equity Within the Supply Chain	TBD		LEED V4 Pilot Credit
				S	C	Credit 5.4	Human PHD: Social Equity Within the Project Team	TBD		LEED V4 Pilot Credit

0	0	0	0	S	C	Poly-Credit 6	Develop or Expand Local Skills, Capabilities + Long-Term Employment + Mix	TBD		Envision
				S	C	Select One	Option 1: Hire Locally - (Envision QL1.3 Enhance Level)	TBD		Envision
							Option 2: Specific Skills Outreach - (Envision QL1.3 Superior Level)	TBD		Envision
							Option 3: Local Capacity Development - (Envision QL1.3 Conserving Level)	TBD		Envision
							Option 4: Long Term Competitiveness - (Envision QL1.3 Restorative Level)	TBD		Envision
0	0	0	0	S	C	Poly-Credit 7	Use Regionally Sourced + Manufactured Materials and Products	TBD		LEED | Envision
				S	C	Credit 7.1	Regional Materials LEED MRc5	TBD		Envision
				S	C	Credit 7.2 Select One	Option 1: Regional Materials - 60% Soils, Aggregates + Materials (Envision RA1.1 Enhanced Level)	TBD		Envision
							Option 2: Regional Materials - 95% Soils, Aggregates + Materials (Envision RA1.1 Conserving Level)	TBD		Envision
0	0	0	0	S	C	Poly-Credit 8	Stimulate Sustainable Growth and Development	TBD		Envision
				S	C	Select One	Option 1: Improve Local Productivity - (Envision QL1.2 Superior Level)	TBD		Envision
							Option 2: Business and People Attractiveness - (Envision QL1.2 Conserving Level)	TBD		Envision
							Option 3: Developmental Rebirth - (Envision QL1.2 Restorative Level)	TBD		Envision

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0	0	0	0			PH	PRODUCTIVITY, HEALTH + DIVERSITY			
0	0	0	0	S	C	Poly-Req 1	Minimum IAQ + Views to the Exterior	Required		LEED | RELi
				S	C	Req 1.1	Minimum Indoor Air Quality Performance	Required		LEED NC V4
				S	C	Req 1.2	Environmental Tobacco Smoke Control	Required		LEED NC V4
				S	C	Req 1.3	Low-Emitting Materials	Required		LEED NC V4
				S	C	Req 1.4	Views to Exterior for 25% of Occupied Space	Required		Adapted LEED NC 2009
0	0	0	0	S	C	Poly-Req 2	Minimum Protection for Prime Habitat + Floodplain Functions	TBD		LEED | Envision
				S	C	Req 2.1	Construction Activity Pollution Prevention	Required		LEED BD+C V4
				S	C	Req 2.2	Preserve Prime Habitat (Adapted: Envision NW1.1 Superior Performance Level)	Required		Adapted Envision
				S	C	Req 2.3	Preserve Prime Farmland (Envision NW1.3 Superior Performance Level - 95% Protection)	Required		Envision
				S	C	Req 2.4	Preserve Floodplain Functions (Envision NW1.3 Improved Performance - Avoid or Mitigate Impacts)	Required		Envision
0	0	0	0	S	C	Poly-Credit 1	Human PHD: Expanded IAQ, Daylight + Views, Fresh Air	TBD		LEED NC V4
				S		Credit 1.1	Enhanced Indoor Air Quality Strategies	TBD		LEED NC V4
				S		Credit 1.2	Interior Lighting	TBD		LEED NC V4
				S		Credit 1.3	Daylight	TBD		LEED NC V4
				S		Credit 1.4	Quality Views	TBD		LEED NC V4
				S		Credit 1.5	Acoustic Performance	TBD		LEED NC V4
0	0	0	0	S	C	Poly-Credit 2	Human PHD: Active Design for Buildings, Communities and Urban Environments	TBD		Active Design
				S		Credit 2.1	Active Design for Buildings (Design of Stairs, Walk-routes, Exercise + Outdoor Access)	TBD		Active Design
					C	Credit 2.2	Active Design for Community Groups (Transit, Recreation, Green Space, Healthy Food)	TBD		Active Design
					C	Credit 2.3	Active Design for Urban Environments (Landuse Mix, Transit / Bikes, Open Space, Food, Streetscape)	TBD		Active Design
				S	C	Credit 3	Human PHD: Provide for Social Equity: Interdisciplinary / Intercultural Opportunities	TBD		RELi | Stars
0	0	0	0	S	C	Poly-Credit 4	Human + Eco PHD: Reduce Pesticides, Prevent Surface + Groundwater Contamination	TBD		Envision
				S	C	Credit 4.1	Reduce Pesticide + Fertilizer Impacts (Envision NW2.2 Conserving Level - No Pesticides, Herbicides)	TBD	Y	Envision
				S	C	Credit 4.2 Select One	Option 1: Prevent Surface + Groundwater Contamination (Envision NW2.3 Conserving Level)	TBD	Y	Envision
							Option 2: Prevent Surface + Groundwater Contamination (Envision NW2.3 Restorative Level)	TBD	Y	Envision
0	0	0	0	S	C	Poly-Credit 5	Ecological PHD: Protect Wetlands + Avoid Slopes and Adverse Geology	TBD		Envision
				S	C	Credit 5.1	Protect Wetlands and Surface Water (Envision NW1.2)	TBD	Y	Envision
				S	C	Credit 5.2	Avoid Adverse Geology (Envision NW1.4)	TBD	Y	Envision
				S	C	Credit 5.3	Avoid Unsuitable Development on Steep Slopes (Envision NW1.6)	TBD	Y	Envision
0	0	0	0	S	C	Poly-Credit 6	Ecological PHD: Biodiversity, Habitat + Soil	TBD		LEED | Envision
							Option 1. LEED NC V4 Site Development - Protect or Restore Habitat: Option 1 - Restoration	TBD		LEED NC V4
				S		Credit 6.1 Select One	Option 1. LEED NC V4 Site Development - Protect or Restore Habitat: Option 2 - Financial Support	TBD		LEED NC V4
							Option 3. Preserve Species Biodiversity: Restore + Create Habitat (Envision NW3.1 Restorative Level)	TBD		Envision
							Option 1. LEED ND V4 Site Design for Habitat / Wetland / Water Body Conservation: Case2. Option 1.	TBD	Y	LEED ND V4
					C	Credit 6.1 Select One	Option 2. LEED NC V4 Site Development - Protect or Restore Habitat: Option 2 - Financial Support	TBD		Adapt LEED NC V4
							Option 3. Preserve Species Biodiversity: Restore + Create Habitat (Envision NW3.1 Restorative Level)	TBD		Envision

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0	0	0	0			EW	ENERGY, WATER + FOOD			
0	0	0	0	S	C	Poly-Req 1	Minimum Water Efficiency + Resilient Water and Landscapes	Required		LEED
				S	C	Req 1.1	Indoor Water Use Reduction (20% < LEED Baseline)	Required	Y	LEED BD+C V4
				S	C	Req 1.2	Outdoor Water use Reduction (30% < Calculated Baseline)	Required	Y	LEED BD+C V4
				S	C	Req 1.3	Rainwater Management - Option 1. 95th Percentile of Rainfall Events	Required	Y	LEED BD+C V4
0	0	0	0	S	C	Poly-Req 2	Minimum Energy Efficiency + Atmospheric Impacts	Required		LEED
				S	C	Req 2.1	Minimum Energy Performance (5% < ASHRAE 90.1 2010)	Required	Y	LEED BD+C V4
				S	C	Req 2.2	Fundamental Refrigerant Management	Required	Y	LEED BD+C V4
0	0	0	0	S	C	Poly-Credit 1	Plan For Rainwater Harvesting , Resilient Landscapes + Food Production	TBD		RELi
				S	C	Credit 1.1	Rainwater management + Water Recycling / Reuse: Space and Planning	TBD	Y	RELi
				S	C	Credit 1.2	On-Site Food Production: Space and Planning	TBD	Y	RELi / LEED ND V4
0	0	0	0	S	C	Poly-Credit 2	Plan the Site and Orientation For Sun + Wind Harvesting, Natural Cooling	TBD		Multiple
				S		Credit 2.1	Building Orientation (Refer to LEED V4 ND Credit: "Solar Orientation" Option 2.)	TBD	Y	LEED ND V4
					C	Credit 2.2 Select One	Option 1: Block Orientation (Refer to LEED V4 ND Credit: "Solar Orientation" Option 1.)	TBD	Y	LEED ND V4
							Option 2: Street Width + Orientation	TBD	Y	2030 Palette
				S	C	Credit 2.3	Solar Access	TBD	Y	2030 Palette
				S	C	Credit 2.4	Vegetative Cooling	TBD	Y	2030 Palette
				S	C	Credit 2.5	Wind Energy: Plan space to optimize wind access.	TBD	Y	RELi
0	0	0	0	S	C	Poly-Credit 3	Water Use Reduction, Near Zero / High Efficiency Water Flows and Resilient Landscapes	TBD		LEED | RELi
				S	C	Credit 3.1	Indoor Water Use Reduction (NC 25% to 50%)	TBD	Y	LEEDBD+C V4
				S	C	Credit 3.2	Outdoor Water Use Reduction (NC 50% or 100%)	TBD	Y	LEED BD+C V4
				S	C	Credit 3.3	Basic Rainwater Harvesting, Recycled Water, On-Site and / or Neighborhood Water Storage	TBD	Y	RELi
				S	C	Credit 3.4	Alternative Sewage Management	TBD	Y	RELi
				S	C	Credit 3.5	Near Zero / High Efficiency, Net Zero and Net Positive Water	TBD	Y	RELi
				S	C	Credit 3.6	Rainwater Management (For Extreme Rain Events: See HA Credit 2.1)	TBD	Y	RELi
0	0	0	0	S	C	Poly-Credit 4	Energy Optimization, Near Zero / Carbon Neutral, Net Zero, Net Positive Energy Flows	TBD		Multiple
				S	C	Credit 4.1	Energy Optimization (NC 6% to 50%)	TBD	Y	LEED BD+C V4
				S	C	Credit 4.2	On-site or Neighborhood Renewable Energy Production	TBD	Y	Adapted LEED V4
				S	C	Credit 4.3	Compliance with AIA 2030 Commitment or Minnesota SB 2030	TBD	Y	2030 Challenge + SB2030
				S	C	Credit 4.4	Renewable Energy - Distributed Generation + Production: Wind, PV + Polished Biogas	TBD	Y	Adapted LEED Pilot Cr
				S	C	Credit 4.5	Near Zero / Carbon Neutral, Net Zero + Net Positive Energy Flows	TBD	Y	RELi / IFLI / LBC
				S	C	Credit 4.6	District Heating and Cooling	TBD	Y	LEED ND V4
				S	C	Credit 4.7	Green Power + Carbon Offsets (50% / 100%) LEED BD+C V4:	TBD		LEED BD+C V4
0	0	0	0	S	C	Poly-Credit 5	Edible Landscaping, Urban Agriculture + Resilient Food Production	TBD		RELi
				S	C	Credit 5.1	Amend or Implement Regulation Allowing On-Site Food Production	TBD		RELi
				S	C	Credit 5.2	On-site Vegetable, Nut + Berry Production	TBD	Y	RELi
				S	C	Credit 5.3	On-site Aquaponics + Poultry Production	TBD	Y	RELi
				S	C	Credit 5.4	Transitionally Labeled or Organic Certification + Distributed	TBD	Y	RELi
0	0	0	0	S	C	Poly-Credit 6	Reduced Site Environmental Impacts: Lighting, Heat-Island, Airborne Toxins	TBD		LEED | Envision
				S	C	Credit 6.1	Light Pollution Reduction	TBD		LEED BC+C / ND V4
				S	C	Credit 6.2	Tree-Lined and Shaded Streetscapes	TBD		LEED ND V4
				S	C	Credit 6.3	Heat-Island Reduction - Roof and Non-Roof	TBD	Y	LEED BC+C / ND V4
				S	C	Credit 6.4	Reduce Air Pollutant Emissions - Negligable Air Quality Impact (Envision CR1.2 Conserving Level)	TBD		Envision V2

RELi PROJECT TALLY

RESILIENCY ACTION LIST

For Communities, Buildings, Homes + Infrastructure

Pilot V1.1

An Action List + Strategic Resource Incorporated into the Green Property Underwriting Standards
C3 Living Design . Capital Markets Partnership . AREA Research . University of Minnesota Arch8561

Released For Field Interpretation
MAY 2015 | ORIGIN AUG 2014

0	0	0	0			MA	MATERIALS + ARTIFACTS			
0	0	0	0	S	C	Poly-Req 1	Minimum Material Effectiveness + Life Cycle Planning	Required		Multiple
				S	C	Req-1	Storage + Collection of Recyclables	TBD		LEED V4
				S	C	Req-2	Construction + Demolition Waste Management Planning	TBD		LEED V4
				S	C	Req-3	Project Material Selection + Use Planning	TBD		RELi
				S	C	Credit 1	Safer, Non-Toxic Materials (SMaRT or equivalent Certified)	TBD	Y	RELi
				S	C	Credit 2	Material + Artifact Effectiveness: Full Life Cycle Design for durability, adaptability, flexibility	TBD	Y	Adapted - Autodesk
				S	C	Credit 3	Material + Artifact Effectiveness: Design for Disassembly, Reuse, Recycling + Composting	TBD	Y	Adapted - AutoDesk
0	0	0	0	S	C	Poly-Credit 4	Material Effectiveness: Use Recycled Content Materials, Salvaged Materials + Local Materials	TBD		LEED
				S	C	Credit 4.1	Recycled Content (10% or 20%)	TBD		LEED NC 2009
				S	C	Credit 4.2	Materials Reuse (5% or 10%)	TBD		LEED NC 2009
				S	C	Credit 4.3	Regional Materials (10% or 20%)	TBD		LEED NC 2009
				S	C	Credit 4.4	Certified Rapidly Renewable + Sustainable Bio-Based Materials (2.5%)	TBD		ADAPTED: LEED
				S	C	Credit 5	Use Legally Logged Wood from Ecologically Managed Forests (FSC Certified)	TBD	Y	RELi | LEED
				S	C	Credit 6	Reduce Net Embodied Energy + Carbon, Water and Toxins	TBD	Y	ADAPTED LEED | SMART
0	0	0	0	S	C	Poly-Credit 7	Divert Waste from Landfills, Reduce Excavated Soils Taken from Site	TBD		LEED | Envision
				S	C	Credit 7.1	Construction and Demolition Waste Management 50% / 75%	TBD	Y	LEED BD+C V4
				S	C	Credit 7.1	Reduce Excavated Materials Taken Off Site 80%+ / 95%+ (Envision RA1.6)	TBD to TBD		Envision

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APPLIED CREATIVITY AND CONTEXTURAL FACTORS FOR SAFETY + RESILIENCY

L1	L2	L3	BR							
0	0	0	0			AC	Applied Creativity, Innovation + Exploration			
0	0	0	0			Poly-Credit 1	Applied Creativity in Resiliency + Integrative Design	TBD		
				S	C	Credit 1.1	Applied Creativity : Resilient Economics, Equity, Education AND / or Ecology Indicators	TBD		
				S	C	Credit 1.2	Applied Creativity: Green, Healthy, Living, Restorative, Regenerative of Sustainable Indicators	TBD		
				S	C	Credit 1.3	Applied Creativity : Leadership Metrics and Measures from sources beyond RELi	TBD		
				S	C	Credit 1.4	Applied Creativity : To Be Established	TBD		
				S	C	Credit 1.5	Applied Creativity : To Be Established	TBD		
				S	C	Credit 1.6	Applied Creativity : To Be Established	TBD		
				S	C	Credit 1.7	Applied Creativity : To Be Established	TBD		
				S	C	Credit 1.8	Applied Creativity : To Be Established	TBD		
				S	C	Credit 1.9	Applied Creativity : To Be Established	TBD		
				S	C	Credit 1.10	Applied Creativity : To Be Established	TBD		
0	0	0	0			Poly-Credit 2	Contextual Factors + Project Responsive Topics	TBD		
				S	C	Credit 2.1	Contextual Factors: Project specific Leadership + Next Generation Certification / Program Indicator	TBD		
				S	C	Credit 2.2	Contextual Factors: Improving Safety + Resiliency	TBD		
				S	C	Credit 2.3	Contextual Factors: Influential Regional, District or Site Contextual Factors	TBD		
				S	C	Credit 2.4	Contextual Factors: Leadership Metrics and Measures from sources beyond RELi	TBD		
				S	C	Credit 2.5	Contextual Factors: To Be Established	TBD		
				S	C	Credit 2.6	Contextual Factors: To Be Established	TBD		
				S	C	Credit 2.7	Contextual Factors: To Be Established	TBD		
				S	C	Credit 2.8	Contextual Factors: To Be Established	TBD		
				S	C	Credit 2.9	Contextual Factors: To Be Established	TBD		
				S	C	Credit 2.10	Contextual Factors: To Be Established	TBD		
0	0	0	0			Poly-Credit 3	Exemplary Performance	TBD		
				S	C	Credit 3.1	Exemplary Performance: Performance exceeding the Credits identified in the RELi Action List	TBD		
				S	C	Credit 3.2	Exemplary Performance: To Be Established	TBD		
				S	C	Credit 3.3	Exemplary Performance: To Be Established	TBD		
				S	C	Credit 3.4	Exemplary Performance: To Be Established	TBD		
				S	C	Credit 3.5	Exemplary Performance: To Be Established	TBD		
				S	C	Credit 3.6	Exemplary Performance: To Be Established	TBD		
				S	C	Credit 3.7	Exemplary Performance: To Be Established	TBD		
				S	C	Credit 3.8	Exemplary Performance: To Be Established	TBD		
				S	C	Credit 3.9	Exemplary Performance: To Be Established	TBD		
				S	C	Credit 3.10	Exemplary Performance: To Be Established	TBD		
L1	L2	L3	BR							
0	0	0	0				TALLY			

Appendix 4: Development of the Future-Proofing Rating System

Appendix 4: Development of the Future-Proofing Rating System

The scoring system used to determine the future-proof capacity of each case study building went through several iterations. These iterations focused both on the credits that were available and what Principles they supported and on the interpretation and presentation of the point scores. Starting with the RELi rating system, additional credits were developed to support specific Principles as discussed in Chapter 6. Multi-Criteria Decision Analysis was used for weighting the scores, and the allocation and presentation of the credits was revised to show both raw scores and normalized scores for each case study.

The first iteration of the scoring system was based upon Multi-Criteria Decision Analysis spreadsheets available on the internet. The Analytic Hierarchy spreadsheet developed by Simon Bernard of SCB Associates Ltd. (www.scbuk.com) was selected. Using this MCDA spreadsheet resulted in varying scores for similarly ranked Principles. In the initial calculations, Principles were allowed to be ranked from 1 to 12 to develop a clear hierarchy of the Principles from most important to least important. No Principles were allowed to have the same score. The result was that impacts of individual Principles varied from well over 30% to well under 1%. This meant that certain points were receiving an excessive amount of importance. Therefore, several variations of the scoring were tested and rejected.

In the second iteration of the scoring system, the rank of the Principles within the MCDA spreadsheets were limited to between 1 and 3, rather than 1 to 12. This iteration of the scoring system still allowed for some credits to be over-weighted and, again, resulted in different weighting percentages in the MCDA spreadsheet even though Principles were given the same rank. Thus, these rankings defeated the purpose of calling one principle equal to another.

In the third iteration of the system, automatically calculated ranking on the MCDA spreadsheets were manually overridden to keep the weightings constrained. This iteration required changing the rank of a principle on the MCDA spreadsheet to bring its weighting to within the acceptable limits of 5% to 15%. Again, the MCDA spreadsheet continued to give unequal weighting to Principles that were given the same rank, and so this iteration was rejected.

In the fourth iteration of the scoring system, negative points for credits that were examined and not achieved was tested but not incorporated into this system. This concept was rejected for two reasons: First, the system would unfairly penalize projects that cannot possibly achieve all points. Indeed, it is a regular occurrence that not all points are achieved on LEED projects and even the highest level of certification in LEED 2.1 requires 75% of the points to be achieved. In LEED 4, only 73% of the possible points have to be earned to achieve the highest level of certification. In addition, many of the RELI credits focus on different types of projects. For instance, Envision incorporated by RELi credits focus more on infrastructure projects – not buildings. It is therefore difficult, if not impossible, for a project to achieve all of the points available. Second, no other rating system uses negative points. The use of negative credits was viewed as unfairly negative and unnecessary for this system.

In the fifth iteration, the focus turned to controlling the weightings (as opposed to the rankings in the third iteration above) manually rather than allowing the MCDA spreadsheet to calculate weightings automatically. The MCDA calculated ranks were translated into manually entered weighting percentages with a lower limit of 5% and an upper limit of 15%. If all Principles were weighted equally, the average weighting would be 8.3%. This range is considered appropriate because it allows for a multiple of .60 to 1.80 compared to an average weighting the 8.3%. In contrast, the weightings resulting from the MCDA spreadsheet varied from 1% or less to more than 35%, or multipliers of .125 to 5.

One of the key aspects discovered when testing the spreadsheet calculations was that by manipulating the relative ranks of certain Principles, one could claim a high degree of success in future-proofing a building and only focus on certain Principles. This did not meet the intent of the future-proofing system because all aspects of all 12 Principles were considered important to achieve a truly future-proof building. Not only did the range of weighting percentages have to be constrained, but also that the process had to be simplified, that ranking the Principles had to be a later step to discourage preferential treatment of certain Principles, and that the credits earned had to be comparable at an absolute scale as well as normalized scales for types of building and regional impacts.

Testing the scoring calculations resulted in several refinements to the scoring process. The final iteration of the scoring system discarded the use of the MCDA ranking spreadsheets in favor of manually entered percentage weightings for each Principle. The ranking for each Principle was still available as a tool to help compare the relative weight of each Principle, but became a supporting tool rather than the primary way of showing the desired weighting. This final iteration used absolute scoring by points and percentages to provide a consistent system to compare the scores of different buildings. Then weighting of the Principles allowed for emphasis on certain Principles that are more important to an individual project. Last, the weighted scores were expressed in absolute numbers and percentages. The Future-Proofing score sheets for Clark Hall, Playhouse Theater, and Savery Hall provided in Chapter 7 reflect this latest iteration of the scoring system.

Future-Proofing Criteria

Future-Prooofing Criteria Categories

CV	COMMUNITY COHESION, SOCIAL + ECONOMIC VITALITY
EW	ENERGY, WATER + FOOD
F-P	FUTURE-PROOFING HISTORIC BUILDINGS
HA	HAZARD ADAPTATION + MITIGATION
HP	HAZARD PREPAREDNESS
MA	MATERIALS + ARTIFACTS
PA	PANORAMIC APPROACH
PH	PRODUCTIVITY, HEALTH + DIVERSITY

Contributes to these Future-Proofing Principles								Credit Number	Credit Name	Source
12	3	6					CV	Poly-Req 1.1	Option 1: Broad community alignment (Envision QL1.1 Superior Level)	Envision
12	3	6					CV	Poly-Req 1.2	Option 2: Holistic assessment and collaboration (Envision QL1.1 Conserving Level)	Envision
12	3	6					CV	Poly-Req 1.3	Option 3: Community Renaissance (Envision QL1.1 Restorative Level)	Envision
12	3	6					CV	Poly-Credit 1.1	Understanding and balance - (Envision QL3.2 Improved Level / required for this credit)	Envision
12	3	6					CV	Poly-Credit 1.2	Alignment with community values- (Envision QL3.2 Enhanced Level / required for this credit)	Envision
12	3	6					CV	Poly-Credit 1.3.1	Option 1: Community preservation and enhancement - (Envision QL3.2 Superior Level)	Envision
12	3	6					CV	Poly-Credit 1.3.2	Option 2: Community connections and collaboration - (Envision QL3.2 Conserving Level)	Envision
12	3	6					CV	Poly-Credit 1.3.3	Option 3: Restoration of community and character - (Envision QL3.2 Restorative Level)	Envision
9							CV	Poly-Credit 2.1	Surrounding Density + Diverse Uses (Option 1. Surrounding Density)	LEED NC V4
9							CV	Poly-Credit 2.2	Access to Quality Transit	LEED NC V4
9							CV	Poly-Credit 2.3	Bicycle Facilities	LEED NC V4
9							CV	Poly-Credit 2.4	Reduced Parking Footprint	LEED NC V4
8							CV	Poly-Credit 3.1	Surrounding Density + Diverse Uses (LEED NC, Option 2. Diverse Uses)	LEED BD+C V4
8							CV	Poly-Credit 3.2	Surrounding Density + Diverse Uses (RELi Resilient Use Categories)	RELi

2	6							CV	Poly-Credit 3.3	Provide Community Access to Useful Space	RELi
2	6							CV	Poly-Credit 3.5	Joint Use of Facilities	LEED Schools V4
9								CV	Poly-Credit 6.1	Option 1: Hire Locally - (Envision QL1.3 Enhance Level)	Envision
9								CV	Poly-Credit 6.2	Option 2: Specific Skills Outreach - (Envision QL1.3 Superior Level)	Envision
9								CV	Poly-Credit 6.3	Option 3: Local Capacity Development - (Envision QL1.3 Conserving Level)	Envision
9								CV	Poly-Credit 6.4	Option 4: Long Term Competitiveness - (Envision QL1.3 Restorative Level)	Envision
9								CV	Poly-Credit 7.1	Regional Materials LEED MRc5	Envision
9								CV	Poly-Credit 7.2	Option 1: Regional Materials - 60% Soils, Aggregates + Materials (Envision RA1.1 Enhanced Level)	Envision
9								CV	Poly-Credit 7.3	Option 2: Regional Materials - 95% Soils, Aggregates + Materials (Envision RA1.1 Conserving Level)	Envision
9								CV	Poly-Credit 8.1	Option 1: Improve Local Productivity - (Envision QL1.2 Superior Level)	Envision
9								CV	Poly-Credit 8.2	Option 2: Business and People Attractiveness - (Envision QL1.2 Conserving Level)	Envision
9								CV	Poly-Credit 8.3	Option 3: Developmental Rebirth - (Envision QL1.2 Restorative Level)	Envision
	6		9					EW	Poly-Req 1.1	Indoor Water Use Reduction (20% < LEED Baseline)	LEED BD+C V4
	6		9					EW	Poly-Req 1.2	Outdoor Water use Reduction (30% < Calculated Baseline)	LEED BD+C V4
	6		9					EW	Poly-Req 1.3	Rainwater Management - Option 1. 95th Percentile of Rainfall Events	LEED BD+C V4
	6		9					EW	Poly-Req 2.1	Minimum Energy Performance (5% < ASHRAE 90.1 2010)	LEED BD+C V4
	6		9					EW	Poly-Req 2.2	Fundamental Refrigerant Management	LEED BD+C V4
	6	8	9					EW	Poly-Credit 1.1	Rainwater management + Water Recycling / Reuse: Space and Planning	RELi
	6	8	9					EW	Poly-Credit 1.2	On-Site Food Production: Space and Planning	RELi / LEED ND V4
	6	8	9					EW	Poly-Credit 2.3	Solar Access	2030 Palette
	6	8	9					EW	Poly-Credit 2.4	Vegetative Cooling	2030 Palette
	6	8	9					EW	Poly-Credit 2.5	Wind Energy: Plan space to optimize wind access.	RELi
	6		9					EW	Poly-Credit 3.1	Indoor Water Use Reduction (NC 25% to 50%)	LEEDBD+C V4
	6		9					EW	Poly-Credit 3.2	Outdoor Water Use Reduction (NC 50% or 100%)	LEED BD+C V4
	6	8	9					EW	Poly-Credit 3.3	Basic Rainwater Harvesting, Recycled Water, On-Site and / or Neighborhood Water Storage	RELi
	6	8	9					EW	Poly-Credit 3.4	Alternative Sewage Management	RELi

	6		9					EW	Poly-Credit 3.5	Near Zero / High Efficiency, Net Zero and Net Positive Water	RELi
	6		9					EW	Poly-Credit 3.6	Rainwater Management (For Extreme Rain Events: See HA Credit 2.1)	RELi
	6		9					EW	Poly-Credit 4.1	Energy Optimization (NC 6% to 50%)	LEED BD+C V4
	6	8	9					EW	Poly-Credit 4.2	On-site or Neighborhood Renewable Energy Production	Adapted LEED V4
	6		9					EW	Poly-Credit 4.3	Compliance with AIA 2030 Commitment or Minnesota SB 2030	2030 Challenge + SB2030
	6	8	9					EW	Poly-Credit 4.4	Renewable Energy - Distributed Generation + Production: Wind, PV + Polished Biogas	Adapted LEED Pilot Cr
	6		9					EW	Poly-Credit 4.5	Near Zero / Carbon Neutral, Net Zero + Net Positive Energy Flows	RELi / IFLI / LBC
	6		9					EW	Poly-Credit 4.6	District Heating and Cooling	LEED ND V4
	6		9					EW	Poly-Credit 4.7	Green Power + Carbon Offsets (50% / 100%) LEED BD+C V4:	LEED BD+C V4
	6		9					EW	Poly-Credit 6.1	Light Pollution Reduction	LEED BC+C / ND V4
	6		9					EW	Poly-Credit 6.2	Tree-Lined and Shaded Streetscapes	LEED ND V4
	6		9					EW	Poly-Credit 6.3	Heat-Island Reduction - Roof and Non-Roof	LEED BC+C / ND V4
	6		9					EW	Poly-Credit 6.4	Reduce Air Pollutant Emissions - Negligable Air Quality Impact (Envision CR1.2 Conserving Level)	Envision V2
4		7						HA	Req 1.0	Sites of Avoidance + Repair: 500 Year Flood Plain, Storm Surge + Sea Rise	RELi
4	5	7						HA	Req 2.0	Fundamental Emergency Operations: Back-up Power + Operations	RELi
4	5	7						HA	Req 3.0	Fundamental Emergency Operations: Thermal Safety During Emergencies	RELi
4		7						HA	Req 4.0	Safer Design for Extreme Weather, Wildfire + Seismic Events	Fortified
3	4	6	7					HA	Poly-Credit 2.1	Adaptive Design for Resilient Management of Extreme Rain Events	RELi
3	4	6	7					HA	Poly-Credit 2.2	Adaptive Design for Sea Rise, Storm Surge	RELi
3	4	6	7					HA	Poly-Credit 2.3	Adaptive Design for Extreme Weather, Wildfire, Fire + Seismic Events	Fortified
3	4	6	7					HA	Poly-Credit 2.4	NYC Urban Green Proposals: Conform with the NYC Building Resiliency Task Force Proposals	RELI + NYC Urban Green
3	4	6	7					HA	Poly-Credit 2.5	Avoid Proximity to Hazardous Sites	RELi
3	4	6	7					HA	Poly-Credit 2.6	Conventional + Naturalized Rainwater and Flood Management	RELi
3	4	6	7					HA	Poly-Credit 2.7	Safeguard Toxic + Hazardous Materials in Flood, Surge and Sea Rise Areas	RELi
4	5	7						HA	Poly-Credit 3.1	Advanced Emergency Operations: Back-up Power + Operations: Critical Services, Lighting	RELi
4	5	7						HA	Poly-Credit 3.2	Advanced Emergency Operations: Thermal Safety During Emergencies	RELi
4	5	7						HA	Poly-Credit 3.3	Advanced Emergency Operations: On-Site Water Storage for Operations	RELi
4	5	7						HA	Poly-Credit 3.4	Thermal Safety: Moderate to Large Cooling Center	RELi

4	5	7						HA	Poly-Credit 3.5	Thermal Safety: Advanced Cooling Center	RELi
9								HA	Poly-Credit 4.1	Landscape based Passive Cooling	2030 Palette
9								HA	Poly-Credit 4.2	Passive Lighting	2030 Palette
9								HA	Poly-Credit 4.3	Passive Heating	2030 Palette
9								HA	Poly-Credit 4.4	Passive Cooling	2030 Palette
4	6	7						HA	Poly-Credit 5.1	Protect below ground system vents and entrances from flooding	RELi
4	6	7						HA	Poly-Credit 5.2	Plan systems for 500 Year Floods	RELi
4	6	7						HA	Poly-Credit 5.3	Plan Systems for Extreme Rain Events	RELi
4	6	7						HA	Poly-Credit 5.4	Provide Distributed Generation Power Sources	RELi
			9	10				MA	Poly-Req 1.1	Storage + Collection of Recyclables	LEED V4
			9	10				MA	Poly-Req 1.2	Construction + Demolition Waste Management Planning	LEED V4
3	4		9	10				MA	Poly-Req 1.3	Project Material Selection + Use Planning	RELi
			9					MA	Credit 1.0	Safer, Non-Toxic Materials (SMaRT or equivalent Certified)	RELi
1	2	3	9	10				MA	Credit 2.0	Material + Artifact Effectiveness: Full Life Cycle Design for durability, adaptability, flexibility	Adapted - Autodesk
	3	6	9	10				MA	Credit 3.0	Material + Artifact Effectiveness: Design for Disassembly, Reuse, Recycling + Composting	Adapted - AutoDesk
		6	9	10				MA	Poly-Credit 4.1	Recycled Content (10% or 20%)	LEED NC 2009
	3	6	9	10	12			MA	Poly-Credit 4.2	Materials Reuse (5% or 10%)	LEED NC 2009
			9	10				MA	Poly-Credit 4.3	Regional Materials (10% or 20%)	LEED NC 2009
			9	10				MA	Poly-Credit 4.4	Certified Rapidly Renewable + Sustainable Bio-Based Materials (2.5%)	ADAPTED: LEED
			9					MA	Poly-Credit 4.5	Use Legally Logged Wood from Ecologically Managed Forests (FSC Certified)	RELi | LEED
			9	10				MA	Poly-Credit 4.6	Reduce Net Embodied Energy + Carbon, Water and Toxins	ADAPTED LEED | SMART
			9	10				MA	Poly-Credit 7.1	Construction and Demolition Waste Management 50% / 75%	LEED BD+C V4
			9	10				MA	Poly-Credit 7.2	Reduce Excavated Materials Taken Off Site 80%+ / 95%+ (Envision RA1.6)	Envision
7								PA	Req 1.0	Study: Short-Term Hazard Preparedness + Mitigation	RELi
7								PA	Req 2.0	Integrative Process, Development + Community Stakeholder Involvement	IP | LEED | Envision

1	3	6	7					PA	Poly-Req 3.1	Fundamental Commissioning	LEED NC V4
1	3	6	7					PA	Poly-Req 3.2	Building Level Metering	LEED NC V4
1	3	6	7					PA	Poly-Req 3.3	Enhanced Commissioning + Monitor Based (LEED Credit Path 2)	LEED NC V4
1	3	6	7					PA	Poly-Req 3.4	Plan for Long-Term Monitoring and Maintenance [Envision 2.0 LD3.1 Conserving Level]	Envision
9								PA	Credit 1.2	Health Impact Assessment (HIA)	RELi
7								PA	Credit 2.0	Establish a Sustainability + Resiliency Management System	Envision
7								PA	Credit 3.0	Address Conflicting Regulations + Policies	Envision
				7				PA	Poly-Credit 4.1	Part 1 - Study: Explore Potential By-Product + Utilization Synergies relevant to the projects	Adapted: Envision
				7				PA	Poly-Credit 4.2	Part 2 - Design: Develop and execute strategies from the opportunities studied in Part 1	Adapted: Envision
				7				PA	Poly-Credit 5.1	Part 1 - Study: Explore Improved Infrastructure + Element Integration relevant to the project	Adapted: Envision
				7				PA	Poly-Credit 5.2	Part 2 - Design: Develop and execute strategies from the opportunities studied in Part 1	Adapted: Envision
2	5	6	7	8				PA	Poly-Credit 6.1	Part 1 - Study: Explore opportunities for long-term adaptability relevant to the project	RELi
2	5	6	7	8				PA	Poly-Credit 6.2	Part 2 - Design: Develop and execute strategies from the opportunities studied	RELi
				7				PA	Poly-Credit 7.1	Part 1 - Study: Explore opportunities for Advanced Resiliency	RELi
				7				PA	Poly-Credit 7.2	Part 2 - Design Execution: Develop and execute strategies from the opportunities studied	RELi
9								PH	Poly-Req 1.1	Minimum Indoor Air Quality Performance	LEED NC V4
9								PH	Poly-Req 1.2	Environmental Tobacco Smoke Control	LEED NC V4
9								PH	Poly-Req 1.3	Low-Emitting Materials	LEED NC V4
9								PH	Poly-Req 1.4	Views to Exterior for 25% of Occupied Space	Adapted LEED NC 2009
9								PH	Poly-Credit 1.1	Enhanced Indoor Air Quality Strategies	LEED NC V4
9								PH	Poly-Credit 1.2	Interior Lighting	LEED NC V4
9								PH	Poly-Credit 1.3	Daylight	LEED NC V4
9								PH	Poly-Credit 1.4	Quality Views	LEED NC V4
9								PH	Poly-Credit 1.5	Acoustic Performance	LEED NC V4
12								PH	Credit 3.0	Human PHD: Provide for Social Equity: Interdisciplinary / Intercultural Opportunities	RELi | Stars
10								PH	Poly-Credit 4.1	Reduce Pesticide + Fertilizer Impacts (Envision NW2.2 Conserving Level - No Pesticides, Herbicides)	Envision
10								PH	Poly-Credit 4.2.1	Option 1: Prevent Surface + Groundwater Contamination (Envision NW2.3 Conserving Level)	Envision
10								PH	Poly-Credit 4.2.2	Option 2: Prevent Surface + Groundwater Contamination (Envision NW2.3 Restorative Level)	Envision

11								F-P	Credit 1.1	Pursue and complete a local landmark designation	Future-Proofing
11								F-P	Credit 1.2	Pursue and complete a State or National landmark designation	Future-Proofing
11								F-P	Credit 1.3	Pursue and complete a preservation or conservation easement for impacted cultural heritage assets impacted by proposed project	Future-Proofing
11								F-P	Credit 2.1	Pursue and gain approval from the local landmarks commission for proposed alterations	Future-Proofing
11								F-P	Credit 2.2	Pursue and gain approval from the State Historic Preservation Officer (SHPO) for proposed alterations (Washington Register designation)	Future-Proofing
11								F-P	Credit 2.3	Pursue and gain approval from the Secretary of the Interior for proposed alterations (National Register Designation)	Future-Proofing
12								F-P	Credit 3.1	Option 1. Historic Building Reuse	LEED V4 BD+C MR Credit: Building Life-Cycle Impact Reduction, Option 1
12								F-P	Credit 3.2	Option 2. Renovation of Abandoned or Blighted Building	LEED V4 BD+C MR Credit: Building Life-Cycle Impact Reduction, Option 2
12								F-P	Credit 3.3	Option 3. Building and Material Reuse	LEED V4 BD+C MR Credit: Building Life-Cycle Impact Reduction, Option 3
10	12							F-P	Credit 3.4	Option 4. Whole-Building Life-Cycle Assessment	LEED V4 BD+C MR Credit: Building Life-Cycle Impact Reduction, Option 4
11								F-P	Credit 4.1	Documented application of one of the Secretary of the Interior's Treatments for Historic Properties	Future-Proofing
11								F-P	Credit 4.2	Documented appliacation and compliance with a UNESCO Approved Cultural Heritage Policy Document	Future-Proofing
2	3	6	7	8	10			F-P	Credit	Design for Flexibility: Employ at least three strategies from LEED V4	LEED V4 MR Credit: Design for Flexibility

Future-Proofing Principles

Principle #1: Prevent Decay									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
1	2	3	9	10	0	0	MA	Credit 2.0	Material + Artifact Effectiveness: Full Life Cycle Design for durability, adaptability, flexibility	0	0	0	1
1	3	6	7	0	0	0	PA	Poly-Req 3.1	Fundamental Commissioning	1	1	1	0.6
1	3	6	7	0	0	0	PA	Poly-Req 3.2	Building Level Metering	0	0	0	0
1	3	6	7	0	0	0	PA	Poly-Req 3.3	Enhanced Commissioning + Monitor Based (LEED Credit Path 2)	1	1	1	1.3
1	3	6	7	0	0	0	PA	Poly-Req 3.4	Plan for Long-Term Monitoring and Maintenance [Envision 2.0 LD3.1 Conserving Level]	0	0	0	1
									Total	2	2	2	3.9

Future-Proofing Principles													
Principle #2: Flexibility & Adaptability									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
2	6	0	0	0	0	0	CV	Poly-Credit 3.3	Provide Community Access to Useful Space	1	0	0	0
2	6	0	0	0	0	0	CV	Poly-Credit 3.5	Joint Use of Facilities	0	1	1	0
1	2	3	9	10	0	0	MA	Credit 2.0	Material + Artifact Effectiveness: Full Life Cycle Design for durability, adaptability, flexibility	0	0	0	1
2	5	6	7	8	0	0	PA	Poly-Credit 6.1	Part 1 - Study: Explore opportunities for long-term adaptability relevant to the project	0	0	0	1
2	5	6	7	8	0	0	PA	Poly-Credit 6.2	Part 2 - Design: Develop and execute strategies from the opportunities studied	0	0	0	1
2	3	6	7	8	10	0	F-P	Credit	Design for Flexibility: Employ at least three strategies from LEED V4	0	0	0	0.6
									Total	1	1	1	3.6

Future-Proofing Principles													
Principle #3: Extend Service Life									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
12	3	6	0	0	0	0	CV	Poly-Req 1.1	Option 1: Broad community alignment (Envision QL1.1 Superior Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Req 1.2	Option 2: Holistic assessment and collaboration (Envision QL1.1 Conserving Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Req 1.3	Option 3: Community Renaissance (Envision QL1.1 Restorative Level)	0	0	0	0
12	3	6	0	0	0	0	CV	Poly-Credit 1.1	Understanding and balance - (Envision QL3.2 Improved Level / required for this credit)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.2	Alignment with community values- (Envision QL3.2 Enhanced Level / required for this credit)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.1	Option 1: Community preservation and enhancement - (Envision QL3.2 Superior Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.2	Option 2: Community connections and collaboration - (Envision QL3.2 Conserving Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.3	Option 3: Restoration of community and character - (Envision QL3.2 Restorative Level)	0	0	0	1
3	4	6	7	0	0	0	HA	Poly-Credit 2.1	Adaptive Design for Resilient Management of Extreme Rain Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.2	Adaptive Design for Sea Rise, Storm Surge	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.3	Adaptive Design for Extreme Weather, Wildfire, Fire + Seismic Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.4	NYC Urban Green Proposals: Conform with the NYC Building Resiliency Task Force Proposals	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.5	Avoid Proximity to Hazardous Sites	0	0	0	0

3	4	6	7	0	0	0	HA	Poly-Credit 2.6	Conventional + Naturalized Rainwater and Flood Management	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.7	Safeguard Toxic + Hazardous Materials in Flood, Surge and Sea Rise Areas	0	0	0	0
3	4	0	9	10	0	0	MA	Poly-Req 1.3	Project Material Selection + Use Planning	0	0	0	1
1	2	3	9	10	0	0	MA	Credit 2.0	Material + Artifact Effectiveness: Full Life Cycle Design for durability, adaptability, flexibility	0	0	0	1
0	3	6	9	10	0	0	MA	Credit 3.0	Material + Artifact Effectiveness: Design for Disassembly, Reuse, Recycling + Composting	0	0	0	0
0	3	6	9	10	11	0	MA	Poly-Credit 4.2	Materials Reuse (5% or 10%)	0	0	0	0
1	3	6	7	0	0	0	PA	Poly-Req 3.1	Fundamental Commissioning	1	1	1	0.6
1	3	6	7	0	0	0	PA	Poly-Req 3.2	Building Level Metering	0	0	0	0
1	3	6	7	0	0	0	PA	Poly-Req 3.3	Enhanced Commissioning + Monitor Based (LEED Credit Path 2)	1	1	1	1.3
1	3	6	7	0	0	0	PA	Poly-Req 3.4	Plan for Long-Term Monitoring and Maintenance [Envision 2.0 LD3.1 Conserving Level]	0	0	0	1
2	3	6	7	8	10	0	F-P	Credit	Design for Flexibility: Employ at least three strategies from LEED V4	0	0	0	0.6
									Total	8	8	8	13

Future-Proofing Principles													
Principle #4: Fortify									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
4	0	7	0	0	0	0	HA	Req 1.0	Sites of Avoidance + Repair: 500 Year Flood Plain, Storm Surge + Sea Rise	1	1	1	0
4	5	7	0	0	0	0	HA	Req 2.0	Fundamental Emergency Operations: Back-up Power + Operations	1	1	1	1
4	5	7	0	0	0	0	HA	Req 3.0	Fundamental Emergency Operations: Thermal Safety During Emergencies	0	0	0	1
4	0	7	0	0	0	0	HA	Req 4.0	Safer Design for Extreme Weather, Wildfire + Seismic Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.1	Adaptive Design for Resilient Management of Extreme Rain Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.2	Adaptive Design for Sea Rise, Storm Surge	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.3	Adaptive Design for Extreme Weather, Wildfire, Fire + Seismic Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.4	NYC Urban Green Proposals: Conform with the NYC Building Resiliency Task Force Proposals	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.5	Avoid Proximity to Hazardous Sites	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.6	Conventional + Naturalized Rainwater and Flood Management	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.7	Safeguard Toxic + Hazardous Materials in Flood, Surge and Sea Rise Areas	0	0	0	0
4	5	7	0	0	0	0	HA	Poly-Credit 3.1	Advanced Emergency Operations: Back-up Power + Operations: Critical Services, Lighting	1	0	1	1
4	5	7	0	0	0	0	HA	Poly-Credit 3.2	Advanced Emergency Operations: Thermal Safety During Emergencies	0	0	0	1
4	5	7	0	0	0	0	HA	Poly-Credit 3.3	Advanced Emergency Operations: On-Site Water Storage for Operations	0	0	0	0

4	5	7	0	0	0	0	HA	Poly-Credit 3.4	Thermal Safety: Moderate to Large Cooling Center	0	0	0	0
4	5	7	0	0	0	0	HA	Poly-Credit 3.5	Thermal Safety: Advanced Cooling Center	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.1	Protect below ground system vents and entrances from flooding	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.2	Plan systems for 500 Year Floods	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.3	Plan Systems for Extreme Rain Events	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.4	Provide Distributed Generation Power Sources	0	0	0	0
3	4	0	9	10	0	0	MA	Poly-Req 1.3	Project Material Selection + Use Planning	0	0	0	1
									Total	3	2	3	5

Future-Proofing Principles

Principle #5: Increase redundancy									Credit Name	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
5	0	0	0	0	0	0	EW	Poly-Credit 5.1	Amend or Implement Regulation Allowing On-Site Food Production	0	0	0	0
5	0	0	0	0	0	0	EW	Poly-Credit 5.2	On-site Vegetable, Nut + Berry Production	0	0	0	0
5	0	0	0	0	0	0	EW	Poly-Credit 5.3	On-site Aquaponics + Poultry Production	0	0	0	0
5	0	0	0	0	0	0	EW	Poly-Credit 5.4	Transitionally Labeled or Organic Certification + Distributed	0	0	0	0
4	5	7	0	0	0	0	HA	Req 2.0	Fundamental Emergency Operations: Back-up Power + Operations	1	1	1	1
4	5	7	0	0	0	0	HA	Req 3.0	Fundamental Emergency Operations: Thermal Safety During Emergencies	0	0	0	1
4	5	7	0	0	0	0	HA	Poly-Credit 3.1	Advanced Emergency Operations: Back-up Power + Operations: Critical Services, Lighting	1	0	1	1
4	5	7	0	0	0	0	HA	Poly-Credit 3.2	Advanced Emergency Operations: Thermal Safety During Emergencies	0	0	0	1
4	5	7	0	0	0	0	HA	Poly-Credit 3.3	Advanced Emergency Operations: On-Site Water Storage for Operations	0	0	0	0
4	5	7	0	0	0	0	HA	Poly-Credit 3.4	Thermal Safety: Moderate to Large Cooling Center	0	0	0	0
4	5	7	0	0	0	0	HA	Poly-Credit 3.5	Thermal Safety: Advanced Cooling Center	0	0	0	0
2	5	6	7	8	0	0	PA	Poly-Credit 6.1	Part 1 - Study: Explore opportunities for long-term adaptability relevant to the project	0	0	0	1
2	5	6	7	8	0	0	PA	Poly-Credit 6.2	Part 2 - Design: Develop and execute strategies from the opportunities studied	0	0	0	1
									Total	2	1	2	6

Future-Proofing Principles

Principle #6: Reduce Obsolescence									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
12	3	6	0	0	0	0	CV	Poly-Req 1.1	Option 1: Broad community alignment (Envision QL1.1 Superior Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Req 1.2	Option 2: Holistic assessment and collaboration (Envision QL1.1 Conserving Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Req 1.3	Option 3: Community Renaissance (Envision QL1.1 Restorative Level)	0	0	0	0
12	3	6	0	0	0	0	CV	Poly-Credit 1.1	Understanding and balance - (Envision QL3.2 Improved Level / required for this credit)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.2	Alignment with community values- (Envision QL3.2 Enhanced Level / required for this credit)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.1	Option 1: Community preservation and enhancement - (Envision QL3.2 Superior Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.2	Option 2: Community connections and collaboration - (Envision QL3.2 Conserving Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.3	Option 3: Restoration of community and character - (Envision QL3.2 Restorative Level)	0	0	0	1
2	6	0	0	0	0	0	CV	Poly-Credit 3.3	Provide Community Access to Useful Space	1	0	0	0
2	6	0	0	0	0	0	CV	Poly-Credit 3.5	Joint Use of Facilities	0	1	1	0
0	6	0	9	0	0	0	EW	Poly-Req 1.1	Indoor Water Use Reduction (20% < LEED Baseline)	2	2	2	1.3
0	6	0	9	0	0	0	EW	Poly-Req 1.2	Outdoor Water use Reduction (30% < Calculated Baseline)	1	2	0	1.3
0	6	0	9	0	0	0	EW	Poly-Req 1.3	Rainwater Management - Option 1. 95th Percentile of Rainfall Events	0	0	0	1.3

0	6	0	9	0	0	0	EW	Poly-Req 2.0	Minimum Energy Efficiency + Atmospheric Impacts	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Req 2.1	Minimum Energy Performance (5% < ASHRAE 90.1 2010)	1	1	1	0.6
0	6	0	9	0	0	0	EW	Poly-Req 2.2	Fundamental Refrigerant Management	1	1	1	0.6
0	6	8	9	0	0	0	EW	Poly-Credit 1.1	Rainwater management + Water Recycling / Reuse: Space and Planning	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 1.2	On-Site Food Production: Space and Planning	1	0	0	0.6
0	6	8	9	0	0	0	EW	Poly-Credit 2.3	Solar Access	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 2.4	Vegetative Cooling	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 2.5	Wind Energy: Plan space to optimize wind access.	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 3.1	Indoor Water Use Reduction (NC 25% to 50%)	2	2	2	0
0	6	0	9	0	0	0	EW	Poly-Credit 3.2	Outdoor Water Use Reduction (NC 50% or 100%)	1	2	0	1.3
0	6	8	9	0	0	0	EW	Poly-Credit 3.3	Basic Rainwater Harvesting, Recycled Water, On-Site and / or Neighborhood Water Storage	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 3.4	Alternative Sewage Management	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 3.5	Near Zero / High Efficiency, Net Zero and Net Positive Water	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 3.6	Rainwater Management (For Extreme Rain Events: See HA Credit 2.1)	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.1	Energy Optimization (NC 6% to 50%)	10	9	7	11
0	6	8	9	0	0	0	EW	Poly-Credit 4.2	On-site or Neighborhood Renewable Energy Production	0	0	0	0

0	6	0	9	0	0	0	EW	Poly-Credit 4.3	Compliance with AIA 2030 Commitment or Minnesota SB 2030	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 4.4	Renewable Energy - Distributed Generation + Production: Wind, PV + Polished Biogas	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.5	Near Zero / Carbon Neutral, Net Zero + Net Positive Energy Flows	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.6	District Heating and Cooling	1	0	1	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.7	Green Power + Carbon Offsets (50% / 100%) LEED BD+C V4:	0	1	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 6.1	Light Pollution Reduction	1	1	0	0.6
0	6	0	9	0	0	0	EW	Poly-Credit 6.2	Tree-Lined and Shaded Streetscapes	1	1	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 6.3	Heat-Island Reduction - Roof and Non-Roof	0	1	0	0.6
0	6	0	9	0	0	0	EW	Poly-Credit 6.4	Reduce Air Pollutant Emissions - Negligable Air Quality Impact (Envision CR1.2 Conserving Level)	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.1	Adaptive Design for Resilient Management of Extreme Rain Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.2	Adaptive Design for Sea Rise, Storm Surge	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.3	Adaptive Design for Extreme Weather, Wildfire, Fire + Seismic Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.4	NYC Urban Green Proposals: Conform with the NYC Building Resiliency Task Force Proposals	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.5	Avoid Proximity to Hazardous Sites	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.6	Conventional + Naturalized Rainwater and Flood Management	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.7	Safeguard Toxic + Hazardous Materials in Flood, Surge and Sea Rise Areas	0	0	0	0

4	6	7	0	0	0	0	HA	Poly-Credit 5.1	Protect below ground system vents and entrances from flooding	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.2	Plan systems for 500 Year Floods	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.3	Plan Systems for Extreme Rain Events	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.4	Provide Distributed Generation Power Sources	0	0	0	0
0	3	6	9	10	0	0	MA	Credit 3.0	Material + Artifact Effectiveness: Design for Disassembly, Reuse, Recycling + Composting	0	0	0	0
0	0	6	9	10	0	0	MA	Poly-Credit 4.1	Recycled Content (10% or 20%)	2	2	2	0.6
0	3	6	9	10	11	0	MA	Poly-Credit 4.2	Materials Reuse (5% or 10%)	0	0	0	0
1	3	6	7	0	0	0	PA	Poly-Req 3.1	Fundamental Commissioning	1	1	1	0.6
1	3	6	7	0	0	0	PA	Poly-Req 3.2	Building Level Metering	0	0	0	0
1	3	6	7	0	0	0	PA	Poly-Req 3.3	Enhanced Commissioning + Monitor Based (LEED Credit Path 2)	1	1	1	1.3
1	3	6	7	0	0	0	PA	Poly-Req 3.4	Plan for Long-Term Monitoring and Maintenance [Envision 2.0 LD3.1 Conserving Level]	0	0	0	1
2	5	6	7	8	0	0	PA	Poly-Credit 6.1	Part 1 - Study: Explore opportunities for long-term adaptability relevant to the project	0	0	0	1
2	5	6	7	8	0	0	PA	Poly-Credit 6.2	Part 2 - Design: Develop and execute strategies from the opportunities studied	0	0	0	1
2	3	6	7	8	10	0	F-P	Credit	Design for Flexibility: Employ at least three strategies from LEED V4	0	0	0	0.6
									Total	33	34	25	32

Future-Proofing Principles													
Principle #7: Plan Ahead									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
4	0	7	0	0	0	0	HA	Req 1.0	Sites of Avoidance + Repair: 500 Year Flood Plain, Storm Surge + Sea Rise	1	1	1	0
4	5	7	0	0	0	0	HA	Req 2.0	Fundamental Emergency Operations: Back-up Power + Operations	1	1	1	1
4	5	7	0	0	0	0	HA	Req 3.0	Fundamental Emergency Operations: Thermal Safety During Emergencies	0	0	0	1
4	0	7	0	0	0	0	HA	Req 4.0	Safer Design for Extreme Weather, Wildfire + Seismic Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.1	Adaptive Design for Resilient Management of Extreme Rain Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.2	Adaptive Design for Sea Rise, Storm Surge	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.3	Adaptive Design for Extreme Weather, Wildfire, Fire + Seismic Events	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.4	NYC Urban Green Proposals: Conform with the NYC Building Resiliency Task Force Proposals	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.5	Avoid Proximity to Hazardous Sites	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.6	Conventional + Naturalized Rainwater and Flood Management	0	0	0	0
3	4	6	7	0	0	0	HA	Poly-Credit 2.7	Safeguard Toxic + Hazardous Materials in Flood, Surge and Sea Rise Areas	0	0	0	0
4	5	7	0	0	0	0	HA	Poly-Credit 3.1	Advanced Emergency Operations: Back-up Power + Operations: Critical Services, Lighting	1	0	1	1
4	5	7	0	0	0	0	HA	Poly-Credit 3.2	Advanced Emergency Operations: Thermal Safety During Emergencies	0	0	0	1
4	5	7	0	0	0	0	HA	Poly-Credit 3.3	Advanced Emergency Operations: On-Site Water Storage for Operations	0	0	0	0

4	5	7	0	0	0	0	HA	Poly-Credit 3.4	Thermal Safety: Moderate to Large Cooling Center	0	0	0	0
4	5	7	0	0	0	0	HA	Poly-Credit 3.5	Thermal Safety: Advanced Cooling Center	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.1	Protect below ground system vents and entrances from flooding	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.2	Plan systems for 500 Year Floods	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.3	Plan Systems for Extreme Rain Events	0	0	0	0
4	6	7	0	0	0	0	HA	Poly-Credit 5.4	Provide Distributed Generation Power Sources	0	0	0	0
7	0	0	0	0	0	0	PA	Req 1.0	Study: Short-Term Hazard Preparedness + Mitigation	1	1	1	1
7	0	0	0	0	0	0	PA	Req 2.0	Integrative Process, Development + Community Stakeholder Involvement	1	1	1	1
1	3	6	7	0	0	0	PA	Poly-Req 3.1	Fundamental Commissioning	1	1	1	0.6
1	3	6	7	0	0	0	PA	Poly-Req 3.2	Building Level Metering	0	0	0	0
1	3	6	7	0	0	0	PA	Poly-Req 3.3	Enhanced Commissioning + Monitor Based (LEED Credit Path 2)	1	1	1	1.3
1	3	6	7	0	0	0	PA	Poly-Req 3.4	Plan for Long-Term Monitoring and Maintenance [Envision 2.0 LD3.1 Conserving Level]	0	0	0	1
7	0	0	0	0	0	0	PA	Credit 2.0	Establish a Sustainability + Resiliency Management System	0	0	0	0
7	0	0	0	0	0	0	PA	Credit 3.0	Address Conflicting Regulations + Policies	0	0	0	0
0	0	0	0	7	0	0	PA	Poly-Credit 4.1	Part 1 - Study: Explore Potential By-Product + Utilization Synergies relevant to the projects	0	0	0	0
0	0	0	0	7	0	0	PA	Poly-Credit 4.2	Part 2 - Design: Develop and execute strategies from the opportunities studied in Part 1	0	0	0	0
0	0	0	0	7	0	0	PA	Poly-Credit 5.1	Part 1 - Study: Explore Improved Infrastructure + Element Integration relevant to the project	0	0	0	1
0	0	0	0	7	0	0	PA	Poly-Credit 5.2	Part 2 - Design: Develop and execute strategies from the opportunities studied in Part 1	0	0	0	1

2	5	6	7	8	0	0	PA	Poly-Credit 6.1	Part 1 - Study: Explore opportunities for long-term adaptability relevant to the project	0	0	0	1
2	5	6	7	8	0	0	PA	Poly-Credit 6.2	Part 2 - Design: Develop and execute strategies from the opportunities studied	0	0	0	1
0	0	0	0	7	0	0	PA	Poly-Credit 7.0	Study + Living Design for Advanced Resiliency using a diversity of ecology based perspectives	0	0	0	0
0	0	0	0	7	0	0	PA	Poly-Credit 7.1	Part 1 - Study: Explore opportunities for Advanced Resiliency	0	0	0	0
0	0	0	0	7	0	0	PA	Poly-Credit 7.2	Part 2 - Design Execution: Develop and execute strategies from the opportunities studied	0	0	0	0
2	3	6	7	8	10	0	F-P	Credit	Design for Flexibility: Employ at least three strategies from LEED V4	0	0	0	0.6
									Total	7	6	7	14

Future-Proofing Principles													
Principle #8: Diversify									Credit Name	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
8	0	0	0	0	0	0	CV	Poly-Credit 3.1	Surrounding Density + Diverse Uses (LEED NC, Option 2. Diverse Uses)	1	1	1	0.6
8	0	0	0	0	0	0	CV	Poly-Credit 3.2	Surrounding Density + Diverse Uses (RELi Resilient Use Categories)	1	1	1	1
0	6	8	9	0	0	0	EW	Poly-Credit 1.1	Rainwater management + Water Recycling / Reuse: Space and Planning	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 1.2	On-Site Food Production: Space and Planning	1	0	0	0.6
0	6	8	9	0	0	0	EW	Poly-Credit 2.3	Solar Access	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 2.4	Vegetative Cooling	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 2.5	Wind Energy: Plan space to optimize wind access.	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 3.3	Basic Rainwater Harvesting, Recycled Water, On-Site and / or Neighborhood Water Storage	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 3.4	Alternative Sewage Management	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 4.2	On-site or Neighborhood Renewable Energy Production	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 4.4	Renewable Energy - Distributed Generation + Production: Wind, PV + Polished Biogas	0	0	0	0
0	0	8	0	0	0	0	EW	Poly-Credit 5.1	Amend or Implement Regulation Allowing On-Site Food Production	0	0	0	0
0	0	8	0	0	0	0	EW	Poly-Credit 5.2	On-site Vegetable, Nut + Berry Production	0	0	0	0

0	0	8	0	0	0	0	EW	Poly-Credit 5.3	On-site Aquaponics + Poultry Production	0	0	0	0
2	5	6	7	8	0	0	PA	Poly-Credit 6.1	Part 1 - Study: Explore opportunities for long-term adaptability relevant to the project	0	0	0	1
2	5	6	7	8	0	0	PA	Poly-Credit 6.2	Part 2 - Design: Develop and execute strategies from the opportunities studied	0	0	0	1
2	3	6	7	8	10	0	F-P	Credit	Design for Flexibility: Employ at least three strategies from LEED V4	0	0	0	0.6
									Total	3	2	2	4.9

Future-Proofing Principles													
Principle #9: Be Local & Healthy									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
9	0	0	0	0	0	0	CV	Poly-Credit 2.1	Surrounding Density + Diverse Uses (Option 1. Surrounding Density)	1	1	1	3.1
9	0	0	0	0	0	0	CV	Poly-Credit 2.2	Access to Quality Transit	1	1	1	3.8
9	0	0	0	0	0	0	CV	Poly-Credit 2.3	Bicycle Facilities	1	1	1	0.6
9	0	0	0	0	0	0	CV	Poly-Credit 2.4	Reduced Parking Footprint	1	1	1	1.3
0	0	0	0	0	0	0	CV	Poly-Credit 6.0	Develop or Expand Local Skills, Capabilities + Long-Term Employment + Mix	0	0	0	0
9	0	0	0	0	0	0	CV	Poly-Credit 6.1	Option 1: Hire Locally - (Envision QL1.3 Enhance Level)	1	1	1	1
9	0	0	0	0	0	0	CV	Poly-Credit 6.2	Option 2: Specific Skills Outreach - (Envision QL1.3 Superior Level)	1	1	1	1
9	0	0	0	0	0	0	CV	Poly-Credit 6.3	Option 3: Local Capacity Development - (Envision QL1.3 Conserving Level)	1	1	1	0
9	0	0	0	0	0	0	CV	Poly-Credit 6.4	Option 4: Long Term Competitiveness - (Envision QL1.3 Restorative Level)	0	0	0	0
9	0	0	0	0	0	0	CV	Poly-Credit 7.1	Regional Materials LEED MRc5	1	0	2	1
9	0	0	0	0	0	0	CV	Poly-Credit 7.2	Option 1: Regional Materials - 60% Soils, Aggregates + Materials (Envision RA1.1 Enhanced Level)	0	0	0	0
9	0	0	0	0	0	0	CV	Poly-Credit 7.3	Option 2: Regional Materials - 95% Soils, Aggregates + Materials (Envision RA1.1 Conserving Level)	0	0	0	0
9	0	0	0	0	0	0	CV	Poly-Credit 8.1	Option 1: Improve Local Productivity - (Envision QL1.2 Superior Level)	1	1	1	1

9	0	0	0	0	0	0	CV	Poly-Credit 8.2	Option 2: Business and People Attractiveness - (Envision QL1.2 Conserving Level)	1	1	1	1
9	0	0	0	0	0	0	CV	Poly-Credit 8.3	Option 3: Developmental Rebirth - (Envision QL1.2 Restorative Level)	0	0	0	1
0	6	0	9	0	0	0	EW	Poly-Req 1.1	Indoor Water Use Reduction (20% < LEED Baseline)	2	2	2	1.3
0	6	0	9	0	0	0	EW	Poly-Req 1.2	Outdoor Water use Reduction (30% < Calculated Baseline)	1	2	0	1.3
0	6	0	9	0	0	0	EW	Poly-Req 1.3	Rainwater Management - Option 1. 95th Percentile of Rainfall Events	0	0	0	1.3
0	6	0	9	0	0	0	EW	Poly-Req 2.0	Minimum Energy Efficiency + Atmospheric Impacts	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Req 2.1	Minimum Energy Performance (5% < ASHRAE 90.1 2010)	1	1	1	0.6
0	6	0	9	0	0	0	EW	Poly-Req 2.2	Fundamental Refrigerant Management	1	1	1	0.6
0	6	8	9	0	0	0	EW	Poly-Credit 1.1	Rainwater management + Water Recycling / Reuse: Space and Planning	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 1.2	On-Site Food Production: Space and Planning	1	0	0	0.6
0	6	8	9	0	0	0	EW	Poly-Credit 2.3	Solar Access	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 2.4	Vegetative Cooling	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 2.5	Wind Energy: Plan space to optimize wind access.	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 3.1	Indoor Water Use Reduction (NC 25% to 50%)	2	2	2	0
0	6	0	9	0	0	0	EW	Poly-Credit 3.2	Outdoor Water Use Reduction (NC 50% or 100%)	1	2	0	1.3
0	6	8	9	0	0	0	EW	Poly-Credit 3.3	Basic Rainwater Harvesting, Recycled Water, On-Site and / or Neighborhood Water Storage	0	0	0	0

0	6	8	9	0	0	0	EW	Poly-Credit 3.4	Alternative Sewage Management	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 3.5	Near Zero / High Efficiency, Net Zero and Net Positive Water	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 3.6	Rainwater Management (For Extreme Rain Events: See HA Credit 2.1)	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.1	Energy Optimization (NC 6% to 50%)	10	9	7	11
0	6	8	9	0	0	0	EW	Poly-Credit 4.2	On-site or Neighborhood Renewable Energy Production	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.3	Compliance with AIA 2030 Commitment or Minnesota SB 2030	0	0	0	0
0	6	8	9	0	0	0	EW	Poly-Credit 4.4	Renewable Energy - Distributed Generation + Production: Wind, PV + Polished Biogas	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.5	Near Zero / Carbon Neutral, Net Zero + Net Positive Energy Flows	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.6	District Heating and Cooling	1	0	1	0
0	6	0	9	0	0	0	EW	Poly-Credit 4.7	Green Power + Carbon Offsets (50% / 100%) LEED BD+C V4:	0	1	0	0
0	0	0	0	0	0	0	EW	Poly-Credit 5.1	Amend or Implement Regulation Allowing On-Site Food Production	0	0	0	0
0	0	0	0	0	0	0	EW	Poly-Credit 5.2	On-site Vegetable, Nut + Berry Production	0	0	0	0
0	0	0	0	0	0	0	EW	Poly-Credit 5.3	On-site Aquaponics + Poultry Production	0	0	0	0
0	0	0	0	0	0	0	EW	Poly-Credit 5.4	Transitionally Labeled or Organic Certification + Distributed	0	0	0	0
0	6	0	9	0	0	0	EW	Poly-Credit 6.1	Light Pollution Reduction	1	1	0	0.6
0	6	0	9	0	0	0	EW	Poly-Credit 6.2	Tree-Lined and Shaded Streetscapes	1	1	0	0

0	6	0	9	0	0	0	EW	Poly-Credit 6.3	Heat-Island Reduction - Roof and Non-Roof	0	1	0	0.6
0	6	0	9	0	0	0	EW	Poly-Credit 6.4	Reduce Air Pollutant Emissions - Negligable Air Quality Impact (Envision CR1.2 Conserving Level)	0	0	0	0
9	0	0	0	0	0	0	HA	Poly-Credit 4.1	Landscape based Passive Cooling	3	2	2	3
9	0	0	0	0	0	0	HA	Poly-Credit 4.2	Passive Lighting	0	0	0	0
9	0	0	0	0	0	0	HA	Poly-Credit 4.3	Passive Heating	0	0	0	1
9	0	0	0	0	0	0	HA	Poly-Credit 4.4	Passive Cooling	0	0	0	0
0	0	0	9	10	0	0	MA	Poly-Req 1.1	Storage + Collection of Recyclables	1	1	1	0.6
0	0	0	9	10	0	0	MA	Poly-Req 1.2	Construction + Demolition Waste Management Planning	1	1	1	1.3
3	4	0	9	10	0	0	MA	Poly-Req 1.3	Project Material Selection + Use Planning	0	0	0	1
0	0	0	9	0	0	0	MA	Credit 1.0	Safer, Non-Toxic Materials (SMaRT or equivalent Certified)	0	0	0	1
1	2	3	9	10	0	0	MA	Credit 2.0	Material + Artifact Effectiveness: Full Life Cycle Design for durability, adaptability, flexibility	0	0	0	1
0	3	6	9	10	0	0	MA	Credit 3.0	Material + Artifact Effectiveness: Design for Disassembly, Reuse, Recycling + Composting	0	0	0	0
0	0	6	9	10	0	0	MA	Poly-Credit 4.1	Recycled Content (10% or 20%)	2	2	2	0.6
0	3	6	9	10	11	0	MA	Poly-Credit 4.2	Materials Reuse (5% or 10%)	0	0	0	0
0	0	0	9	10	0	0	MA	Poly-Credit 4.3	Regional Materials (10% or 20%)	1	0	2	0.6
0	0	0	9	10	0	0	MA	Poly-Credit 4.4	Certified Rapidly Renewable + Sustainable Bio-Based Materials (2.5%)	0	0	0	0

0	0	0	9	0	0	0	MA	Poly-Credit 4.5	Use Legally Logged Wood from Ecologically Managed Forests (FSC Certified)	0	0	0	0
0	0	0	9	10	0	0	MA	Poly-Credit 4.6	Reduce Net Embodied Energy + Carbon, Water and Toxins	0	0	0	0
0	0	0	0	0	0	0	MA	Poly-Credit 7.0	Divert Waste from Landfills, Reduce Excavated Soils Taken from Site	0	0	0	0
0	0	0	9	10	0	0	MA	Poly-Credit 7.1	Construction and Demolition Waste Management 50% / 75%	2	2	2	1.3
0	0	0	9	10	0	0	MA	Poly-Credit 7.2	Reduce Excavated Materials Taken Off Site 80%+ / 95%+ (Envision RA1.6)	0	0	0	1
9	0	0	0	0	0	0	PA	Credit 1.2	Health Impact Assessment (HIA)	0	0	0	0
9	0	0	0	0	0	0	PH	Poly-Req 1.1	Minimum Indoor Air Quality Performance	1	1	1	0.6
9	0	0	0	0	0	0	PH	Poly-Req 1.2	Environmental Tobacco Smoke Control	1	1	1	0.6
9	0	0	0	0	0	0	PH	Poly-Req 1.3	Low-Emitting Materials	4	3	4	2.5
9	0	0	0	0	0	0	PH	Poly-Req 1.4	Views to Exterior for 25% of Occupied Space	1	0	0	0
9	0	0	0	0	0	0	PH	Poly-Credit 1.1	Enhanced Indoor Air Quality Strategies	1	2	3	0.6
9	0	0	0	0	0	0	PH	Poly-Credit 1.2	Interior Lighting	2	0	2	0.6
9	0	0	0	0	0	0	PH	Poly-Credit 1.3	Daylight	1	0	0	0
9	0	0	0	0	0	0	PH	Poly-Credit 1.4	Quality Views	1	0	0	0
9	0	0	0	0	0	0	PH	Poly-Credit 1.5	Acoustic Performance	0	0	0	0
									Total	54	47	46	51

Future-Proofing Principles													
Principle #10: Life Cycle Analysis									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
0	0	0	9	10	0	0	MA	Poly-Req 1.1	Storage + Collection of Recyclables	1	1	1	0.6
0	0	0	9	10	0	0	MA	Poly-Req 1.2	Construction + Demolition Waste Management Planning	1	1	1	1.3
3	4	0	9	10	0	0	MA	Poly-Req 1.3	Project Material Selection + Use Planning	0	0	0	1
1	2	3	9	10	0	0	MA	Credit 2.0	Material + Artifact Effectiveness: Full Life Cycle Design for durability, adaptability, flexibility	0	0	0	1
0	3	6	9	10	0	0	MA	Credit 3.0	Material + Artifact Effectiveness: Design for Disassembly, Reuse, Recycling + Composting	0	0	0	0
0	0	6	9	10	0	0	MA	Poly-Credit 4.1	Recycled Content (10% or 20%)	2	2	2	0.6
0	3	6	9	10	11	0	MA	Poly-Credit 4.2	Materials Reuse (5% or 10%)	0	0	0	0
0	0	0	9	10	0	0	MA	Poly-Credit 4.3	Regional Materials (10% or 20%)	1	0	2	0.6
0	0	0	9	10	0	0	MA	Poly-Credit 4.4	Certified Rapidly Renewable + Sustainable Bio-Based Materials (2.5%)	0	0	0	0
0	0	0	9	10	0	0	MA	Poly-Credit 4.6	Reduce Net Embodied Energy + Carbon, Water and Toxins	0	0	0	0
0	0	0	9	10	0	0	MA	Poly-Credit 7.1	Construction and Demolition Waste Management 50% / 75%	2	2	2	1.3
0	0	0	9	10	0	0	MA	Poly-Credit 7.2	Reduce Excavated Materials Taken Off Site 80%+ / 95%+ (Envision RA1.6)	0	0	0	1
10	0	0	0	0	0	0	PH	Poly-Credit 4.1	Reduce Pesticide + Fertilizer Impacts (Envision NW2.2 Conserving Level - No Pesticides, Herbicides)	0	0	0	0

10	0	0	0	0	0	0	PH	Poly-Credit 4.2.1	Option 1: Prevent Surface + Groundwater Contamination (Envision NW2.3 Conserving Level)	1	1	1	1
10	0	0	0	0	0	0	PH	Poly-Credit 4.2.2	Option 2: Prevent Surface + Groundwater Contamination (Envision NW2.3 Restorative Level)	0	0	0	1
10	12	0	0	0	0	0	F-P	Credit 3.4	Option 4. Whole-Building Life-Cycle Assessment	0	0	0	0
2	3	6	7	8	10	0	F-P	Credit	Design for Flexibility: Employ at least three strategies from LEED V4	0	0	0	0.6
									Total	8	7	9	10

Future-Proofing Principles														
Principle #11: Use Cultural Heritage Policy Documents									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
11	0	0	0	0	0	0	F-P	Credit 1.1	Pursue and complete a local landmark designation	0	0	0	1
11	0	0	0	0	0	0	F-P	Credit 1.2	Pursue and complete a State or National landmark designation	1	0	0	1
11	0	0	0	0	0	0	F-P	Credit 1.3	Pursue and complete a preservation or conservation easement for impacted cultural heritage assets impacted by proposed project	0	0	0	0
11	0	0	0	0	0	0	F-P	Credit 2.1	Pursue and gain approval from the local landmarks commission for proposed alterations	0	0	0	1
11	0	0	0	0	0	0	F-P	Credit 2.2	Pursue and gain approval from the State Historic Preservation Officer (SHPO) for proposed alterations (Washington Register designation)	0	0	0	1
11	0	0	0	0	0	0	F-P	Credit 2.3	Pursue and gain approval from the Secretary of the Interior for proposed alterations (National Register Designation)	0	0	0	1
11	0	0	0	0	0	0	F-P	Credit 4.1	Documented application of one of the Secretary of the Interior's Treatments for Historic Properties	1	0	1	1
11	0	0	0	0	0	0	F-P	Credit 4.2	Documented appliacation and compliance with a UNESCO Approved Cultural Heritage Policy Document	0	0	0	0
									Total	2	0	1	6

Future-Proofing Principles													
Principle #12: Promote Understanding									**Credit Name**	Clark Hall	Playhouse Theater	Savery Hall	SIERR Building
12	3	6	0	0	0	0	CV	Poly-Req 1.1	Option 1: Broad community alignment (Envision QL1.1 Superior Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Req 1.2	Option 2: Holistic assessment and collaboration (Envision QL1.1 Conserving Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Req 1.3	Option 3: Community Renaissance (Envision QL1.1 Restorative Level)	0	0	0	0
12	3	6	0	0	0	0	CV	Poly-Credit 1.1	Understanding and balance - (Envision QL3.2 Improved Level / required for this credit)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.2	Alignment with community values- (Envision QL3.2 Enhanced Level / required for this credit)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.1	Option 1: Community preservation and enhancement - (Envision QL3.2 Superior Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.2	Option 2: Community connections and collaboration - (Envision QL3.2 Conserving Level)	1	1	1	1
12	3	6	0	0	0	0	CV	Poly-Credit 1.3.3	Option 3: Restoration of community and character - (Envision QL3.2 Restorative Level)	0	0	0	1
0	3	6	9	10	12	0	MA	Poly-Credit 4.2	Materials Reuse (5% or 10%)	0	0	0	0
12	0	0	0	0	0	0	PH	Credit 3.0	Human PHD: Provide for Social Equity: Interdisciplinary / Intercultural Opportunities	1	1	1	0
12	0	0	0	0	0	0	F-P	Credit 3.1	Option 1. Historic Building Reuse	0	0	2	1.3
12	0	0	0	0	0	0	F-P	Credit 3.2	Option 2. Renovation of Abandoned or Blighted Building	0	0	0	0.6
12	0	0	0	0	0	0	F-P	Credit 3.3	Option 3. Building and Material Reuse	0	0	0	0
10	12	0	0	0	0	0	F-P	Credit 3.4	Option 4. Whole-Building Life-Cycle Assessment	0	0	0	0
									Total	7	7	9	8.9

Appendix 5: Thesis Presentation and Discussion

Thesis Presentation:

Future-Proofing: Seeking Resilience in Historic Buildings

Rick Mohler - Graduate School Head

Brian Rich - Thesis Author

Thesis Committee Members:

Jeffrey Karl Ochsner - (chair) Professor at UW Architecture Department (JKO)

Kathryn Rogers-Merlino - Assistant Professor at UW Architecture Department (KRM)

Tyler Sprague - Assistant Professor at UW Architecture Department (TS)

Thesis Review Committee (from left to right)

Matt Aalfs - Principal at BuildingWork LLC (MA)

David Strauss - Principal at SHKS (DS)

Ayad Rahmani - Associate Professor - WSU Architecture Department (AR)

Ann Huppert - Assistant Professor at UW Architecture Department (AH)

AH - I just want to understand your thesis correctly. So... the current rating system does not allow for the proper preservation of buildings... for the longevity. And you show the Lewis and Clark School in Spokane as one example. It follows a current rating system that gives it that result.

BR - Well, the Lewis and Clark High School was probably done with some LEED rating system in mind, but I think there was something that happened when they gutted the building and rebuilt it that prevented, ultimately, the moisture migration out of the building. It trapped it under the glazing on the terra cotta, and in Spokane when the temperatures drop real quickly - you're from Eastern Washington, you know what happens there - it froze and the glazing just started spalling off. But the building had been there for nearly 100 years - just fine, before hand - so what was different? What did somebody do in that design? And how could they have done something better? What's the thought process? And so my thesis is if you use the Principles of Future-Proofing as - if you will - a screening tool for things to consider as you're designing buildings, maybe you can avoid those kinds of problems in the future and don't damage the building.

AR - It expands on the schedule and these criteria and includes other things like cultural heritage and other things that sort of... obsolescence... and so the categories expand and that you've found protects and preserves buildings in a much more meaningful, authentic way, I suppose. Is that your thesis, I guess?

BR - Yes

MA - Can I ask you... So it sounds like there is no rating system for these kinds of projects, and you're proposing one.

BR - That's right.

MA - And, just to make sure I'm understanding correctly, these twelve principles are part of your proposal?

BR - Yes

MA - They don't exist elsewhere in the world?

BR - Correct, I created them.

MA - So you're creating a new rating system for this type of work that doesn't exist.

BR - Yes.

MA - OK, so that's what I thought.

BR - Yup, yup. That's exactly it.

DS - So in the context of the Spokane debacle, explain to me how when using this rating system would have prevented the spalling due to the freeze thaw.

BR - So, if I'm thinking specifically about the principal of, say, durability, I'm going to look at it and say "what's going to compromise the durability of the masonry on the exterior of the building?" Vapor drive is obviously one of those things that can compromise it. And, so, I might want to back up and do a WUFI analysis of the wall system that I'm proposing to see how that vapor drive impacts the building and if there was any potential for moisture to collect under the glazing of the terra cotta. Does that make sense?

DS - It does, but I'm just curious, in that particular case, we're not entirely sure... Any kind of coating on the glazing itself wasn't the problem, right? It was the coating on the mortar that was the problem, and so... What I'm trying to get at is, if I'm going through this checklist and I think and it says... make sure that the mortar joints breathe. Well, your rating system doesn't probably get into that level of detail - or does it?

BR - No, it doesn't. It doesn't. It is something that is at a conceptual level. You have to think through the implications of. And so really, when you go back to the twelve principles, they are supposed to be the reminders as you're looking at a design and as you filter every design decision that you've looked at.

DS - Kinda like reading the Ten Commandments every day.

BR - Yeah.

[Laughter from all]

BR - A little bit. You wake up and go to work and that's the first thing you practice. You read the Ten Commandments and say, OK, I'm going to live by these goals... With the Spokane school example, there's actually many different things that can happen in there. Like the UW buildings, that building was gutted and... right down to the structure and the exterior skin. And they rebuilt it by furring out the walls, putting insulation in there, putting a vapor barrier on it, putting new drywall on with vapor impermeable paint and stuff. So there's multiple layers in there that might be inhibiting the movement of moisture through that wall. Is it possible that it's the mortar in the joints? Maybe. Is it something else? Maybe. I didn't do the... that analysis.

MA - So this is an explicit or implicit critique of LEED, let's say, and SEED and the other systems that are out there, but you're not critiquing or challenging the way that those get applied, who does it, how it gets done, how it gets revised. You're basically borrowing that... the process.

BR - Yeah. I'm borrowing the notion of a point system and its scoring, yeah. I looked at some other ways of trying to, uh, trying to apply the system and I mentioned in my presentation about the subjective use or application of those twelve principles.... Well that's great and that's what we do every day when we read our Ten Commandments at the beginning... when we're thinking about the beginning of our design, but that doesn't necessarily result in a consistent application, uh, or consistent understanding of how future-proof the building is. That's where that rating system comes in because it is numerical.

MA - I guess it brings up questions like... It sounded like... I wasn't clear who was doing the scoring. So it's like LEED where the designers themselves do their own scoring and they get to weigh the categories how they please between five and fifteen percent?

BR - There's a lot of different ways the systems can be used, and yes, that's one of them. An architect or designer can look at it that way.

MA - So, but... but... Does that... You're imagining they would then potentially finish their design and then plug in some algorithm that maximizes their score based on weighing all the categories

BR - I would hope they don't. I would hope that... And part of the reason I set up the five step process, there, was to encourage you to look first at the building and weigh the principles and how you deal with each principle and then prioritize them. That is another way to do it, though. You can think about your building in a certain environment, and say that I want this building to be more of X than of Y. For instance, um, a hospital design: medical technology is always changing. There is always something new and something you want to be able to accommodate in your building. So, perhaps, in that context, adaptability and flexibility of the building is far more important, than, uh, principle eleven or twelve for historic value, or, uh, life cycle benefits. It may be that the flexibility and adaptability is what makes that building more future-proof. So one of the things that I thought about is, is there a way to suggest, for different building types, a weighting system. For example, for medical facilities, you might give, uh, flexibility and adaptability the fifteen percent weighting and decrease the weighting in other buildings. And propose that to people as something to use. There's multiple different LEED systems out there... There could be multiple different variations of future-proofing rating systems as well.

DS - So the, um, benefit of LEED was to foreground a building's role in averting the climate crisis that we're in... So it did that. It foregrounded it, but, frankly, it's worked to a limited extent. But what it also did was sell product.

BR - Yes, it did.

DS - So, in this particular case, I think the product that you're selling, or would be sold, is actually building insurance. Insurance companies would be inclined to appreciate a building that scored high on the future-proofing rating, because then they'd be assured its going to last. It's not going to be affected by seismic events, etcetera. In that context, I think you need to think a lot more like an actuary than and architect.

[all laugh]

BR - That would be hard!

DS - Yeah, I mean... It's very challenging... And then that brought up the question that I would have actually thought was... There's probably some kind of theoretical basis for this whole discussion and among other things, its thoroughly anti-Ruskinian, right? Because we should let them rot.

BR - It is. Ruskin has some interesting little tidbits in there about yeah, if you need to do some maintenance, you know, do some maintenance, but if it's ready to collapse, let it collapse. And that actually really gets to the last question down here for me about what is future-proof? When is a building future-proof? How long does it have to last? Well, if you're in more of a Viollet-Le-Duc point of view than a Ruskinian point of view, you're going to say you're going to do ongoing maintenance to that building to continue the ability to serve the occupants and what ever functions it needs or change that building so it can accommodate a new function and continue to serve.

MA - I think it's an interesting, what you're proposing, which is a value system for the renovation, preservation, or adaptation of historic buildings and I don' think there is one currently. I think that there's a bunch of different competing, uh, value systems that don't really work well in the real world. And, I'd say from the basis of my current experience, working on a good number, half a dozen historic buildings. I think the three value systems that are in place that we're trying to navigate as the architect, um, one, preservation. OK, and so, local landmark preservation boards, just good preservation practice, and, in some cases, the National Park Service for historic tax credit projects. And, particularly, like the SIERR Building was a historic tax credit project, so that might be why it scored higher in your system. But those systems, and in particular the National Park Service, are really geared towards preservation and not towards adaptation. In fact, they don't care about adaptation at all, for the most part. Like, they don't want you to change their way to preserve, okay? Then the other one is... is what we think of as sustainability with respect to energy consumption. That is a good system but is very often in conflict with preservation because it would mean tearing down those beautiful single pane windows and replacing then, you know, with a much more, you know, higher U-value window.

BR - Maybe.

MA - Very often it does.

BR - Very often it does.

MA - And if you're working with them it does. I'm just saying, but we want to keep the windows. There's a conflict there - that's what I'm getting at.

BR - Sure, sure.

MA - And the third one is adaptation and flexibility because the developer... the... the real estate person wants maximum flexibility.

BR - Do you think so?

MA - Yeah. Yeah, they do.

BR - Hmmm. My point of view is different.

MA - They want more space. They want more change. They want to change the building. They don't want to keep the building the same. They want to add floors to it. They want to... They want to make it work better, towards a higher paying tenant, right? So what I'm saying is that we have three value systems that are in deep conflict with each other with respect to historic buildings. And those are the three value systems that we're constantly, as the architect, are trying to navigate. I think what you're saying is that there's a way of trying to bring these values together, and I think that's real interesting.

BR - And balance them, and that's hard. My perception of the developer is the seven year, buy it, build it quick and then at the end of your seven year loan you're going to get out of it. And who cares what happens to it after that.

MA - Yeah, I'm saying the same thing as you, but I think the developers, for the most part, aren't even interested in preservation.

BR - No.

MA - They're interested in rents, their value. And preservation is a hoop they have to jump through and they only jump through it if they have to and really what they're looking at is how do they increase their value. And very often that puts and architect in a bind.

DS - But I'd say... Your point, though, is that tractability is, in fact, it has market value, even though it's a seven year turnover. that if I can move 30 people into an office space, that's one thing. But if use demising walls and break it up into smaller offices I get this value out of it. So developers are interested in that kind of flexibility.

BR - And from that point of view, I would hope that the developers are encouraged to design a building, uh, and build a building which is, in many more ways, flexible, durable - as a shell at least that can then be used in an adaptable and flexible way. It's a long term investment point of view.

AH - I'm just thinking about once you get into the new building and those costs. It seems to me that, of course these are valid principles, but you're getting into a whole different ball game. If that's where this... bringing these three different facets together is really pertinent for preservation. And the whole question of flexibility that I'm sitting here thinking about. Frankly, the reality of that theater which I wasn't very aware of...

BR - The Playhouse Theater...

AH - The playhouse theater has a bit of brick, still [laughter] and, um...

DS - You noticed that!

AH - but that's sort of where it's okay that's preservation of some idea of something. So, to me, that suggests tremendous flexibility and there you're not dealing with a developer, you're dealing with the University, I think at that point. And that's an interesting point that these three University projects where they gutted... you know, there's a shell, so that gives you great flexibility. And then there's the question of retaining historic fabric. I just think there's a lot of different.. I mean it is a complex project. I was interested, going back to how you identified the problem because I think that you didn't... I don't know, if in fact, the answer to the Spokane problem is we don't exactly know what went wrong. I don't assume that the project was predicated on the idea that we're going to have this physical disaster. I mean that there wasn't... So where... where did you identify the crux of the problem cause I doubt that that was done given that it was a school. I mean it wasn't done for short term gain... It wasn't just a developer flipping a project, so there it really goes back how do these criteria really get someone to... to not make that big mistake that was made. I don't know what the mistake was, so I....

BR - Nor do I. Nor do I. I have no knowledge... I have my observations from when I was there.

AH - OK. Come to a question: Is there a clear connection between these principles and someone to... Do you think the problem there was lack of long term thinking or was it just a disastrous materials choice or somewhere in between that this set of criteria would get someone to think differently?

BR - My guess is that there was a technical issue there in terms of what that wall assembly was, and somebody didn't understand it. Um, do I know exactly what that is? No, I don't.

MA - Getting back to... If that's a lack of knowledge... presumably there's been several experts who all had their eyes on it... there's redundancy in that system. I'm more curious when you made the statement that this is a resource... that... I think you said you said its not a commodity or can't be commodified or something like that.

AH - The building isn't...

MA - Well, no, the scoring system... and to me, I would, uh, I would almost look at it as it will be commodified because it's not a... You're framing it as something is used by the people who are within the system. Its not a prescriptive thing where some watchdog group comes along and say "OK, did you meet these requirements and I'm going to score you..." You're folloing the model of LEED, which clearly has been commodified.

BR - In some ways I appreciate the notion of it becoming commodified. Where does everyone feel the pain first? Right there in the pocket book. And like LEED, if people are seeing financial benefits out of being a LEED Certified, LEED Gold, LEED Platinum project, then people are going to move that way.

MA - Well, I think the idea of insurance - I think you could kind of leverage that aspect of it.

BR - Yeah.

MA - I don't know if... I don't know what everyone's feelings are, but it seems like the kind of tension, uh, between preservation and maximizing dollars, especially if you look at Capital Hill and the facadism that's going on up there. That's kind of like the evidence that we're battling between these two different value systems. But it seems like there is some potential there rather than just say I'm going to ignore the commodification and just hope that people make the best decisions by reading the Ten Commandments. You could get at that tension a little more directly.

AR - What was your process to develop these twelve, um, you know, principles, because that seems like... just describe that a little bit.

BR - So when I read a bunch of articles I searched for the term "future-proof" and then I looked at the context in which that word was used. And some times they literally said it is future-proof because I planned ahead. It is more future-proof because it's durable. Sometimes there was an implied meaning there, and so what I was doing was figuring out, OK, what are these things that people mean every time that they use the word "future-proof." And after reviewing, I don't know, a hundred... two hundred articles, there was a few things that fell out. And I was like, Oh, these are important, those are important. Those were the attributes of future-proofing.

MA - And what other disciplines are using those? In what fields...

BR - Oh, all over the place. Electronics, industrial design, landscape, climate change...

MA - But not only in architecture...

BR - Not specifically architecture all the time. there are some mentions in the AEC industry as well. And so what I was trying to do was to figure out those general attributes, that no matter what the context was. Then I was trying to take those and, in the Principles here, apply them specifically to the built environment.

MA - Well, I guess I'm sort of looking at this big picture and wondering if calling your system future-proofing is a little... I think you need your own name. I think it should be... I think it should be linked to architecture and historic buildings and renovation, preservation, and adaptation thereof. As opposed to this other term that has so many other connotations from future-proofing. I don't know, just a thought. Because my first question was: did this come from future-proofing, or did you make it? Did you develop it? It's not clear necessarily, and just calling it future-proofing seems a little like you're really inventing this new thing. I think it should relate to what it's actually applied to - so historic buildings.

BR - I'm using a... maybe a brief title here, but if I was to go back to the very first slide, and show you the whole title, which reads Future-proofing: Seeking Resilience in the Historic Built Environment...

MA - Yes!

BR - And it's that subtitle that's missing.

MA - Yes, I think so. Just at the conceptual level.

BR - And when I was trying to figure out the right word, I actually debated between using the word "resilience" and future-proofing. And I decided, quite deliberately, I did not want to use the word "resilience" because it was the popular term and it had a lot of preconceptions as to what that meant. And so, I chose this as a different one to avoid that conflict.