ABSTRACT

Title of Thesis:	SUSTAINABILITY THROUGH ADAPTATION: REIMAGINING EXISTING SPACES WITH MASS TIMBER CONSTRUCTION
	Amber N. Robbs, Master of Architecture and Certificate in Historic Preservation, Spring 2020
Thesis Directed By:	Professor Brian Kelly, School of Architecture, Planning, & Preservation

In a period when it is becoming more and more apparent how we, as humans, have been negatively impacting our planet, it is important for us, as designers, to take a step back and evaluate how new methods of sustainable design can be incorporated into the existing built environment to leave a positive impression on our climate. We have discussed sustainability through design, building typologies, construction materials, and building systems but we can also explore the sustainable method of reusing the existing built environment. This thesis explores how adaptively reusing existing buildings can be a sustainable source of architecture. Buildings that have fallen into neglect and/or ruin can be revitalized through the construction method of mass timber to produce less greenhouse gas emissions during the structure’s life cycle while leaving a larger, healthier impact on our climate.

This thesis explores the benefits of mass timber as a sustainable construction method and demonstrates how mass timber can be used as an alternative to steel

frame construction on the site of a 1919 US Navy industrial building. The existing masonry and steel-framed structure stands as a neglected building that can be adapted through sustainable methods. By respecting the structure's heritage and original purpose, this thesis proposes a secondary building and revitalization of the existing structure through reusing existing structures with recycled material, like mass timber.

The thesis looks at opening the site to the evolving community of the Washington D.C. Navy Yard. Maintaining the site as a community gathering space, this thesis proposes a food hall program, building off the weekly farmers markets that take place in the structure's adjacent plaza, and aims to fill the community's need for a public civic space in the adjoining community library program. The program of this thesis aims to draw people in to explore the built environment of alternative and sustainable construction methods.

SUSTAINABILITY THROUGH ADAPTATION:
REIMAGINING EXISTING SPACES WITH MASS TIMBER CONSTRUCTION

Amber Nicole Robbs

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Architecture
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Advisory Committee:
Brian Kelly, Chair
Karl Du Puy, Committee Member
Matthew Bell, Committee Member

Dedication

I am dedicating this thesis to my family who has always supported the dream of the little 10-year-old girl who drafted floor plans of every room in the house in the hopes of one day going to college to become an architect.

Love,

Me

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Chapter 1 Introduction

Recycling has become second nature to most modern communities as we strive to take care of our environment. We are working to find new ways to reduce, reuse, and recycle everything from cars to plastic bottles and most importantly, materials that can be harmful to our planet. Sustainable design has become the goal for architecture as professionals seek to reduce the negative impact the built environment can have on our environment. Adaptive reuse can be a sustainable form of recycling the built environment. The built environment stands as a glimpse into our past and a physical representation of how we have impacted our environment.

Through adaptive reuse, a structure and/or space can be reimagined and given a new purpose to add value to the structure's future. By respecting the structure's heritage and original purpose, the existing built environment can become a part of sustainable construction by reusing existing structures with recycled material, like mass timber. By reusing the built environment instead of demolishing an existing structure to build a new building in its place, adaptive reuse can retain the original building's embodied energy and negative impacts through sustainable construction methods and minimal environmental impact while giving the built environment a new purpose.

This thesis seeks to explore how adaptively reusing existing buildings can be a sustainable source of architecture. Buildings that have fallen into neglect and/or ruin can be revitalized through using recycled materials like mass timber to produce less greenhouse gas emissions during the structure's life cycle while leaving a larger, healthier impact on our climate. This thesis will explore the benefits of adaptive reuse and mass timber construction as a sustainable construction method to demonstrate how mass timber can be used as an alternative to steel frame construction in the built environment.

Chapter 2 Precedent Analysis

2.1 Butler Square

Built in 1908, this warehouse was the largest wholesale warehouse of its time west of Chicago. Butler Square was designed by local Minneapolis architect Harry Wild Jones. The nine-story tall timber structure provided five hundred thousand square feet of warehouse and distribution space due to its heavy timber construction. The heavy timber posts and beams came from the contractor's, T.B. Walker, own Douglas fir tree farm and lumber mill just one hundred and twenty-five miles away in Aitkin, Minnesota[1]. The columns were precut and put together on a module measuring 14' by 16'. The Douglas columns started at 24" wide and gradually diminished to 9" by the top level. The structure was also supported by 3' thick masonry firewalls throughout the building.


One of the Sights of Minneapolis
BUTLER BLOCK, Sixth Street, between First and Second Avenues North.
BUTLER BROTHERS, NEW YORK. CHICAGO. ST. LOUIS. MINNEAPOLIS.
"The House that Covers the Country"

Figure 1: Historic Image of Butler Square from the local newspaper (Source: https://www.butlersquare.com/photos)

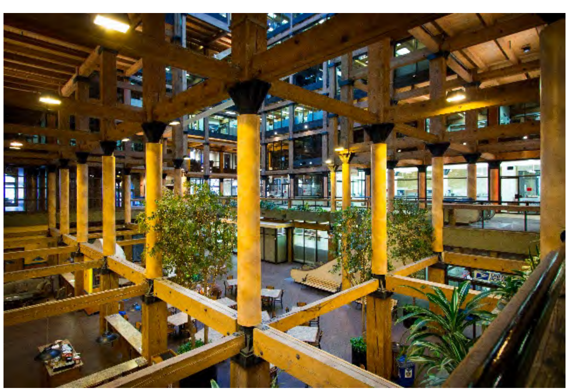

Figure 2: Heavy timber atrium (Source: Jenna Bauer via Thinkwood.com)

In 1971 Butler Square was placed on the National Register of Historic Places for its significant example of Chicago School design and as an example of early 1900s

[1] Think Wood. n.d. Butler Square. Accessed November 12, 2019.

warehouse/office buildings in Minnesota[2]. Just four years later, developer Charles Coyer and Miller Hanson Westerback Bell Architects set out to restore life to the aging warehouse by turning it into a mixed-use office-retail complex. This renovation catalyzed preservation, restoration, and adaptive reuse projects within the Minneapolis Warehouse District.

Figure 3: Exterior view of Butler Square today (Source: https://www.butlersquare.com/photos)

Because the building was built as a warehouse there was minimal access to natural daylighting. The 1974 renovation created a central atrium to bring in natural light so that the exterior of the building could be preserved while still bringing in the needed natural lighting for office and retail space. During the 1974 renovations, the floors were raised to preserve the natural wood ceilings of the existing structure using an early version of Nail-Laminated Timber, a mass timber product. Today, the building is a mix of the original historic heavy timber post-and-beam construction and modern mass timber construction. Butler Square was

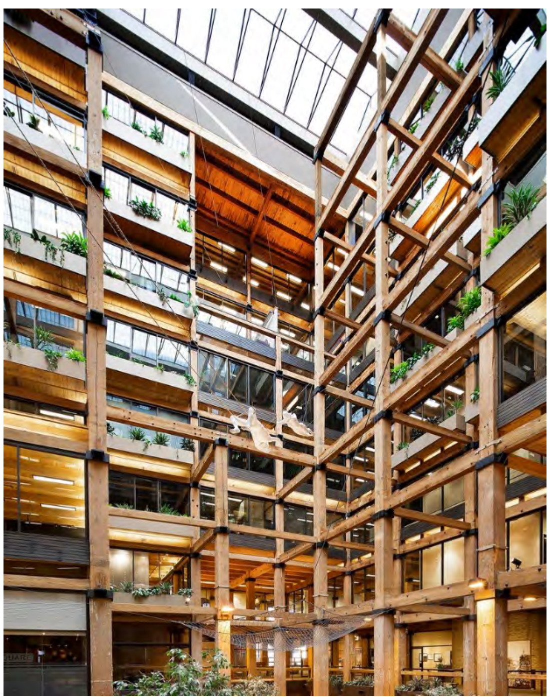

Figure 4: Natural daylighting from atrium (Source Pete Sieger via Flickr.com)

[2] Butler Square | Minneapolis Office Space. n.d. Butler Square. Accessed November 12, 2019.

the first century-old, multi-tenant commercial building in the nation to achieve LEED-Exiting Building Operations & Maintenance certification (LEED-ED O&M), the oldest building in the Midwest to achieve LEED certification, and the first building in Minnesota to achieve LEED-ED O&M[3].

Butler Square illustrates how timber construction can be adapted in a historically significant structure to support a modern use through sustainable design. Butler Square has been a gateway precedent in the Midwest for revitalizing existing structures and mass timber construction. Today Butler Square is surrounded by redeveloped warehouse structures and new mass timber construction. As the 1974 renovations of Butler Square combined the existing heavy timber and masonry construction with early mass timber products, this thesis can benefit from the construction techniques of the 1974 renovations and the sustainable practices that Butler Square has maintained over the years.

2.2 URBN Campus

Originally built between 1868 and 1939 as part of Philadelphia's historic Navy Yard, the URBN warehouse campus served as a series shipbuilding and repair facilities for the US

Figure 5: Historic Images of the Philadelphia Navy Yard as a ship building, repair, and scrapping site (Source: MSRDesign)

[3] Think Wood. n.d. Butler Square. Accessed November 12, 2019.

Figure 6: Exterior images of URBN campus (Source: top - Lara Swimmer Photography & Bottom - MSR Design)

Navy until the one hundred eighty-seven building campus was decommissioned in 1996[4]. Three years later the decommissioned navy yard was added to the National Register of Historic Places. In 2004 a comprehensive master plan was developed to turn the former navy yard into a mixed-use complex that offered benefits to developers from the Federal Historic Preservation Tax Incentive Program.

Urban Outfitter's founder, Dick Hayne, was one of the first companies to consider the site and purchased four buildings, two hundred eighty-five thousand square feet, to redevelop into the company's headquarters. The twenty-three months of design and renovation included building documentation to gain Federal Historic Preservation Tax incentives. The architects, MSRDesign, focused on utilizing the factory characteristics of the building's industrial materiality, open volumes, and access to natural daylighting to adapt the warehouses into a multi-phase corporate campus for

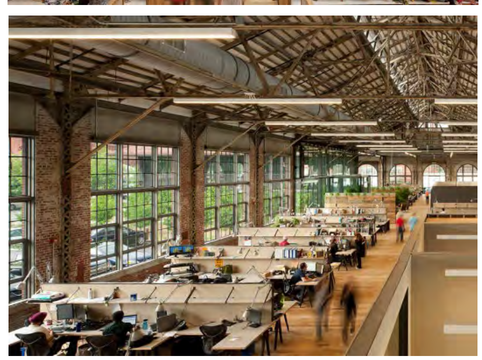

Figure 7: Interior images of MSR Design's adaptive reuse design (Source: MSR Design)

[4] Igor Fracalossi and MSR Design. 2010. Urban Outfitters Corporate Campus / MSR Design. ArchDaily. December 1. Accessed November 12, 2019.

URBN[5]. The renovated office spaces stimulate creativity and collaboration among employees while honoring the existing history of the site.

Figure 8: Section throught the URBN campus (Source MSR Design)

Figure 9: Transformation of URBN buildings over the life of the Navy Yard (Source: MSR Design via Arch Daily)

The URBN campus is a great precedent for this thesis that illustrates how structures can be transformed from a public, naval industrial use to a community-based space. The URBN campus was transformed to create a communal office space that maximizes the building's open spaces, materiality, and natural daylight to inspire employees throughout their day to day work and promotes productivity and a positive work environment. MSR Design was able to reimagine a portion of the historic Philadelphia Navy Yard while embracing the history of the navy yard district and URBN’s culture. The design of the campus allows the history of the Navy Yard to be celebrated and honored by layering the old with the new.

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[5] Igor Fracalossi and MSR Design. 2010. *Urban Outfitters Corporate Campus / MSR Design.* ArchDaily. December 1. Accessed November 12, 2019.

2.3 GoSpotCheck Headquarters

Figure 10: GoSpotCheck Headquarters set within the historic context of LoDo (Source: Tryba Architects)

Set in the Lower Downtown (LoDo) district of Denver, the GoSpotCheck Headquarters sits as a historic urban infill between two historic buildings. The building is an addition to the historic Rocky Mountain Seed Building that celebrates the historic character of the existing streetscape through modern construction methods and materials. Tryba Architects was committed to designing a building that restored an urban gap in the streetscape by immersing the building into its surroundings. The jewel box façade followed the scale and proportions of its neighboring buildings to blend seamlessly with one another. The jewel box design created a gateway like building for the LoDo district that serves as a lantern, signifying the entrance to the neighborhood from the south and east.

The GoSpotCheck Headquarters also serves as a precedent to this thesis through its unique steel and glulam structure. The mass timber product serves as

Figure 11: Elevation diagram illustrating the addition's relationship to the surrounding historic context through scale, proportion, and radiating lines (Source: Tryba Architects)

lateral support to the building's steel frame primary structure. The glulam beams are attached to the steel frame structure with heavy, steel plate and bolt connections. By exposing and using glulam beams and wood decking within the structure, the architects were paying homage to the original historic Rocky Mountain Seed Building, tying the two structures together.

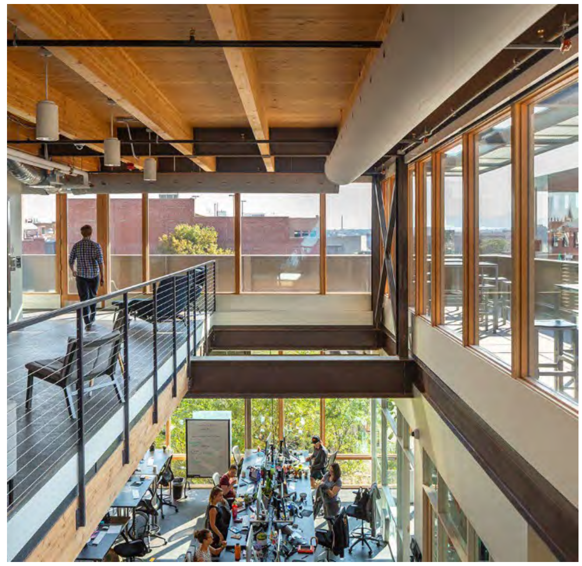


Figure 12: Interior image of the steel and glulam structure (Source: Tryba Architects)

2.4 Quincy Market

Constructed in 1826, Boston's Quincy Market is an extension of historic Faneuil Hall. As the commercial demand of the market outgrew Faneuil Hall, Quincy Market was built to meet the demand for commercial growth. The market hall was designed with tall floor heights to lead shoppers down the center hallway, through the long rectangle pavilion of vendor stalls. In 1966, the whole market complex was designated as a National Historic Landmark for its historic significance as one of the nation's largest market complexes built in the early 1800s.

Figure 13: Interior of Quincy Hall at opening (Source: Smith, H.G.)

Quincy Market stands as a programmatic precedent for this thesis to explore how a historic market hall works and how a market hall can stand as the center of a community. Of the six buildings in the Faneuil Hall market complex, Quincy market was originally full of grocery type stalls and has adapted to modern culture and is now home to many food-stalls, fast-food style stalls, and restaurants. Today the market is one of Boston's most popular tourist destinations and is also a popular lunch spot of local downtown employees. The surrounding plaza provides excess vending spaces for stalls that sell snacks and trinkets.

Figure 14 Activation of plaza space between Quincy Hall and South Market Building (Source: flickr.com)

Totals	Stores (sqft)	Kiosks (sqft)	food (sqft)	exterior dining (sqft)	bar (sqft)	circulation (sqft)	back of house (sqft)		
Number	31	41	43	3	6				
Average	1,086	42	1,017	1,188	300				
Total Square Feet	48,770	1,730	23,540	4,375	3,350	31,400	24,000	Total:	137,165

Figure 15: Break down of Quincy Market, South Market, and North Market program types by average square feet, amount, and total square feet (Source: Author)

Chapter 3 Climate Change

3.1 Signs of Climate Change

Homo sapiens have been discovering, adapting, and living off the earth's resources since the beginning of our existence. It is becoming clear that the way we have been using these resources since the beginning of the Industrial Revolution has been leaving a negative impact on the place we call home. The Industrial Revolution marked the dramatic increase in industrial activities that our modern civilization depends upon. These activities have resulted in an increasing concentration of atmospheric carbon dioxide (CO_2). According to the IPCC, 2013: Summary for Policymakers, the atmospheric concentrations of greenhouse gases have all increased since 1750. CO_2 has increased by 40%, methane (CH_4) by 150%, and nitrous oxide (N_2O) by 20% due to human activity.[6] Since the mid-1700s these contributing industrial activities have been growing in popularity as they are perfected and become

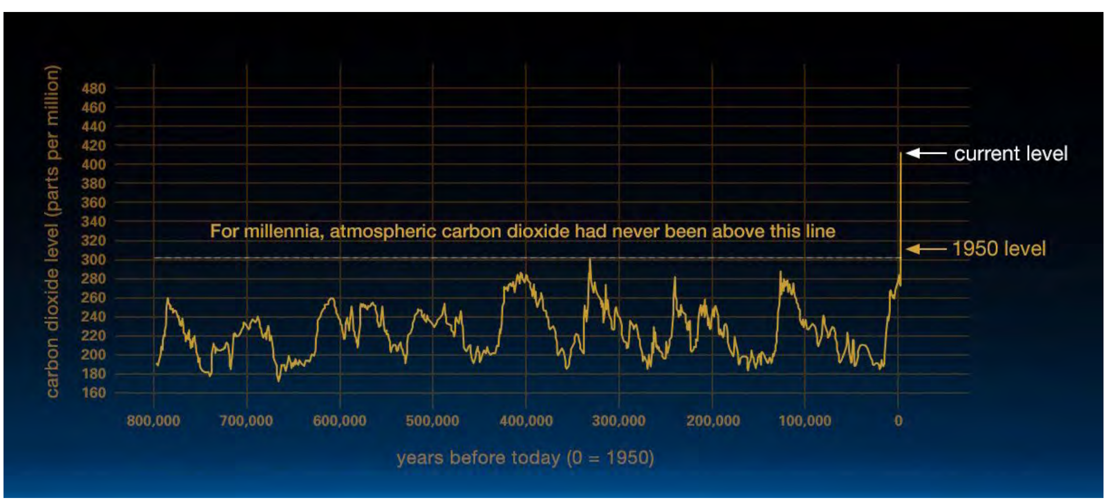


Figure 16: Atmospheric CO_2 Levels (Source: climate.nasa.gov)

[6] "IPCC, 2013: Summary for Policymakers." Accessed October 5, 2018.

a part of modern society. Around 1950, our use of these activities drastically spiked and have led to our current unprecedented rate of greenhouse gas emissions.

Throughout Earth's history, there have been seven known glacial advances and retreats. The last cycle, the ice age, occurred seven hundred years ago and marked the beginning of our climate as we know it. According to the findings by NASA, the current warming cycle is unique to the last seven cycles because 95% of it can be attributed to human activity since the Industrial Revolution.[7] Evidence shows that this warming will continue to proceed at an unprecedented rate with each passing decade.

Studies have shown that there is no reason to question that the increased levels of greenhouse gas emissions are causing the earth to heat up. Physical evidence of earth warming can be found in the decrease of glaciers mass in the tropical mountains, Antarctica, and Greenland and the increase in sea levels. More evidence for climate change can be found from ancient history in tree rings, ocean sediments, coral reefs, and the layers of sedimentary rocks. The changes in these natural forms prove that the

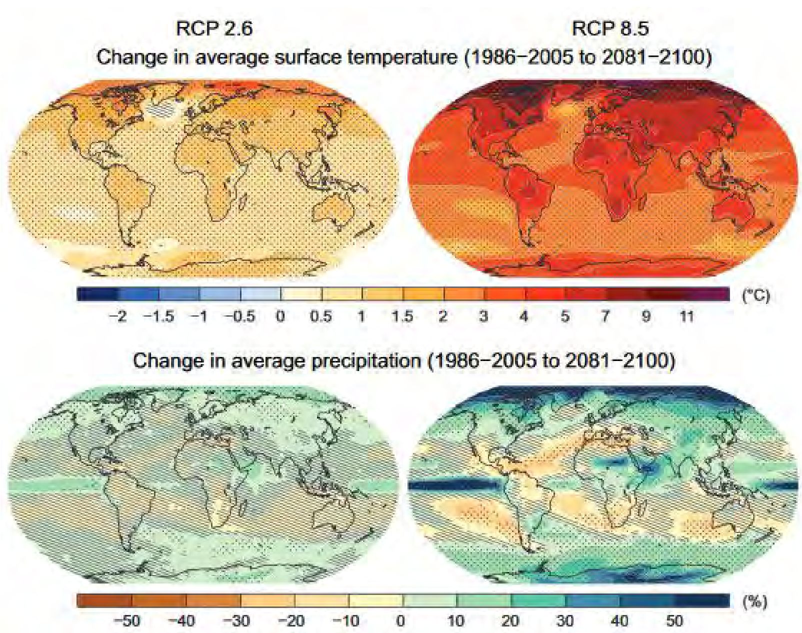


Figure 17: Top: annual surface temperature change. Bottom: change in average precipitation. (Source: IPCC 2013)

[7] "Climate Change Evidence: How Do We Know?" Accessed October 6, 2019.

current warming period is occurring at a rate ten times faster than the average post-ice-age rate[8]. The sooner we act to reverse the negative impact we have instilled on our planet, the sooner we can ensure a positive climate for generations to come.

Almost 200 nations adopted the climate agreement at the COP21 (Conference of the Parties) summit in Paris that aims to limit our planet's average global temperature rise to less than two degrees Celsius (3.6 degrees Fahrenheit). By 2050, the annual CO_2 emissions could decrease by 14% to 96% than the emissions recorded in 1990[9] if we continue to do our part and take care of our planet. During this period of climate change, it is important for us, as a species, to realize the impact we have made and work to make significant changes for the better.

3.2 Impact of Base Building Construction

Climate change is a fundamental part of designing in today's climate. The construction of our buildings can negatively impact the environment through greenfield development, cement production, and the burning of fossil fuels (oil, gas, and coal). Base building construction accounts for almost 40% of annual energy and raw

Figure 18: Shanghai on its hottest day of recorded history at 105.6°F (Source: Architect Magazine)

[8] "Climate Change Evidence: How Do We Know?" Accessed October 6,2019.
[9] "IPCC, 2013: Summary for Policymakers." Accessed October 5, 2018.

material consumption, 25% of the wood harvest, 16% of freshwater supplies, 44% of landfills, 45% of CO_2 production, and up to 50% of greenhouse emissions from industrialized countries.[10] We, as architects, designers, and creators, can design the built environment in a way that produces minimal amounts of CO_2 and reverse the negative impact we have instilled in our climate.

The changes in the climate have led to an increase in dramatic natural disasters, sea-level rise, temperature rising, etc., all things that affect how the built environment is experienced, used, and built. By 2100 the rising ocean will force as many as two billion people to migrate further inland and/or to higher ground.[11] If CO_2 continues to burn at an unprecedented rate and we are not actively working to cut back on how the built environment is impacting our climate, it could become harder to build in the first place. If we continue to build the way we are now, the continental United States will experience an average of twenty to thirty more days above 90 degrees Fahrenheit annually by 2050.[12] Any day above 90 degrees Fahrenheit can cut into the outdoor

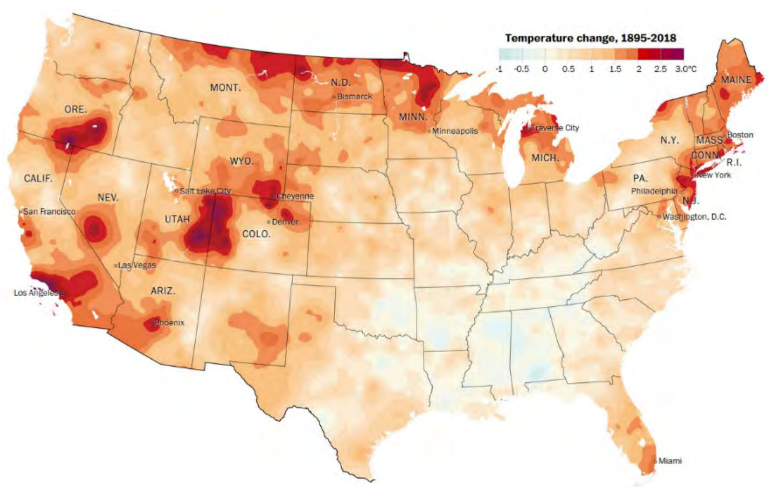


Figure 19: Temperature change in the Continental United States since 1895 to 2018 (Source: The Washington Post)

[10] Kerr, Warren, ed. 2004. "Adaptive Reuse. Preserving Our Past, Building Our Future." Accessed October 6, 2019.

[11] Cramer, Ned. 2017. "The Climate Is Changing. So Must Architecture." Accessed October 6, 2019.

[12] Cramer, Ned. 2017. "The Climate Is Changing. So Must Architecture." Accessed October 6, 2019.

labor supply by 14%, adding to more construction days, increasing the amount of CO_2 used per project.

In order to make a difference, architects, designers, and creators must find a way to reduce the use of energy and carbon-intensive technologies that are used daily in the built environment. Two of the most commonly used building materials are steel and concrete. Concrete alone attributes to 5% of annual global CO_2 emission, with China producing 3% of the 5%,[13] while steel and iron contribute to 3.2% of global CO_2 emission.[14] Steel is the newest of these construction materials as it became popular during the Industrial Revolution for its durability and strength that allows us to build higher and bigger. As the properties of steel construction proved to be superior to those of classic wood construction, the negative environmental impact of construction began to increase along with the use of steel and concrete materials. The manufacturing, transportation, and installation of steel and concrete consume a large amount of energy (embodied energy) and fossil fuels. Steel and concrete are not natural materials and cannot regrow

Figure 20: Construction of the Burj Khalifa and surrounding area. (Source: "The Concrete Conundrum")

[13] Crow, James Mitchell. 2008. "The Concrete Conundrum." Accessed October 6, 2019.
[14] Tingley D.D., Davison B. 2013. *Minimizing the Environmental Impact of Steel Structures.* Accessed October 6, 2019.

and reproduce. Every time steel is recycled the steel must be melted at alarming temperatures, using massive amounts of energy and fossil fuels[15].

3.3 Architecture's Response

The profession of architecture is striving to make an interdisciplinary effort to tackle climate change in many ways. Through optimizing the energy efficiency of existing and new buildings to reducing the greenhouse gas emissions of construction to creating biological curtains, architects all over the world are looking for ways to reduce our negative impact on climate change[16]. We can build structures that can produce and store more clean energy from renewable sources and architects are being pushed more and more to meet net-zero building standards and local policies for a sustainable building when at all possible.

In the United States, the profession of architecture provided $7 million in contributions while the construction industry made $122 million and the real estate industry made $234 million in contributions to fund research for climate change in 2016.[17] These professions are seeing the impact that the built environment has had on our climate and are setting aside funds to further policies, awareness, and research into climate change and there is still much more work to be done to change how the built environment has negatively impacted the climate in recent centuries. The American Institute of Architects has created a mission, the AIA 2030 Commitment, to

[15] Evan. 2016. "What Building Material (wood, steel, concrete) Has The Smallest Overall Environment Impact?" Accessed October 6, 2019.

[16] Walsh, Niall Patrick. 2018. "6 Architectural Responses to Climate Change in 2018." Accessed October 6, 2019.

[17] Cramer, Ned. 2017. "The Climate Is Changing. So Must Architecture." Accessed October 6, 2019.

support the 2030 challenge by transforming the way we practice architecture in America to work towards carbon-neutral buildings, developments, and major renovations by 2030.[18] Of the twenty thousand architecture firms in the United States, only six hundred and twenty-five firms have committed to the AIA 2030 Commitment as of October 2019. As designers, we have a critical role to play in the fight against climate change and we have the tools and resources to make a difference.

[18] n.d. "The 2030 Commitment." Accessed October 6, 2019.

Chapter 4 Context

4.1 Navy Yard History

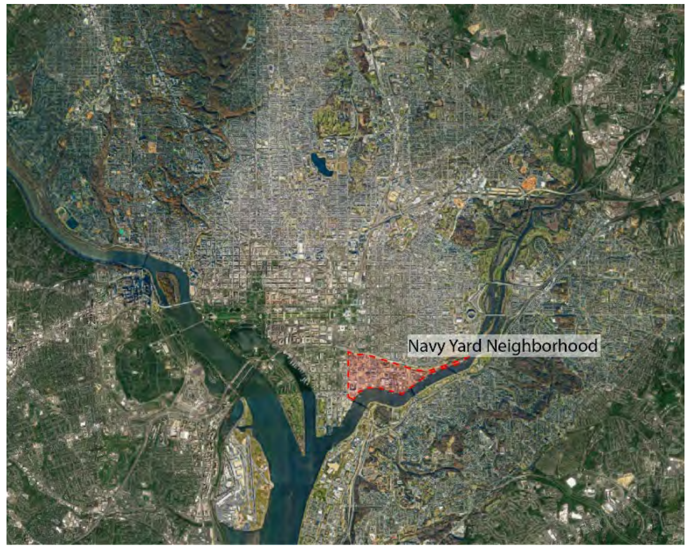


Figure 21: Washington D.C. Navy Yard Neighborhood (Source: Author)

Established in 1799, the Washington D.C. Navy Yard was built to be the nation's largest naval shipbuilding facility. The neighborhood is located on the northern banks of the Anacostia River, just south of Interstate 695 and bounded by South Capitol Street on the western edge. The Navy Yard was Washington, D.C.'s first industrial district, and thrived as a nautical hub for most of the ninth century. The wharfs of the Navy Yard were quickly surrounded by commercial districts, industrial centered businesses, and prospering neighborhoods.

Figure 22: Navy Yard District after World War II (Source: Google Earth)

As the nation started to become involved in the first World War, the Navy Yard turned from mainly ship production to producing weaponry and military machinery. By the end of World War II, the Navy Yard district had hit its peak in production and was comprised of one hundred and thirty-two buildings that spanned over a hundred and twenty-seven acres. After World War II the Navy reduced its operations in the Navy Yard as there was less demand for weaponry and military machinery. The economy of the Navy Yard quickly began to deteriorate as there was less naval work, the pollution of the Anacostia River increased, and work on Interstate 395 began. For many years the Navy Yard was a neglected part of Washington D.C. that was dominated by crime and adult entertainment.

With the construction of the United States Department of Transportation (U.S. DOT) office complex in 2007 and Nationals Park in 2008, the Navy Yard neighborhood has seen a complete transformation. Shortly after these projects were completed the Navy Yard began to see a rapid increase in the development of commercial and residential developments, public parks, and the Anacostia Riverwalk trail system. Today the Navy Yard neighborhood is still home to the United States Navy's longest continuously operated federal facility, keeping the history and identity of the neighborhood alive as the area continues to develop and change rapidly.

Figure 23: Map of the Navy Yard Neighborhood showing the Nationals Park, DOT Complex, Navy Complex, and thesis site (Source: Author)

4.2 Site History

The site selected for this thesis is located a block from the Anacostia River waterfront in the Navy Yard neighborhood, located north of Tingey Street SE, west of 3rd Street SE, east of New Jersey Avenue SE, and south of the DOT complex. Building 170, historically known as "Electric Substation, Sub-Station B & Shop 5 Erecting[19]" is one of the last sites in the neighborhood that has not been adapted, rehabilitated, or demolished for new construction. Building 170 covers about eight thousand square feet and sits on about thirty-seven thousand square feet of plaza space adjacent to the U.S. DOT and Federal Highway Administration building complex.

Figure 24: Building 170 in September 2019 (Source: Author)

[19] United States Depatment of the Interior National Park Service. April 2007 (updated October 2007). National Register of Historic Places Registration Form. Accessed October 27, 2019.

Building 170 was constructed in 1919 as part of the United States Navy industrial complex, also known as the Navy Yard Annex, as a direct result of the nation's involvement in World War I. It was used following World War I and during World War II for the production of naval weaponry and ordnance technology, serving as a critical piece of day-to-day operations, housing switching equipment for the control of ordnance production machines.[20] After the wars, when the Navy downsized the Navy Yard industrial complex, Building 170 was transferred to the General Services Administration (GSA) along with fifty-five acres of land in 1963. GSA planned to redevelop their newly acquired fifty-five acres of land for offices and

Figure 25: Building 170, the Boilermaker Shops, the Foundry Lofts, and the Lumber Shed at the Yards Park in 2003 (Source: https://www.jdland.com/)

Figure 26: Building 170, the Boilermaker Shops, the Foundry Lofts, and the Lumber Shed at the Yards Park in September 2004 (Source: https://www.jdland.com/)

[20] United States Depatment of the Interior National Park Service. April 2007 (updated October 2007). National Register of Historic Places Registration Form. Accessed October 27, 2019.

mixed-use spaces for federal agencies. Part of GSA's vision for the redevelopment was to adapt the existing structures left over from the Annex industrial period but many of the buildings never got the opportunity to be transformed under GSA.

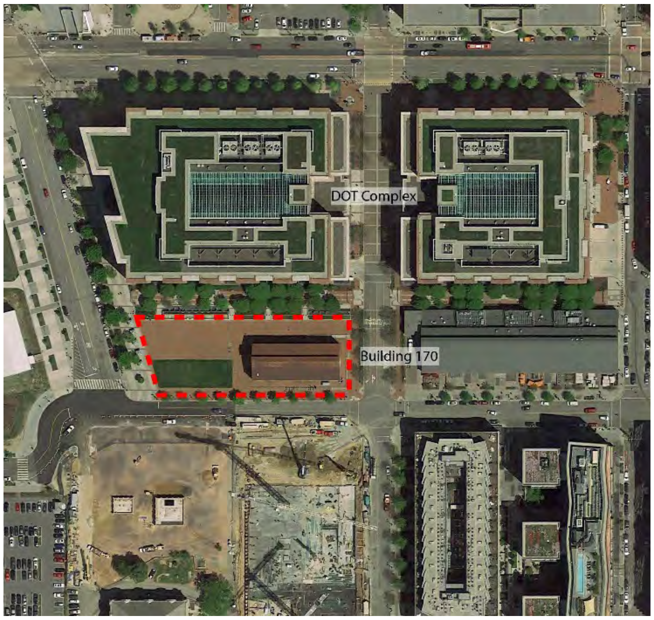


Figure 27: Site adjacent to DOT complex surrounded by new construction (Source: Author)

In 2006, as construction began on the new U.S. DOT complex that is adjacent to the thesis site, upgrades were made to the property surrounding Building 170. These upgrades included the installation of fountains, landscaping, and brick pavers to create a minimal plaza around Building 170. Currently, the U.S. DOT uses the strip of the plaza between their complex and Building 170 as an educational experience titled "Transportation Walk: The Evolution of America on the Move." Objects that have been a part of our nation's history of transportation are placed throughout the plaza, there is a series of three posted from the early 1900s that advertise different means of transportation on the north side of Building 170.

Figure 28: Condition of Building in September 2019 (Source: Author)

On January 3, 2008, Building 170 was designated as one of fifteen contributing properties to the Washington Navy Yard Annex Historic District, the boundary increase to the Washington Navy Yard Historic District that was listed on the National Register in 1973 and designated as a National Historic Landmark in 1976. Building 170 has been deemed historically significant for its integral part of the industrial complex at the Navy Yard Annex and its physical representation of the Navy Yard's expansion as a result of World War I, showing a similar design, scale, and materials to other buildings that were built as part of the Navy Yard and Navy Yard Annex[21]. Building 170 is also architecturally significant for its illustration of early-twentieth-century power plant facilities. The following is the official National Register of Historic Places description of Building 170:

> "Building 170 is a three-story, linear, masonry building six structural bays (50 feet) in width and ten structural bays (125 feet) in length. The building is capped by a gable roof with a monitor at the ridge, a configuration that provides for the maximum natural light and efficient ventilation for the interior. The monitor features full-length glazing set in original multi-light industrial steel windows, as does the upper-most story of the north and south elevations. Both the roof of the monitor and that of the main portion of the building is clad in standing-seam metal. Brick pilasters delineate the fenestration present on all elevations. In contrast to the horizontal bands of windows present in the monitor and at the upper-most story

[21] United States Depatment of the Interior National Park Service. April 2007 (updated October 2007). National Register of Historic Places Registration Form. Accessed October 27, 2019.

of the north and south elevations, windows throughout the rest of the building occur as tall groupings (spanning two or more stories) and emphasize the verticality of the building. Original vehicular openings fitted with roll-up doors are centrally located at the first story of the east and west elevations. Modifications to the south elevation include sheet metal patching and brick infill of openings.[22]"

Figure 29: Interior of Building 170 (Source: Developer Kelly Silverman)

Today the Colonial Revival steel-framed building stands vacant and neglected besides a weekly farmer's market that occurs every Saturday, weather permitting, on the plaza, and sometimes spills into the existing structure. The façade is covered in a locally-sourced red brick and is exposed to the steel-framed construction on the interior.[23] The metal shed roof and continuous ridge monitor are exposed in the open interior of the space as are the unpaved, dirt floors.

4.3 Site Selection Process

The site selection process for this thesis began by exploring areas of the east coast that have a high concentration of existing structures that have been neglected and/or have fallen into disrepair. To support this thesis, it was important to look for an existing structure with a historical presence in an area of economic stability,

[22] United States Depatment of the Interior National Park Service. April 2007 (updated October 2007). National Register of Historic Places Registration Form. Accessed October 27, 2019.
[23] District of Columbia Office of Planning. 2009. "District of Columbia Inventory of Historic Sites." District of Columbia, 229. Accessed October 27, 2019.

accessibility, and a connection to the surrounding community. Exploration began by looking into the navy yards, port areas, and neglected industrial sites of Baltimore, Boston, Philadelphia, New York, and Washington D.C. by analyzing the surrounding neighborhood and the area's plan for development. Many of these neighborhoods/sites have been redeveloped in recent years or have a master plan for redevelopment but few of them showed current economic stability for a community-centered program that will bring new life to an existing, neglected structure.

The Navy Yard of Washington D.C. showed room for a community program in an economically stable fabric that has undergone immense development since the construction of Nationals Park and the Department of Transportation complex in the mid-2000s. Because of the recent development, few existing buildings have not been adapted or preserved. Building 170, just south of the Department of Transportation complex, and Building 202, located just outside the Navy Yard complex, are the two

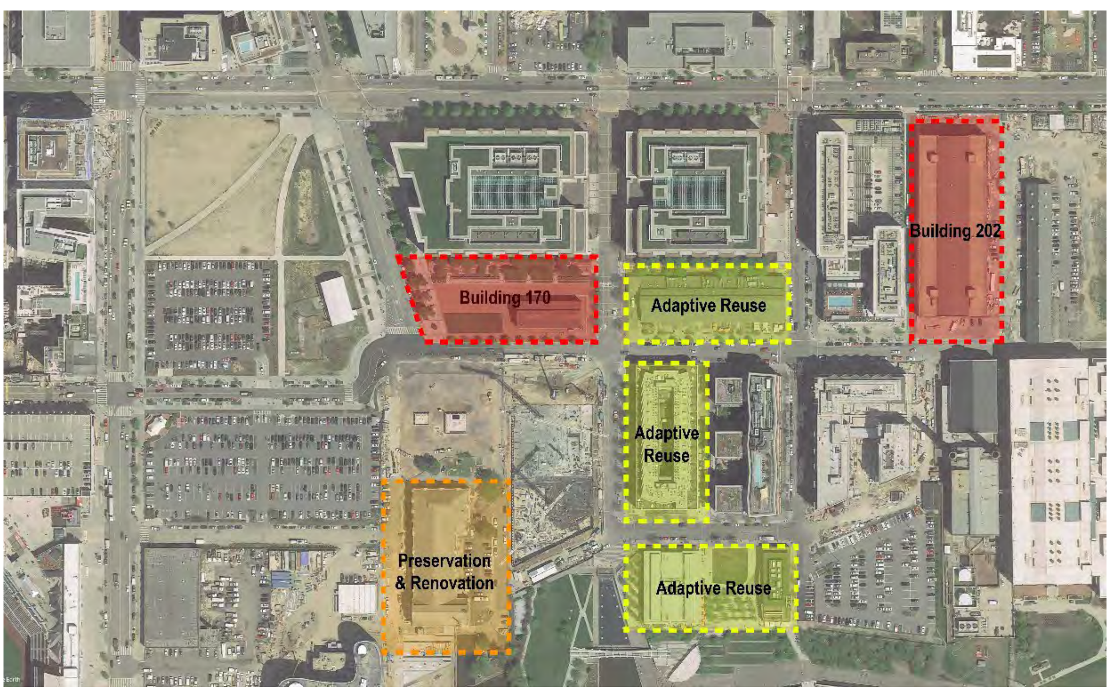


Figure 30 Existing buildings of the Washington D.C. Navy Yard neighborhood (Source: Author)

remaining buildings of the Navy Yard neighborhood that have not been adapted or preserved.

Building 170 proved to be a promising site option for this thesis because of its historic significance to the Navy Yard neighborhood, accessibility, and urban context. As one of the fourteen contributing properties to the Washington Navy Yard Annex Historic District, Building 170 has the potential to support the adaption of an existing structure to become a building that supports and encourages community connection.

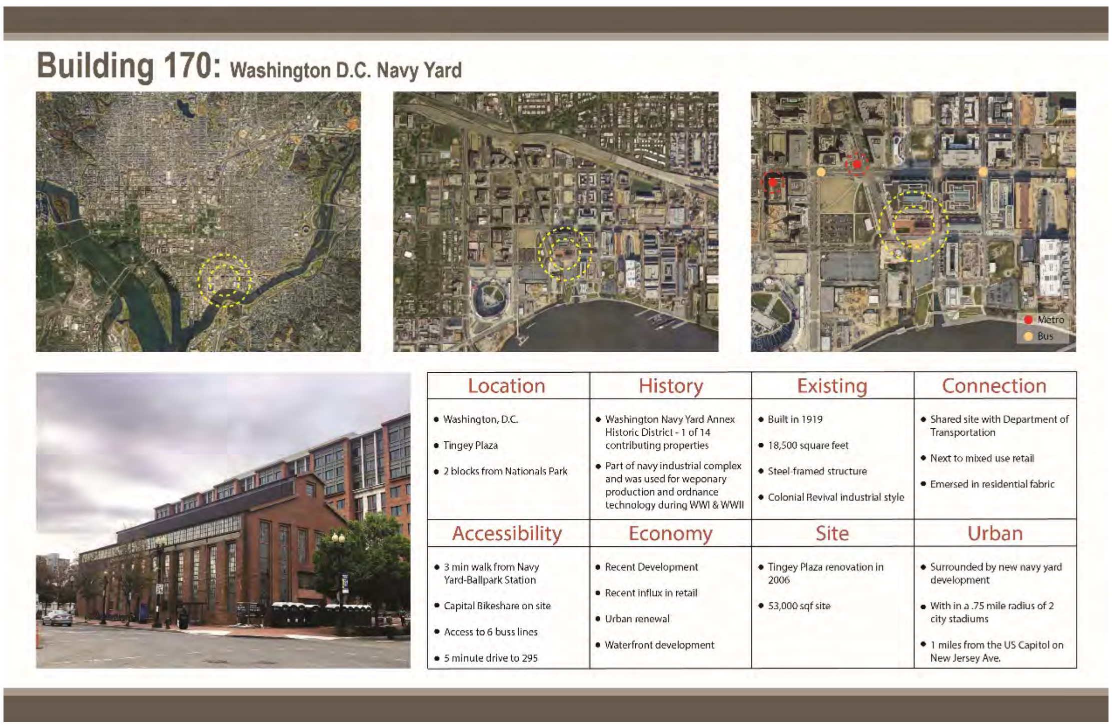


Figure 31: Site Breakdown of Building 170 (Source: Author)

Baltimore's Port Covington is another site option that showed strong potential to have an existing structure that could support this thesis. Over the last two decades, there have been many proposals to redevelop the Port Covington area from an industrial waterfront to a neighborhood with offices, residential, shopping, restaurants, and waterfront properties. Recently Sagamore Development, a private real estate firm owned by Under Armour CEO Kevin Plank, has come up with a master plan for the area that includes a new state-of-the-art campus for Under Armor. The first phase of construction is scheduled to begin in January of 2020 and the redevelopment of Port Covington will be underway. This masterplan by Sagamore Development aims to demolish many of the existing buildings on the site to make way for new buildings that fit the master plan. An existing structure on this site that is set for demolition could be saved and adapted to stand as a precedent for reusing existing structures as a sustainable construction option.

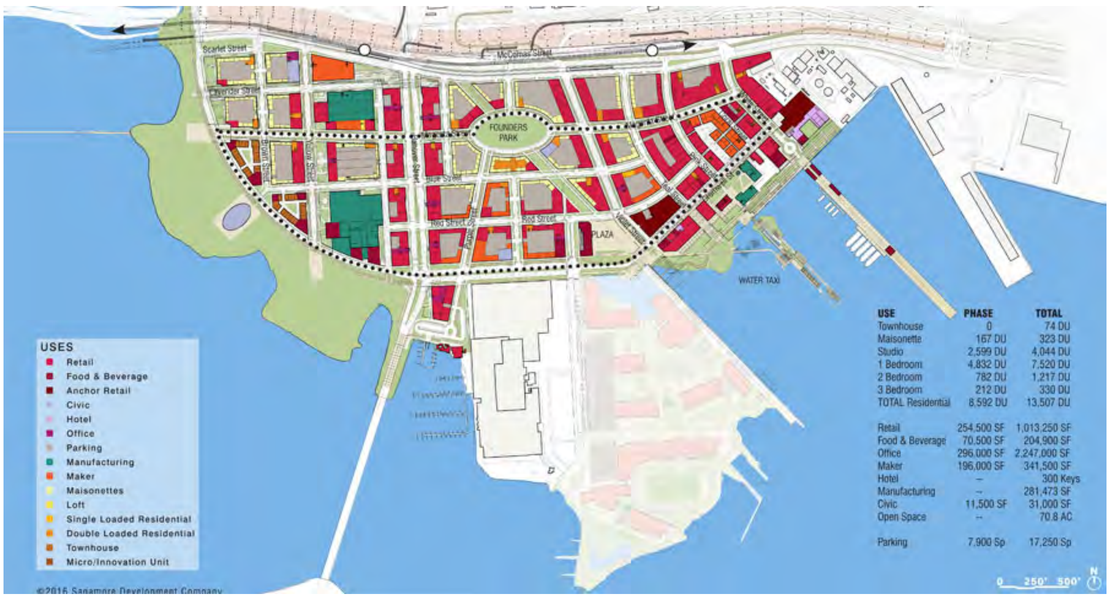


Figure 32: Sagamore Development's Master Plan for Port Covington (Source: Baltimore Sun)

The existing industrial building in the northwest corner of the Port Covington site shows the potential to illustrate the benefits of reusing an existing structure for sustainable construction and environmental benefits. The building sits just south of Interstate 95 and west of the Port Covington exit ramp. In Sagamore’s masterplan of Port Covington, this building will be demolished to make way for a civic, mixed-use program. As this site will be surrounded by 1.38 million sqft office, 337,450 sqft of retail, 976,667 sqft of residential, and 285,000 sqft of hotel in twelve city blocks of development, the existing building could be adapted to represent the industrial history of the Port Covington area and be an example for the future development of this area to show the benefits of reusing an existing structure.

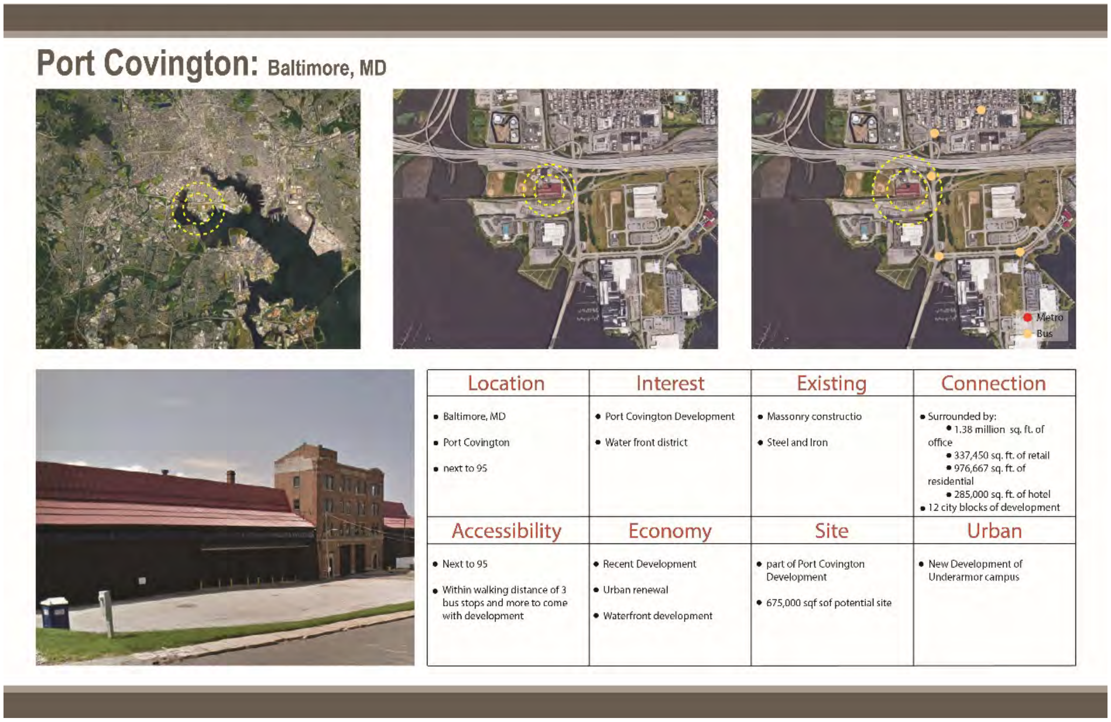
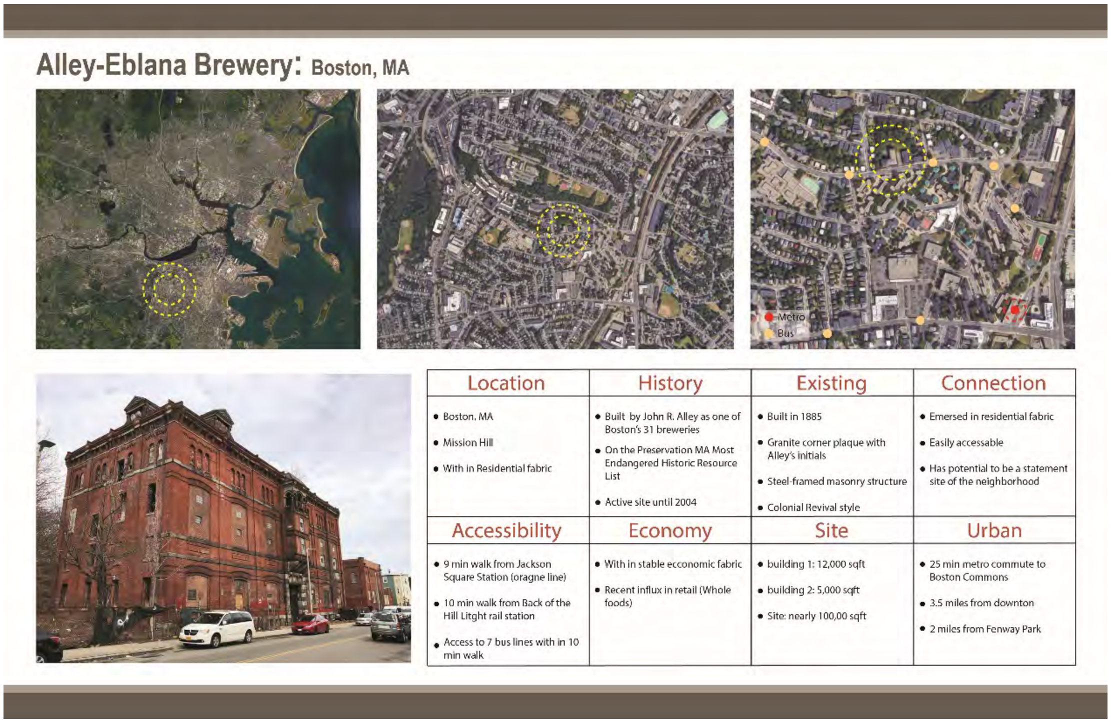


Figure 33: Site Breakdown of Port Covington (Source: Author)

Boston, Massachusetts' naval and industrial history provided many sites throughout the city to research and explore as possible site options. The Charleston Navy Yard, the Seaport neighborhood, abandoned mill buildings, and abandoned breweries are all viable contenders as a possible site to support this thesis. Ultimately, the Alley-Eblana Brewery in the Mission Hill neighborhood stood out as a great site option for this thesis to explore sustainable adaptive reuse within a residential fabric. The Alley-Eblana Brewery site is different from the Washington D.C. site and Baltimore site because it sits in a fabric of mostly single-family residential homes. The Alley-Eblana Brewery was built as one of Boston's thirty-one breweries in 1895. Today it is on the Preservation Massachusetts' Most Endangered Historic Resources

List and has sat vacant since 2004. This site has the potential to become the center of the community due to its connection and accessibility to the surrounding community.



Location	History	Existing	Connection
• Boston, MA • Mission Hill • With in Residential fabric	• Built by John R. Alley as one of Boston's 31 breweries • On the Preservation MA Most Endangered Historic Resource List • Active site until 2004	• Built in 1885 • Granite corner plaque with Alley's initials • Steel-framed masonry structure • Colonial Revival style	• Emersed in residential fabric • Easily accessable • Has potential to be a statement site of the neighborhood
Accessibility	**Economy**	**Site**	**Urban**
• 9 min walk from Jackson Square Station (oragne line) • 10 min walk from Back of the Hill Litght rail station • Access to 7 bus lines with in 10 min walk	• With in stable ecconomic fabric • Recent influx in retail (Whole foods)	• building 1: 12,000 sqft • building 2: 5,000 sqft • Site: nearly 100,00 sqft	• 25 min metro commute to Boston Commons • 3.5 miles from downton • 2 miles from Fenway Park

Figure 34: Site Breakdown of Alley-Eblana Brewery (Source: Author)

Overall, each of the sites, Building 170 in the Washington D.C. Navy Yard; Port Covington in Baltimore, Maryland; and the Alley-Eblana Brewery in the Mission Hill neighborhood of Boston, Massachusetts have qualities that can support this thesis to show the sustainable benefits of adaptively reusing an existing structure. In the site matrix below (*Figure 19)*, each building has been given a numerical ranking to compare the site's properties and characteristics to analyze which of the three sites will best support this thesis. The three most important characteristics of the site are its historical presents, the quality and importance of the existing structure, and the economic stability of the surrounding area. With the intent for the site's program to benefit, educate, and connect the surrounding community it is important for the building to express the history of the area, promote the identity of the community, and be supported by the existing economy in the area. Other characteristics of the site that have been analyzed are the site's accessibility, connection, surrounding context, and buildable space.

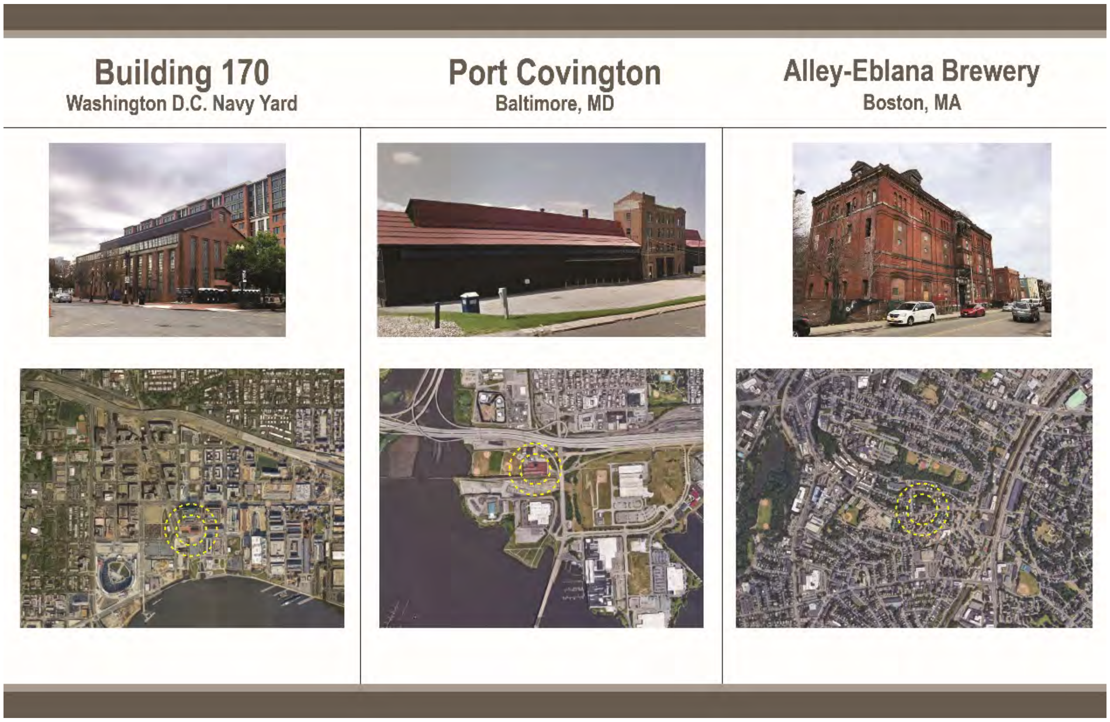


Figure 35: Comparison of Building 170, Port Covington, and Alley-Eblana Brewery (Source: Author)

		Building 170 Washington D.C. Navy Yard	Port Covington Baltimore, MD	Alley-Eblana Brewery Boston, MA
Historical Presents	4	4	2	4
Existing Structure	4	3	2	4
Point of Interest	2	2	1	1
Connection to Community	3	3	3	3
Accessibility	2	2	1	2
Economic Stability	4	4	4	2
Buildable Space	2	2	2	2
Urban Context	1	1	1	.5
Total	22	21	16	18.5

Figure 36: Site Matrix (Source: Author)

4.4 Site Analysis

Today, Building 170 is immersed in a very different fabric than the Navy Yard's original industrial context. Since the construction of the Department of Transportation complex and Nationals Park in 2008, the Navy Yard neighborhood has experienced rapid growth in the area's development. Building 170 is one of the few properties left in the neighborhood that has not been purchased for development and/or redevelopment.

Currently, the Navy Yard neighborhood is home to ten thousand five hundred residents in six thousand eight hundred existing units and will be home to thirty thousand residents at full build-out, with five thousand one hundred units currently under construction.[24] The neighborhood contains two major league sports stadiums: Nationals Park, home of the Washington Nationals, completed in 2008, and Audi Field, home to the D.C. United, completed in 2018. These stadiums are immersed in four hundred eighty thousand square feet of retail fabric and four hundred twenty thousand square feet of retail that is currently under construction. The Navy Yard neighborhood currently contains a Harris Teeter and Whole Foods market among many restaurants and retailers. At full build-out, the Navy Yard will offer sixty restaurants and thirty-four retailers. There are also nineteen existing office buildings in the Navy Yard neighborhood with two office buildings currently under construction and five office buildings proposed to break ground in the next five years to hold thirty-five thousand employees over 6.5 million sqft[25].

[24] Capitol Riverfront BID. 2019. Capitol Riverfront. Accessed November 11, 2019
[25] Capitol Riverfront BID. 2019. Capitol Riverfront. Accessed November 11, 2019

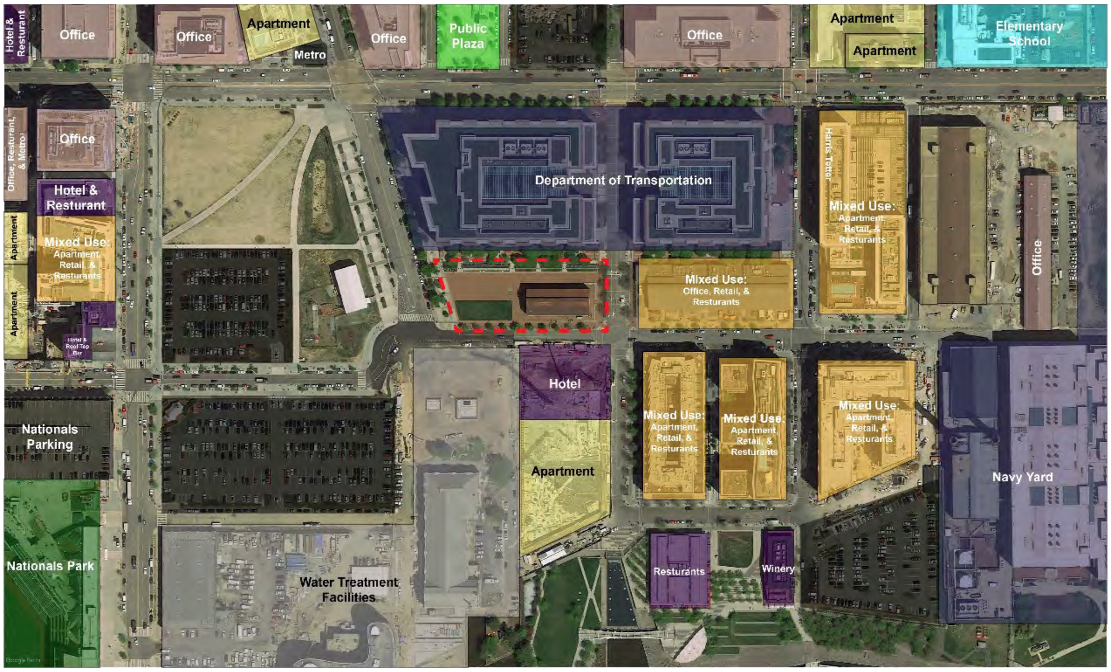


Figure 38: Land use of the Navy Yard neighborhood (Source: Author)

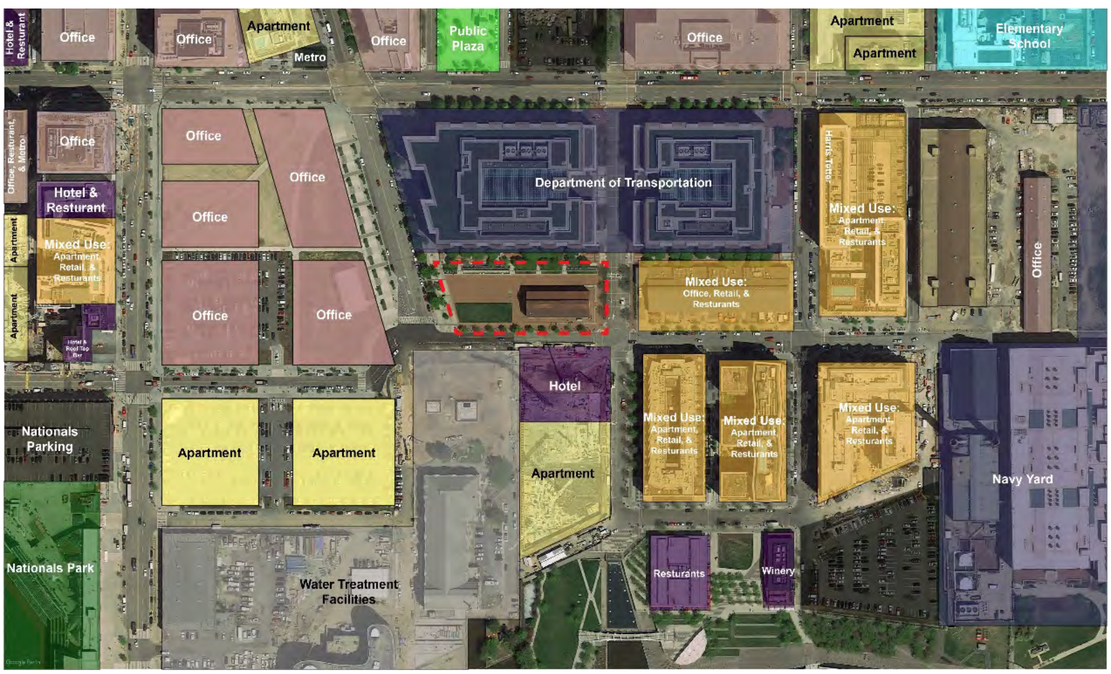


Figure 37: Future land use of the Navy Yard neighborhood (Source: Author)

The Navy Yard neighborhood is just six blocks from the capitol easily accessible by many different forms of transportation. The neighborhood is just a ten-minute drive from Ronald Reagan Washington National Airport off Interstate-295, Interstate-395, and Interstate-695. It is easily accessible by ten Washington

Metropolitan Area Transit Authority (WMATA) bus routes, the Circulator bus, and four metro lines, mainly the green line. The neighborhood contains fifty dock slips, eight Capital Bikeshare docks, and a variety of scooter shares.

Building 170 shares a site with a Capital Bikeshare docking station, just on the south side of the building. The site is within a ten-minute walking radius of six WMATA bus stops and a three-minute walk from the green line Navy Yard-Ballpark Station. Building 170 is a five-minute drive from Interstate-295, Interstate-395, and Interstate-695.

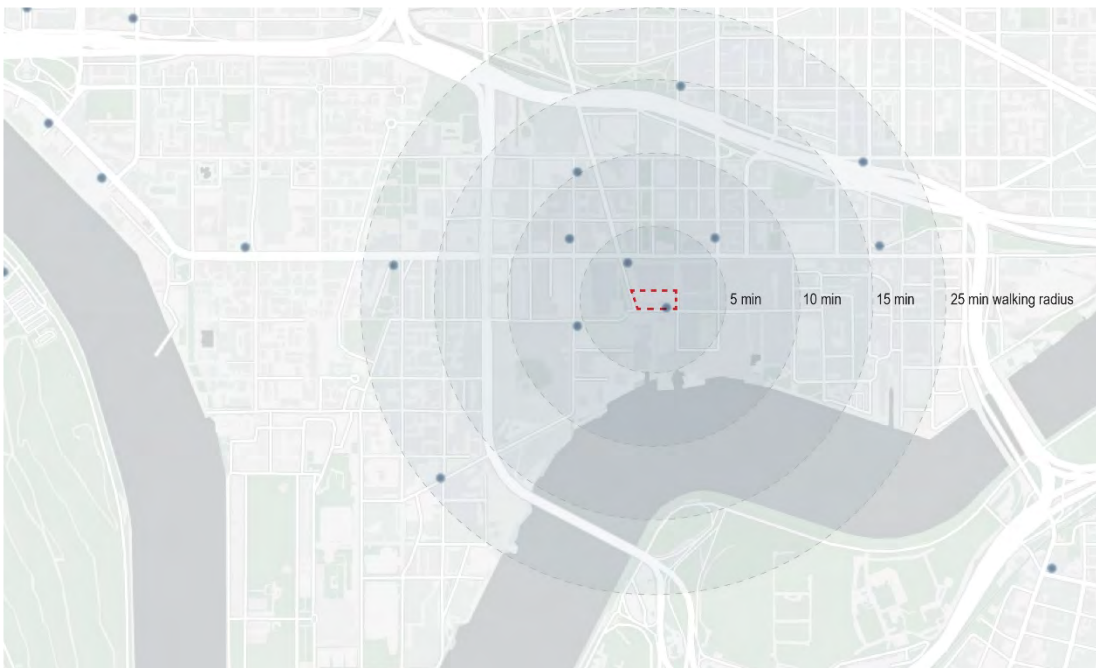


Figure 39: Walking radius to Capital Bikeshare locations (Source: Author)

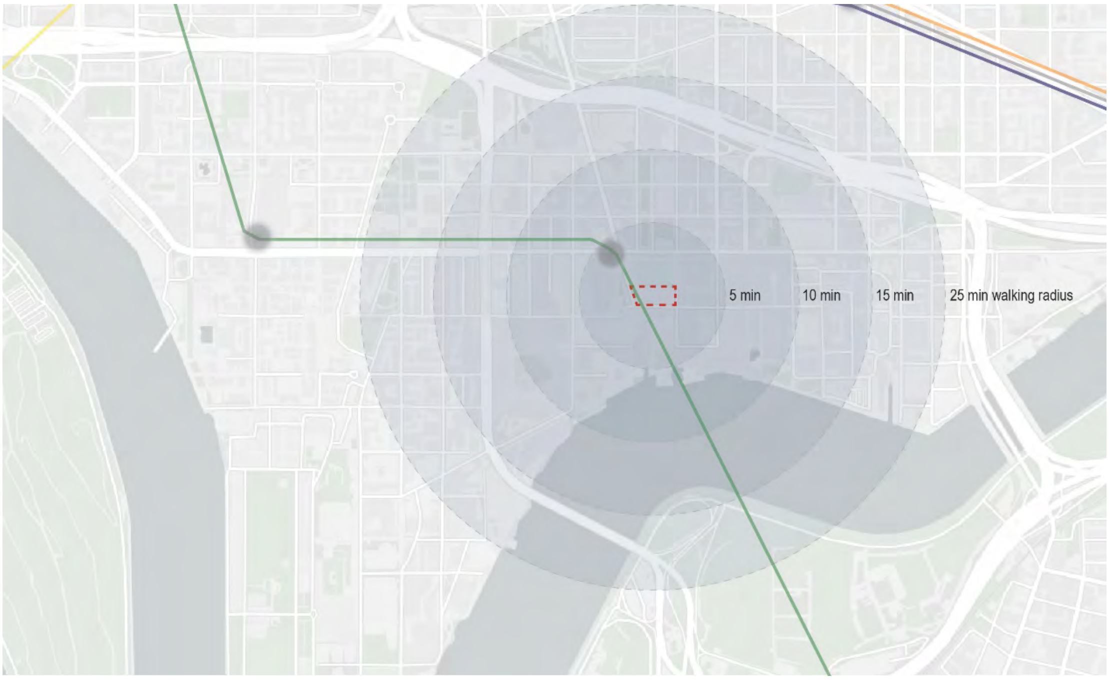


Figure 41: Walking radius to metro stops (Source: Author)

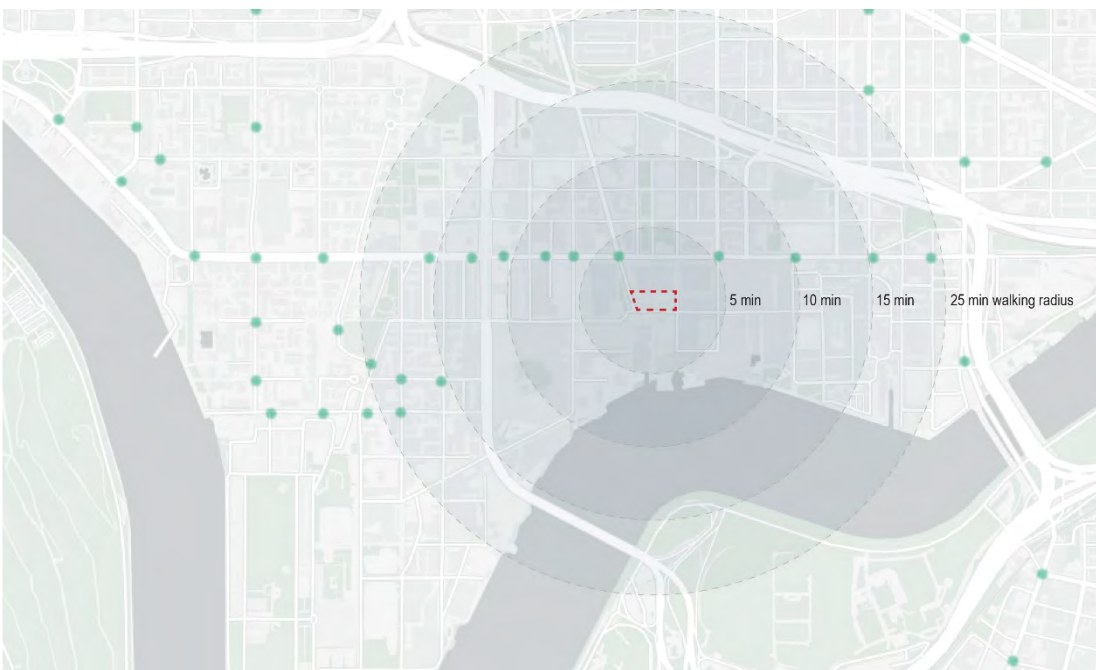


Figure 40: Walking radius to bus stops (Source: Author)

Chapter 5 Preservation and Adaptive Reuse Regulations

5.1 Introduction

Preservation is defined by the National Park Service and U.S. Department of the Interior "as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of a historic property.[26]" Whereas adaptive reuse is the process that transforms an unused or ineffective item into a new item that is used for a different purpose when the original cannot support the item anymore. Adaptive reuse is a creative means to recycling the existing and the best adaptive reuse practices are respectful to the buildings original purpose, highlight the building architectural features, and express the buildings historical significance, especially when the site has been deemed historic at any level; national, state/district, and/or local. As the site of this thesis, Building 170, is one of fifteen contributing properties to the Washington Navy Yard Annex Historic District, some regulations should be considered at the federal and district levels to properly adapt the structure and honor the building's history.

Historic preservation is regulated at three levels: Federal, State, and local. The government began regulating historic properties with the establishment of the US National Trust for Historic Preservation in 1949. In 1966 the Nationals Historic Preservation Act was passed, giving the Secretary of the Interiors a detailed role in

[26] National Park Service U.S. Department of the Interior. n.d. Preservation as a Treatment and Standards for Preservation-Technical Preservation Services, National Park Service. Accessed December 10, 2019.

the national preservation process and created the National Register of Historic Places, State Historic Preservation Offices, and Section 106 Review process.

5.2 Federal Benefits and Regulations

Because Building 170 is a contributing property to a National Registered Historic District the site is considered in federal planning, eligible for tax credits, and eligible for federal grants for historic preservation. Building 170 and the entire Navy Yard Annex District must be considered by federal agencies, federally licensed, and federally assisted projects under Section 106 of the National Historic Preservation Act of 1966, allowing the Advisory Council on Historic Preservation (ACHP) to comment and defend the district from being affected by federal projects. This process is how Building 170 and its neighbor, The Boilermaker Shops, were maintained at their existing condition when the Department of Transportation complex was constructed in 2006.

As a contributing property to the Navy Yard Annex Historic District, Building 170 is eligible for twenty percent tax credit for certified rehabilitation of income-producing certified historic structures. These tax credits can be combined with a straight-line depreciation period for thirty-one and a half years for the depreciable basis of the rehabilitated building reduced by the amount of the tax credit claimed.[27] The site is also eligible for federal grants when funding is available.

Since the property is not under federal ownership, there are no restrictions placed on the property just because it is a contributing property to a National

[27] *National Parks Service. n.d. National Register of Historic Places FAQs. Accessed December 12, 2019.*

Registered Historic District. If the property is to use federal assistance in the form of grants and/or tax credits, then the Advisory Council on Historic Preservation must be given an opportunity to comment on the project.

5.3 District of Columbia and Southeast Federal Center Local Regulations

With Building 170 originally being a federally owned property that has been turned over to a private developer it is now managed through a master plan, historic covenant, programmatic agreement, and design guidelines making Building 170 one of the more complicated properties in the District of Columbia. Under the Southeast Federal Center Revised Master Plan, established in 2003, the Southeast Federal Center (SFC) was proposed to be developed as a mixed-use neighborhood of residential, office, retail, recreational, and cultural uses[28]. To avoid, minimize, and mitigate adverse effects on any historic properties in the SFC, local Historic Preservation Design Guidelines were established with the consultation of the District of Columbia SHPO and ACHP to guide to historic structures of the revised master plan.

"Adverse Effect" is defined in the SFC design guidelines as "the effect of an undertaking on a resource that diminishes the integrity of the resource's location, design, setting, materials, workmanship, feeling or association.[29]" Building 170 and all new construction adjacent to Building 170 will be reviewed under the Historic Preservation Design Guidelines. The preservation design goals of the design

[28] 2003, edited June 2007. "Historic Preservation Design Guidelines for Development of the Southeast Federal Center." Washington D.C. Office of Planning. Accessed December 13, 2019.
[29] 2003, edited June 2007. "Historic Preservation Design Guidelines for Development of the Southeast Federal Center." Washington D.C. Office of Planning. Accessed December 13, 2019.

guidelines are to preserve National Register-Eligible historic structures, create a visual relationship between historic buildings, and establish an area of special architectural character that enhances the historic context. Building 170 is a contributing property to a National Register Historic District but has not been deemed a National Register-Eligible property, meaning that under these guidelines Building 170 is of the historic buildings that should be visually connected and enhances the historic context of the area but its not one of the six properties under the SFC design guidelines that must be preserved.

Building 170 can be adapted properly, complying with the Programmatic Agreement and Historic Covenant of the District of Columbia as stated below:

> "• The treatment of fenestration may vary depending on the significance and condition of the historic fenestration or building, or on the practicability of repair versus replacement. Potential treatments of historic fenestration include retention and repair, replacement to match the existing configuration and muntin detailing, or replacement recalling the configuration and detail of the historic fenestration.
>
> • Alterations to building facades may include some adjustments to the sizes of existing masonry openings (for example, as shown in the illustrative diagrams). Enlargement of infilled masonry openings to their historic configuration is encouraged.
>
> • Existing masonry will be cleaned in a manner consistent with the Secretary's Standards. Exposed masonry will generally not be painted and will be repaired and repointed only as necessary. Repairs will be undertaken with masonry units and mortar that match or are compatible with their original counterparts.
>
> • Existing character-defining rooflines, monitors, skylights, ventilators, and other significant features will be maintained where possible. Original roofing materials will be repaired where possible and replaced in kind where necessary. New mechanical equipment and penthouses will be located and designed to minimize visual impact.

- Planned building additions will be compatible with the original building in form, materials, and color, per the Secretary's Standards.
- Removal of Non-Contributing additions will be undertaken so as not to damage the building or leave unsightly scars. Original fabric exposed through the removal of additions will be generally restored to its original configuration.
- Alterations needed to address floodplain issues require careful consideration and will be reviewed on a case-by-case basis.[30]"

[30] 2003, edited June 2007. "Historic Preservation Design Guidelines for Development of the Southeast Federal Center." Washington D.C. Office of Planning. Accessed December 13, 2019.

Chapter 6 Mass Timber

6.1 Introduction

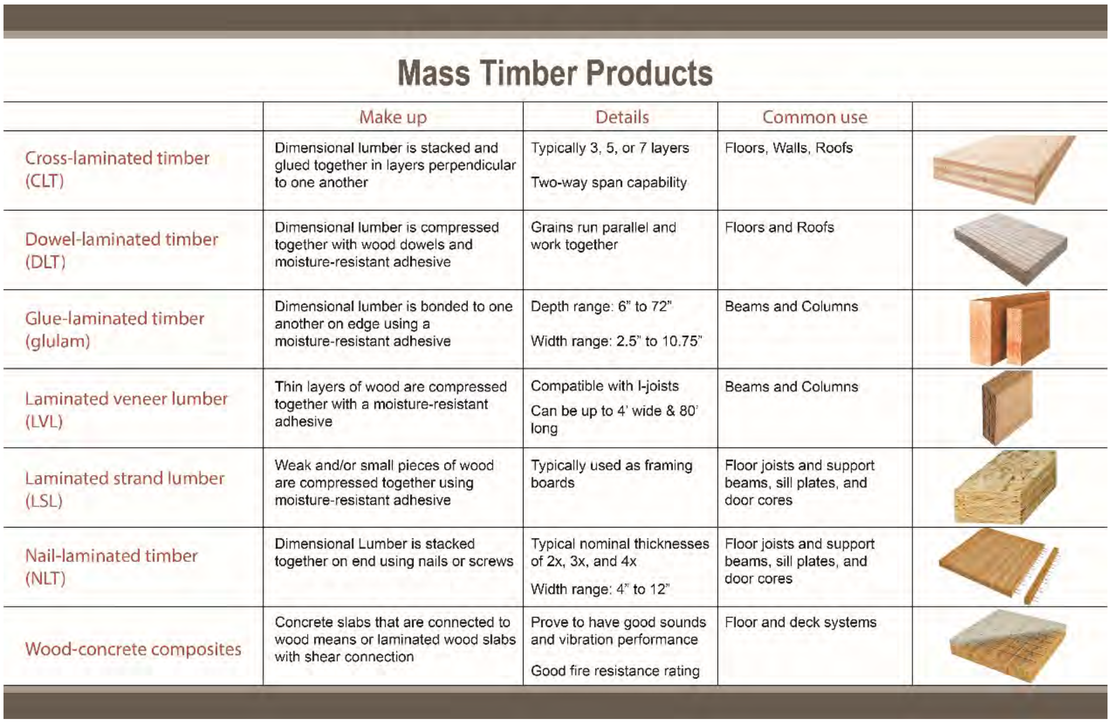
In a period of climate change, it is important to take advantage of the solutions that are naturally provided to us. Timber has been a primary material of construction since the first timber home was built in the Mesolithic period in Great Britain, dating back to 8000 B.C. Wood construction has proven to be a reliable material as there are still timber structures from nearly a thousand years that are still standing today. In North America, some indigenous people and early settlers relied on timber construction for its efficiency and proximity to settlements. Our continent is covered in trees ready to help us fight climate change. Timber is an organism that helps to remove CO_2 from the atmosphere by collecting CO_2 and storing it within the material over the timber's life cycle. To decrease the levels of CO_2 in the atmosphere we need to maintain existing forest land, increase tree coverage, and harvest wood sustainably.

6.2 What is Mass Timer?

Through mass timber construction, we can not only store CO_2 within our forests, but we can also remove CO_2 from our atmosphere from the built environment. Mass timber is a construction type of large genetically engineered wood products that are typically made through a process of laminating and compressing multiple layers of

Figure 42: Interior of the Wood Innovation and Design Centre (Source: Ema Peter via Architecture Magazine)

wood together to produce solid pieces of wood. Cross-laminated timber (CLT), dowel-laminated timber (DLT), glue-laminated timber (glulam), laminated veneer lumber (LVL), laminated strand lumber (LSL), nail-laminated timber (NLT), and wood-concrete composites are all mass timber products. The three most commonly used mass timber products are CLT, NLT, and glulam.



Mass Timber Products

	Make up	Details	Common use	
Cross-laminated timber (CLT)	Dimensional lumber is stacked and glued together in layers perpendicular to one another	Typically 3, 5, or 7 layers Two-way span capability	Floors, Walls, Roofs	
Dowel-laminated timber (DLT)	Dimensional lumber is compressed together with wood dowels and moisture-resistant adhesive	Grains run parallel and work together	Floors and Roofs	
Glue-laminated timber (glulam)	Dimensional lumber is bonded to one another on edge using a moisture-resistant adhesive	Depth range: 6" to 72" Width range: 2.5" to 10.75"	Beams and Columns	
Laminated veneer lumber (LVL)	Thin layers of wood are compressed together with a moisture-resistant adhesive	Compatible with I-joists Can be up to 4' wide & 80' long	Beams and Columns	
Laminated strand lumber (LSL)	Weak and/or small pieces of wood are compressed together using moisture-resistant adhesive	Typically used as framing boards	Floor joists and support beams, sill plates, and door cores	
Nail-laminated timber (NLT)	Dimensional Lumber is stacked together on end using nails or screws	Typical nominal thicknesses of 2x, 3x, and 4x Width range: 4" to 12"	Floor joists and support beams, sill plates, and door cores	
Wood-concrete composites	Concrete slabs that are connected to wood means or laminated wood slabs with shear connection	Prove to have good sounds and vibration performance Good fire resistance rating	Floor and deck systems	

Figure 43: Mass Timber Products Matrix (Source: Author)

Figure 44: CLT board (Source: Technology in Architecture)

- CLT panels are made up of dimensional lumber that is stacked and glued together in layers perpendicular to one another. CLTs are made using three, five, or seven layers of dimensional lumber and are most commonly used for floors, walls, and roofs because of its two-way span capabilities.

- DLT is created by compressing dimensional lumber together with wood dowels and moisture-resistant adhesive. Because the grains of the dimensional wood run together in a DLT panel, DLT is most commonly used for floors and roofs.

Figure 45: DLT panel (Source: Meng Gong)

- Glulam is created form bonding dimensional lumber on edge to one another using a moisture-resistant adhesive. A glulam member can come in a standard or custom size. Its depth can range from 6” to 72” and its width can range from 2.5” to 10.75”. Glulam is commonly used for beams and columns in residential and commercial structures.

Figure 46: Glulam beam (Source: bimobject)

- LVL is made from compressing multiple thin layers of wood together with a moisture-resistant adhesive. Because LVL is typically sized to be compatible with I-joists, LVL is typically used for headers, beams, and rim boards. LVL can be up to four feet in width and eighty feet long in size.

Figure 47: LVL (Source: Element Five)

- LSL is made up of pieces of wood that could potentially be too weak or small to stand on its own. These pieces of wood are compressed together using a moisture-resistant adhesive. LSL is typically used as framing boards for floor joists and support beams, sill plates, and door cores.

Figure 48: LSL (Source: European Wood)

- NLT is made from stacking layers of dimensional lumber on end together using nails or screws. NLT is a construction method that has been used for nearly a century and has been designed over time to be more sustainable. NLT typically comes in the nominal thicknesses of 2x, 3x, and 4x with a width ranging from 4” to 12”. It is commonly used for floors and roofs, it has also been used for elevator shafts.

Figure 49: NLT Panel (Source: Meng Gong)

- Wood concrete composites are concrete slabs that are connected to wood beams or a laminated wood slab with a shear connection. Wood concrete composites are typically used as floor and deck systems.

Figure 50: Wood Concrete Composite (Source: Structure Craft)

CLT was created in the 1990s by Gerhard Schichhofer in Austria and grew in popularity throughout Europe over the next decade. In 2002 Austria published its first national guideline for mass timber construction. As mass timber reach grew to Australia, Canada, and the United States it was included in the 2015 edition of the International Building Codes (IBC). Today the tallest mass timber structure, the Mjosa Tower, stands at 280 ft tall in Brumunddal, Norway. This eighteen-story, mixed-use building is made up of CLT and glulam construction. Completed in March 2019, the architect (Voll Arkitekter), the structural engineer (Moelven Limitre), and the timber supplier (Moelven Limitre) used locally sourced timber to create the mass timber products of the building.

Figure 51: Mjøsa tower. (Source: Nina Rundsveen via metalocus.es)

6.3 Sustainable Properties

Historically, just like timber construction, concrete has also been used by ancient civilizations where wood was not as readily available. As concrete and timber materials stood as two of the most popular construction materials throughout history, both had very different impacts on the environment. Concrete remains an unrenewable resource while timber can be reused. With the popularity of steel and concrete construction rising alongside the industrial revolution so did the impact construct has on our environment. It has been found through a study at the University of Washington and Yale University that if the expansion of wood construction was to be limited to the annual growth of wood, the combination of emissions reduction and carbon sequestration of mass timber construction has the potential to eliminate construction emission altogether[31]. Timber buildings require less energy from the harvesting process through manufacturing and construction to the end of the building's life compared to concrete and steel buildings. Because trees grow across our continent, materials for wood construction can be sourced locally to reduce transportation costs and energy. Timber materials also weigh less than steel and concrete construction materials further reducing the impact transportation of construction materials can have on the environment.

Timber is different from steel and concrete because it is a natural material that can be regrown and reproduced. Wood is a renewable, biodegradable, non-toxic, and energy-efficient building material.[32] Mass timber has proven to leave a lighter carbon footprint than other building materials that are more fossil fuel-intensive. The lifecycle of a timber structure proves to produce significantly lower greenhouse gas emissions than other construction types because of its sustainable material properties, transportation, and construction process, and ability to remove

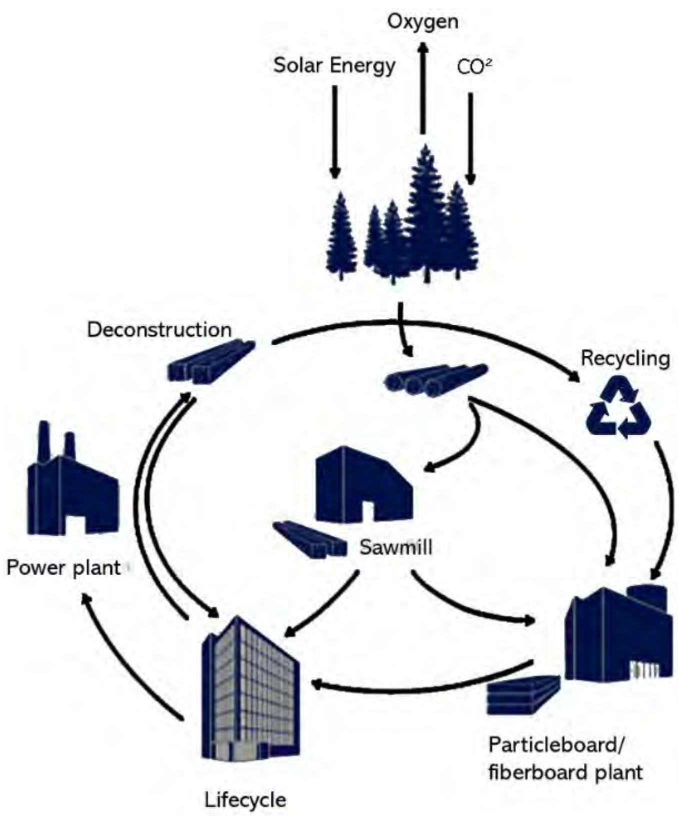


Figure 52: Lifecycle of mass timber construction (Source: Author)

[31] Frank Lowenstein, Brian Donahue, and David Foster. 2019. "Let's Fill Our Cities with Taller, Wooden Buildings." Accessed October 12, 2019.

[32] Evan. 2016. "What Building Material (wood, steel, concrete) Has The Smallest Overall Environment Impact?" Accessed October 13, 2019.

CO_2 from the environment. A study shows that a timber house in both cold and warm climates has 31% less life-cycle emissions that a concrete house and 26% less life-cycle emissions than a steel house.[33] The wood products of a timber structure typically store more carbon than what would be emitted during the harvest, manufacturing, construction, and end-use of the structure making timber structures a reliable weapon against climate change.

Mass timber construction can be a faster, more efficient construction process. According to Bernhard Gafner of Fast + Epp, a structural engineering firm, a mass timber project can be constructed 25% faster, require up to 90% less transportation, and 75% fewer workers on-site than that of a steel and concrete structure.[34] Structurally, mass timber construction has also proven to offer high-performance value in fire protection and seismic resistance. A CLT panel's char rate can meet the two- and three-hour fire resistance code without gypsum protection:

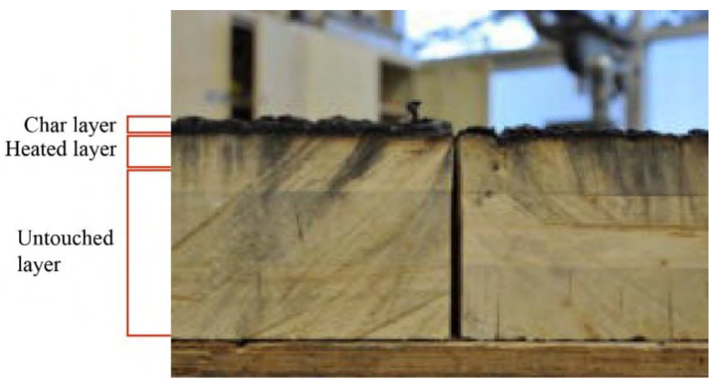


Figure 53: CLT char illustration (Source: Think Wood, Edited by Author)

> "One series of full-scale compartment tests compared the performance of light-gauge steel, light-frame wood, and CLT. Tests included a three-story encapsulated CLT apartment simulation that ran for three hours. Results of the apartment simulation show the effectiveness of encapsulation in significantly delaying CLT's potential contribution to fire growth and proved that the structure can withstand complete burnout. Another test focused on a 25½-foot

[33] "Sustainability." Think Wood. Accessed October 13, 2019.
[34] American Wood Council. n.d. Mass Timber in North America: Expanding the possibilities of wood building design. reThink Wood. Accessed October 13, 2019.

> CLT stair/elevator shaft (exposed on the inside face with two layers of gypsum protection on the fireside) and studied the smoke propagation and leakage as well as its structural stability as a fire exit. The test ran for 2 hours and showed no sign of smoke or heat penetration into the shaft.[35]"

Using CLT components in lateral systems have also been designed to meet the building code standards and have been engineered using advanced performance-based seismic design procedures.

Hopefully, mass timber construction will continue to expand its reach across our profession so that professionals can take advantage of a building material that holds many sustainable properties that can benefit our planet in a period of climate change. We need to realize the impact we have had on our environment over the past couple of centuries and revaluate how we use unsustainable materials so that we can create a better atmosphere for us and the coming generations.

Figure 54: John W. Oliver Design Building at UMass Amherst (Source: auburn.edu)

[35] American Wood Council. n.d. Mass Timber in North America: Expanding the possibilities of wood building design. reThink Wood. Accessed October 13, 2019.

Chapter 7 Architecture Intervention

7.1 Program Selection

As the site of this thesis sits in the Navy Yard neighborhood, a community that is seeing rapid change and development it became apparent that the architecture that has risen in the area has been driven primarily by developers who have not been keeping the civic needs of the people in mind. The area is in dire need of a community space that speaks to the heart of the people who live there and with all the construction going on, the neighborhood still lacks a local community space. A public community library would be a great opportunity for a community space, but the closest permanent public library is the SE neighborhood Library which is a twenty-minute walk from the heart of the navy yard.

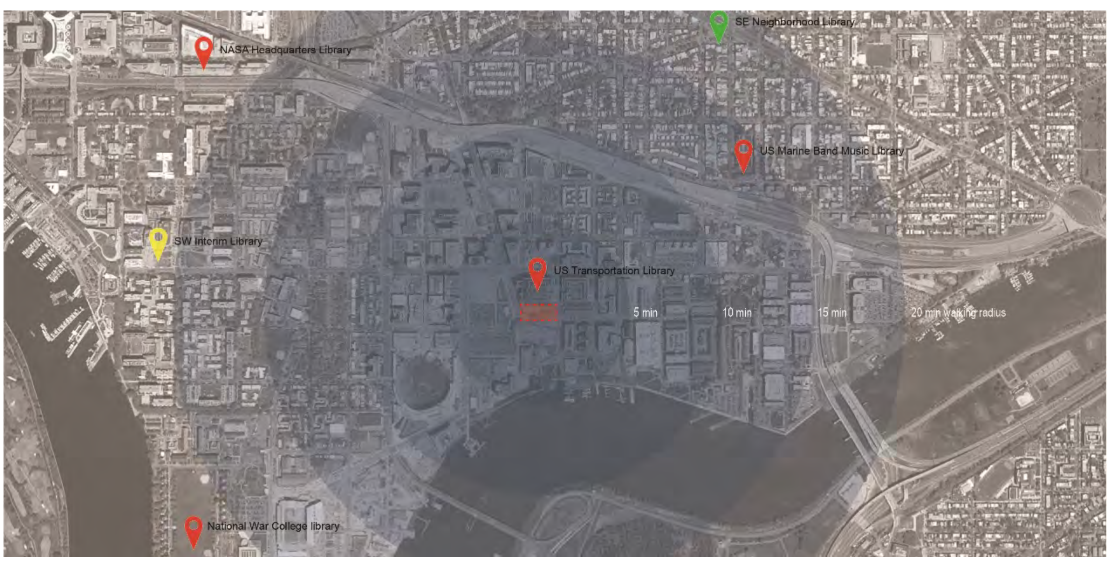


Figure 55: Walking radius to local Libraries (Source: Author)

The site this thesis is where three corridors terminate: N st SE, the corridor that connects the site to Nationals Park; Tingey St SE, the corridor that connects the site to the existing Navy Yard; and most importantly, New Jersey Ave. the corridor that connects the entire neighborhood to the Capitol building that sits just a mile north of the neighborhood. The site's location at the place where these three corridors terminate proves that this site is a natural location for the heart of the Navy Yard community.

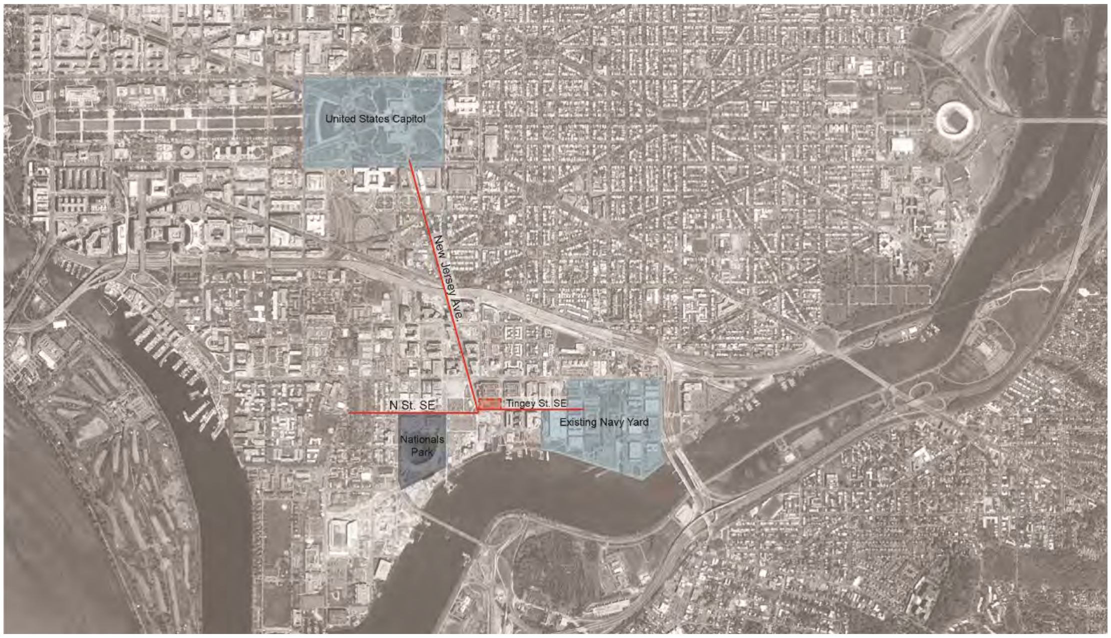


Figure 56: Termination of New Jersey Ave. SE, Tingey St. SE, and N St. SE at the site (Source: Author)

Today the site occasionally takes on its duty for local events while the existing structure, Building 170, stands as a backdrop to these community events. The existing structure stands among new development that has adapted the navy yard and changed its identity making it even more important to keep as many original buildings as possible to maintain the history and original purpose of the area. The new residents to the neighborhood will need a space to claim as their own for community events and engagement giving this thesis the perfect opportunity to proposes that the site of Building 170 takes on its duty at the heart of the neighborhood and becomes a community library and market space.

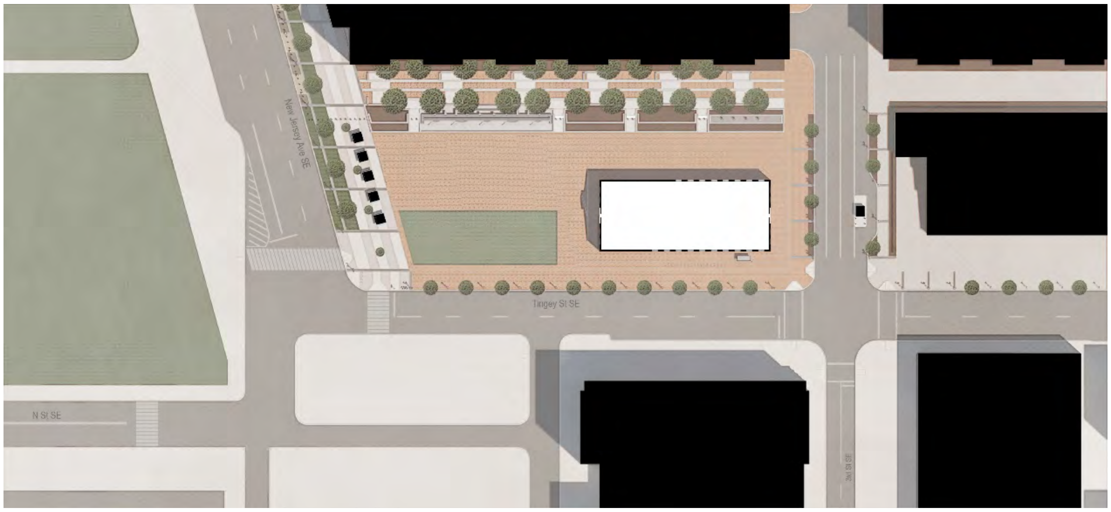


Figure 57: Existing Site Condition (Source: Author)

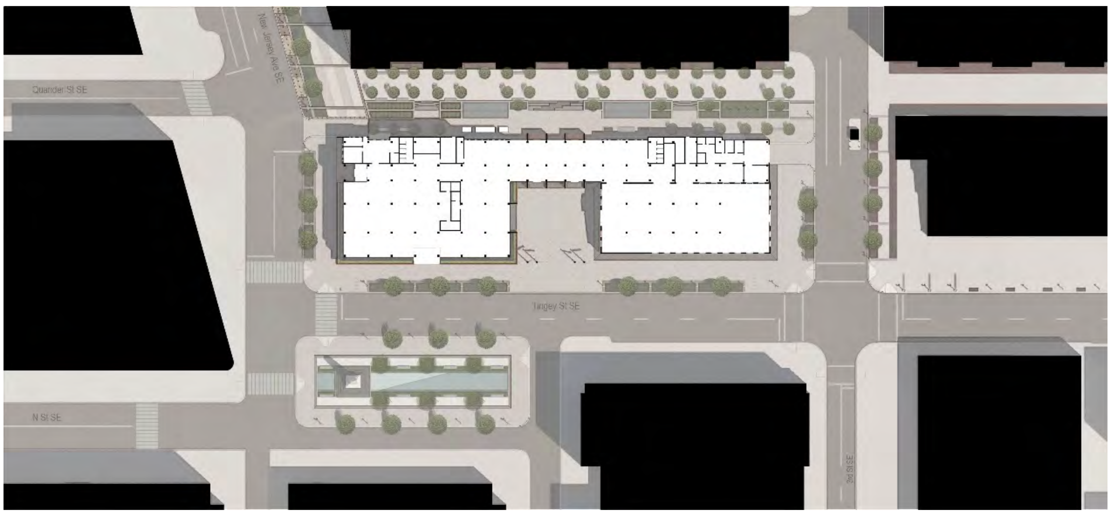


Figure 58: Proposed Site Condition (Source: Author)

7.2 Urban Historic Layers

The design of this thesis centers the two community programs off of a central plaza that allows the programs to flow from the interior to the exterior. The central plaza illustrates the Navy Yard Annex historic district through the existing building, plaza elements, and perforated metal screen on the east façade of the library that illustrates the fifteen contributing properties to the historic district. The plaza could serve many community activities, for example, on a warm Saturday afternoon when the food hall is opened from the interior to the exterior the program could spill out on to the plaza and engage the surrounding community.

Figure 59: Navy Yard Plaza facing Building 170 (Author: Source)

The Navy Yard plaza connects through the building to the Navy Yard transportation history promenade. This promenade walks you through the different forms of transportation that have been created in the Washington Navy Yard Annex in the same way the existing DOT history promenade, which sits parallel to the Navy Yard transportation history promenade, takes you on an experience through the ways transportation have changed throughout the history of our nation. These promenades that sit between the site and the DOT office complex create an opportunity for the community to be reminded of not only local history but also national history through physical elements like travel posters from the nineteenth and twentieth centuries, steamboat pipes, a retired naval ship's anchor, and many other elements that speak to the industrial economy of the Navy Yard Annex and the history of the DOT.

Figure 60: Proposed Site Plan highlighting historic urban elements (Source: Author)

The recently finished plaza that sits south of the site creates the perfect opportunity for a monument that could mark the Navy Yard Annex Historic District while acting as a terminating object that would pull you into the heart of the community from New Jersey Ave. As visitors would proceed down New Jersey the monument would sit in comparison to the entrance of the library portion of the program. The history of the navy yard begins to come to life in the façade of the new structure through the repurposed metal of maybe an old naval ship or a demoed building from the navy yard that has been given new life in a perforated metal screen that illustrates old maps of the area. Figure 62 illustrates how the etchings of a 1935 plan of Washington D.C. on the North West corner of the perforated metal screen begins to take visitors through the history of the area moving to a 1935 master plan of the Navy Yard Annex on the west façade. It is through these urban elements that the design of this thesis speaks to the history of the area and most importantly, honors the site and the existing building while listening to the rapidly growing community that it belongs to.

Figure 61: Perspective looking down New Jersey Ave. towards the site (Source: Author)

Figure 62: Perspective of entrance off of New Jersey Ave. to the library portion of the program (Source: Author)

7.3 Design

As honoring the existing is a driving factor behind the design of the thesis the program of the new building, the library, mirrors that of the existing building, the food hall, connected by a loggia circulation that is continued from floor to floor with the back of house off to the north.

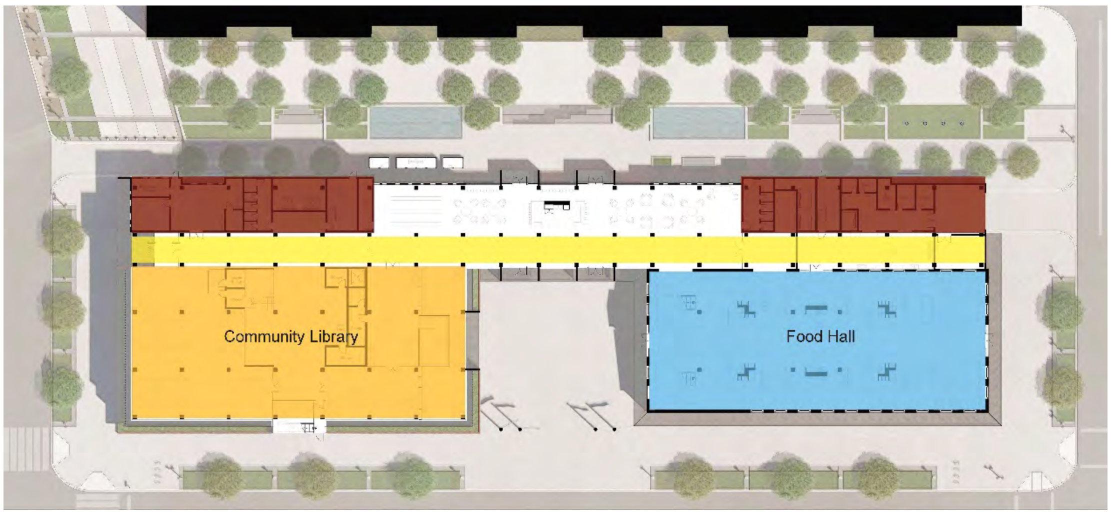


Figure 63: 1st Floor Plan - illustration of program overview (Source: Author)

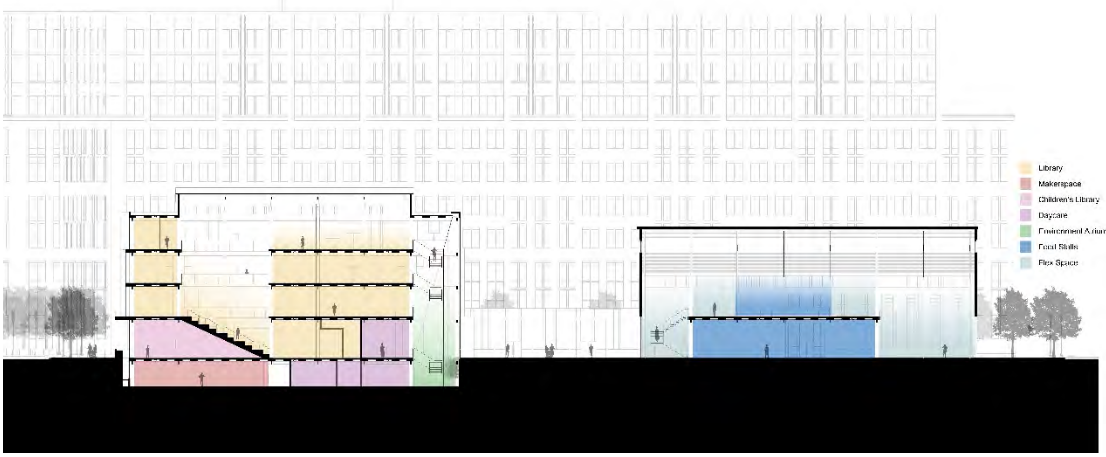


Figure 64: Longitudinal Section - illustration of program (Source: Author)

The longitudinal section through the site illustrated in Figure 64 shows how the primary areas of program stem off the plaza, separated by an atrium and circulation in both the library and food hall. Both buildings stack the program from most public to the least amount of energy. The food hall's first floor is primarily dominated by stalls and market kitchens moving up to the second-floor mezzanine that takes on more of an open and interactive restaurant floor plan. In the library, the first floor contains a reading stair that draws visitors up from the main desk and community space to the stacks and open reading areas of the library. Moving up the floors of the library, the stack spaces become quieter as the children's library is on the first floor under the reading stair, allowing the stair to double as an acoustical separator to the rest of the stacks moving up to the top floor that acts more as study space with private meeting rooms and computer spaces.

Figure 65: 1st Floor Plan (Source: Author)

Visitors enter the building in the circulation loggia allowing for a direct flow between the two buildings, with a central café and attached newspaper and magazine stacks off to the north of the circulation between both program's back of house spaces. The stalls of the food hall are spaced off the existing structural grid of Building 170 and create a central path of circulation through the building and up to the second floor.

Figure 66: Perspective of food hall 1st floor program (Source: Author)

Figure 66 shows how building 170 could transform and adapt to create an open community space that allows customers to move freely between stalls under its existing gable roof. The first floor of the existing building organizes the stalls under the new mass timber structure to allow for the open seating and flex space to be exposed to the existing 1919 steel truss system above so that visitors can sit back and experience the vast heights of the existing structure. The food hall is directly connected to a full kitchen and administrative area off of the existing structure to the north of the site to fully service the needs of the stall vendors. The Library mirrors the back of house program of the food hall with its administration off in the NW corner of the site allowing for easy access for the book drop off and pick up from New Jersey Ave. The clear circulation in the middle structural bay of the library provides direct access from the admin area to the main library desk at the bottom of the reading stair.

Figure 67: Perspective showing reading stair on the 1st floor of the library program (Source: Author)

Another driving concept to this thesis was leaving the glulam and CLT structure exposed to show the timber in contrast to the existing masonry and steel structure. As mass timber is a construction method that has been growing in recent years but has yet to be fully accepted, exposing the structure from the interior to the exterior in such a public building would allow visitors to learn about this sustainable construction material firsthand. Figure 67 shows how the reading stair builds from the CLT floor to open stadium-style seating for potential lectures and community events while doubling as a continuation of the library stacks and reading areas. Underneath the reading stair is the children's library that is guarded by a security desk at the entrance off of the circulation loggia. With this same idea of security repeated on the ground level of the community daycare. The secondary programming of the daycare resides on the first floor allowing the primary programming of the daycare in the lower level to have direct access to the outdoor play spaces provided by in environment atrium.

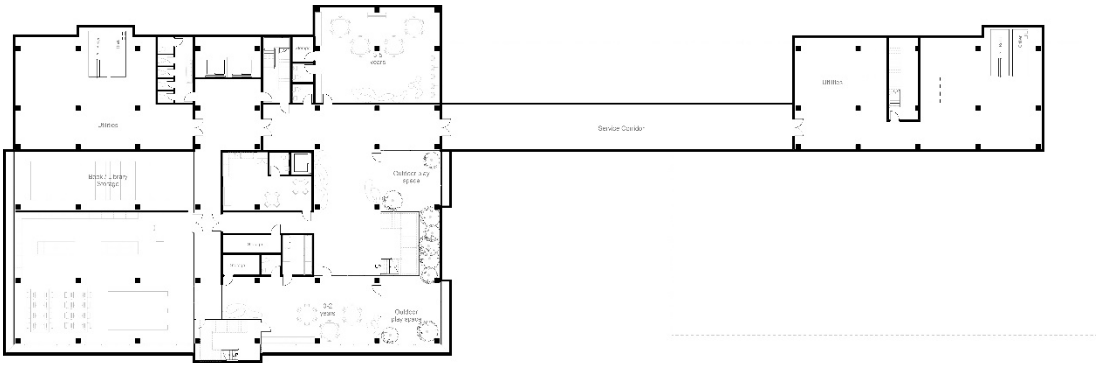


Figure 68: Lower Level Floor Plan (Source: Author)

Figure 69:Perspective of the exterior space in the daycare provided by the environment atrium (Source: Author)

The environment atrium draws in air from above, cleaning and passively cooling it before it enters the atrium while using plants to bio-filter pollutants. The glass box façade allows for natural daylight to filter into the lower level spaces of the daycare to provide interactive learning and play space for the kids. This atrium is one of four ways that the lower level receives natural light. The Environment atrium provides natural light to most of the daycare except for the three-to-five-year-old room which gets its natural light from above skylight towers. The third source of natural light to the lower level is the library’s glazed fire stair that provides natural light into the daycare and the lower level maker space. The maker space is a part of the library program that provides community members the opportunity to work collaboratively using tools they may not have available to them at home in such an urban area. The fourth way in which the lower level receives natural light is through the green wall light wells that double as irrigation for the stormwater collection system that services the site.

Figure 70: 2nd Floor Plan (Source: Author)

Figure 71: Perspective of the library stack areas (Source: Author)

As we move up the building to the second floor, the library reading stair leads to an open reading space that flows into the first level of the library stacks. The stacks have a direct view below to the environment atrium and adjoining plaza as well as the atrium above the reading stair. Across the circulation loggia from the stacks is the local history room, a place that could potentially house some of the records there are on the area that is currently in the College Park National Archives facility.

Figure 72: Perspective of 2nd-floor terrace space that looks on to the Navy Yard Plaza below (Source: Author)

The second floor of the library is connected to the food hall through the adjoining terrace that serves as an outdoor space overlooking the central plaza below. Directly off the terrace entering the food hall, the programming mirrors that of the library in the private learning experience of the teaching kitchen that stems from the second level of the existing structure. The second level structure of the food hall sits off the existing, allowing the new to lightly touch the standing 1919 shell as the second level provides extra space for the food hall experience. Visitors can experience the vast heights of the industrial building as they sit down and relax while enjoying the food available throughout the food hall under the exposed steel trusses that date back to 1919.

Figure 73: Perspective of the 2nd level of the food hall (Source: Author)

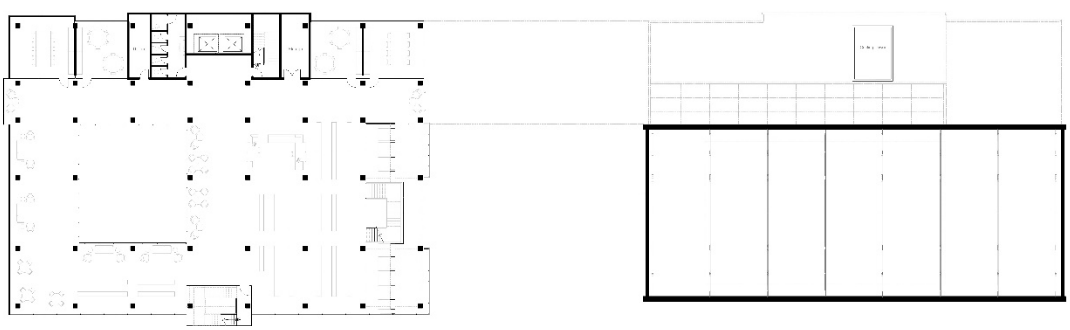


Figure 74: 3rd Floor Plan (Source: Author)

The third floor of the library repeats that of the second floor with more stack space sandwiched between the environment atrium and the atrium that overlooks the reading stair below. This floor also contains more private reading rooms in the north bay of the program.

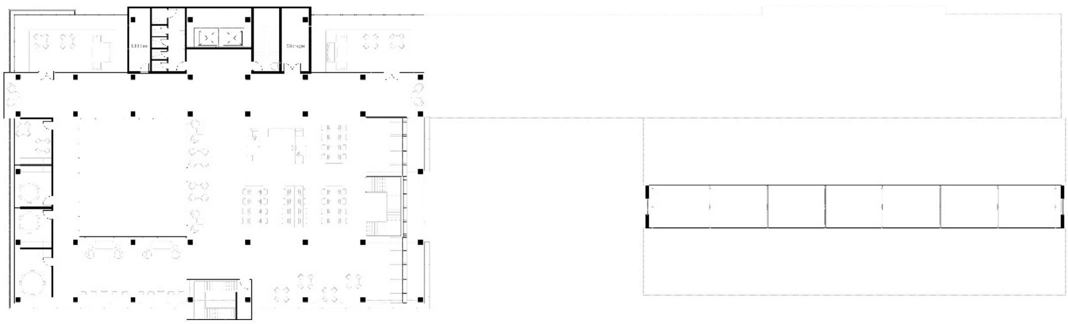


Figure 75: 4th Floor Plan (Source: Author)

The fourth floor of the library is the quietest of the floors with an open computer lab and more opportunities for reading and studying spaces. This floor contains four private collaborative spaces and two exterior terraces in the North West and North East corners of the program. Figure 76 illustrates how the top floor of the library program is connected to the reading stair below through the stack levels to the glulam trusses above.

Figure 76: Perspective of the top floor of the library and atrium glulam truss system (Source: Author)

7.4 Historic References

The structure of the new takes the language of the existing and repeats the gabled roof through the middle four bays of the library to provide maximum natural light and ventilation to the atrium and spaces below in the same way the existing building has provided natural light to its space. The library Glulam truss system brings a modern take to the existing steel trusses of Building 170 using sustainable materials that work to emphasize the verticality of both spaces. -

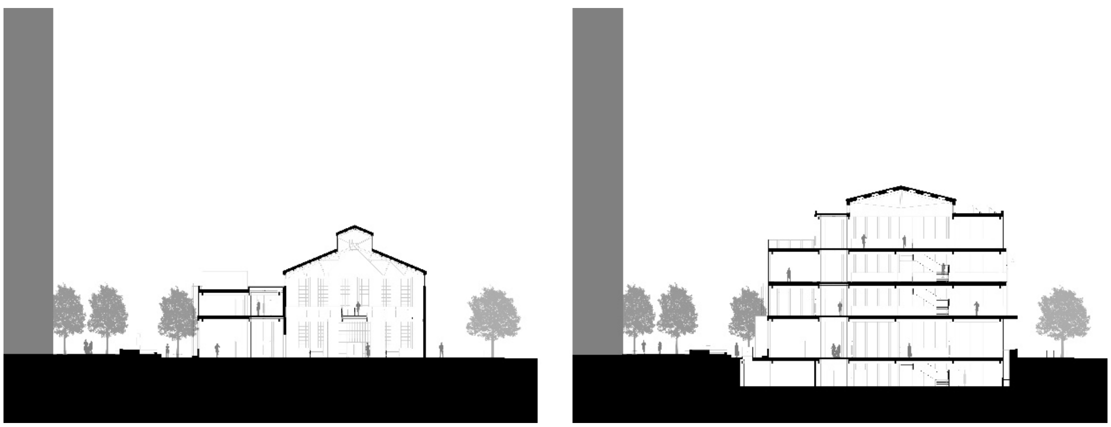


Figure 77: left section - through existing; right section - through library (Source: Author)

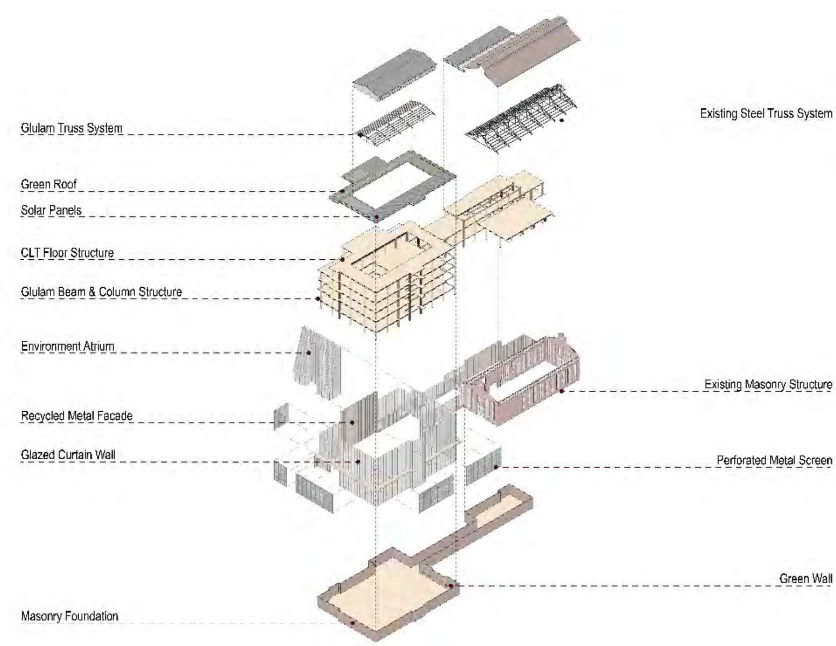


Figure 78: Exploded Axon (Source: Axon)

The exploded axon of figure 78 dives deeper into the relationship between the two structures. The exploded axon illustrates how the glazed curtain walls of the mass timber structure takes from the existing vertical elements of the steel industrial windows to emphasize the verticality of both spaces. The glazed curtain wall also works to showcase the glulam and CLT structure to bring attention to the sustainable construction method of mass timber.

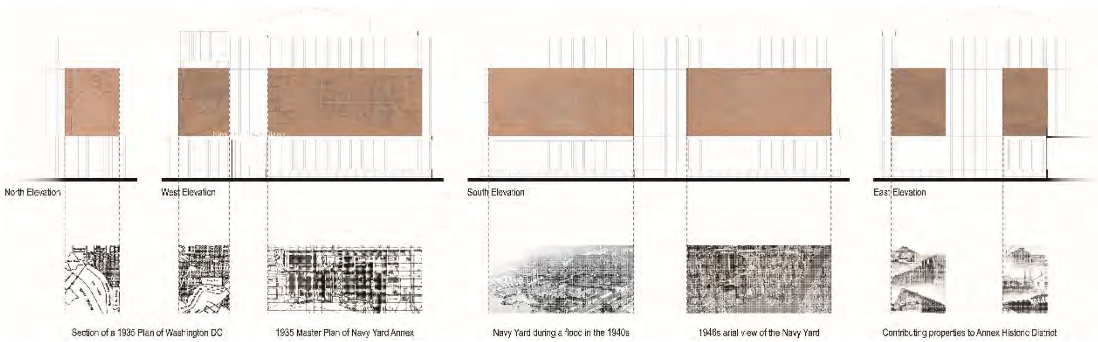


Figure 79: Elevation diagram illustrating the graphics of the perforated metal screens (Source: Author)

The perforated metal screens that wrap the stack levels of the library illustrate imagery from the history of the Navy Yard Annex district moving from an overview map of DC from 1935 on the northwest corner to the 1935 master plan of the Navy Yard annex on the west façade while the perforated metal screens on the south show aerial views of the navy yard taken in the 1940s. The screens on the east elevation of the new, that face the existing building illustrate a graphic comprised of some of the fifteen contributing properties to the historic district to represent not only the history and identity of this community but most importantly respect the existing structure it belongs to.

7.5 Sustainable Structure and Elements

The Glulam columns tie into the Beams and Girders using a steel connection that allows for minimal steel to be exposed as the structure takes on a seamless appearance and expresses that there is minimal need for materials that heavily contribute to the environmental impact of the construction process. In the same way, the glulam truss over the atrium uses a minimal steel rod to work in tension with the compression glulam strut.

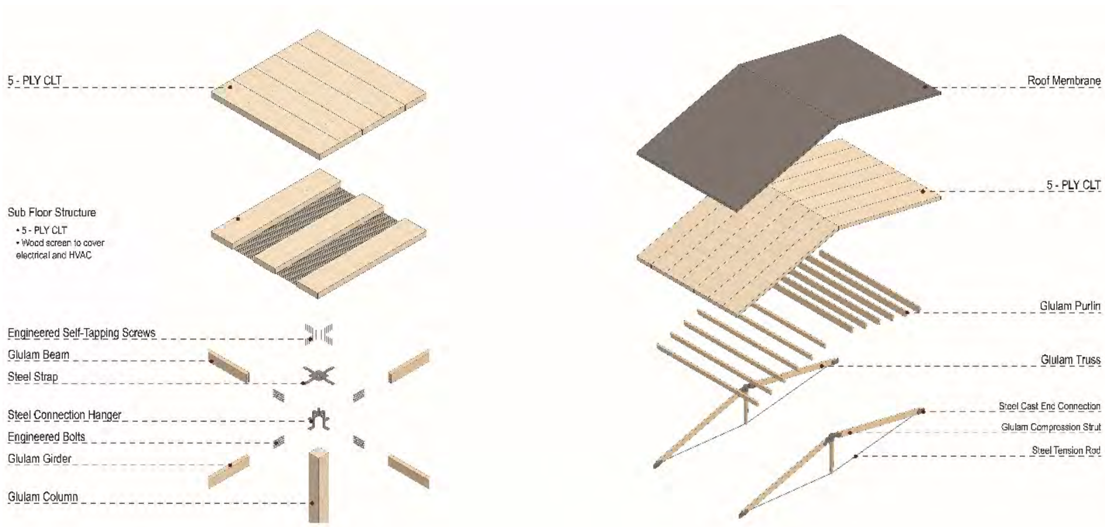


Figure 80: Left - Beam and Column Exploded Axon; Right - Atrium Truss and Roof Structure Exploded Axon (Source: Author)

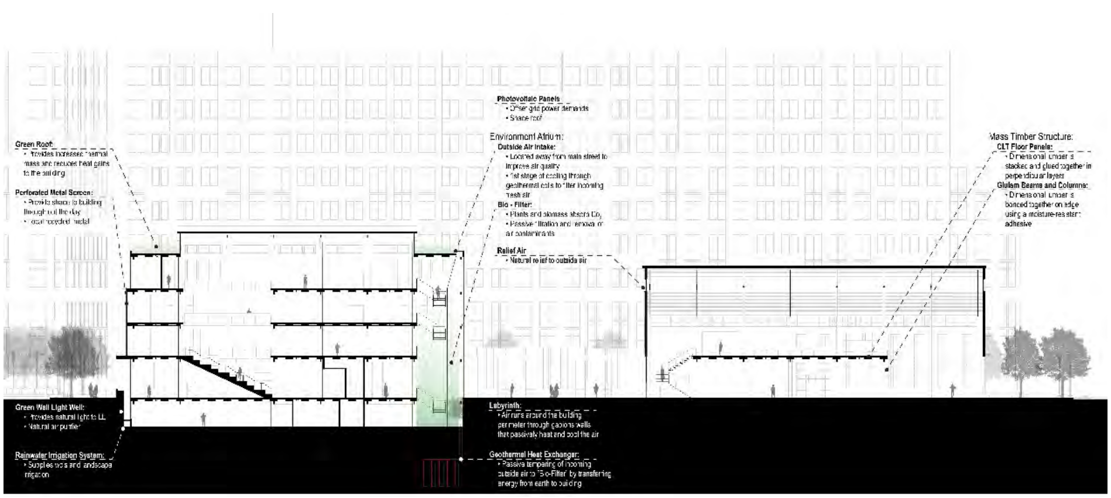


Figure 81: Sustainability Section (Source: Author)

After the building is constructed the systems in place will maintain the building's minimal impact on the environment. The roof supplies space for the photovoltaic panels to sit south-facing at thirty-nine degrees, the perfect angle for the latitude and longitude of Washington D.C. to soak up as much solar energy as possible to offset the grid power demands of the program. The green roof and light wells will increase thermal mass and reduce heat gain. The green wall light wells also provide natural light to the lower level and act as a natural air purifier with an irrigation system at the bottom of the wall that will supply the site entire site with the collected stormwater. The lower level also contains the labyrinth which allows air to run around the building perimeter through gabion walls to passively heat and cool the air.

The environment atrium takes in air from the roof, purifying and cooling the air before it enters the atrium to be absorbed by the plants and biomass on the lower level of the atrium. The plants passively filter the air, removing CO_2 and other pollutants to provide a clean environment for the children of the daycare to play to then pass through the geothermal heat exchanger. The geothermal heat exchanger passively tempers the purified air from the atrium to the rest of the library by transferring the energy from the earth to the building. The various existing and new operable windows will provide relief to the outside air for visitors to enjoy the connection of the interior to the exterior when there is appropriate weather.

Chapter 8 Conclusion

Figure 82: Southwest Axon (Source: Author)

As it becomes more apparent how we have been negatively impacting our planet, we need to take a step back and evaluate how new methods of sustainable design can be incorporated into the existing built environment to leave a positive impression on our climate. Just as the United Nations Environment Program's 2019 Global Status Report states that buildings and construction were responsible for thirty-six percent of final energy use and thirty-nine percent of energy and process-related CO_2 emissions in 2018, with eleven percent of these emissions resulting from the manufacturing process of building materials and products such as steel and concrete,[36] we as designers should be looking for new methods of construction that can cut down on the impact of buildings and construction. This thesis offers a solution

[36] (2019), IEA and UNEP (United Nations Environment Programme). 2019. 2019 Global Status Report for Buildings and Construction. Global Alliance for Buildings and Construction, UN Environment and the International Energy Agency. Accessed May 16, 2020.

to the amount of demolition that occurs annually in the United States because of the alarming fact that America's built environment creates over half a billion tons of debris annually with ninety percent of the built environment debris coming from demolition.[37]

This thesis asks the question of why we continue to build, demo, and then rebuild when studies have shown that it can take up to eighty years for a building's operating efficiency to make up for the impact of the building's construction process.[38] Instead of demoing existing structures that maintain embodied energy to be replaced with a new structure with new embodied energy, we can adapt these spaces to bring new life to the structures while also maintaining the history of the site. This thesis illustrates how existing building materials can be used to cut down on the environmental impact of construction by using natural construction materials like mass timber to produce less greenhouse gas emissions during the construction process and structure's life cycle. These methods will allow the building to leave a larger, healthier impact on our climate while also maintaining the history and culture of an existing structure.

The site of the thesis became a great example of how existing buildings can be adapted to not only act as a sustainable construction method but because of its location in an area that has seen rapid development in recent years, the proposed project shows how maintaining an existing structure can remind a community of its

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[37] IEA and UNEP (United NationsEnvironment Programme). 2019. 2019 Global Status Report for Buildings and Construction. Global Alliance for Buildings and Construction, UN Environment and the International Energy Agency. Accessed May 16, 2020.

[38] Kerr, Warren, ed. 2004. "Adaptive Reuse. Preserving Our Past, Building Our Future." Austrialian Government Department of the Environment and Heritage. Commonwealth of Australia. Accessed October 6, 2019.

past. The solution of this thesis stands as the heart of a community that is in dire need of a space to claim as their own by embracing an existing building that has sat as a vacant for many years, bringing new life to the structure and the site to stand as a reminder of the community's thriving industrial past. I believe that an important part of a community's identity is remembering the past in a way that can influence a better future. The solution provided by this thesis shows just one example of how we can adapt our existing structures to not only maintain this sense of identity but use sustainable methods to cut down on the impact buildings and construction have on our environment, the place we call home.

Figure 83: Perspective illustrating the relationship between the two buildings (Source: Author)

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