



## ABSTRACT

Title of Thesis: Sustainable Building Museum for Washington, D.C.

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Discussions of sustainability have become increasingly common in recent times, as there has been a growing concern for the impact of the built environment on the ecological state of the planet. As we experiment with alternate energy sources, long- term development plans, and waste reduction techniques, new materials and design approaches are emerging.

A synthesis of these discussions, this thesis examines how green buildings work in urban environments through the development of a museum and research center on sustainability for Washington, DC, that is itself, environmentally friendly. Utilizing and displaying green building systems, this public museum will teach the design profession as well as individuals through its exhibits and assembly. This learning machine will focus on the generality of sustainability, and the specifics of sustainable *architecture*.

SUSTAINABLE BUILDING MUSEUM FOR WASHINGTON, D.C.

By

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Advisory Committee:

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## DEDICATION

This thesis is dedicated to my mother.

## ACKNOWLEDGEMENTS

I would like to sincerely thank all of the people who have helped and encouraged me along the way.

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## INTRODUCTION

*“They paved paradise, put up a parking lot,  
With a pink hotel, a boutique, and a swingin’ hot spot...*

*Don’t it always seem to go, that you don’t know what you’ve got ‘til it’s gone  
They paved paradise and put up a parking lot....”<sup>1</sup>*

Joni Mitchell

Buildings consume at least 40% of the world's energy, and account for about 25% of all water use. Buildings are responsible for 50% of CFC production, and building construction and operations account for 35% - 40% of municipal solid waste. In the United States, 80% of the things we buy today is thrown away after six months. In manufacturing, 97% of raw material becomes waste, while only 3% becomes the actual product.<sup>2</sup>

By looking at these statistics, it is clear that the environment is not a primary concern in the way we build. This failure to acknowledge our inefficient use of materials and its bad effects on the planet is not the fault of the act of building, but rather a manifestation of our cultural values. We are in need of reconsidering our current building practices and attitudes toward design. These statistics demonstrate that we are debilitating the planet faster than it can regenerate itself. In order to ensure the continuation of our survival with the highest quality of life, we need to reevaluate our attitude towards how we build.

This thesis proposes the formation of an institute dedicated to the documentation and study of sustainable building practices. The Sustainable Building Museum for Washington, DC, will act as a catalyst, a forum for the discussion and exchange of ideas relating to the way we build today, how we have built in the past, and how we should build in the future. This museum will aim to inform us of our environmental achievements as well as concern us with our trouble spots, raise awareness, and inspire people to take responsibility.

There is no formula or recipe for the development of a green building. Design decisions must be made specific to the conditions of the site (climate, landscape, cultural context) and the performance needs of the occupant. This institute will document the Washington, DC, and Baltimore Metropolitan areas in terms of climate and landscape in order to set up appropriate building guidelines for



these areas. It will also work with the local governments to facilitate green design initiatives and incentive programs.

It is a goal of the museum is to further push sustainable building practices into the norm. It will do this by relating individuals to their role in the ecological cycle and gently informing them of ways they can improve the current statistics. This building does not suggest a sudden leap into green building, but rather a gradual transition in the right direction with long term goals in mind.

Sustainability is a major consideration that is part of a holistic design process. The LEED rating system will be considered to monitor ecological design strategies, whereas Ten Shades of Green will be used to incorporate Green Design Principles. The ecological success of the building will be quantified through its LEED rating. Community and time will determine the cultural success.

This thesis begins to address the issue of sustainability through the selection of an appropriate site. The redevelopment of a parking lot on E Street, between 8<sup>th</sup> and 9<sup>th</sup>, NW, will fill a void and reinforce the existing urban fabric through the elimination of a surface parking lot in the city. The site is located on a cross- town bus route, within a five-minute walk from each of the Metro Transit lines, which encourage the use of mass transit and carpooling.

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<sup>1</sup> Mitchell, Joni. Big Yellow Taxi.

<sup>2</sup> Tannenbaum, Robin. "You Do The Math." CriT Magazine. Fall 2001: no. 52

## CHAPTER ONE : SUSTAINABILITY

**sus·tain** (sə-stān')

*tr.v.* **sus·tained, sus·tain·ing, sus·tains**

To keep in existence; maintain<sup>3</sup>

Although sustainability as a social and environmental movement has existed for many years, it has only climbed its way to the spotlight as of late. Following the Industrial Revolution, the presence of a “return to nature” agenda has been evident in a variety of disciplines. Economic books, like *Small is Beautiful*, as well as literary fictions such as *Brave New World*, are just two examples of books in various fields that emerged out of a concern for the future of the built environment based on then current building practices.

Local governments are beginning to take action by offering green design incentives. The U.S. Military has been experimenting with a sustainable design program since 1993.<sup>4</sup> And from a worldwide perspective, many modern societies are beginning to see it as a design responsibility. The 2002 Earth Summit Conference in Johannesburg, and the series of Kyoto Conferences to address Global Warming signify a worldwide movement of change, in addition to the numerous green buildings being constructed internationally by prominent architects such as Kenneth Yeang, Sir Norman Foster, Michael Hopkins and Partners, William McDonough and Renzo Piano.



**Figure 1:** Solar Decathlon Photos taken from the US Department of Energy<sup>5</sup>

The recent popularity of the Solar Decathlon on the Washington, DC Mall is evidence that the public is hungry for knowledge and interested in change. For three weeks, visitors came from all over to explore the 14 houses designed and constructed by teams of university students. Here they learned about energy, water, materials, and passive design strategies.



**Figure 2:** Exhibit Catalogues from the National Building Museum.

The National Building Museum has taken the topic of Sustainability under its scope. In the past, they have hosted the *10 Shades of Green* exhibit. They recently opened an exhibit, Big and Green, in January 2003.

As the National Building Museum focuses on the act of building, sustainability is only one of the many aspects of the design field covered. As a result, exhibits on sustainability are temporary and sporadic.

The United States Green Building Council, also located in Washington DC, is a resource that sets industry- wide green building standards and provides services to design professionals. It does not address the general public, rather it is a support for individuals with background knowledge and specific concerns.

The topic of sustainability requires exploration beyond the capabilities of the existing resources. Public and professional interests demonstrate a need for additional resources on sustainable design, for example, information on the reuse and recycle-ability of products, life cycle and cost analysis, and information about

the embodied energy of available materials, material and cultural implications of design decisions, etc.

## **WHAT IS SUSTAINABILITY?**

Literally, to sustain means to remain. To last. To endure. It is the common goal of all living things to sustain life on the planet. The concept of sustainability has entered into the mainstream so rapidly that it has become a buzzword meaning something different to everyone who applies it. It has evolved beyond a specific definition and exists accurately only as an umbrella term. This is because to be sustainable means something different to each culture, climate and landscape, and relates to ecology, economics, heritage and aesthetics of a particular place. Design solutions that are sustainable in one place are most likely to be inappropriate if applied to another.

Brian Edwards describes sustainability as “not universal, but like classicism, is modified by regional circumstances. It is an order of process and thought necessarily adjusted by local circumstances- the rightness of sustainability and its cultural relevance relies upon the celebration of difference.”<sup>6</sup> Because sustainable architecture is context – based, it offers the opportunity to reinforce the sense of identity of a place. The regional, or vernacular work of architects Brian Mackay-Lyons, Rick Joy and Glen Murcutt emphasizes significance of place through relating back to the cultural history, climate, and the environment.

Different environmental solutions become more apparent in difference cultures, climates and contexts, based on the availability of technology and materials.

Through designing less universally and more appropriately, we achieve a built environment that is sensitive to people and place.

Some buildings that are built with permanent materials, with intention to remain, are considered sustainable for their long life potential. At the same time, buildings made of impermanent materials as temporary structures are also considered sustainable for their ability to be recycled. How is that possible?

The reality is that both of these practices are in fact sustainable. The key to understanding what is sustainable is through determining what is appropriate. The word, *appropriate*, means to be suitable for a particular person or place or condition.<sup>7</sup> When applied to the built environment, to build appropriately means that buildings should be designed to last with the intended use of the building in mind.

William McDonough interprets how to build appropriately as “understanding the limitations of design.” In the *Hannover Principles* (design guidelines and standards written for the EXPO 2000 World’s Fair in Hannover, Germany), he writes that we must “understand the limitation of design. No human creation lasts forever, and design does not solve all problems.”<sup>8</sup>

At the same time, how do you value one “green” solution over another? For instance, in a project, a large quantity of wood is required, but there are no certified lumberyards nearby. Is it more sustainable to purchase the wood from a certified lumberyard and have it shipped to the site, or to purchase uncertified wood locally in order to avoid pollution from transportation? There is no simple answer. Sustainability is a concept driven by valuing the earth’s natural processes and

attempts to mediate our impact on it. Until we are at a stage of development where there are more sustainable resources available, it is the responsibility of the designer to decide what is appropriate.

## **HOW THINGS CAME TO BE.**

The American society is aggressive about building. This is in part due to the fact that our relationship to the landscape began as an aggressive one. The early settlers feared the darkness and mystery of the forested New World. The wilderness was a scary, dangerous place that needed to be tamed and conquered. Forests were cut down for wood, but also as a way to control the landscape. Land and natural resources were plentiful, so there was no need to consider conservation.

Prior to the industrial revolution, the earth was able to compensate for man's impact on natural resources, as it had been on such a small scale in relation to the whole of the planet. The industrial revolution has exponentially increased the scale of our building and resultant resource usage and waste production. Our aggressive relationship with the natural environment in pursuit of raw materials has brought the earth's natural cycles out of balance. We are now consuming materials at a pace faster than the earth can replenish, and creating wastes faster than they can be assimilated.

Although there is no doubt that the industrial revolution brought many positive changes, it is important to recognize that it was not designed.<sup>9</sup> There was no planning for resources, only quantity of product and financial profit. With the onset of mass manufacturing capabilities, industry boomed. Machines are by far more efficient than people, allowing for a faster depletion of resources and more

pollution. Cities have been given the ability to grow without an understanding of how to grow.

The growth of cities like Chicago and New York in the late 1880's verify this testimony. Pollution from industry became so bad in the waterways that the cities began to turn their backs on the amenity that brought them there. The factories and machines that were supposed to be providing for the people were actually smothering them. The dense housing conditions that emerged from the need for factory workers brought on sickness and disease. Ultimately the government stepped in and enforced regulations and public works systems that regulated the future growth of the city. Although a lot of the obvious hygiene and sanitary issues have been resolved, other issues continue to need attention- such as energy and waste management.

For example, urban heat islands have become a growing problem in cities across the world, raising temperatures as much as 5° in some areas.<sup>10</sup> Cities retain and trap heat in the summer as a result of high amounts of pavement and non-porous surfaces. Planting street trees and designating lighter colors and natural surfaces for roof materials can reflect light and heat more readily, with the potential to cool a city by as much as 3° F. By lowering the amount of heat a building absorbs on the roof, less energy will be spent on cooling the building, reducing the overall energy consumption as well.

In an Architecture magazine article by Eric Adams, it was noted that thermal variation images from NASA reveal that the Delta Center has the coolest roof in Salt Lake City.<sup>11</sup> This was not planned to be an energy efficient design decision, the



white colored roof was chosen for reasons of cost- the original black roof system was out of the project budget. On the other hand, the nearby Matheson Courthouse has the hottest roof in Salt Lake City. This black roof was chosen because with its 20-year warranty, it's the state's preferred material.<sup>12</sup> In both of these case studies, materials were chosen to save money.

Sustainable design solutions are often characterized by high initial investments and slow but steady returns. From the financial perspective, green buildings have lower operating costs over long the term. Although unplanned, during the life of the building, the Delta Center will save money and energy on cooling costs because of the reflective roof materials. The Matheson Courthouse will require greater cooling loads (more energy) from the black, heat-absorbing material. While the Courthouse designers were planning for long term, they were not aware of the benefits of energy efficiency on budget.

The goals of our society are centered on minimizing investments for big profits. Rarely do we think about the consequences of our actions and consider the impact the actions have on the future of the world. Rarely do businesses look into the future and plan for the long term. Economically speaking, it is only a matter of time before this trend reverses itself and we begin to invest in the big picture. Stephan Schmidheiny, Co-Founder of the Business Council for Sustainable Development, stated "It's going to be next to impossible for businesses to be competitive without also being 'eco-efficient-' adding more value to a good or service while using fewer resources and releasing less pollution." <sup>13</sup>

## TODAY.

Our indigenous understanding of nature is not yet completely lost, and the appreciation of the many living things on the planet still exists. Knowledge and understanding of what is appropriate will come in time. It is clear that informed decisions would change the goals and methods of building. Although much has changed over time, our view of the natural world remains aggressive. Aside from financial considerations, many of the things we do continue to remove us from the spirituality of the natural world, making it easy to forget and harder to understand the significance of its true role in our lives.

Short term goals and fascination with invention have led us astray. Although we have the technology to create controlled, “ideal,” environments, it does not mean that we should. To understand environmental responsibility, one must value the environment. It’s easier to overlook responsibilities when they are not in direct view.

We are at a level of technological development where we can reflect on the developments of the past, and so we must decide how to grow from here. We are aware of what we are doing. We have the ability to change. If not now, then when?

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<sup>3</sup> “Sustain.” The American Heritage® Dictionary, Fourth Edition.

<sup>4</sup> Snoonian, Deborah. “Architecture Rediscovered Being Green.” Architecture Record. June, 2001: vol. 189, no.6, p.87.

<sup>5</sup> Department of Energy Website <[http://www.eren.doe.gov/solar\\_decathlon/](http://www.eren.doe.gov/solar_decathlon/)>

<sup>6</sup> Edwards, Brian. Green Architecture. London: Wiley Academy, July 2001. vol. 71, no. 4, p. 7.

<sup>7</sup> Wordnet ® 1.6, ©1997 Princeton University

<sup>8</sup> WM +P Website <[http://www.mcdonoughpartners.com/projects/p\\_hannover.html](http://www.mcdonoughpartners.com/projects/p_hannover.html)>

<sup>9</sup> McDonough, William and Michael Braungart.

Cradle to Cradle: Remaking The Way We Make Things.

New York: North Point Press, 2002.

<sup>10</sup> Adams, Eric. “Urban Heat.” Architecture. January 1999.

<sup>11</sup> Ibid.

<sup>12</sup> Ibid.

<sup>13</sup> McDonough, William and Michael Braungart.

## CHAPTER TWO : MUSEUM PARADIGM

**mu·se·um** (my-zē'əm)

*n.*

A building, place, or institution devoted to the acquisition, conservation, study, exhibition, and educational interpretation of objects having scientific, historical, or artistic value.<sup>14</sup>

## DEVELOPMENT OF MUSEUMS

A museum is a place for communication and sharing of ideas in a format available and easily understandable to the public. Museums are interesting because of the mixture of public and private agendas. The space is meant to be inviting and welcoming to the visitor while still offering a degree of privacy for each individual in order to contemplate his or her relation to the piece of work.



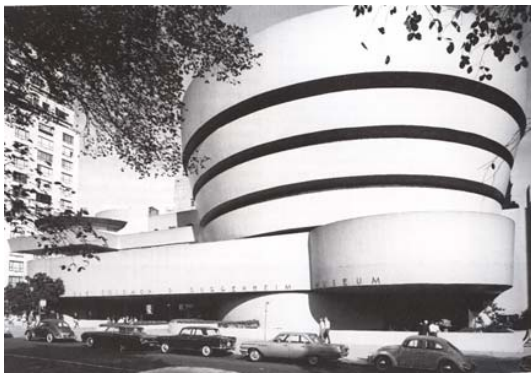
**Figure 3.** The British Museum in London, designed and constructed by Robert Smirkey between 1823-47, was meant to convey the message “we have conquered the earth, and the objects shown here justify our claims as the true inheritors of historical destiny (Jenks).”

Jenks, Charles. “The Contemporary Museum.” Architectural Design: UK, 1997.

Historically, the museum has played a very specific role as a building type. Used as milestones of accomplishments, these museums were built of such a monumental scale, that the place felt unwelcoming to visitors. “Displays of cultural achievement, museums were typically monumental places of learning, often intimidating and having an air of cultural dominance.”<sup>15</sup> Museums developed into a type of background architecture, they were neutral spaces of contemplation meant to showcase artifacts or art. In these types of museums, artifacts are displayed as being frozen in time and separate from their natural context.

It wasn’t until the middle of the 20<sup>th</sup> century that the museum type began its transformation. Frank Lloyd Wright’s Guggenheim Museum in New York was the

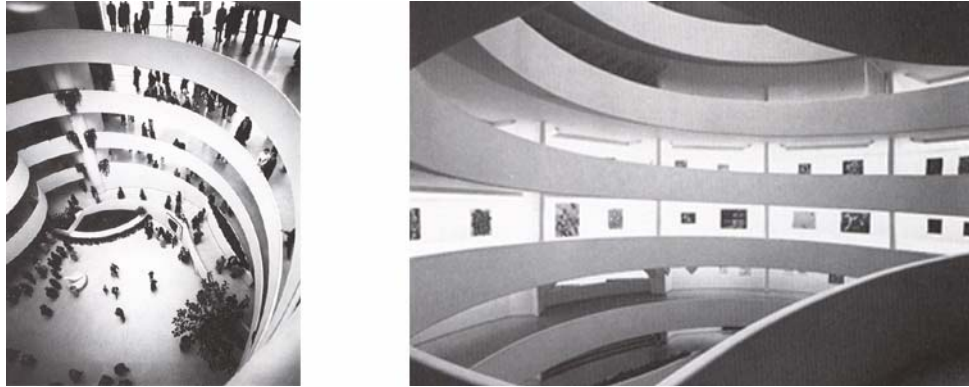
first revolutionary foreground museum building. It challenged the neutral, right-angled spaces found in most museums by creating a dynamic space with round walls and a ramp that traversed the full height of the exhibition space. Wright commented on his creation- “It is not to subjugate the paintings to the building that I conceived this plan. On the contrary, it was to make the building and the painting in uninterrupted, beautiful symphony such as never existed in the World of Art before.”<sup>16</sup>



**Figure 4:** The Solomon R. Guggenheim Museum in New York, designed by Frank Lloyd Wright and built between 1956-59, has a much friendlier and welcoming appeal.

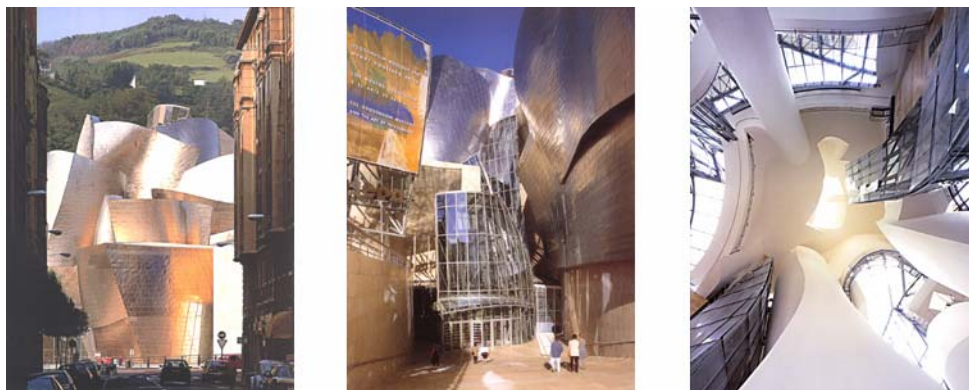
Trachtenberg. Architecture. Prentice Hall: Upper Saddle River, NJ 1986

The Guggenheim “attempts to become more than a passive frame for the curatorial arts of exhibition and actively to enlighten, in an architectural way, the viewers experience of the art shown within it.”<sup>17</sup> It was this conscious decision to bring the architecture into the spotlight that makes it stand aside from other museums. “At every moment, one simultaneously is in intimate proximity to a small group of works yet in the presence of the entire exhibition.”<sup>18</sup>



**Figure 5:** The atrium lined by the open gallery creates a tension between the still artwork and the movement of the people. Ibid.

Wright attempted to bring the meaning of modern art into the display. Works had to hang in front of the curved wall, rather than be attached to it as in the past. This subconsciously reminded people that the art in the museum is out of its natural context.



**Figure 6:** Frank Gehry's Guggenheim Museum in Bilbao, Spain. 1991-97. Ragheb, J. F., Frank Gehry, Architect. Guggenheim Museum: New York. 2001.

Frank Gehry's Guggenheim Museum in Bilbao, Spain, followed Wright's departure from the conventional neutrality of museum architecture. The bright and colorful use of materials, and expressive spatial qualities became immediately iconic. Bringing the architecture into the foreground was key to achieving this building's role as the centerpiece of the city's redevelopment project.

Contemporary Museums must no longer be judged strictly as background or foreground architecture, but on the basis of unity with their contents.<sup>19</sup> Another developing trend of the museum type is the educational/ interactive museum. Deemed “Edutainment” by Architecture Magazine in the December 1995 issue, this museum type has expanded to become interactive and multi- sensory.



**Figure 7:** Cleveland’s Rock and Roll Hall of Fame, designed by I.M. Pei (left) and Akron, Ohio’s Inventure Place by Polshek and Partners Architects (right) engage visitors with interactive and multi-sensory exhibits. Architecture Magazine, December 1995.

The exhibits and information presented engage visitors through employing science experiments, digital recordings and touch-screen technology. The museums attempt to educate and inspire visitors through the experience of place as well as through the exhibits.

In addition to the wave of educational museums, another museum type is developing, the Living Museum. Rather than remain static with historic information, a Living Museum must adapt with time. The United States Holocaust Memorial Museum is an example of a Living Museum. As a memorial, it is significant that the building and the messages it conveys endure. To be an effective

memorial, it must inform the future of events of the past. It strives to recognize a moment in history so that the past may not repeat itself.

The Sustainable Building Museum proposed by this thesis further expands on the transformation of the museum type that began with Wright's Guggenheim Museum in New York. And similar to the Holocaust Memorial Museum in Washington DC, this will be a living museum. The mission of the Sustainable Building Museum is to clarify sustainability, to help both non-experts and design professionals to understand the consequences of their most basic actions, and provide them with the means to use this information to generate form rather than perceive as limits that need to be accommodated. It will be interactive and experiential, like those described as being "edutainment."

*Museum* is the appropriate paradigm for this thesis, offering contemplation, learning, collection, components- a way to link institutional research back to the public. The living component will be the research part of the program, offering general information relating to sustainable design. In addition, it will be similar to Seattle's Green Building Team, the Green Building Alliance in Pittsburgh and the Earth Pledge Foundation in New York, this research facility will be Washington, DC's Sustainable Design Center. Each of these non-profit organizations attempt to raise the bar of green building standards in each of their home cities. They do so by offering information specific to climate and landscape of each particular city, as well as influence local government standards. A museum focusing on sustainable building practices will satisfy the needs of professionals as a research center, and the interest of the public as a museum.



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- <sup>14</sup> “Museum.” The American Heritage Dictionary. Fourth Edition. 2000.
- <sup>15</sup> Maggie Toy, Contemporary Museums
- <sup>16</sup> Trachtenberg and Hyman, Architecture. Prentice Hall: Upper Saddle River, NJ 1986 p. 537.
- <sup>17</sup> Ibid.
- <sup>18</sup> Ibid.
- <sup>19</sup> Newhouse, Victoria. “New Museums Stimulate New Art.” Architecture December 1995

### CHAPTER THREE : THE SITE

**site**

*n.* A physical position in relation to the surroundings.<sup>20</sup>

## MUSEUMS IN WASHINGTON, DC

The plan for Washington, DC, was completed by Pierre L'Enfant in 1791, following George Washington's announcement of the location of the National Capital. The undeveloped land was a clean canvas for the city's founders, leaving a unique opportunity to determine the form of the new capital.

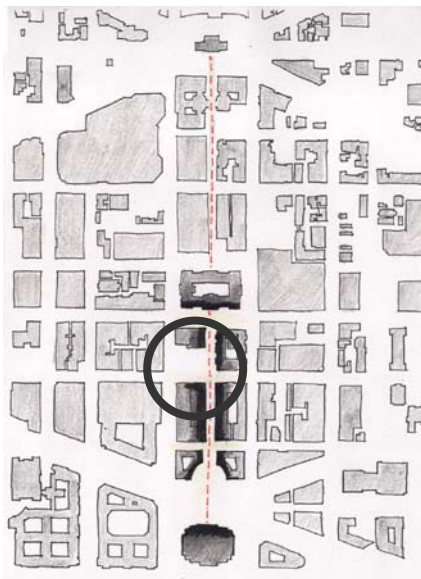


**Figure 8:** Figure ground diagram of Washington, DC, showing the influence of L'Enfant's plan on the form of the city.

L'Enfant's plan respected natural land contours and overlaid grand radial avenues over a grid to create monumental spaces and squares. It left a grand public open space dedicated to the *people*- the National Mall. Although the design of the National Mall has changed since its first inception, the overall parti has remained the same.

An 1846 Act of Congress established the first of the Smithsonian Museums. Englishman James Smithson ‘bequeathed’ his estates to the United States to establish a foundation to increase the diffusion of knowledge.<sup>21</sup> The development of the Smithsonian Institution began the legacy of Washington as a cultural center for arts and sciences. The first building was the Smithsonian Castle, which was followed by the Museum of Natural History, and many others. In recent years, several museums and cultural buildings have emerged within the urban fabric in areas beyond the Monumental Core of the city.

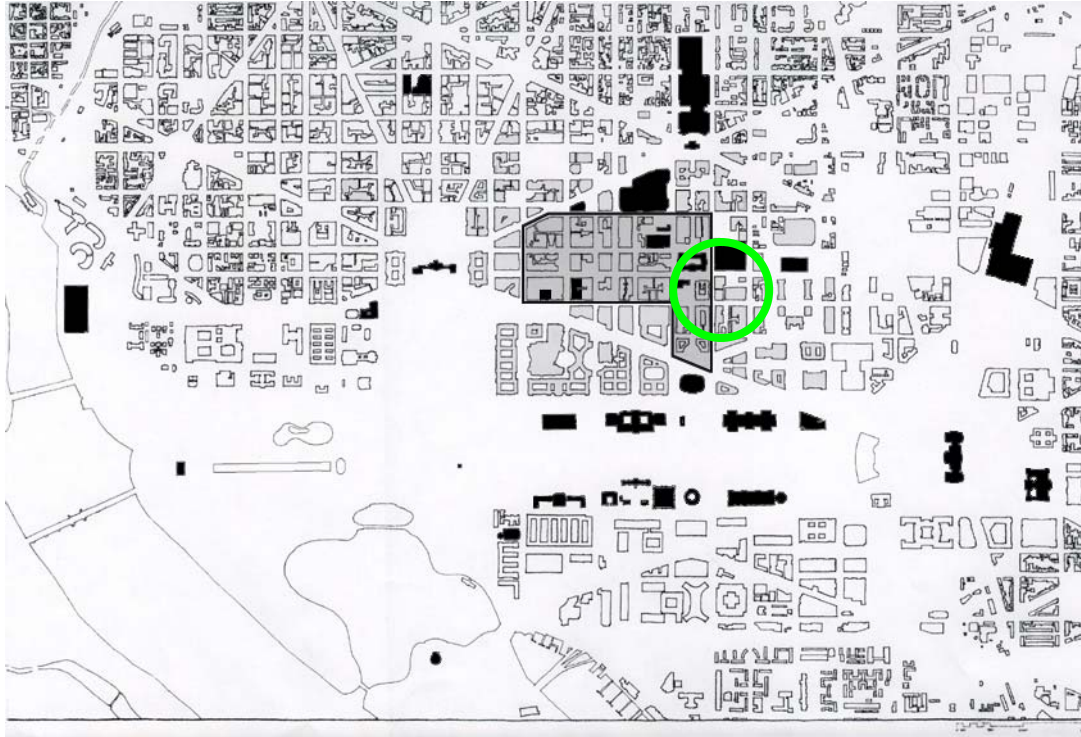
## HISTORY OF THE SITE



The site for the Sustainable Building Museum is part of a local axial order, extending from the National Archives, through the Navy Memorial, to the Portrait Gallery, and beyond to Mount Vernon Square.

**Figure 9:** Local Order.

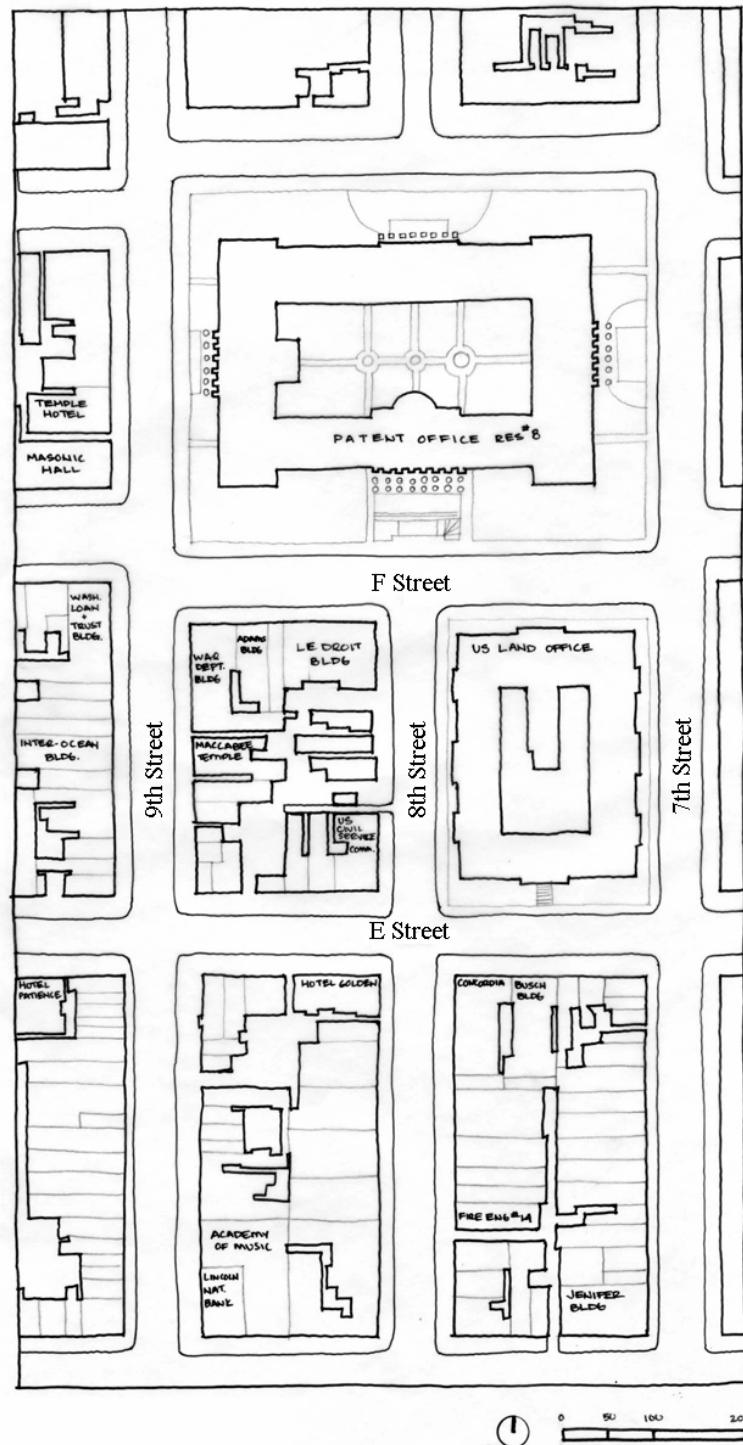
As seen in **Figure 10**, The site is part of the Downtown Arts District of Washington, DC, on the north side of E Street, between 8<sup>th</sup> and 9<sup>th</sup>. This street is part of the original network of streets planned by L’Enfant in 1791 between Massachusetts and Pennsylvania Avenues.



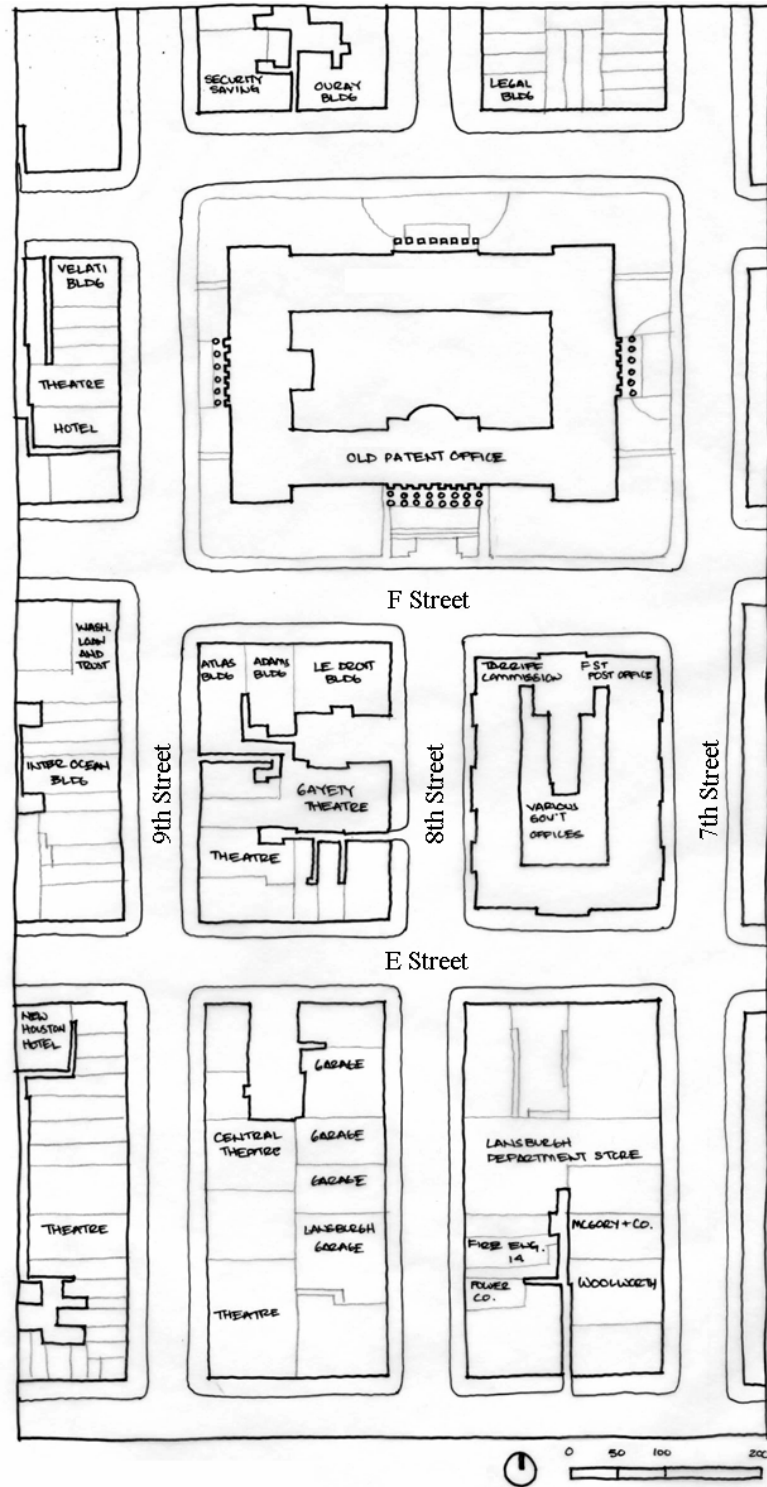
**Figure 10:** Downtown Arts District and Cultural Buildings

The site is located just north of the theater district, sharing the block with the newly opened International Spy Museum. The National Building Museum is four blocks to the east on F Street. The MCI Center is two blocks to the northeast, and the DC Convention Center is being constructed five blocks to the north.

Throughout the 1800's, this area was primarily a residential development, spotted with boarding houses and retail shops. After the Civil War, streets were regraded, sidewalks were improved and a wave of new buildings emerged, bringing retail to the downtown district.

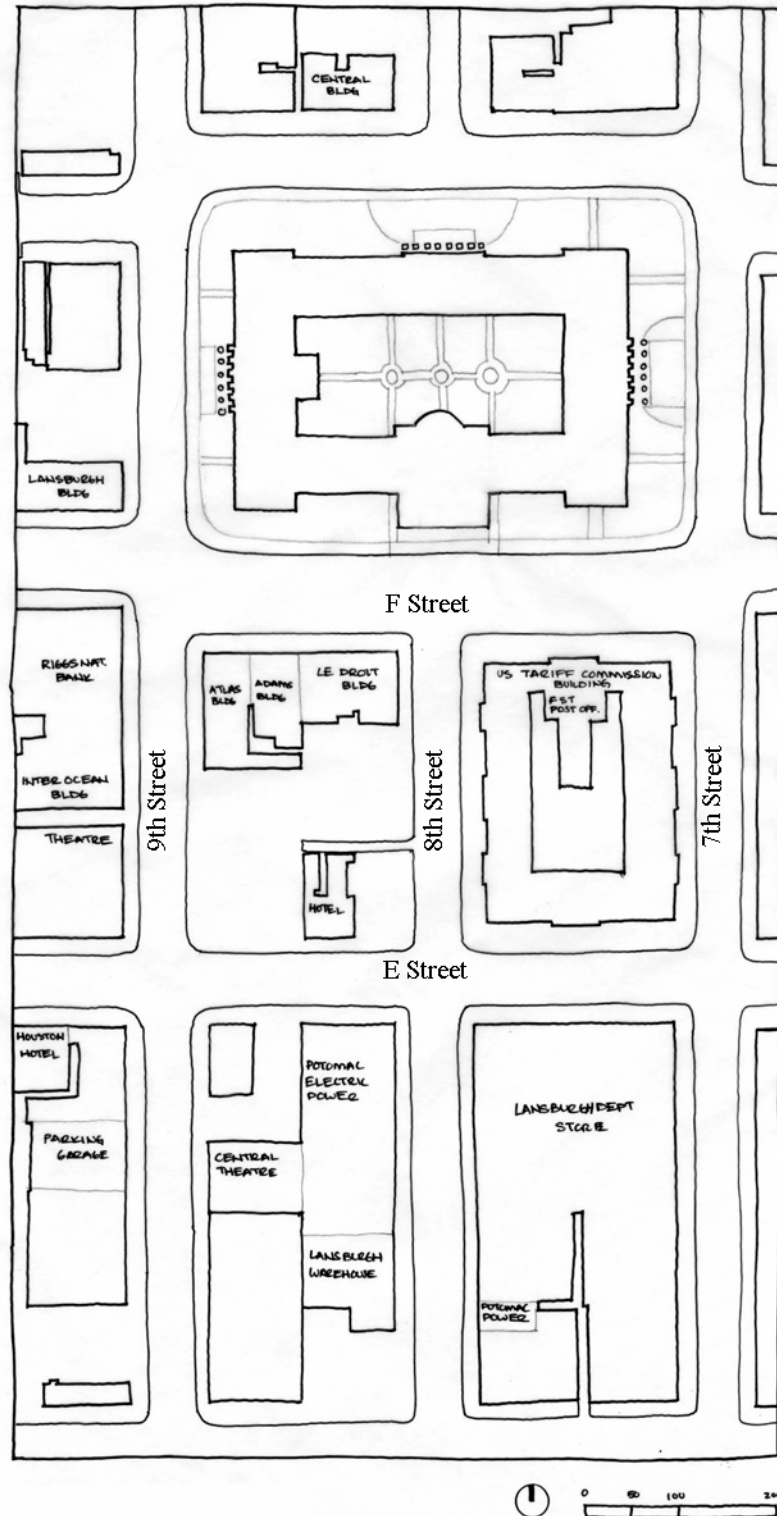


**Figure 11:** 1903 Baist Plan of Vicinity, Plate 30. In the late 1800's, many of the lots were occupied by small buildings. Two of which housed the Maccabee Temple and the Civil Service Commission. The Ledroit building (one of the oldest buildings in Washington, DC), Adams building, and Atlas buildings were built, as well as the nearby Masonic Hall on the corner of F and 9<sup>th</sup>, and the Washington Loan and Trust Buildings.



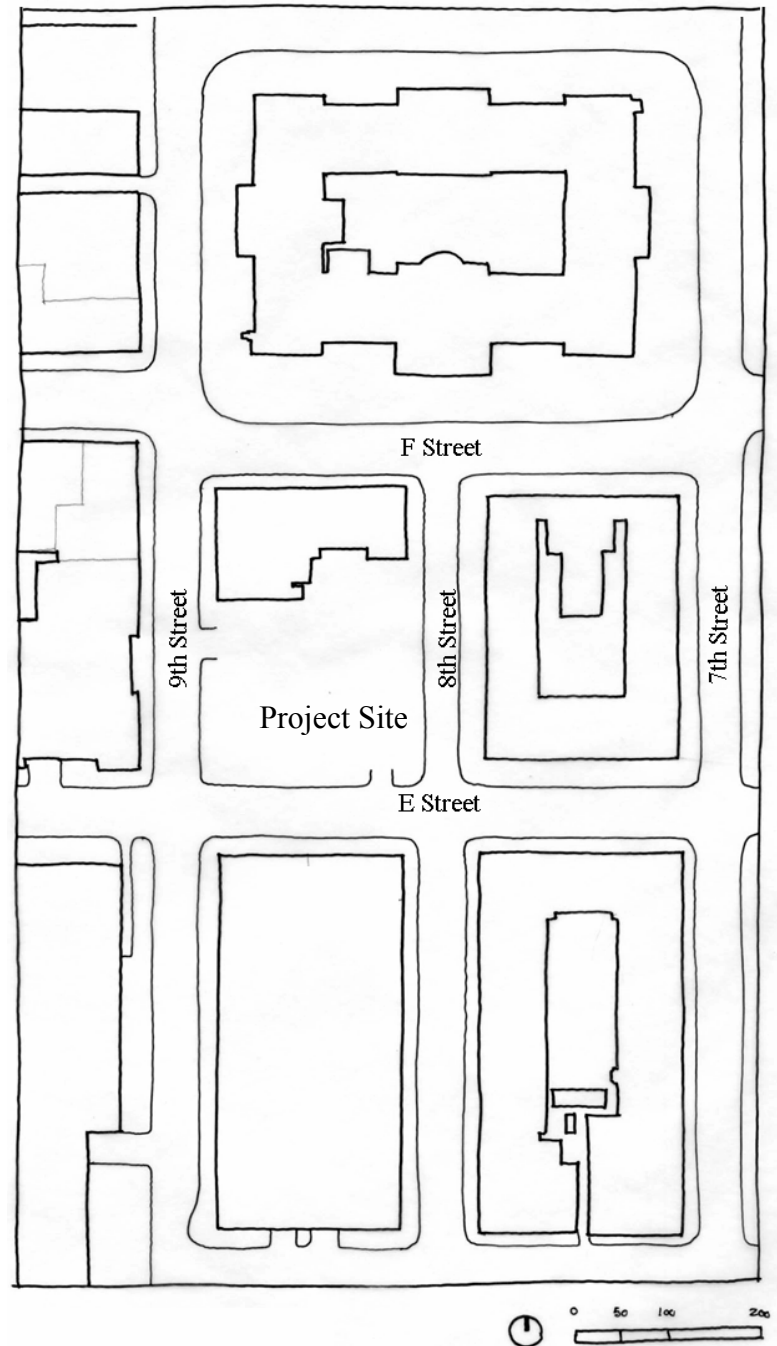
**Figure 12:** 1932 Baist Plan of Vicinity, Plate 30. The Gayety Theatre was one of many theatres along 9<sup>th</sup> St. The US Land and Indian Office had moved out and the building was used for various govt. offices- including the Tariff Commission and Post Office.





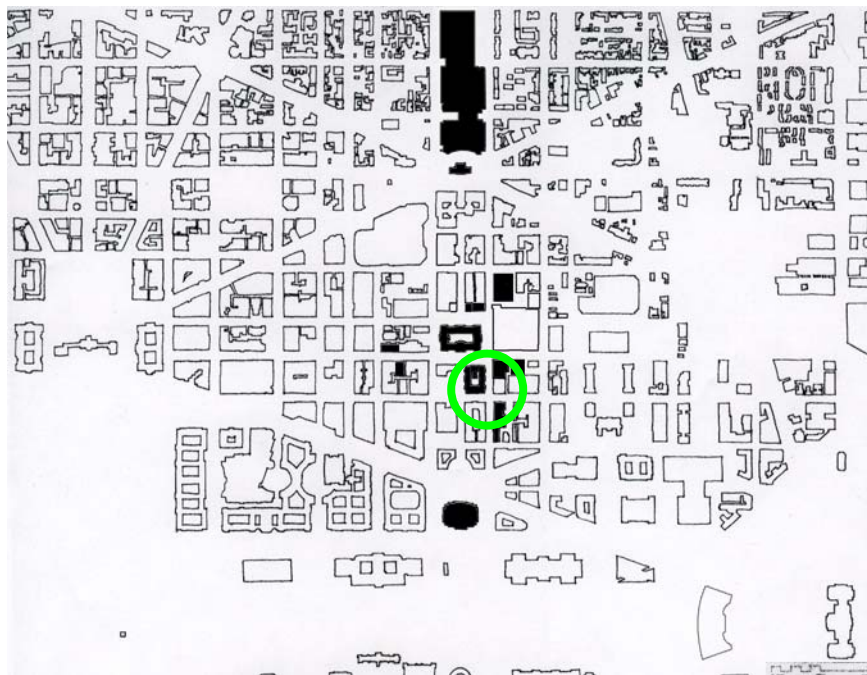
**Figure 13:** 1965 Baist Plan of Vicinity, Plate 30. Following 1965, the FBI Headquarters took residence in the neighboring block of 9<sup>th</sup> and E Streets, and The National Portrait Gallery moved into the Patent Office on F street, and the project site was left near vacant, with only a hotel remaining.



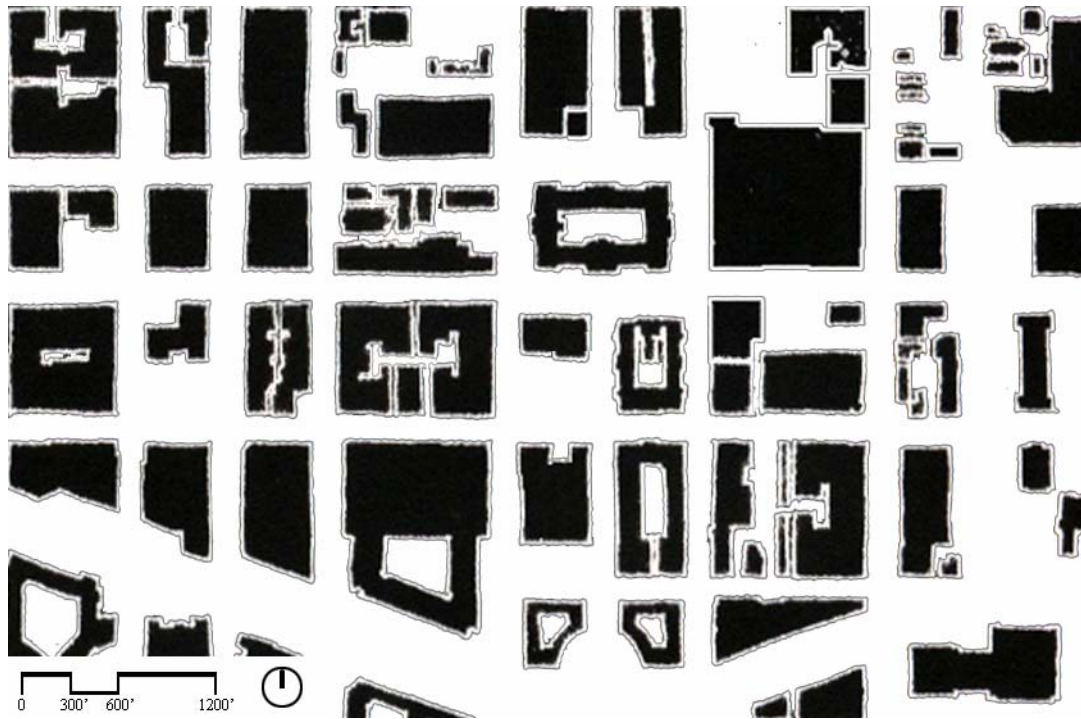


**Figure 14:** The Site. The International Spy Museum, a mixed-use retail and apartment building, was just completed in 2002 on the North portion of the block. The National Portrait Gallery is undergoing renovation. The Tariff Commission Building is being renovated into a hotel, and a new apartment building has been recently completed on the southwest corner of 8<sup>th</sup> and E Streets.

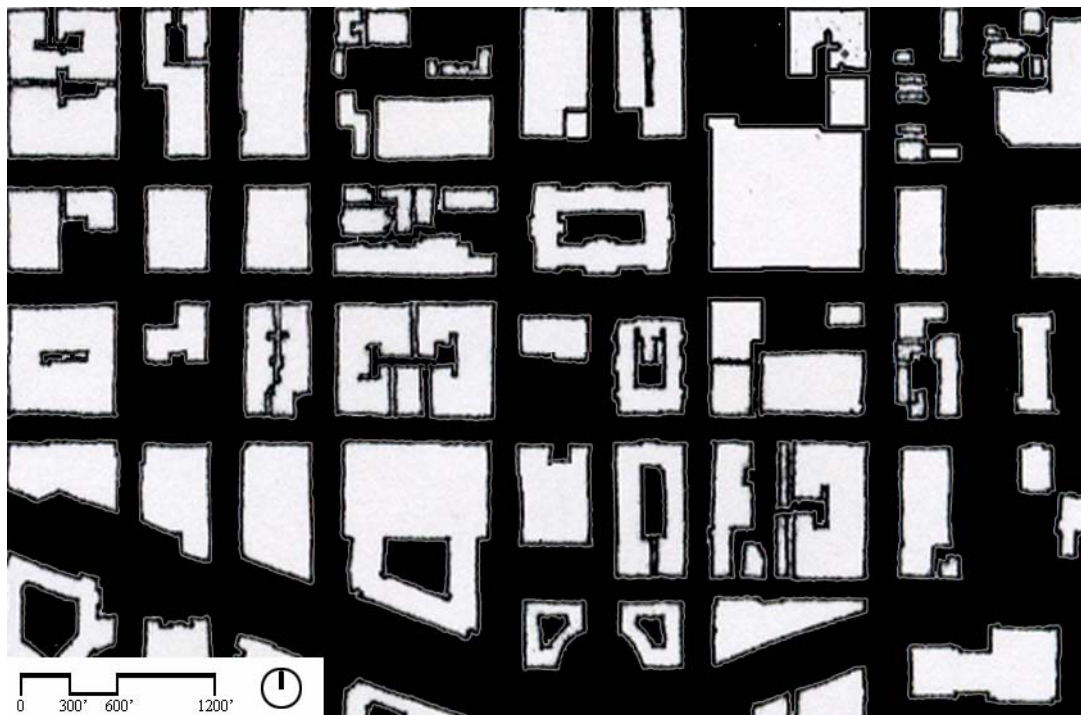
In recent years, this area has been undergoing a healthy wave of transformation. This began in the 1980's with the addition of the Metro Transit System, with stops at Metro Center and Gallery Place. In the 1990's, "momentum built rapidly with hundreds of millions of dollars in new real estate and infrastructure investment."<sup>22</sup> Many of the developments in the area are in fact renovations. Historic facades are being maintained and restored, with new mixed-use buildings developed behind. New apartment housing complexes are bringing more residents to the area, putting people on the streets and reinforcing the development of a pedestrian- oriented neighborhoods.



**Figure 15:** Areas undergoing construction and recently completed work.



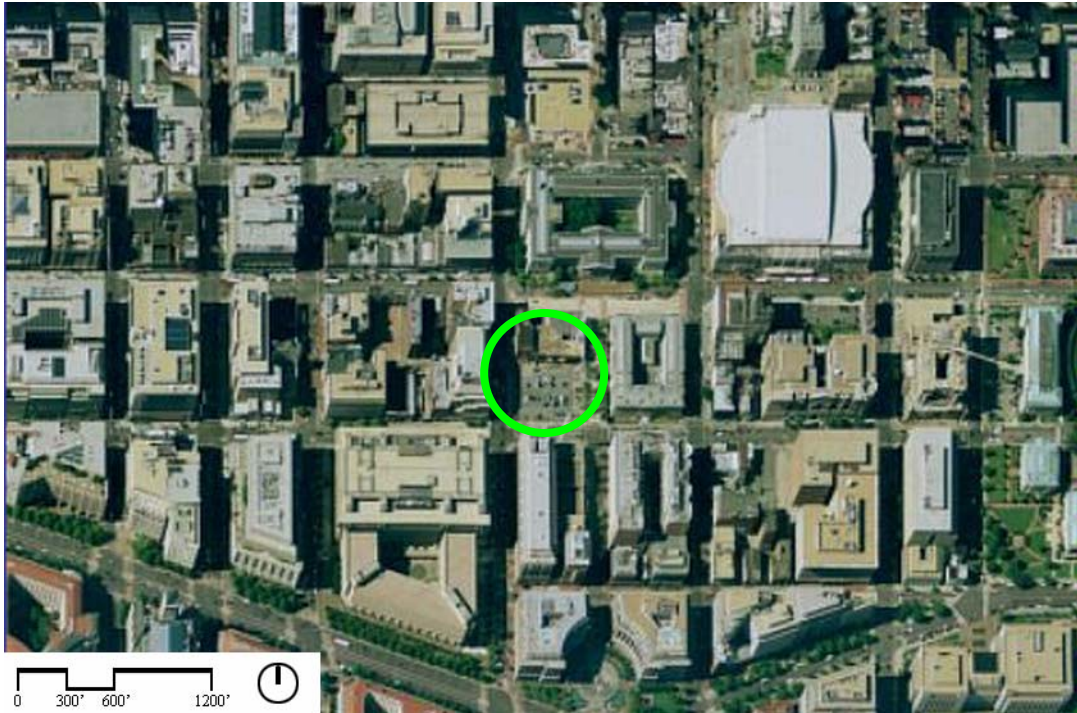
**Figure 16:** Space Positive Diagram. This diagram emphasizes the well-defined street edge and the overriding organization of the grid.



**Figure 17:** Space Negative Diagram. A comparison of figure and ground, these diagrams emphasize voids in the urban fabric due to surface parking and empty lots.



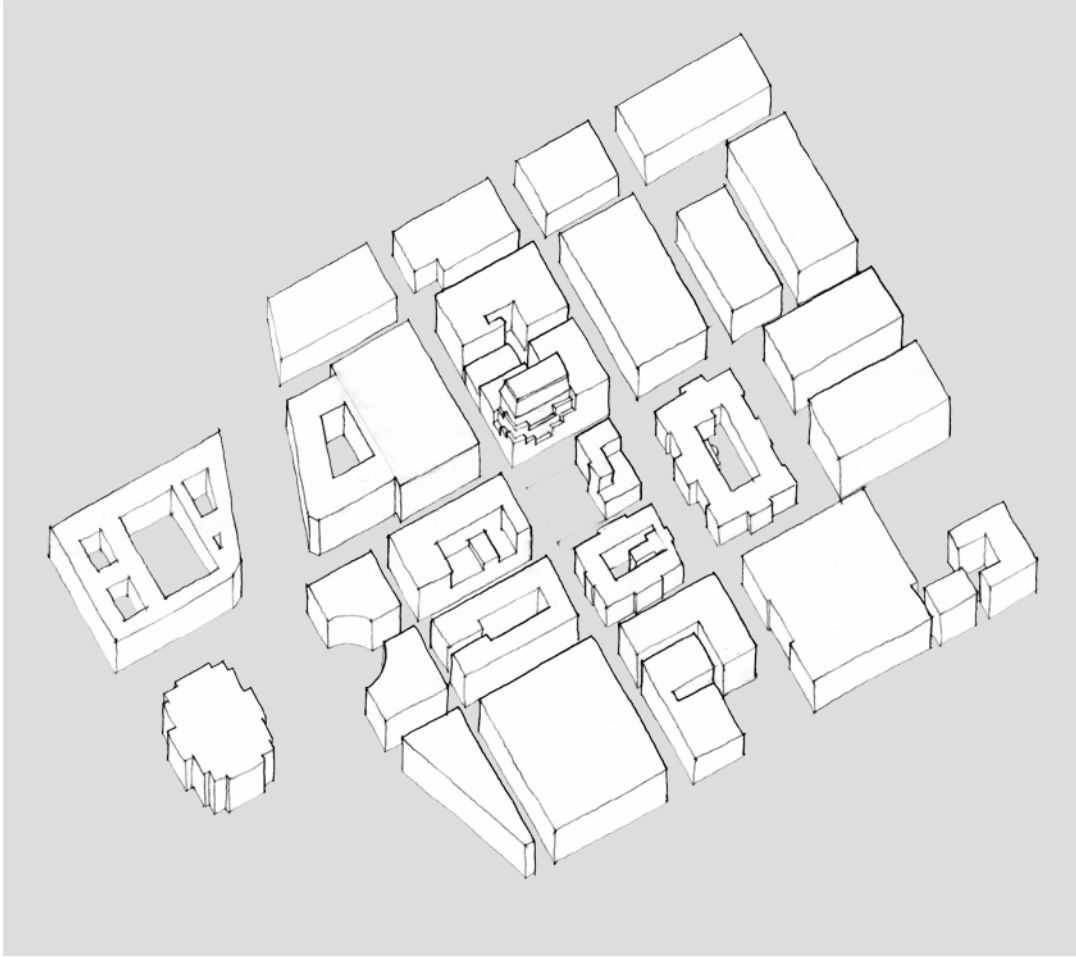
## SITE SURVEY / DOCUMENTATION



**Figure 18:** Aerial Photograph of Vicinity. 2002 GlobeXplorer, AirPhotoUSA.

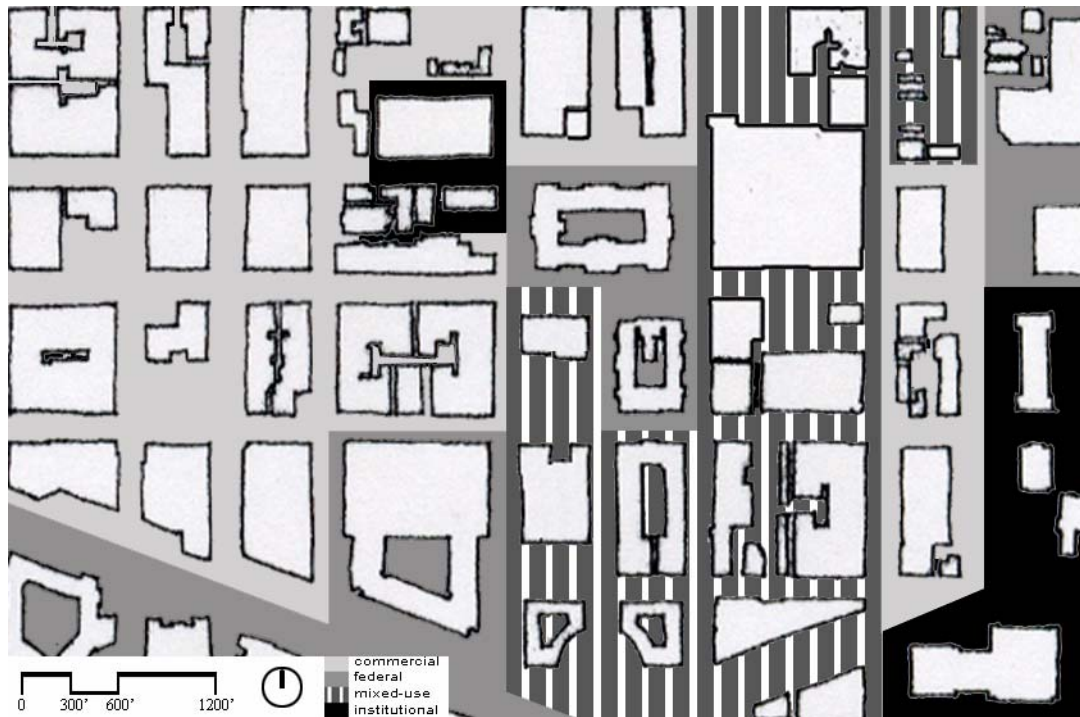


**Figure 19:** Aerial Photograph of Site. 2002 GlobeXplorer, AirPhotoUSA.



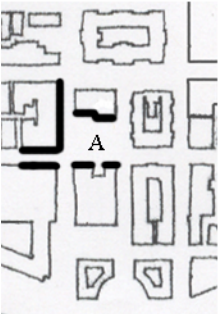
**Figure 20:** Axonometric Diagram of site.

Massing of buildings in the vicinity reveal the rugged conformity to the grid organization, highlighting gaps in the urban fabric.



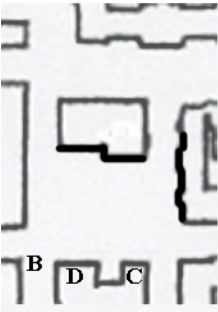
**Figure 21:** Land Use. As part of the downtown core, the land use designations of the area vary between Mixed- Use, Commercial, Institutional, and Federal.

**Figure 22:** E Street, NW.



The north block of E Street, between 8<sup>th</sup> and 9<sup>th</sup> Streets, NW, the site is currently a fee parking lot.

The street level is activated with ground level retail. Maple trees along the sidewalks bring down the scale of the buildings and create a pedestrian friendly walking environment. Parallel parking along the street acts as a buffer between the sidewalk and the moving traffic.



The south block of E Street, between 8<sup>th</sup> and 9<sup>th</sup> Streets, NW, is lined with tall mixed- use buildings.

On the corner of 8<sup>th</sup> street is an 11-story apartment building that was recently completed.

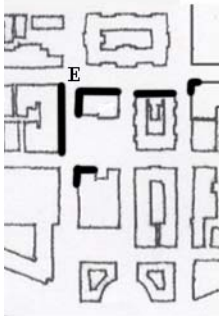
On the corner of 9<sup>th</sup> street is a 10- story office building with ground level retail.



**Figure 23:** 9<sup>th</sup> Street, NW.



E.



The north- west portion of 9<sup>th</sup> Street is lined with tables and chairs for a restaurant seating during nice weather.

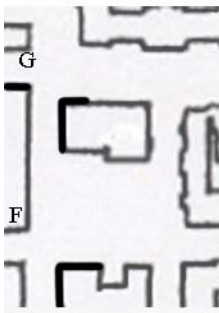
9<sup>th</sup> Street has three lanes of one-way traffic moving southbound. Both sides of the street are lined with parallel parking.



F.



G.



The International Spy Museum occupies the historic 6- story red brick Atlas building on the east side of the block.

A contemporary 11-story office building fronts the west side of the block, as well as the Washington Loan and Trust Building

Wide crosswalks contribute to making this area a pedestrian friendly environment.



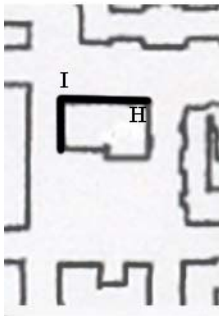
**Figure 24:** F Street, NW.



H.



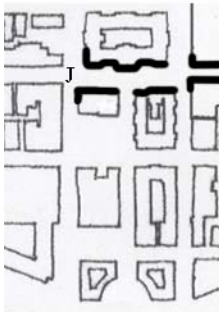
I.



The International Spy Museum complex.  
The historic facades were renovated and restored, and a new building was inserted behind.



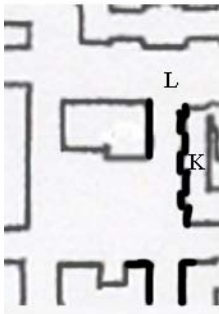
J.



View down F Street, looking East.

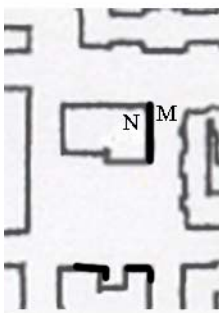
The National Portrait Gallery, with its Magnolia Trees, shown under renovation, fronts the north block and is centered on 8<sup>th</sup> Street.

**Figure 25:** 8<sup>th</sup> Street, NW.



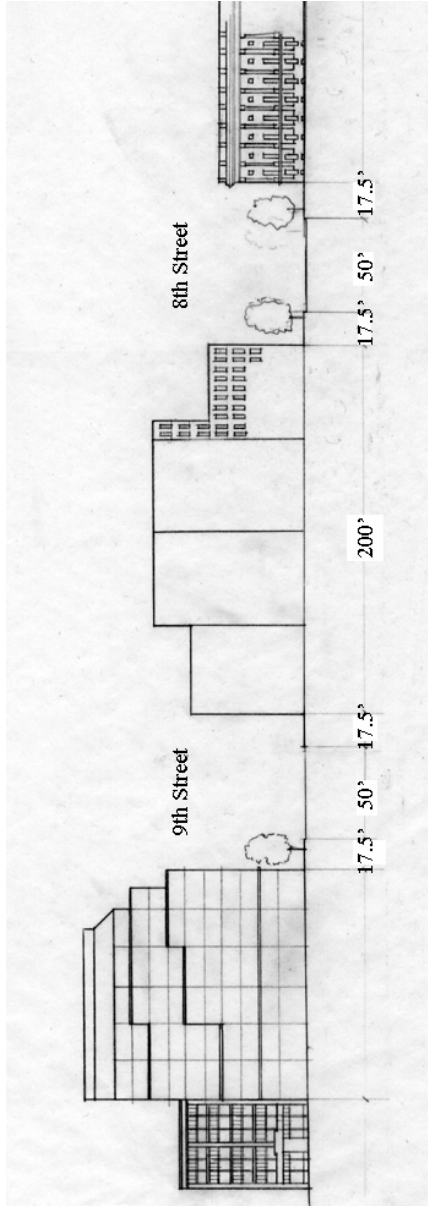
View down 8<sup>th</sup> Street, looking south at the National Archives Building.

US Tariff Commission Building, with its central arcade is currently being converted into an upscale hotel.

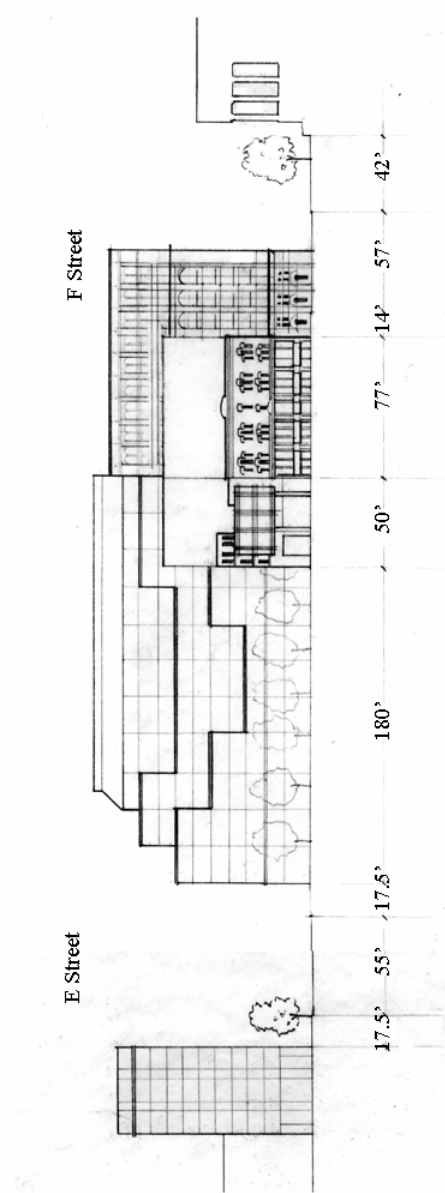


View of buildings fronting the north- west portion of 8<sup>th</sup> Street. Both buildings are part of the International Spy Museum.

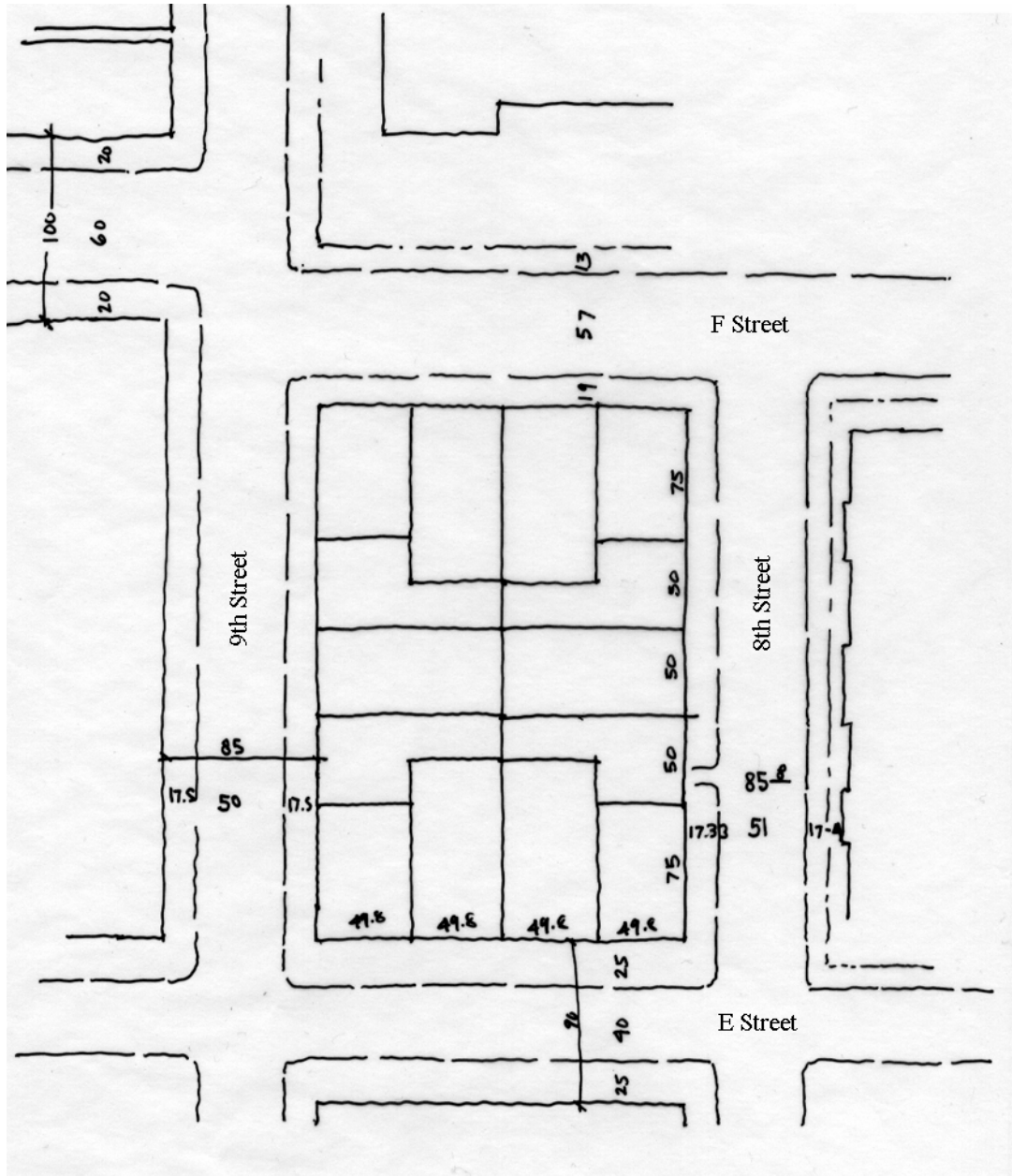
The renovated Le Droit Building and a newly constructed building neighboring it.



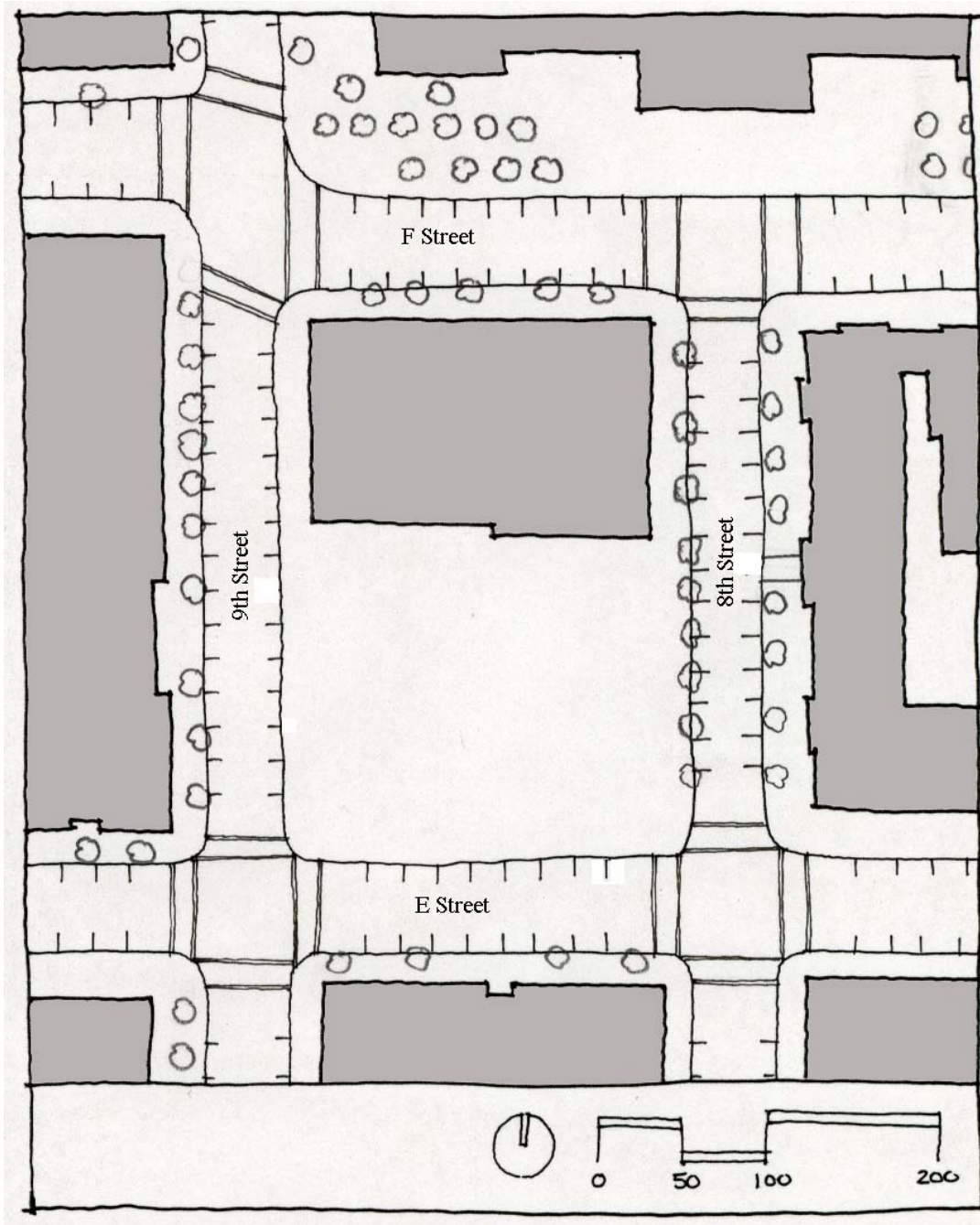
**Figure 26:** Section through E Street, looking north at site.



**Figure 27:** Section through 8<sup>th</sup> Street, looking west at site.

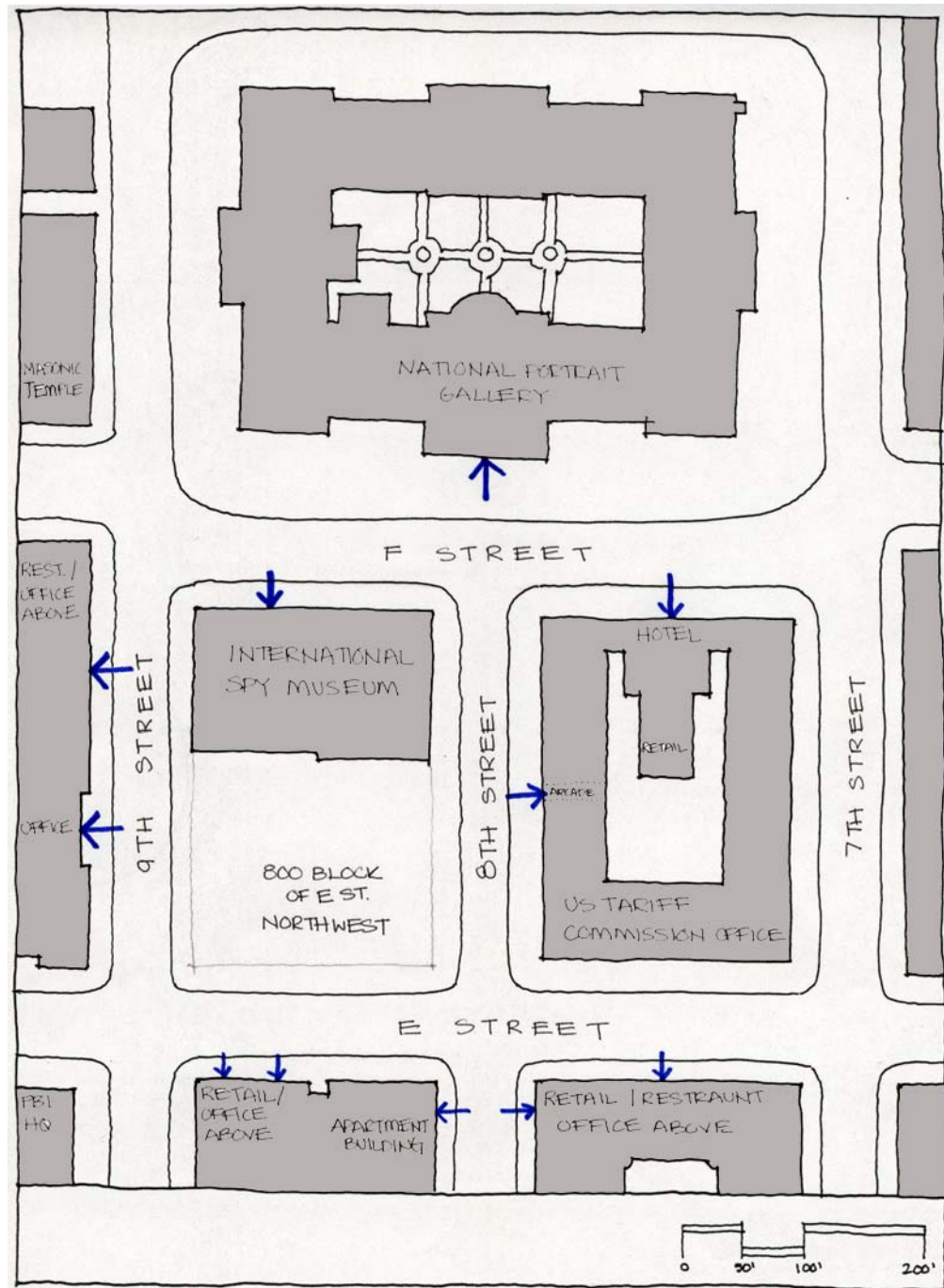


**Figure 28:** Lot and Sidewalk Dimensions.

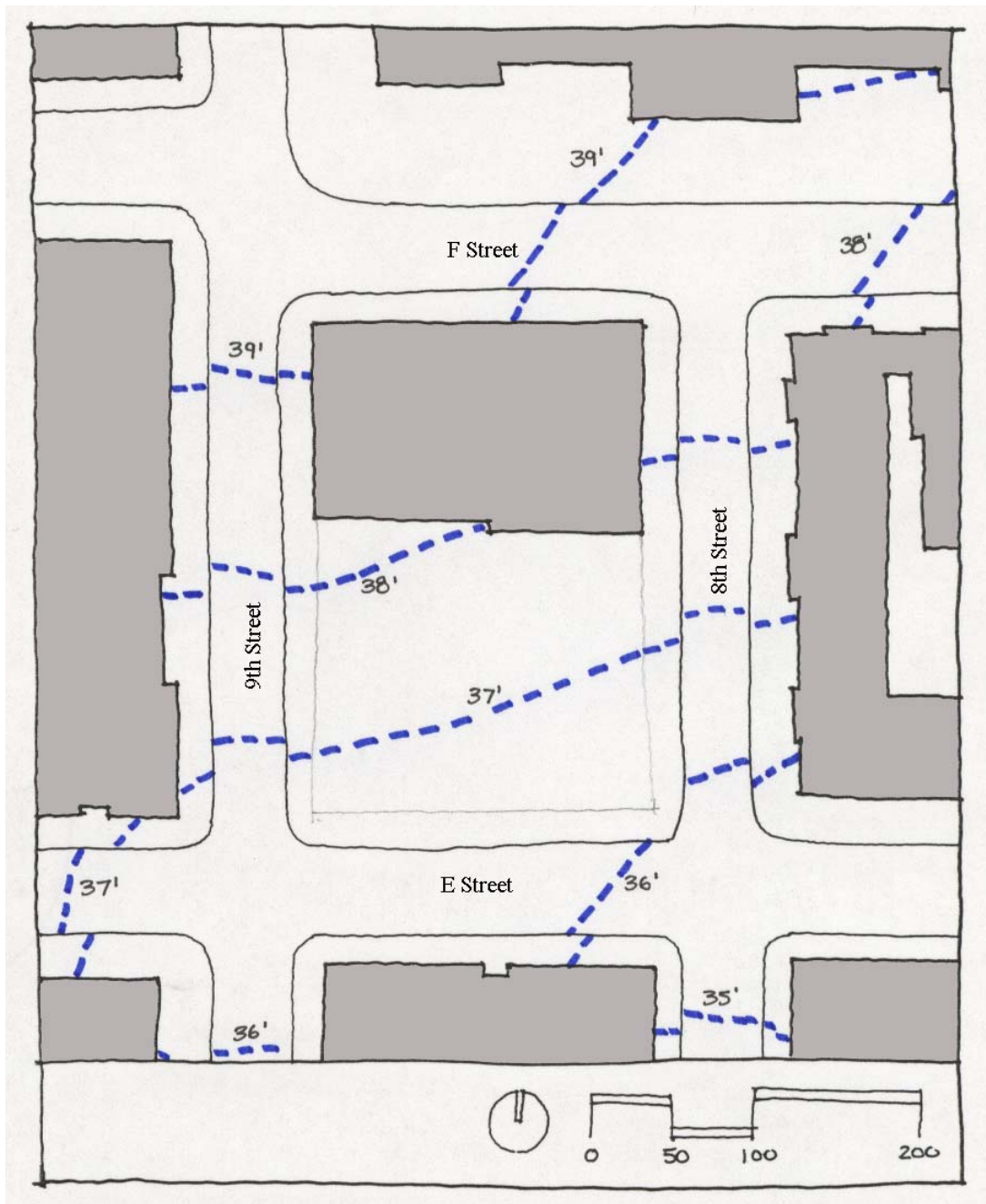


**Figure 29:** Pedestrian Oriented Developments. Wide sidewalks increase the comfort and safety of foot traffic. Trees help to bring down the buildings to a more human scale, while parallel parking spots act as a buffer between people and moving traffic.

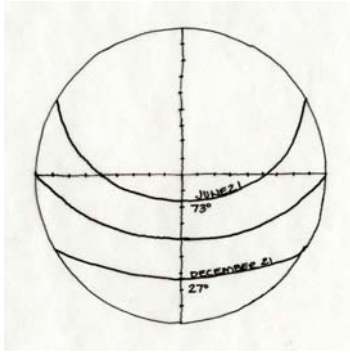




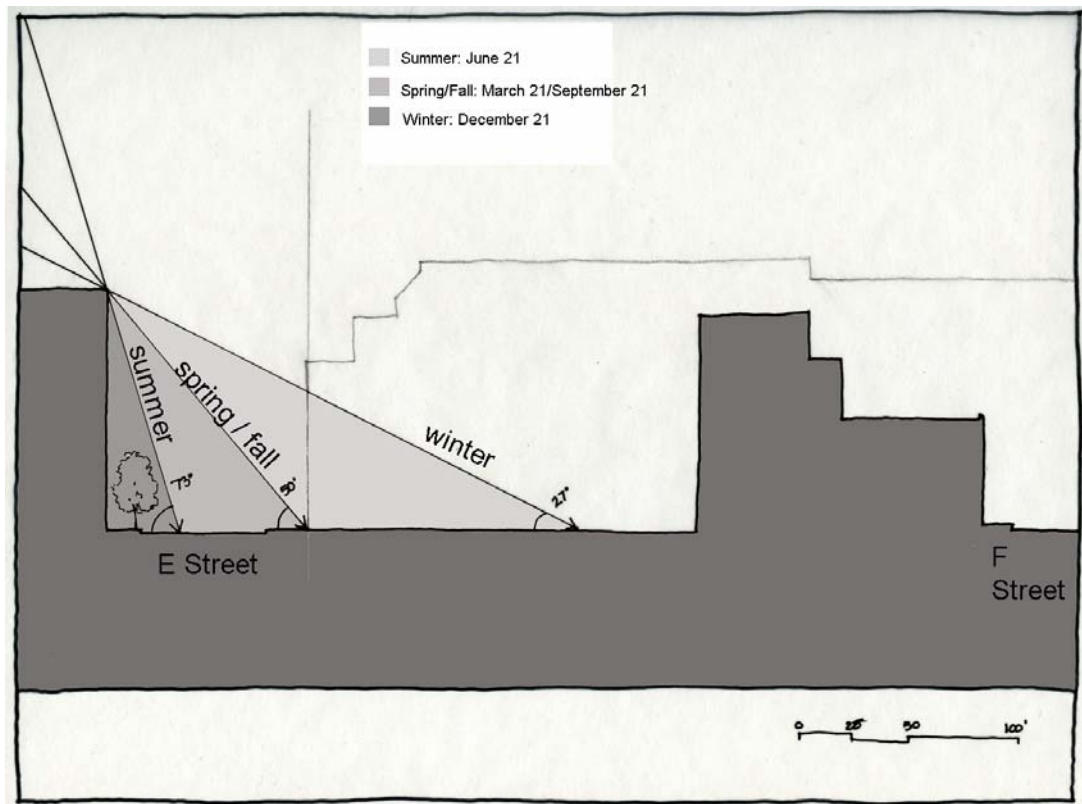
**Figure 30:** Plan of immediate vicinity showing entrances and building types. This diagram can inform where the most pedestrian street activity occurs.



**Figure 31:** Topography. The site slopes slightly upward toward the northwest.

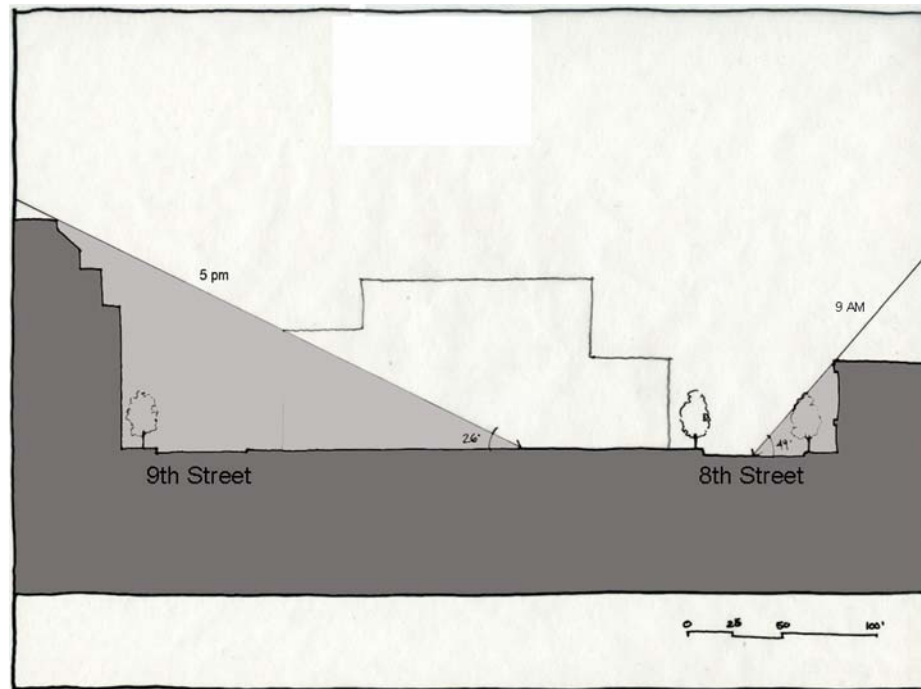


**Figure 32:** Sun Path Diagram for 40° North Latitude. The Sun Path Diagram can be used to determine the altitude of the sun on the site according to season, and thereby suggest shading requirements.

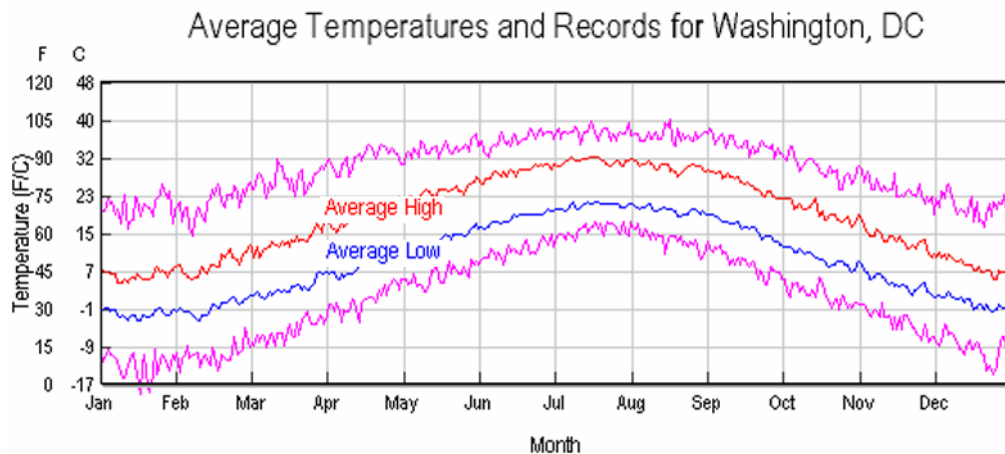


**Figure 33:** Seasonal Shadow Projections. This diagram shows what areas of the sun are penetrated by direct light during the different seasons. <sup>23</sup>

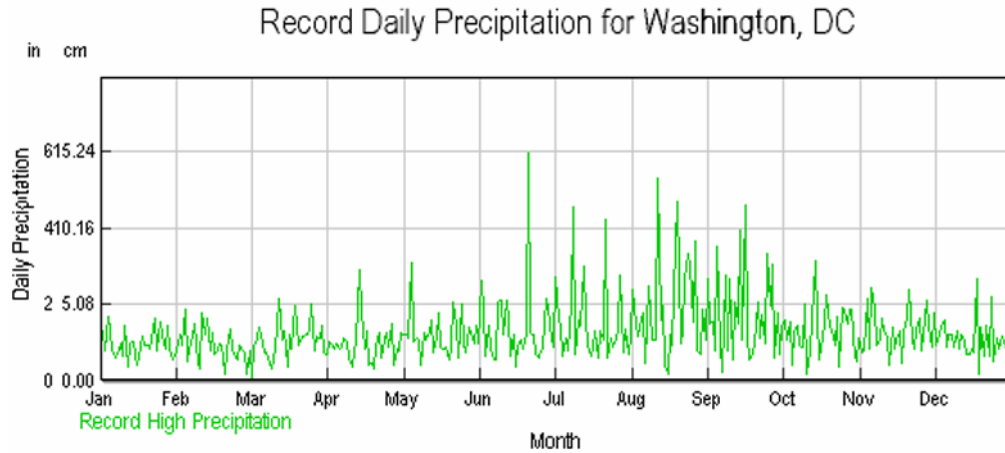




**Figure 34:** Hourly Shadow Diagram for 40° North Latitude on June 21. This diagram shows what parts of the site will be in shade during the day, as well as which areas of the site will be in direct light.<sup>24</sup>



**Figure 35:** Climatic Data.<sup>25</sup> Avg. Temp. and Records for Washington, DC.



**Figure 36:** Climatic Data.<sup>26</sup> Record Daily Precipitation for Washington, DC.

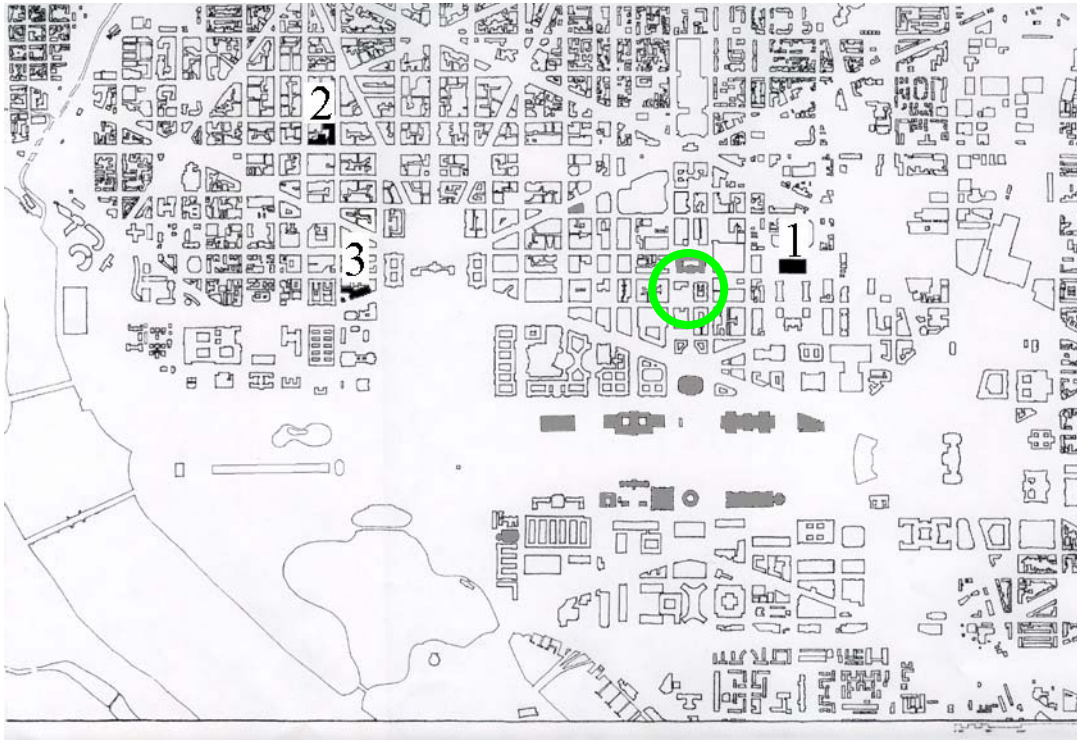


**Figure 37:** Climatic Data.<sup>27</sup> Record Daily Snowfall for Washington, DC.

Monthly Averages												
	January	February	March	April	May	June	July	August	September	October	November	December
High Temperature ( F / C )	42 / 6	46 / 8	56 / 14	67 / 19	76 / 25	85 / 29	89 / 31	87 / 30	80 / 27	69 / 21	58 / 15	47 / 8
Low Temperature ( F / C )	27 / -3	29 / -2	38 / 3	46 / 8	57 / 14	67 / 19	71 / 22	70 / 21	62 / 17	50 / 10	41 / 5	32 / -0
Precipitation ( in / mm )	3 / 69	3 / 69	3 / 80	3 / 69	4 / 93	3 / 86	4 / 96	4 / 99	3 / 84	3 / 77	3 / 79	3 / 79
Snow ( in / cm )	4 / 10	4 / 9	0 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	trace / trace	1 / 1
Wind Speed ( mph / kmh )	10 / 17	11 / 17	11 / 18	11 / 18	10 / 16	9 / 15	9 / 14	9 / 14	9 / 14	9 / 15	10 / 16	10 / 16
Wind Direction	NW	NW	NW	South	South	South	South	South	South	South	South	NW
Cloud Cover (out of 8)	5.2	5.2	5.2	5.0	5.1	4.9	4.9	4.7	4.6	4.4	5.0	5.3

**Figure 38:** Climatic Data.<sup>28</sup> Monthly Averages for Washington, DC.

## SITE ANALYSIS



**Figure 39:** Accessibility. This site is easily accessible to the general public as museum visitors, as well as architects and designers for the research component. It is within close proximity to other building related institutions, such as the (1) National Building Museum, the (2) United States Green Building Council (USGBC), and the (3) American Institute of Architects (AIA).



**Figure 40** Transit. The site is ideally located for mass transit opportunities. At the heart of Metro Transit coverage area, the site is within a five- minute walk of each of the Metro lines. It is also on the D1, D3 and D6 bus lines, and a twelve- minute walk from the National Mall.

## **ZONING**

The north block of E Street between 8<sup>th</sup> Street and 9<sup>th</sup> Street, NW has been classified within the C-4 (Central Business District) overlaid in combination with DD (Downtown Development District) restrictions.

The C-4 downtown core is “comprised of the retail and office centers for the District of Columbia and the metropolitan area, and allows office, retail, housing and mixed uses to a maximum lot occupancy of 100%, a maximum FAR of 8.5 to 10.0, a maximum height of 110 feet and 130 on 110-foot adjoining streets. (Maximum height and FAR depend on width of adjoining streets.)”<sup>29</sup>

The DD is intended to create a balanced mixture of uses by means of incentives and requirements for critically important land uses identified in the Comprehensive Plan, including retail, hotel, residential, entertainment, arts, and cultural uses.<sup>30</sup> As a result, “each building shall devote not less than 50% of the gross floor area of the ground floor to permitted retail, service, arts, and arts-related uses.”<sup>31</sup>

“Any open arcade in the DD Overlay District shall extend the length of the entire block frontage, or shall connect with an open arcade in an abutting building in such a fashion as to provide a continuous walkway.”<sup>32</sup>

“Not less than 75% of each street wall of new construction to a height of not less than 15 feet shall be constructed to, or within 4 feet of, the property line between the subject lot and each abutting street right-of-way.”<sup>33</sup>

“Not less than 50% of the surface area of any street wall at the ground floor level of each building shall be devoted to display windows and to entrances to commercial uses or to the building; provided:

- (a) The windows shall use clear or low emissive glass, except for decorative or architectural accent;
- (b) Entrances to the building, excluding vehicular entrances, shall be separated by not more than 50 ft. on average for the linear frontage of the building”<sup>34</sup>

This site has also been zoned as part of the Downtown Arts District, with the intent to “retain, expand, and support a concentration of spaces and activities for the arts and artists, including the performing and visual arts, cultural facilities, entertainment, and arts-related retail uses.”<sup>35</sup>

The Downtown Arts District requires that not less than 0.25 FAR equivalent of the required gross floor area shall be devoted to retail, service or arts and arts-related uses.<sup>36</sup> This may include unenclosed sidewalk cafes not exceeding 1000 square feet.

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<sup>20</sup> Worldnet ® 1.6, © 1997, Princeton University.

<sup>21</sup> Master Draft 2-2

<sup>22</sup> Lewis, Roger. “Shaping the City.” Washington Post. Saturday, November 30, 2002; Page H03.

<sup>23</sup> Brown, G.Z. and Mark DeKay, Sun, Wind & Light.

<sup>24</sup> Ibid.

<sup>25</sup> <http://www.wunderground.com>

<sup>26</sup> Ibid.

<sup>27</sup> Ibid.

<sup>28</sup> Ibid.

<sup>29</sup> District of Columbia Municipal Regulations, District of Columbia Office of Zoning.  
<http://dcoz.dc.gov/info/reg/reg.shtm>

<sup>30</sup> Ibid., 1700.3, General Provisions

<sup>31</sup> Ibid., 1702.1, Area-wide Use Provisions

<sup>32</sup> Ibid., 1701.2, General Provisions

<sup>33</sup> Ibid., 1701.3, General Provisions

<sup>34</sup> Ibid., 1701.5, General Provisions

<sup>35</sup> Ibid., 1704.1, Downtown Arts District

<sup>36</sup> Ibid., 1704.3, Downtown Arts District

## CHAPTER FOUR : GOALS AND APPROACH

*“As this century draws to a close, we are living in a time when technology dominates our relationship with the domestic environment, work environment and even nature. It has a powerful influence in most of our decision-making. So we need to question whether we are using technology just for the sake of using it.”<sup>37</sup>*

Avi Friedman

## **SPECIAL TOPICS**

The built environment offers a snapshot of the cultural values and technological capabilities of the place and time in which it was created. There are two ways in which society can begin to build towards a more sustainable future: consider ecologically sustainable systems, and incorporating culturally sustainable principles.

For humans to sustain life on Earth, global ecological status must become a priority. Assessing valuable resources, analyzing building practices, and determining how to build more effectively and more efficiently will insure a sustainable future.

Buildings designed must be built with an understanding of what is appropriate both contextually and culturally if they are to last. Humans must be able to relate to the experience of the place. In order to assign it value, people must *want* to maintain it.

Sustainability will only thrive if society begins to understand and accept it as part of its social responsibility. Attitudes toward recycling must be expanded to encourage the reduction of consumption. Society can reduce its waste production and thus focus on producing more meaningful products.



## **TEN SHADES OF GREEN, PETER BUCHANAN<sup>38</sup>**

Ten Shades of Green took the form of a traveling exhibition, attempting to further move environmental responsibility into discussion among the society of architects and designers. It argued that green building called for more than specifying materials and tweaking existing systems. Rather it suggested that green architecture should relate to the environment at a higher level, integrated into both the form and function. The ten shades refer to key themes that should be considered early in the design and development of any project.<sup>39</sup> As these values can be used to suggest values in the design, they can be applied to measure success of the product.

The following descriptions have been taken from a pamphlet from an exhibition held at the National Building Museum.

[01] Low Energy/ High Performance- buildings are organized and shaped to be less dependent on fossil fuel energy through reducing the need for artificial lighting and air- conditioning.

- big windows, shaded by overhangs or recesses
- natural ventilation
- individual control of environment
- application of a double facade

[02] Replenishable Resources- refers to utilizing ambient energy sources, such as the sun, as well as constantly replenished materials, such as wood.

- use of replenishable materials when appropriate
- solar panels to take advantage of the sun as an ambient energy source.

[03] Recycling- means to eliminate waste and pollution because in nature, there is no waste.

- conserve and recycle rainwater for landscaping
- design a building that is robust and adaptable enough for long life, and made from materials and components that can be reused.

[04] Embodied Energy- is all the energy required to extract, manufacture and transport a building's materials as well as that required to assemble and 'finish' it.

- The use of local materials reduces energy lost to transportation, as well as further embeds the building in place.

[05] Long Life, Loose Fit- refers to the life cycle of a building. Considers how to make buildings that will always be valued, that people will identify with and wish to reuse and conserve.

- generously accommodating and flexible in organization
- materials that are appropriate, meaning they last and even improve visually and in tactility with age

[06] Total Life Cycle Costing- means to consider the long-term view and looks at the larger impacts of any action on the environment and society. The costs considered include those to society, local community and individuals, ecology and larger environment, the psyche and sense of the aesthetic- of every aspect of the building, from the extraction, manufacture and transport of its materials, through its erection and useful life to the ultimate recycling of its materials or their degradation back to earth.

[07] Embedded in Place- refers to taking clues from the physical and cultural context.

- local materials and building traditions inform the design approach

[08] Access and Urban Context- refers to a building's location in terms of its accessibility and proximity to a range of other functions

- consider 'ecological footprint' of city through strengthening existing fabric rather than expanding into greenfields
- maximize opportunities for access
- consider proximity of nearby local shops, restaurants, social venues

[09] Health and Happiness- considers the well- being of building occupants, and values people above all.

- maximize opportunities for views, fresh air, & natural light
- opportunities to foster community
- non-polluting materials

[10] Community and Connection- attempts to connect people with each other, to nature and the cosmos, and to past and future generations in order to improve the quality of life for all.

- educate people about and encourage sensitivity to nature
- reinforce community, bring people together

## **LEED™**

Leadership in Energy and Environmental Design is a rating system established by the U.S. Green Building Council. It is a point-based rating system by which a building's greenness can be measured.

**LEED Design Strategies**– Green Building Rating System, version 2.0  
**Bold Type Font** indicates potential credits applicable to this thesis.

### Sustainable Sites

**Prerequisite: Erosion and Sedimentation Control**

**Credit 1: Site Selection**

**Credit 2: Urban Redevelopment**

Credit 3: Brownfield Redevelopment

**Credit 4: Alternative Transportation**

Credit 5: Reduced Site Disturbance

Credit 6: Storm water Management

**Credit 7: Landscape and Exterior Design to Reduce Heat Islands**

**Credit 8: Light Pollution Reduction**

### Water Efficiency

**Credit 1: Water Efficient Landscaping**

**Credit 2: Innovative Wastewater Technologies**

**Credit 3: Water Use Reduction**

### Energy and Atmosphere

**Prerequisite 1: Fundamental Building Systems Commissioning**

**Prerequisite 2: Minimum Energy Performance**

**Prerequisite 3: CFC Reduction in HVAC&R Equipment**

**Credit 1: Optimize Energy Performance**

**Credit 2: Renewable Energy**

Credit 3: Additional Commissioning

**Credit 4: Elimination of HCFC's and Halons**

**Credit 5: Measurement and Verification**

**Credit 6: Green Power**

## Materials and Resources

### **Prerequisite: Storage & Collection of Recyclables**

Credit 1: Building Reuse

### **Credit 2: Construction Waste Management**

Credit 3: Resource Reuse

### **Credit 4: Recycled Content**

### **Credit 5: Local/ Regional Materials**

### **Credit 6: Rapidly Renewable Materials**

### **Credit 7: Certified Wood**

## Indoor Environmental Quality

### **Prerequisite 1: Minimum IAQ Performance**

### **Prerequisite 2: Environmental Tobacco Smoke (ETS) Control**

### **Credit 1: Carbon Dioxide (CO<sub>2</sub>) Monitoring**

Credit 2: Increase Ventilation Effectiveness

### **Credit 3: Construction IAQ Management Plan**

### **Credit 4: Low- Emitting Materials**

### **Credit 5: Indoor Chemical and Pollutant Source Control**

Credit 6: Controllability of Systems

Credit 7: Thermal Comfort

### **Credit 8: Daylight and Views**

## DESIGN INTENT

### *Content*

A place where the public can come, feel welcome to experience the facility and utilize its resources. This building is to be an amenity to the city. A comprehensive experience -displaying its greenness at a variety levels, consciously and intrinsically. The content will aim to influence the form and process of the built environment.

### *Climate as Context*<sup>40</sup>

To understand climate as part of the context and how it influences how much energy is being used. To use climatic considerations to inform the design.

### *Urban Design*

Relate to the scale and proportion of the existing fabric and ordering systems. To spill activity onto the street and activate the ground floor frontage.

### *Energy*

Efficient use of energy is a key consideration that leads to financial and ecological gain. A building that is energy efficient demands less power and saves money on energy bills.

### *Aesthetic*

Part of the challenge will be to demonstrate that a green building doesn't necessarily look different than other buildings. By reinforcing the normalcy of appearance, the green system will not hinder its marketability. It is also important that the building respond to the site and be contextual, but also stand out enough to attract attention in order to create a memorable image in people's minds.

### *Flexibility*

It is important that the building and spaces within accommodate a variety of functions and be flexible should the building tenant redesignate the use in the future.

### *Materials*

Relate to the historical architecture of Museums in Washington, DC as well as utilize recycled and certified materials. Explore the use of greenery as a building material.

### *Green Roof*

Cities retain and trap heat in the summer as a result of the high amounts of pavement and non-porous surfaces. As a way to reduce this "urban heat island" effect in Washington, DC, this building will have a green roof. Plants also can help to cool a city through water evaporation. Green roofs help to lower temperatures, reduce pollution, reduce storm run-off, retain up to 25% of the building's heat in the winter, and reduce heat absorption by up to 50% in the summer.<sup>41</sup> The presence of

native grasses also protects buildings (especially the roofing membrane) from thermal shock and ultraviolet degradation.<sup>42</sup>

### *Air Quality*

Each individual can control his or her own breathing zone in terms of air temperature and flow of fresh air.

### *Enhance lives of inhabitants*

Celebrate cultural and natural pleasures. Sun, light, air, nature, food. Fresh air and natural light naturally enhance the pleasure of a place.

### *Daylighting*

Reduce the need for fluorescent lights by maximizing natural light opportunities. Views to exterior- awareness of life cycles of days and seasons, contributes to health and happiness of building occupants.

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<sup>38</sup> Schumacher, E.F. Small is Beautiful: Economics As If People Mattered. Vancouver: Hartley & Marks, 1999.

<sup>38</sup> Buchanan, Peter. Ten Shades of Green. Architectural League of New York, 2000.

<sup>39</sup> <http://www.ar.utexas.edu/gallery/exhibitions/10shades/>

<sup>40</sup> Brown, G.Z. and Mark DeKay, Sun, Wind & Light.

<sup>41</sup> Brake, Alan G. "Rooftop Oasis" Architecture, June 01

<sup>42</sup> McDonough, William and Michael Braungart.

Cradle to Cradle: Remaking The Way We Make Things.  
New York: North Point Press, 2002. Page 74.

## PROGRAM DESCRIPTION

### 1. Entry

---

#### *Lobby*

Information desk is located here, with access to coat check, restrooms

#### *Café*

This café services the general public, as well as visitors and staff from the museum. It has a separate entrance from the museum, with access to the museum through the atrium

#### *Bookstore*

Allows visitors to bring home and expand on their experiences at the Museum. Further support the “research” nature of the museum by making information available to the public for personal use. It has a separate entrance from the museum, with access to the museum through the atrium

### 2. Atrium / Events Space

---

Places are provided to encourage impromptu discussions. Bring light and air through the center of the building and organizes the program. Heavily planted to bring green into the city, as the heart of the building.

### 3. Exhibition Spaces

---

#### *Built Environment Gallery – Yesterday, Today, Tomorrow*

Review of the full life cycle of the built environment from methods of production, to produced items. This exhibit will offer an analysis of what is built and why from the viewpoint of where we’ve been, where we are, and where we aspire to be. Timeline, value systems, opportunity, and available technology will be considered from a international, national and regional scope.

#### *Tomorrow’s Potential – Domestic Scale*

Encourage individuals to become aware of the effect of their every day decisions. Outlining ways for individual families to implement sustainable practices in their homes and every day lives.

Organic Suburbanite, by Warren Schultz

Product Analysis

Department of Energy CD ROM

#### *Tomorrow’s Potential – Professional Scale*

A study of building materials, Systems Technology, Rating Systems through samples, models, diagrams, software.

The building itself will be part of the example.

Temperature of different parts of the façade (color, cardinal direction,

shading devices)  
Green Roof  
Solar Panels – energy “produced” during that day

*Laws of Nature Gallery –*

This gallery talks about the natural environment in terms of how people interact with nature, and principles of nature such as thermodynamics, ecosystems, and nature’s “services.” Focus on man’s connection to nature and spirituality  
Models, Videos will be used to demonstrate concepts and principles

*Case Studies - Role of Architecture in a Sustainable Tomorrow*

This gallery displays an in depth study of new buildings, products and projects. This exhibit will be continually updated, and the material archived in the Resource Library.

*Temporary/Visiting Exhibits*

Flexible Space for visiting exhibits. Easily subdivided and changeable.

#### **4. Resource Center**

---

*Resource Directory*

A complete listing of local Architects/Designers, Manufacturers, and access to Green Resource Websites.

*Reference Materials – General Stacks*

Collection of Published Documents including books, periodicals and magazines

*Reference Materials – Washington, DC*

How to build in the context of the Washington, DC metropolitan area. Information on local materials, climate conditions, solar models.

*Computer Modeling Stations*

Software – Energy 10

*Materials Samples*

An in-depth study of different eco-friendly building materials. Display of material samples, encouraging creativity and reuse potential.

#### **5. Education Facilities**

---

Classrooms for education programs, information sessions, small lectures, seminars, and workshops. Each classroom is equipped with chalkboards, pin-up space, and media devices. Space is flexible to meet the varying needs of the general public, professionals and school programs.



## **6. Administration**

---

### *Office of the Director*

Oversees all functions of the museum and research center.

### *Office Seating for Permanent Staff*

Committee established to collect information and generate a database.

Permanent staff publishes documents, holds seminars, offers consultations, provides information for public use in the library and resource rooms.

Open plan strengthens the sense of community.

## **7. Rooftop**

---

### *Working Garden*

### *Terrace*

A “greenspace” in the city that can act as a venue for special events.

## **8. Exhibition Support**

---

### *Workroom – exhibition design and renovation*

### *Storage*

## **9. Building Services**

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### *Locker Rooms*

### *Recycling Center*

### *Bicycle Storage*

### *Shipping/Receiving*

## **10. Parking / Service**

---

### *Loading Dock*

## PROGRAM TABULATION

### 1. Entry

---

A. Lobby / Reception	2,000 s.f.
B. Café (adj. to street)	5,000 s.f.
C. Bookstore (adj. to street)	3,000 s.f.
D. Coat Check (50 lockers)	200 s.f.
E. Women's Restroom (3 lav., 3 wc)	350 s.f.
F. Men's Restroom (3 lav., 3 wc, 3 ur)	300 s.f.

---

10,850 s.f.

### 2. Atrium / Events Space

---

A. Atrium	6,500 s.f.
B. Multi Purpose Room	2,000 s.f.

---

8,500 s.f.

### 3. Exhibition Spaces

---

A. Built Environment Gallery	8,000 s.f.
B. Tomorrow's Potential – Domestic Scale	8,000 s.f.
C. Tomorrow's Potential – Professional Scale	8,000 s.f.
D. Laws of Nature Gallery	4,000 s.f.
E. Case Studies	4,000 s.f.
F. Temporary/Visiting Exhibits (flexible)	4,000 s.f.

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36,000 s.f.

### 4. Resource Center

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A. Reception	300 s.f.
B. Resource Directory	2,000 s.f.
C. Reference Materials – General Stacks	4,000 s.f.
D. Reference Materials - Washington, DC	2,000 s.f.
E. Computer Modeling Stations	1,000 s.f.
F. Materials Samples	1,000 s.f.

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10,300 s.f.

### **11. Education Facilities**

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A. Classroom 1	1,000 s.f.
B. Classroom 2	2,000 s.f.
	<hr/>
	3,000 s.f.

### **12. Administration**

---

A. Director's Office	300 s.f.
B. Permanent Staff	2,000 s.f.
C. Conference Room	1,000 s.f.
D. Reception	200 s.f.
E. Lounge / Restrooms / Kitchen	1,000 s.f.
F. Copy / Mail Room	250 s.f.
G. Storage	200 s.f.
	<hr/>
	4,950 s.f.

### **13. Rooftop**

---

A. Working Garden	8,000 s.f.
B. Terrace	8,000 s.f.
	<hr/>
	16,000 s.f.

### **14. Exhibition Support**

---

A. Workroom	1,000 s.f.
B. Storage (basement)	10,000 s.f.
	<hr/>
	11,000 s.f.

## 15. Building Services

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A. Locker Rooms	500 s.f.
B. Recycling Center	500 s.f.
C. Bicycle Storage	300 s.f.
D. Shipping/ Receiving	1,000 s.f.
	<hr/>
	2,300 s.f.

## 16. Service

---

2,000 s.f.

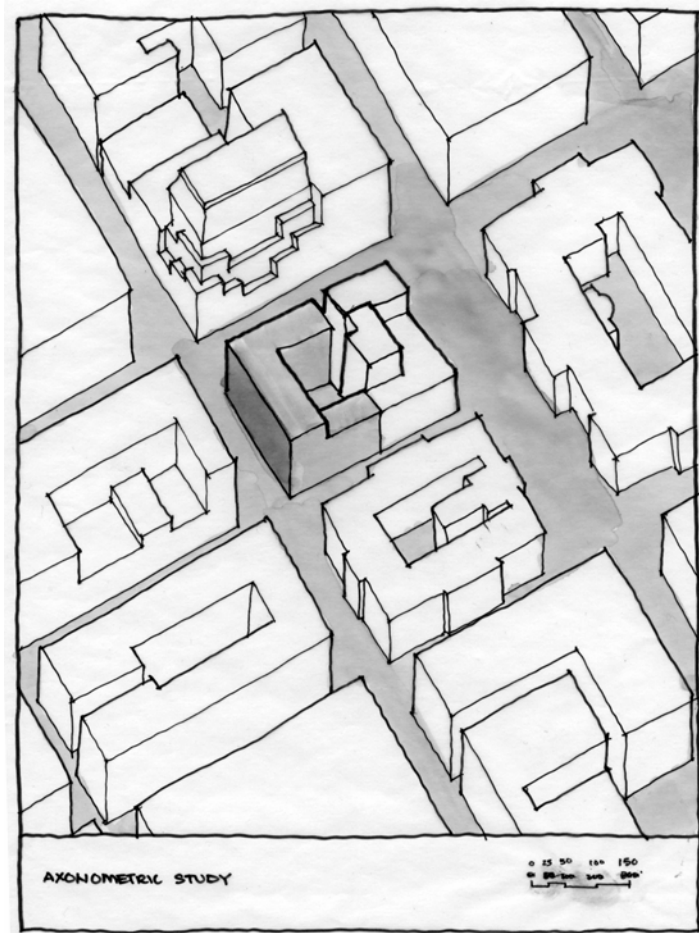
<b>Total</b>	<b>104,900 s.f.</b>
<b>Mechanical (15%)</b>	<b>15,735 s.f.</b>
<b>Circulation (30%)</b>	<b>31,470 s.f.</b>
<b>Grand Total</b>	<b>152,105 s.f.</b>

## CHAPTER FIVE : DESIGN APPROACH

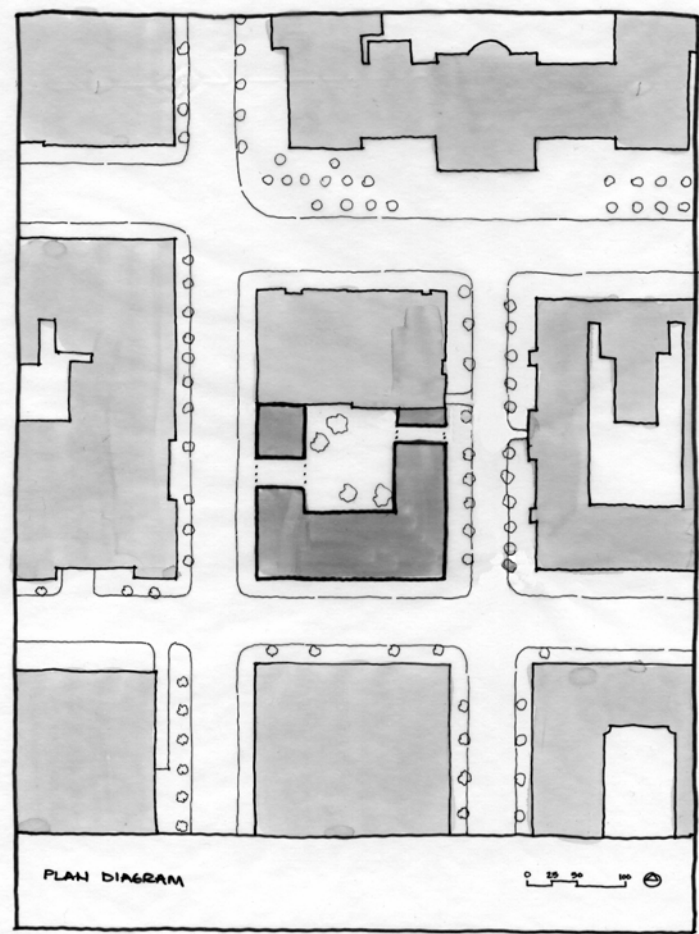
*"Sustainability is about quality of life, not just for the people but also for the planet and all its various systems and creatures, now and in the future. Thus a sustainable architecture is about the psychological sustenance of participating in the vibrant community life that is fostered by buildings which live in harmony with nature."*

Peter Buchanan

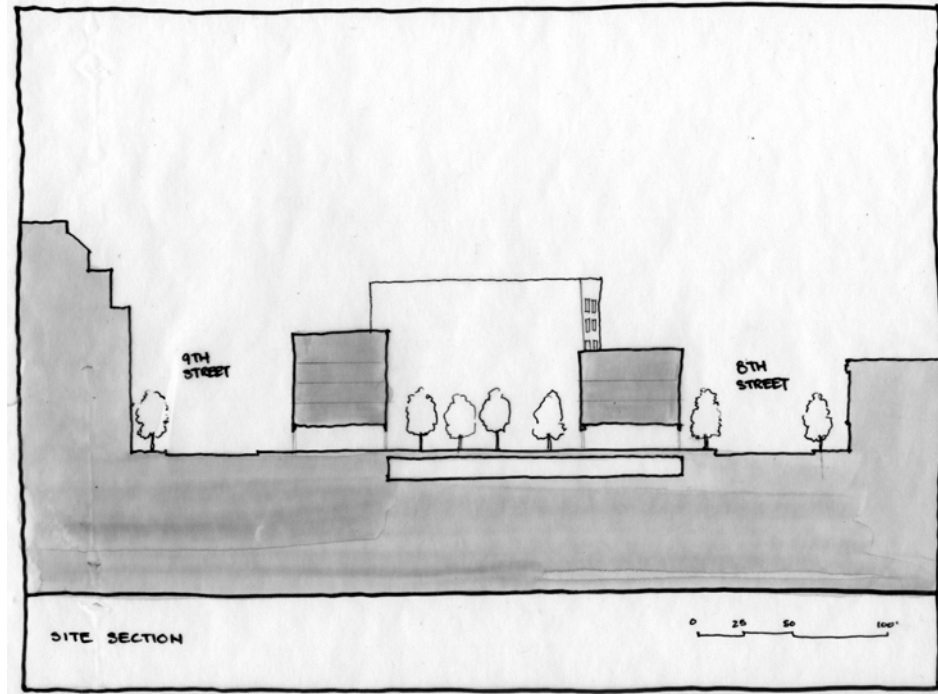
## Parti 1- Courtyard Building



**Figure 41:** Axon of Parti 1- Courtyard Scheme. Similar to neighboring buildings, on a smaller scale, an external space, courtyard organizes building. The massing of the building responds to the neighboring context.



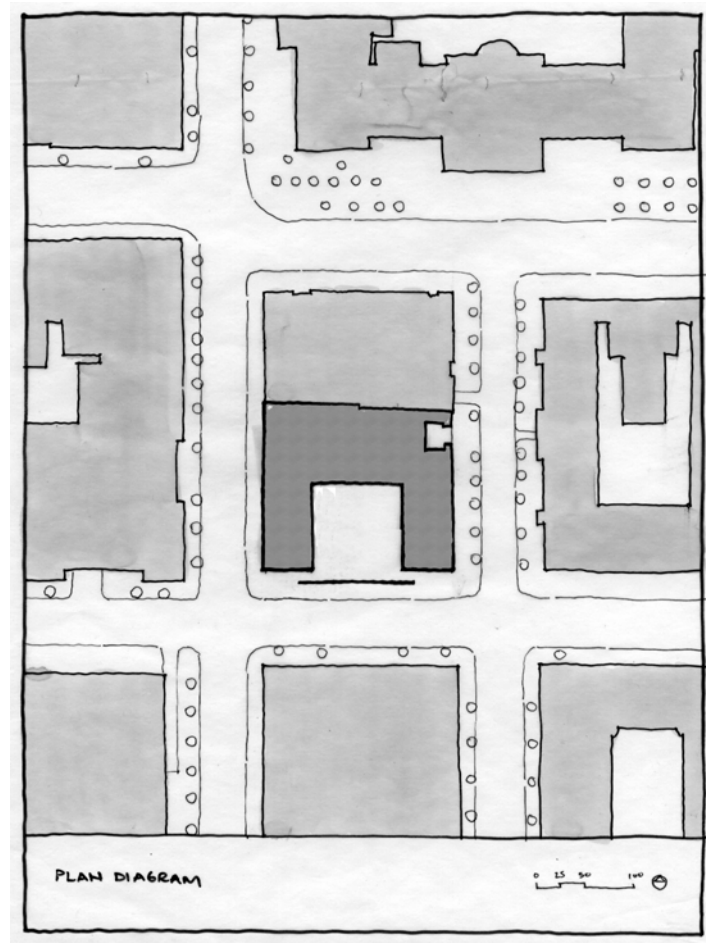
**Figure 42:** Plan of Parti 1- Courtyard Scheme. Entrances align with neighboring buildings. The building wraps around the courtyard green space, provides opportunity for outdoor use on fair weather days and creating a private outdoor space in the city.



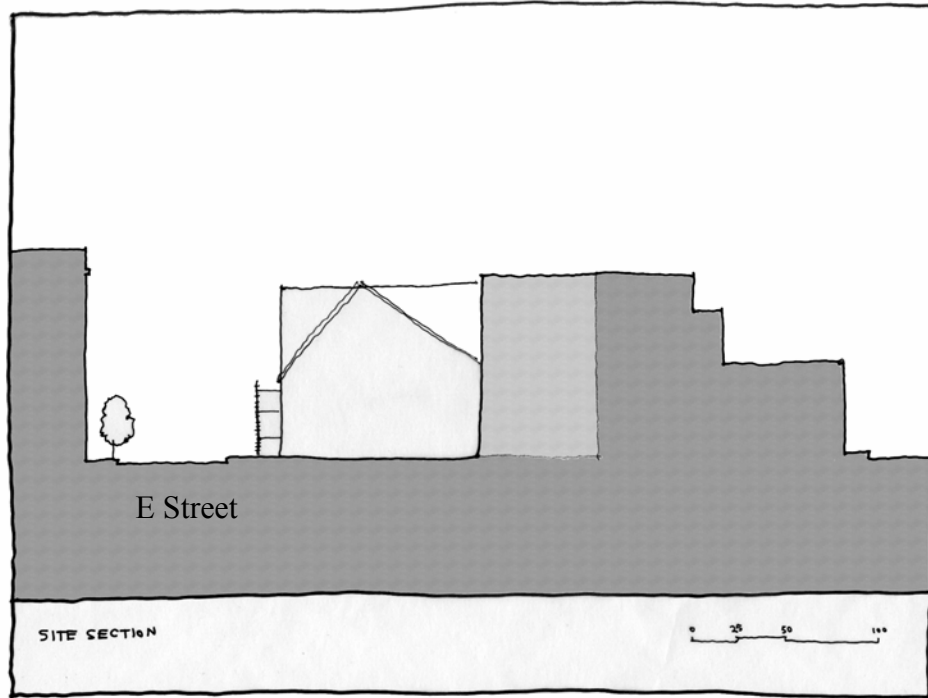
**Figure 43:** Section of Parti 1- Courtyard Scheme, Looking North. Building heights mediate between the varying heights of the neighboring context. The narrow floor plates resulting from the exterior central courtyard maximize opportunities for light and air to penetrate the building.



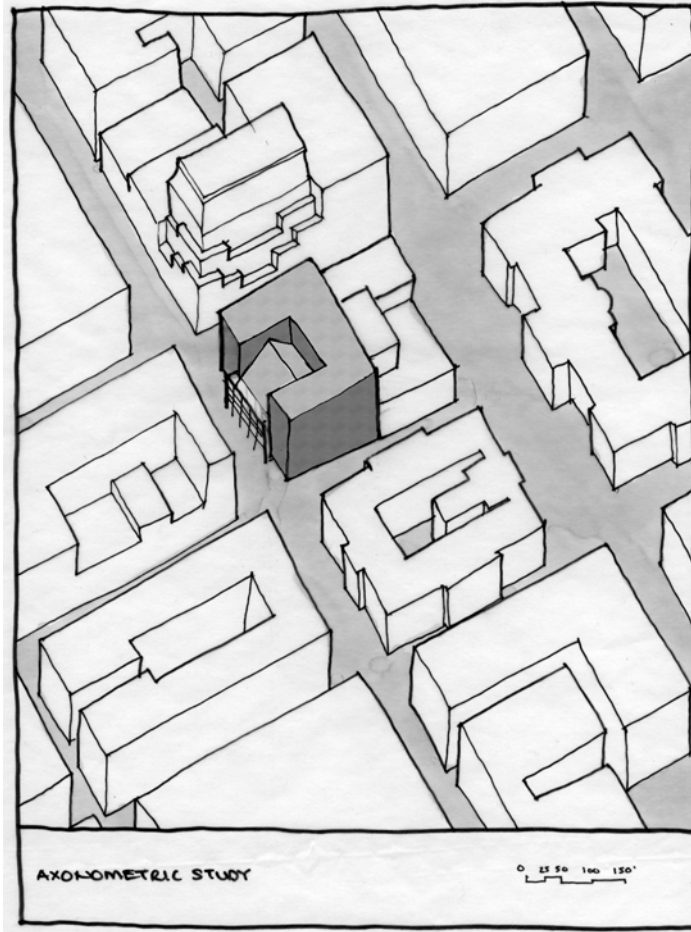
## Parti 2- Interior/Exterior Scheme



**Figure 44:** Plan of Parti 2- Interior/Exterior Scheme. This scheme attempts to blur the transition between interior and exterior spaces by creating an internal plaza. Building pulls in activity off the street while exposing itself.

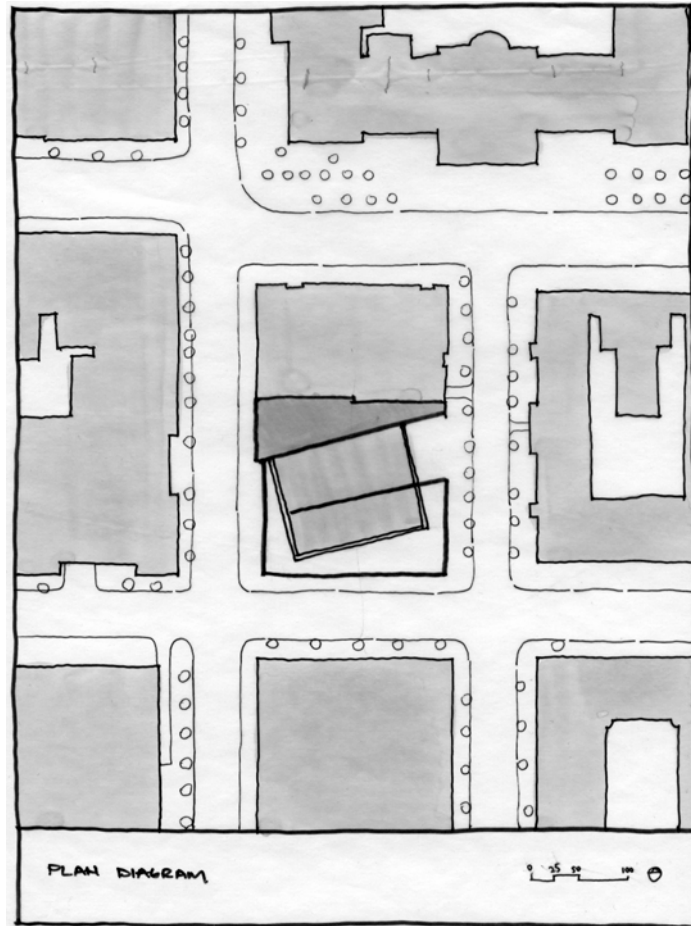


**Figure 45:** Section of Parti 2 - Interior/Exterior Scheme, Looking West. The open area is pulled to one side, allowing the north side to have a more secure, private program, and the south side to be more public. The atrium space brings light deep into the center of the building.

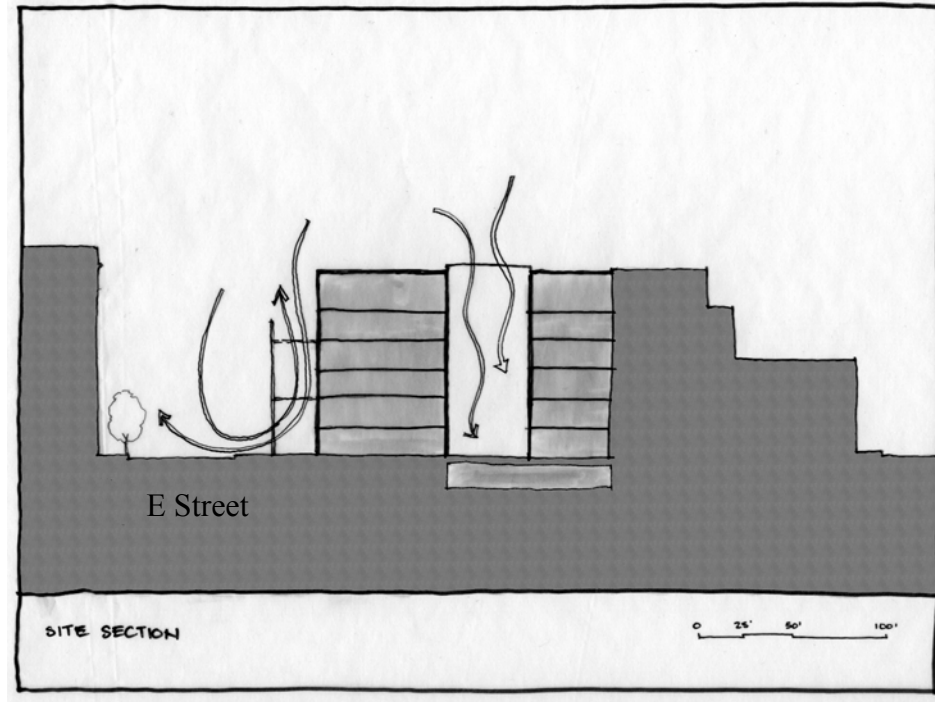


**Figure 46:** Axon of Parti 2- Interior/Exterior Scheme. The building fronts E Street to the south. Screening device mediates between inside and outside

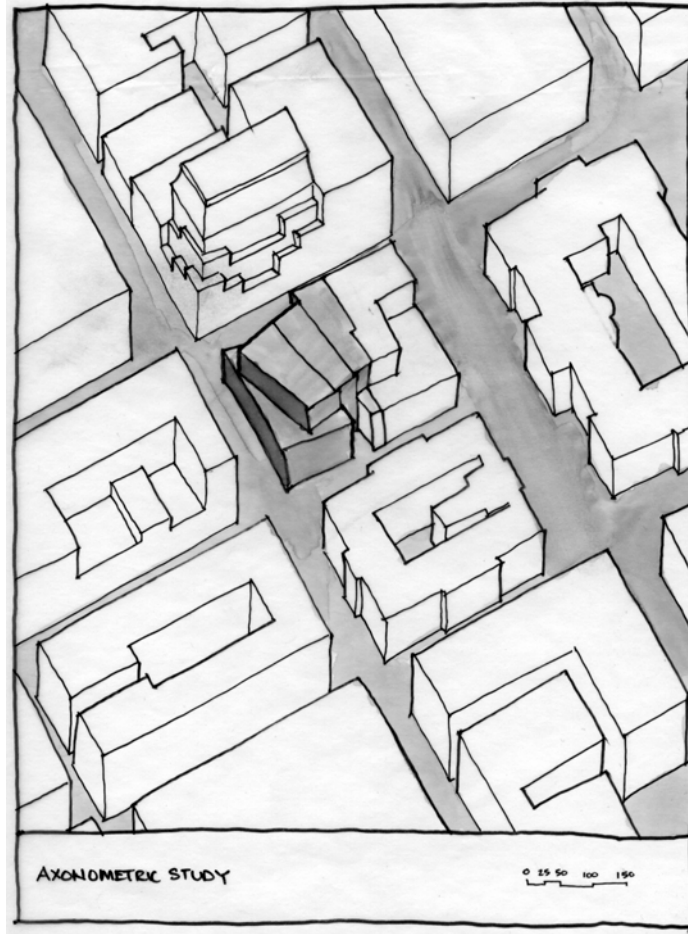
Parti 3- 12° East of South



**Figure 47:** Plan of Parti 3- 12° East of South. Geometry of building addresses both urban organization and the optimal solar orientation. Program is organized around an interior courtyard forming an indoor “street” or plaza. The building fronts the entry passage of the neighboring Tariff Commission Building.

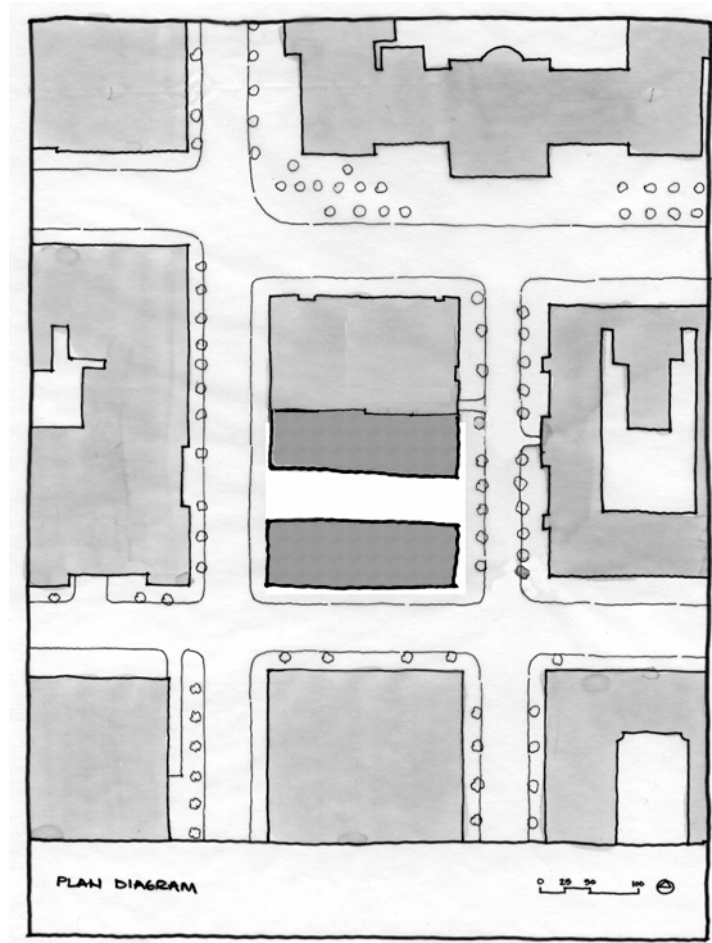


**Figure 48:** Section of Parti 3 - 12° East of South, Looking West. A screening device fronts the south elevation and maintains the street edge on E Street. A central atrium space organizes the building program while bringing natural light down into the center of the building.

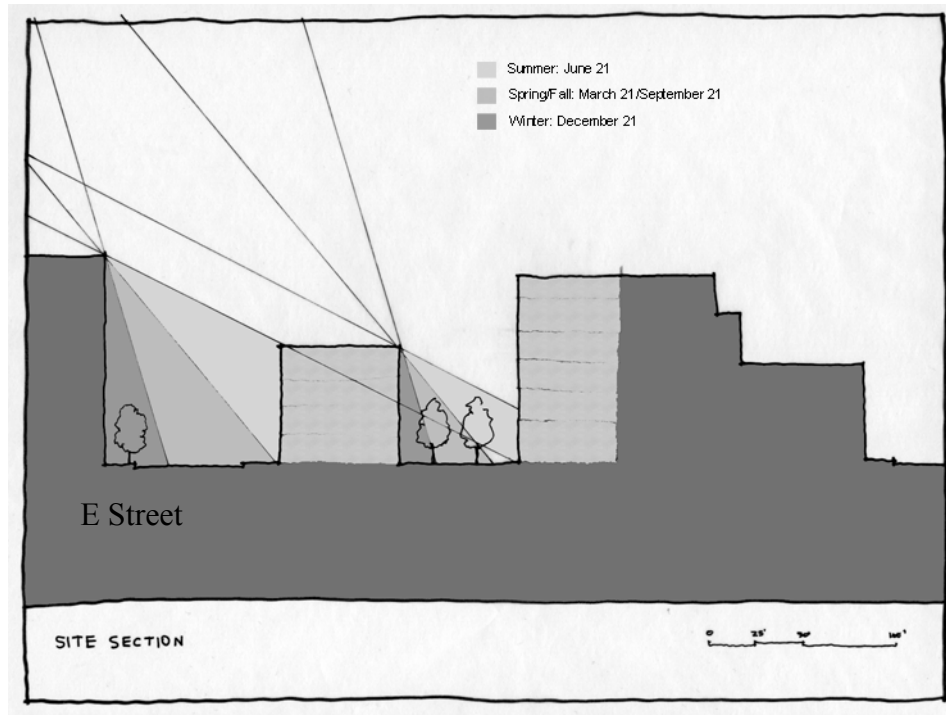


**Figure 49:** Axon of Parti 3- 12° East of South. The massing of the building mediates between the heights of the neighboring buildings.

#### Parti 4- Separate Program

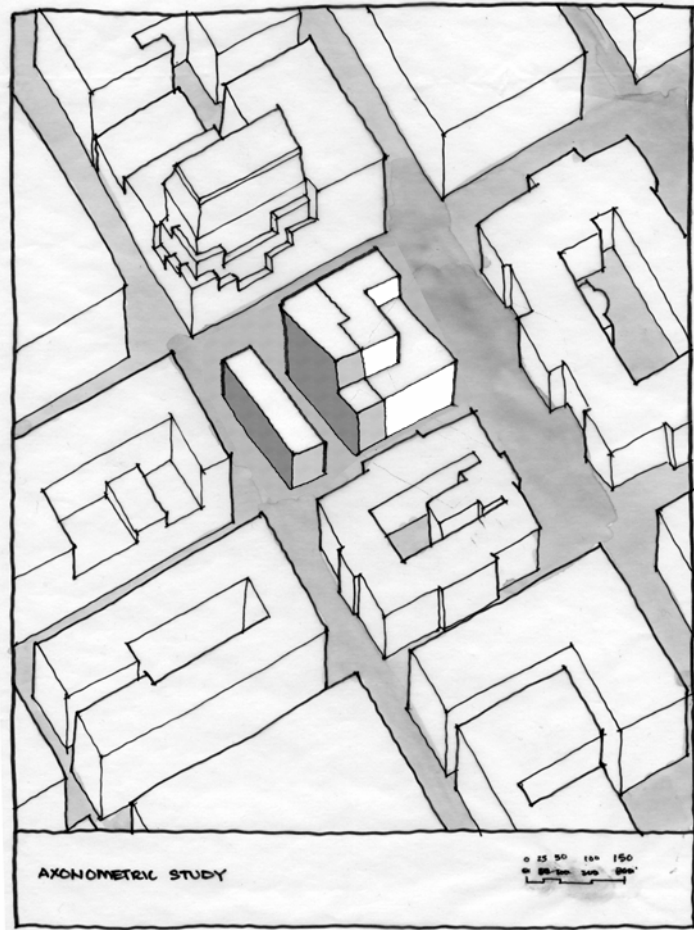


**Figure 50:** Plan of Parti 4- Separate Program Scheme. In this scheme, the more public elements of the program (exhibition spaces) front E Street, while the more private elements of the program (research facility) are reserved for the north building. An exterior green space links the buildings together.



**Figure 51:** Section of Parti 4: Separate Program Scheme, Looking West. This scheme attempts to maximize the amount of sun penetrating the site by increasing the south-facing frontage. The south- public building is only four stories tall in order to limit the shadows cast on the north building.





**Figure 52:** Axon of Parti 4- Separate Program Scheme.

## **CHAPTER SIX : PRECEDENT ANALYSIS**

## Sustainable Buildings – Ecological



**Figure 53:** The Chesapeake Bay Foundation Headquarters, completed in December of 2000, was the first Platinum LEED rated building.<sup>43</sup>

The Chesapeake Bay Foundation Headquarters holds the title of “one of the greenest buildings ever constructed.” This commercial office was constructed new. The wood frame, which characterizes the south facing façade, acts as a sun- shading device. Large window spans and north facing monitors offer views to the bay and maximize opportunities for natural light, and minimizing the need for fluorescent lighting. The open office plan allows for the movement of air throughout the building. Cisterns collect water from the roof, which is reused in the building. Solar panels collect the ambient energy from the sun, reducing the power needs of the building, and thereby reducing costs.

## Sustainable Buildings –Cultural

Buildings that are culturally sustainable pass the test of time. These structures remain for a variety of reasons, because they are cherished and loved by the people who inhabit and occupy them, a significant event has occurred there, or simply because they are durable.



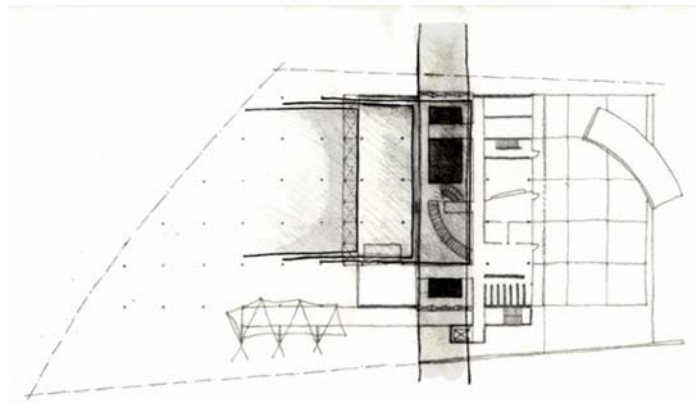
**Figure 54:** The Pyramids of Mycerinus (c. 2500 B.C.), Chefren (c.2530 B.C.), and Ceops (2570 B.C.) at Giza have physically lasted for thousands of years in due to their megalithic construction. The ceremonial significance of these pyramids will retain its value through the culture.<sup>44</sup>



**Figure 55:** Daniel Burnham's Flatiron Building in New York City (1909) is an example of a culturally sustainable building. This wedge-shaped building is an example of its time. It maximizes the F.A.R. allowed on the site under the building, while maintaining the street wall by continuing the scale of the flanking streets. The Flatiron Building will be preserved for its iconic appearance, and because no building could be constructed on this site as space-efficiently under the current zoning.<sup>45</sup>

## Flexible Spaces

The Embassy of Finland, by Heikkinen – Komonen Architects, in Washington, DC, exemplifies flexibility of spaces. Finland Hall can be combined with the Grand Canyon (atrium) to create a larger space through the manipulation of sliding partition walls. The Grand Canyon Atrium bleeds into Finland Hall, which extends infinitely beyond the glass wall to the landscape beyond.

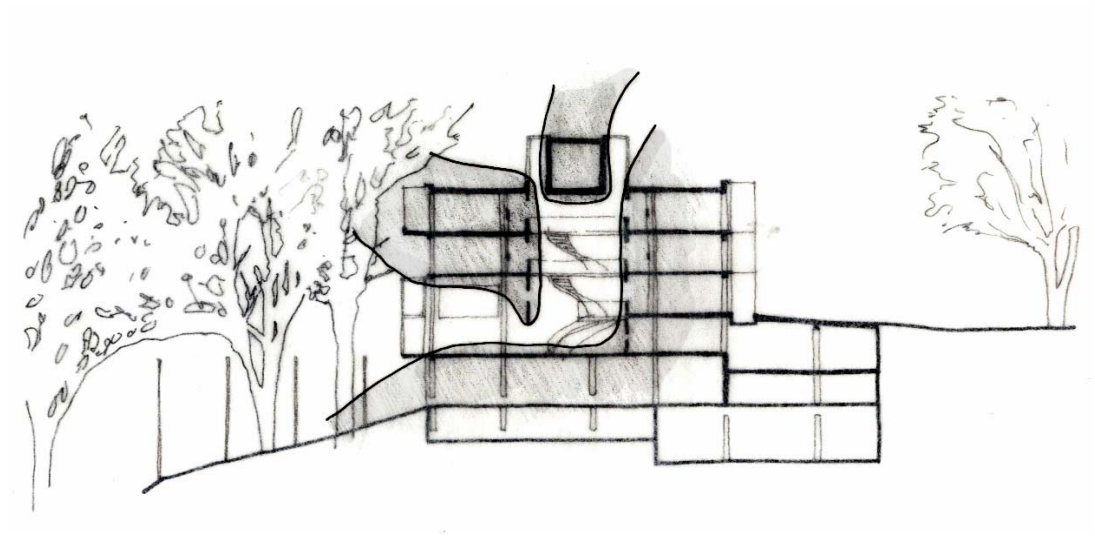


**Figure 56:** Embassy of Finland. Overlapping of Spaces Diagram. The spaces not only overlap inside the building, but interact with the outdoors.



**Figure 57:** Embassy of Finland. Overlapping of Spaces Photo. The floor of Finland Hall carries on from the inside to the outside, reinforcing the continuity of spaces.

## Relating to Nature

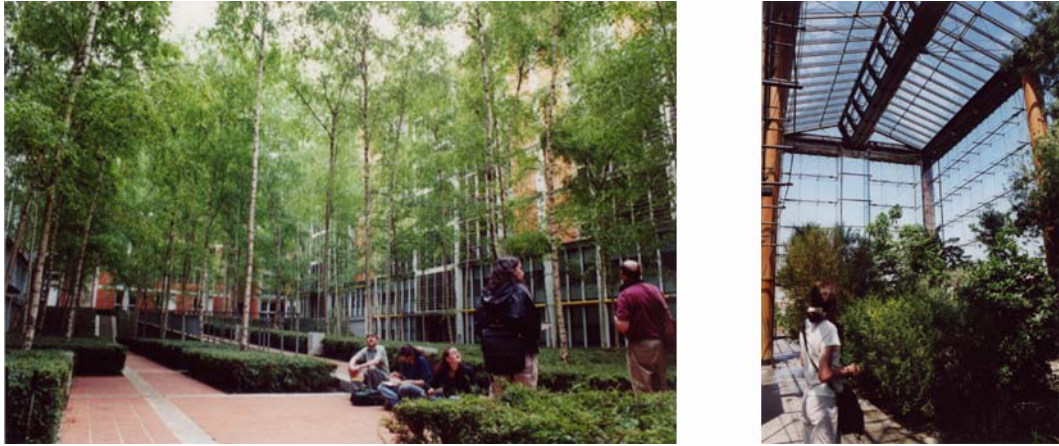


**Figure 58:** Embassy of Finland. Flow through building. One can experience the natural light through the atrium at the same time as views to the landscape beyond. Even at the core of the building, one feels connected to nature.



**Figure 59:** Embassy of Finland. Planting as building material. Linked with nature through the bronze trellis with its climbing plants on south facing façade. It acts as a natural louver, changing in appearance with the seasons.





**Figure 60:** Atrium. Bringing plantings into the heart of the building reinforce nature as the centerpiece.



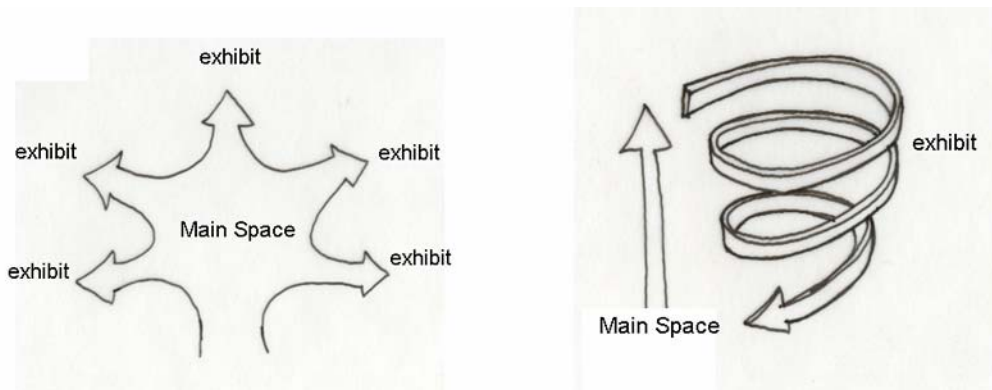
**Figure 61:** Walking among the treetops. Experiencing nature in different ways creates memorable moment.



**Figure 62:** Simulating nature is one way of relating to it. A forest of tree-like columns support the ceiling of this Culture House.

## Museum Circulation

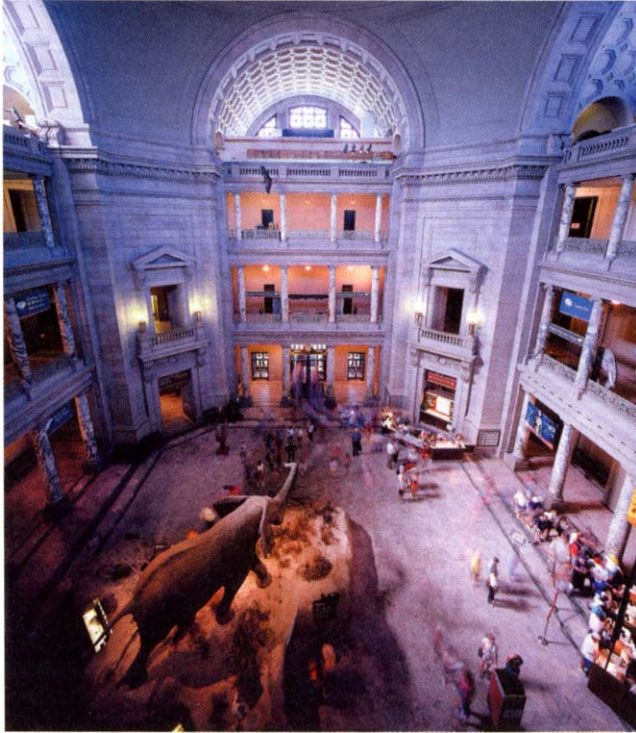
The way people move around in a museum is an important factor in the way they experience the information before them. If visitors are concerned about their environment, it will hinder their ability to become engaged with the exhibit.



**Figure 63:** Museum Circulation. Museums buildings typically follow one of two types of circulation patterns, a “freedom” path on the left, or a controlled path on the right.

In the “freedom” path scenario, the visitor enters into a main space, and then decides where to continue from there. The main exhibits, arranged thematically, present themselves to the visitors. Visitors return to the main space at the end of each display, where they may chose another exhibit. For example, at the Museum of Natural History, visitors arriving from both the north and the south entrances but come to the space place, the Rotunda. The familiarity of the model elephant helps people to orient themselves, creating a sense of comfort.





**Figure 64:** The Rotunda of the Museum of Natural History is a welcoming space with memorable characteristics.

Smithsonian Institution. My Smithsonian: Free Visitor Guide. Fall/Winter. Volume 2. 2002/2003

In the controlled path scenario, all visitors share the same or similar experience. Upon arrival at the museum, they enter a main space, from which they ascend to the beginning of the exhibit. Exhibits are arranged sequentially, sometimes according to a timeline. Frank Lloyd Wright's Solomon R. Guggenheim museum follows a controlled path sequence. From the atrium, visitors are admitted to an elevator, which brings them to the top floor. While viewing the artwork, visitors spiral down around the perimeter of the atrium, back down to the ground floor.

The Holocaust Memorial Museum, by James Ingo Freed in Washington, DC, is a strong example of how a controlled circulation sequence can be reinforced by the architecture to create a specific experience. The entry sequence to the permanent exhibit is manipulated to reinforce and further express the experience of the Holocaust. Visitors must wait in line for an admittance ticket, marked with a

time of entry. They must wait in the grand hall until the time designated on their ticket. From there, visitors may stand in line for an oversized industrial elevator. There are no friendly markings, only bolts and rivets. Observant visitors notice that although the building is full of people, no one is in the elevator when the doors open.



**Figure 65:** The experience of the permanent exhibit at the United States Holocaust Memorial Museum begins with a ride in one of these elevators.

Dannatt, Adrian. United States Holocaust Memorial Museum. Phaidon Press: London, 2002.

The Holocaust Memorial Museum has characteristics of the freedom path scenario as well. A visitor to the museum may loop through the building without ever entering the permanent exhibit – “the building becomes a communal space, and open air park, which keeps the whole alive...The actual museum itself is so self contained that it is possible to walk around the rest of the building without realizing it is there.”<sup>46</sup>

## Living Museums

“Living Museums” are at risk for being popular entertainment. At the same time, “people need to be engaged, moved, informed, even if it means doing so resembles popular entertainment.”

The United States Holocaust Memorial Museum is an example of a Living Museum. As a memorial, it is significant that the building and the messages it conveys sustain. To be an effective memorial, it must inform the future of events that have passed. It strives to recognize an event in history as monumental so that the past may not repeat itself.

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<sup>43</sup> “The Greenest Building on the Bay.” Architecture Record.  
Oct. 2001. vol 189. no. 10. page 100-101

<sup>44</sup> Trachtenberg and Hyman, Architecture. Prentice Hall: Upper Saddle River, NJ 1986 p. 537.

<sup>45</sup> Curtis, William. Modern Architecture Since 1900. Phaidon Press: London, 1996.

<sup>46</sup> Dannatt, Adrian. United States Holocaust Memorial Museum. Phaidon Press: London, 2002.

## CHAPTER SEVEN : SYNTHESIS

*“One thing I know people will say to me is ‘Are you suggesting we go back to being hunger-gatherers?’*

*“That of course is an inane idea,” Ishmael said. “The Leaver life-style isn’t about hunting and gathering, it’s about letting the rest of the community live- and agriculturalists can do that as well as hunter-gatherers.” He paused and shook his head. “What I’ve been at pains to give you is a new paradigm of human history. The Leaver life is not an antiquated thing that is ‘back there’ somewhere. Your task is not to reach back but to reach forward.”*

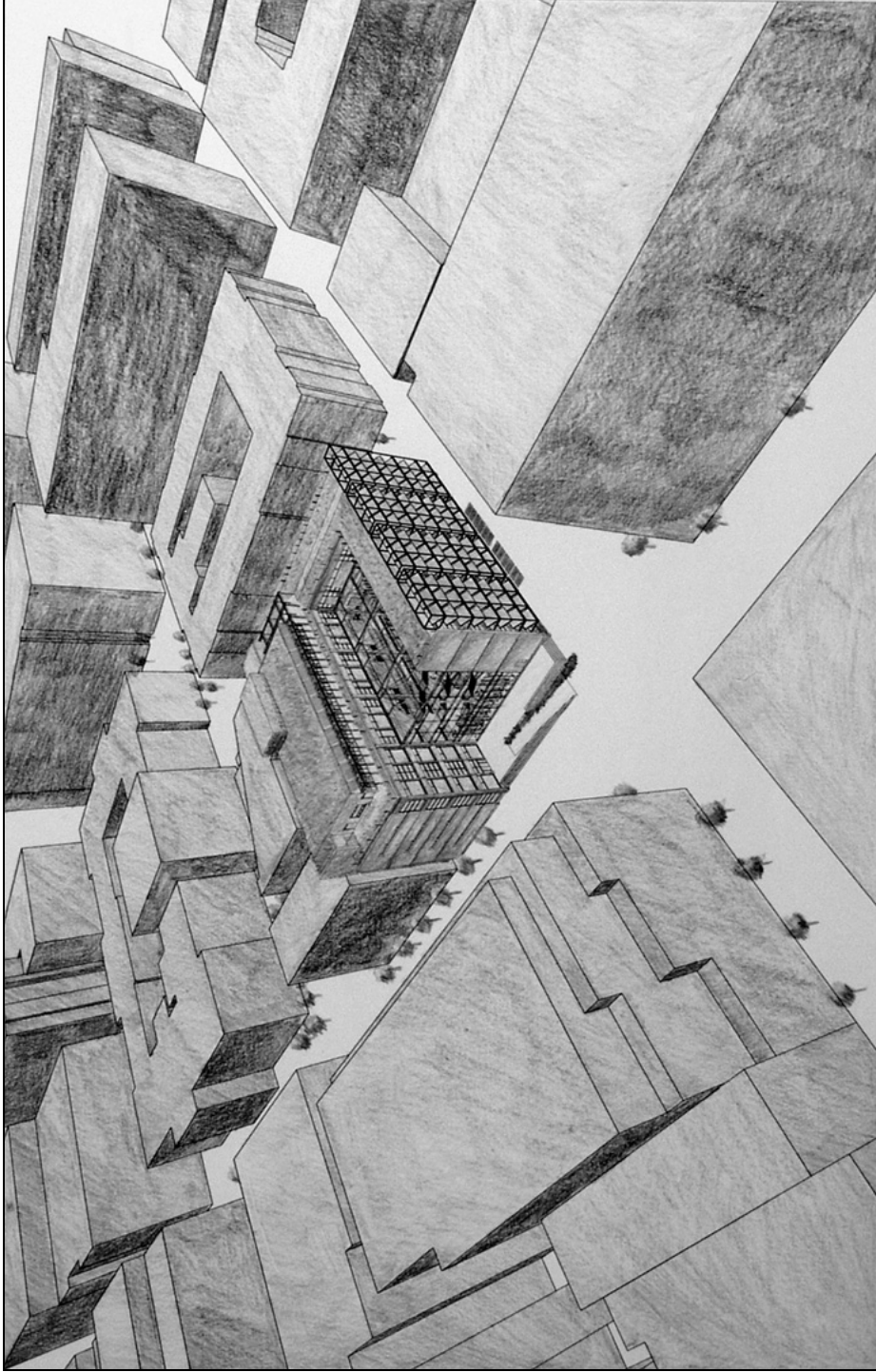
*“But to what? We can’t just walk away from our civilization the way Hohokam did.”*

*“That’s certainly true. The Hohokam had another way of life waiting for them, but you must be inventive, if it’s worthwhile to you. If you care to survive.” He gave me a dull stare. “You’re an inventive people, aren’t you? You pride yourselves on that, don’t you?”*

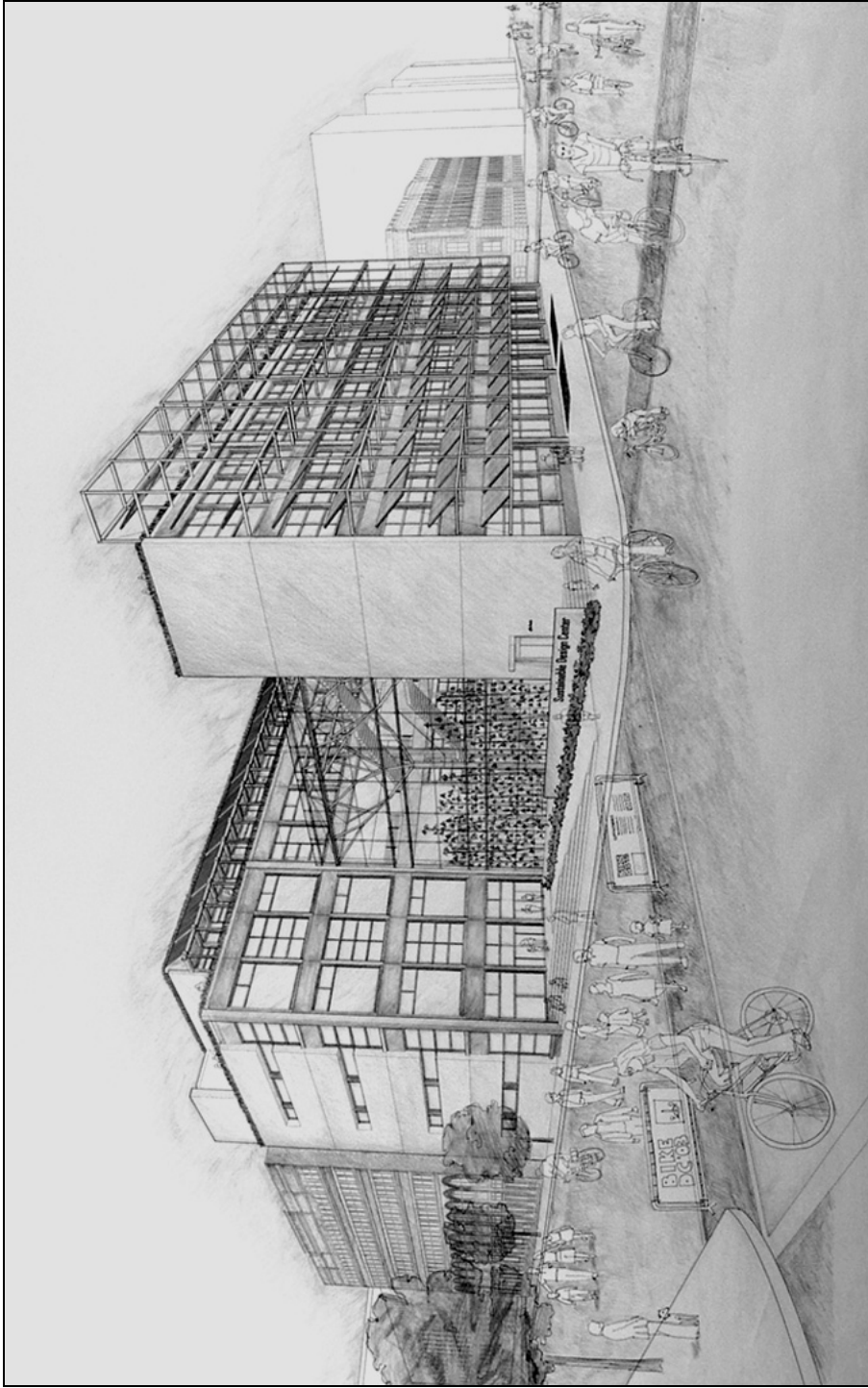
*“Yes.”*

*“Then invent.”<sup>47</sup>*

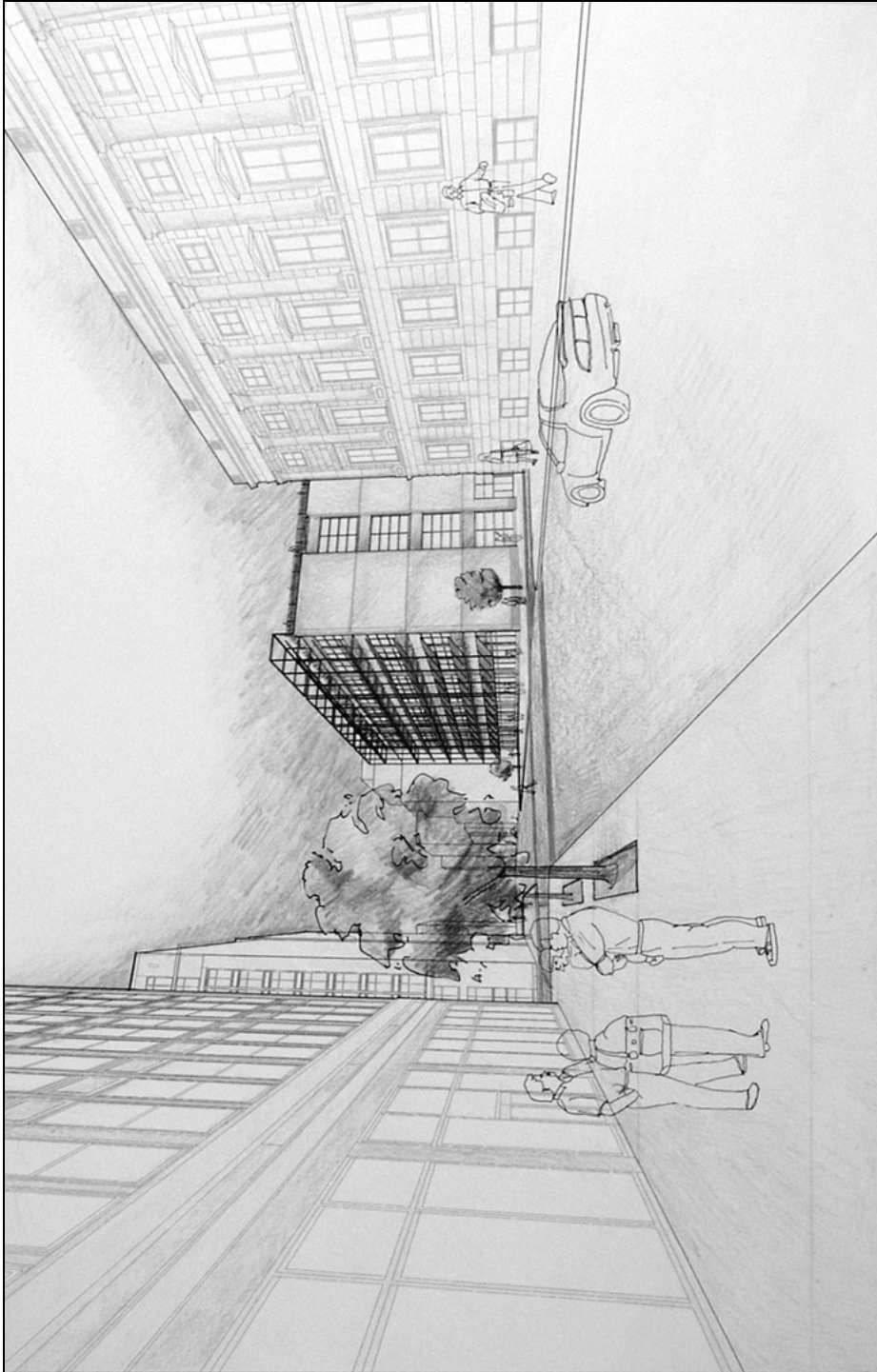
Daniel Quinn



**Figure 66:** Aerial Perspective View of Site. The massing of the Sustainable Design Center blends into its context. A glass façade into the atrium space adds visual interest on the pedestrian plaza.

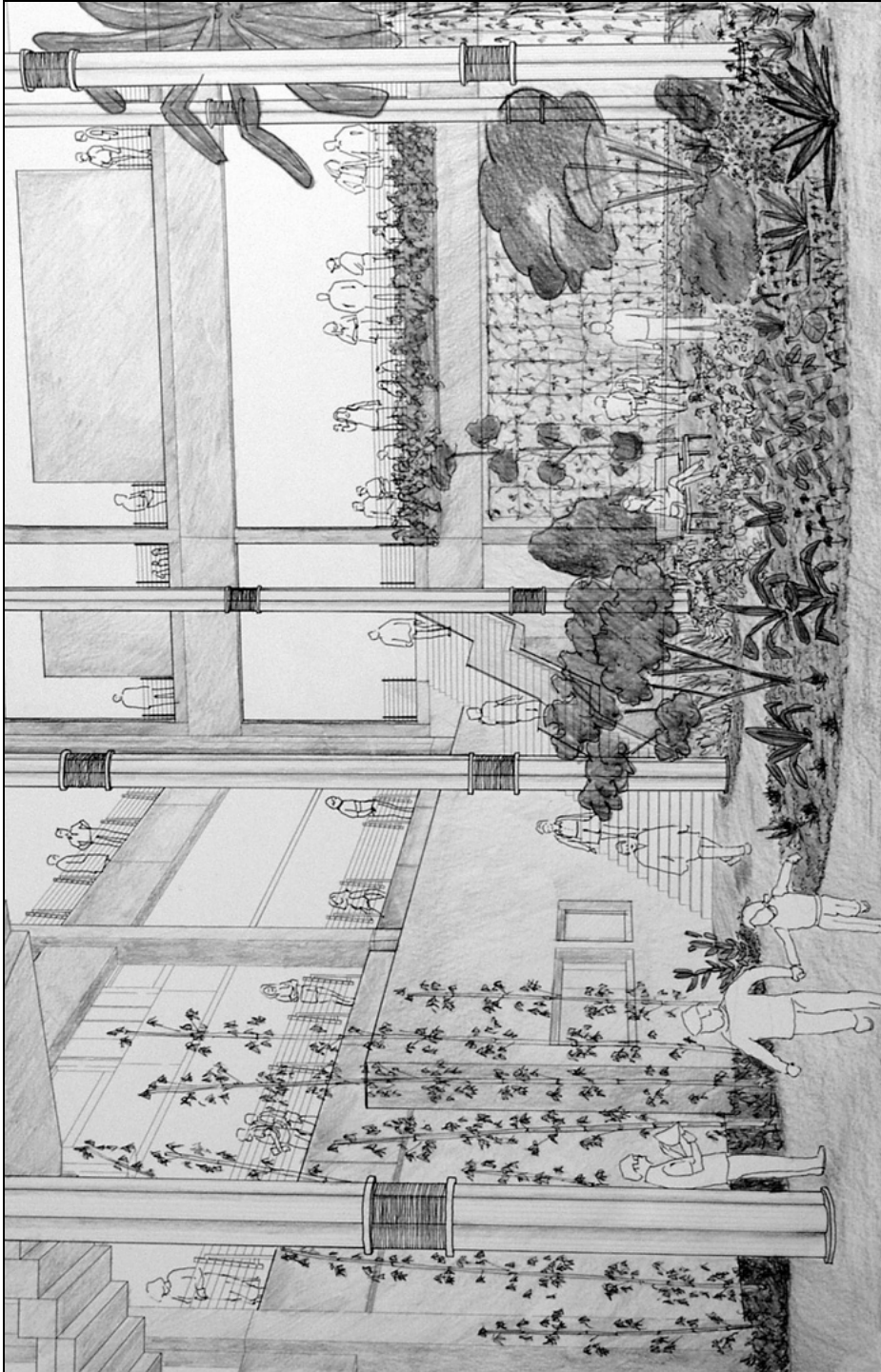


**Figure 67:** View from the corner of E and 9<sup>th</sup> Streets. The solar panels and exposed atrium create an imageable building.



**Figure 68:** View from E Street, looking west.



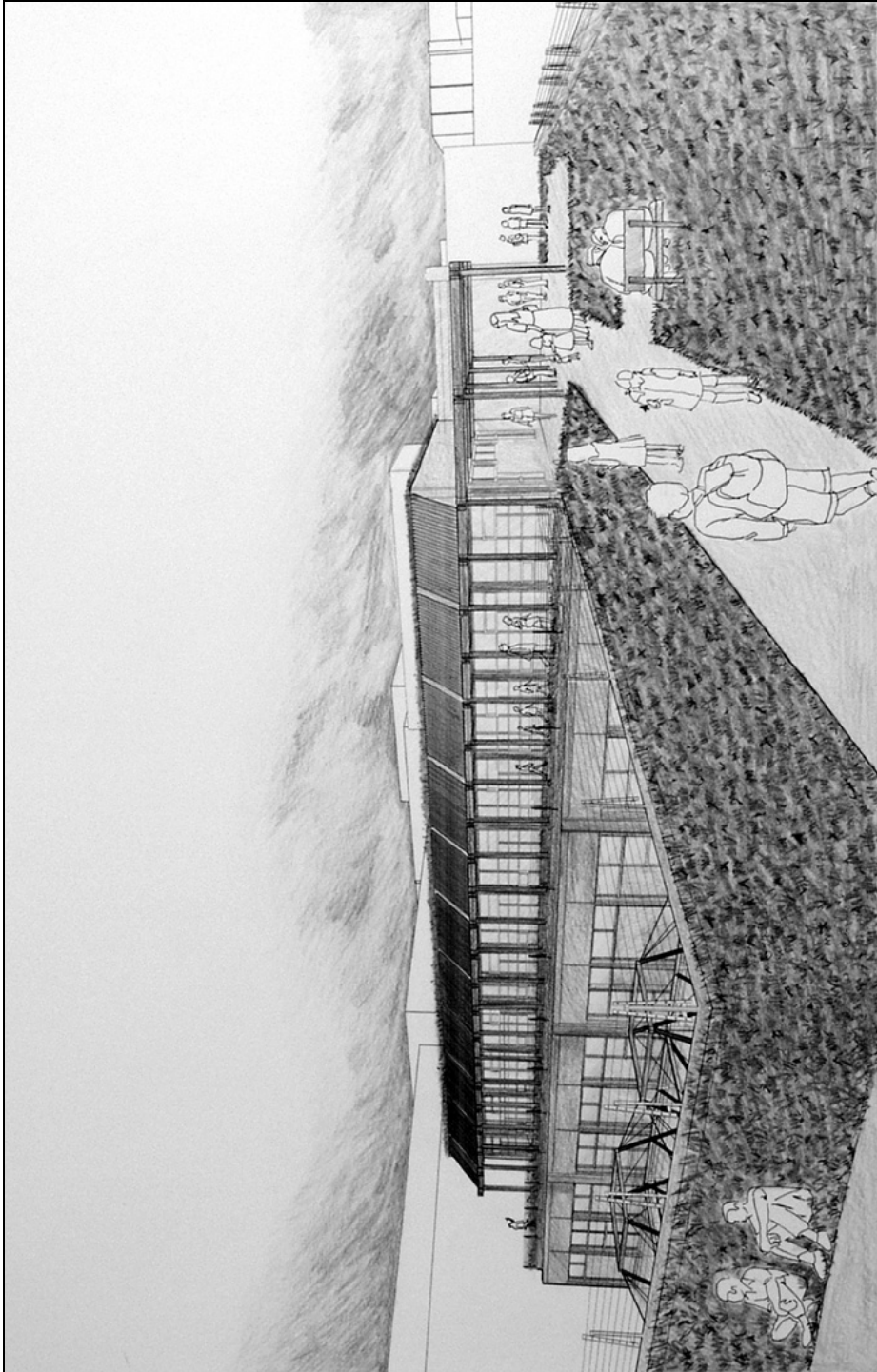


**Figure 69:** Atrium space from the lower level allows for a more intimate relationship with greenery.

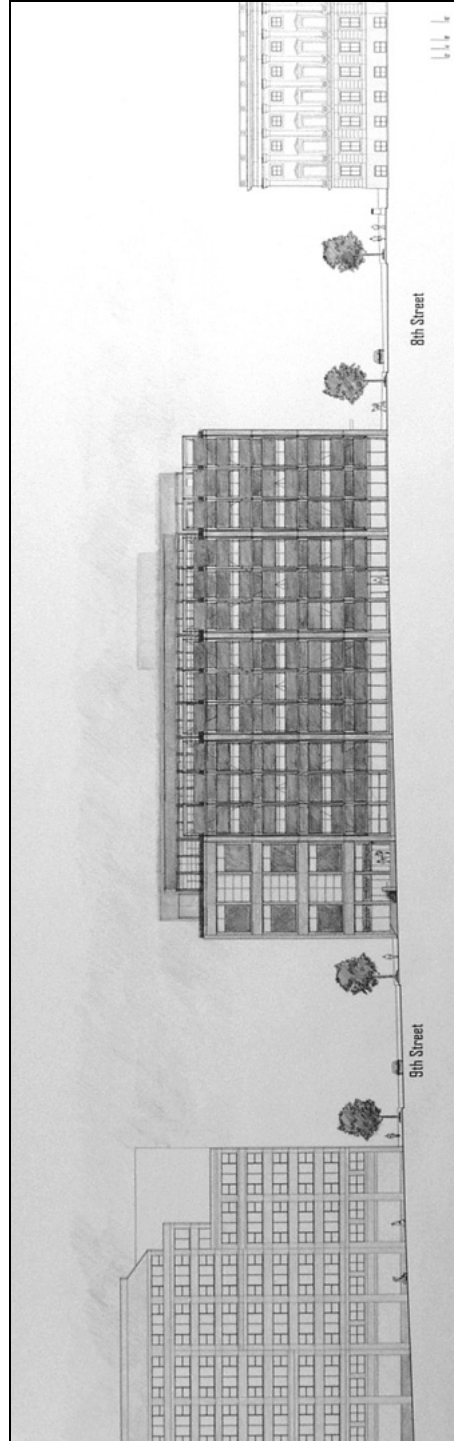




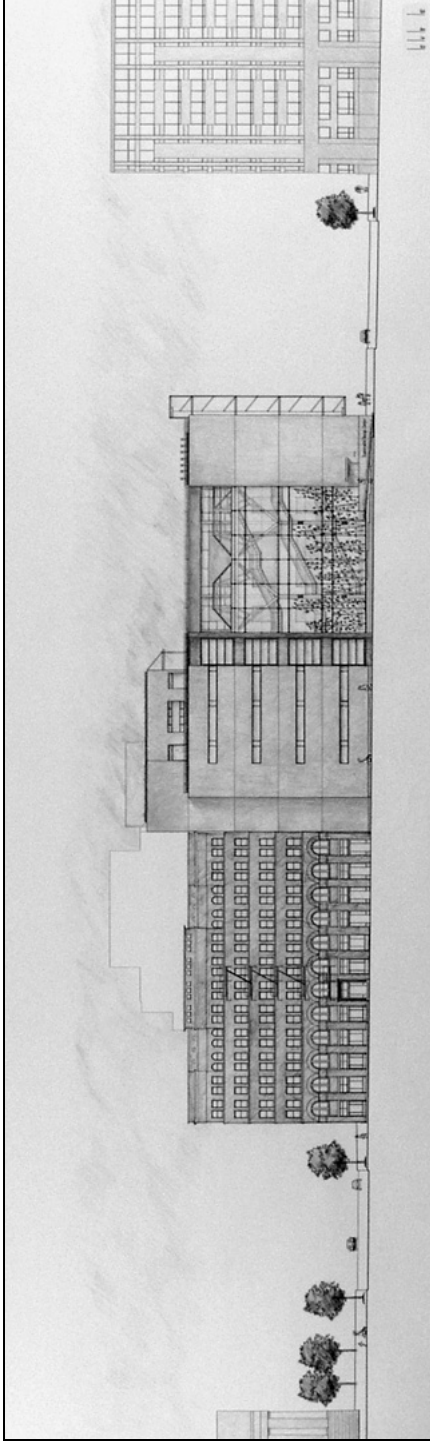
**Figure 70:** View into atrium from exhibit space. Juxtaposition of structural tree canopy to real trees.



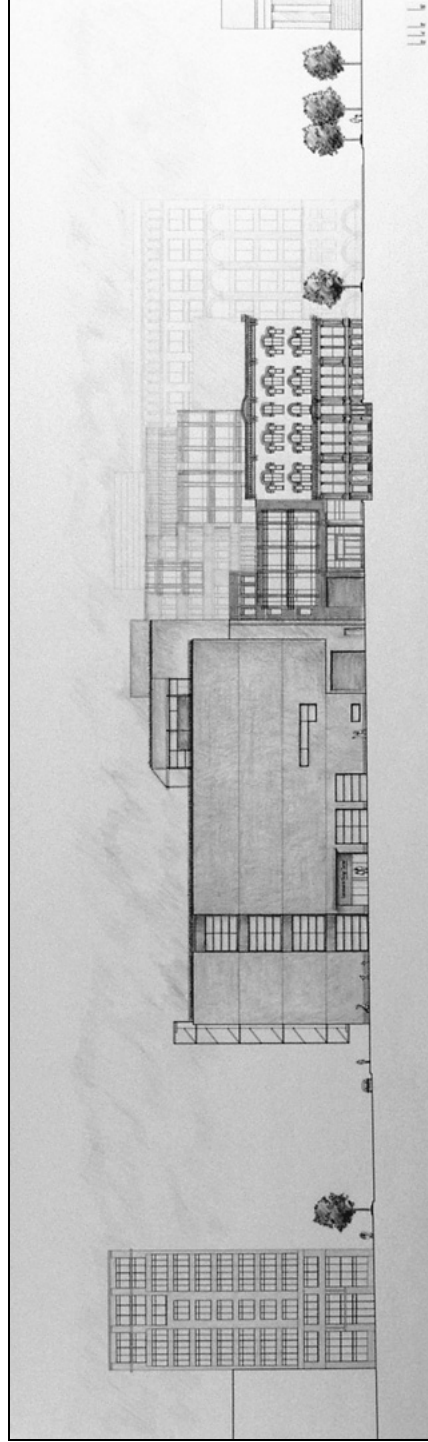
**Figure 71:** View of rooftop Experimental Garden.



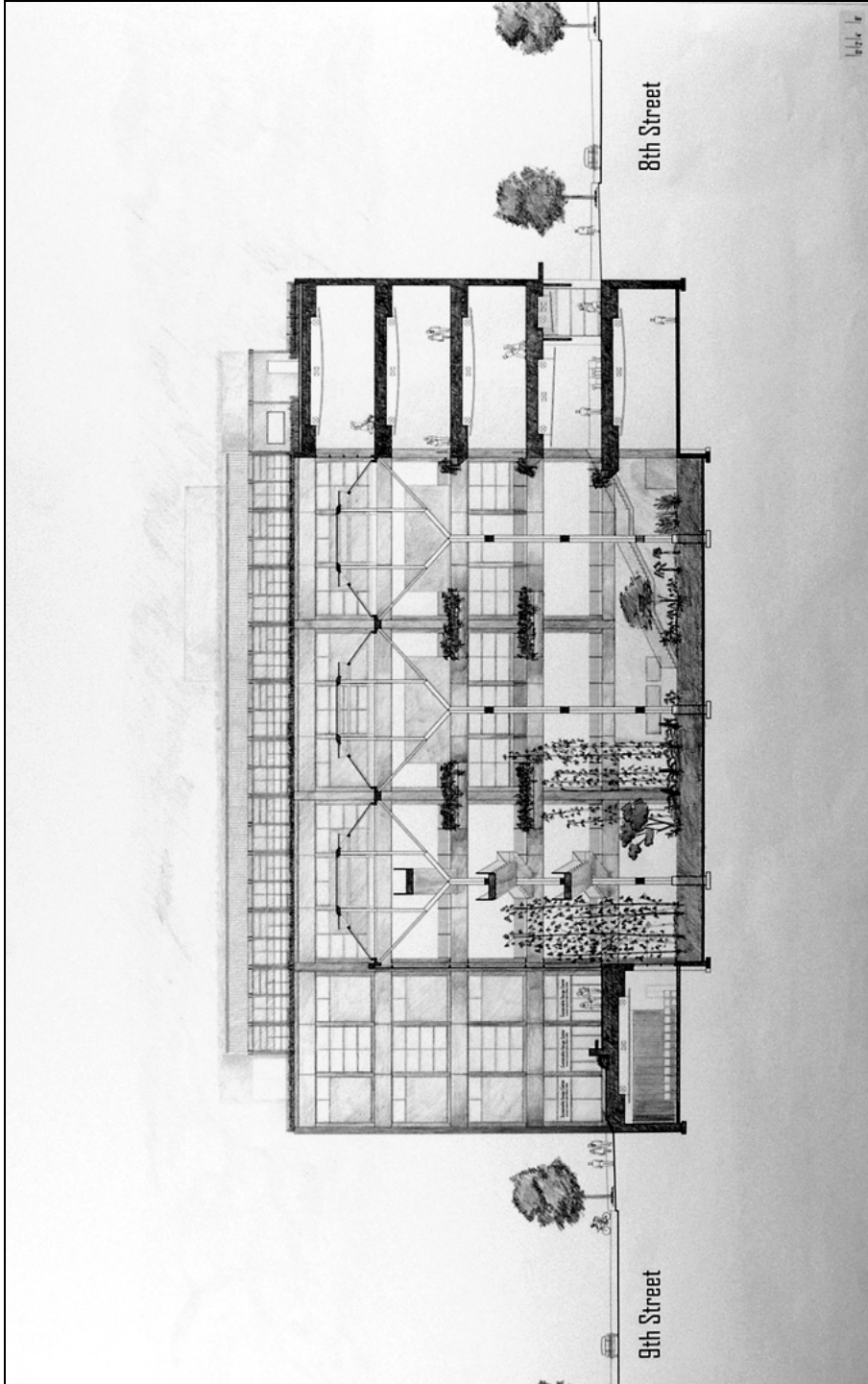
**Figure 72:** Solar Panels dominate the south façade.



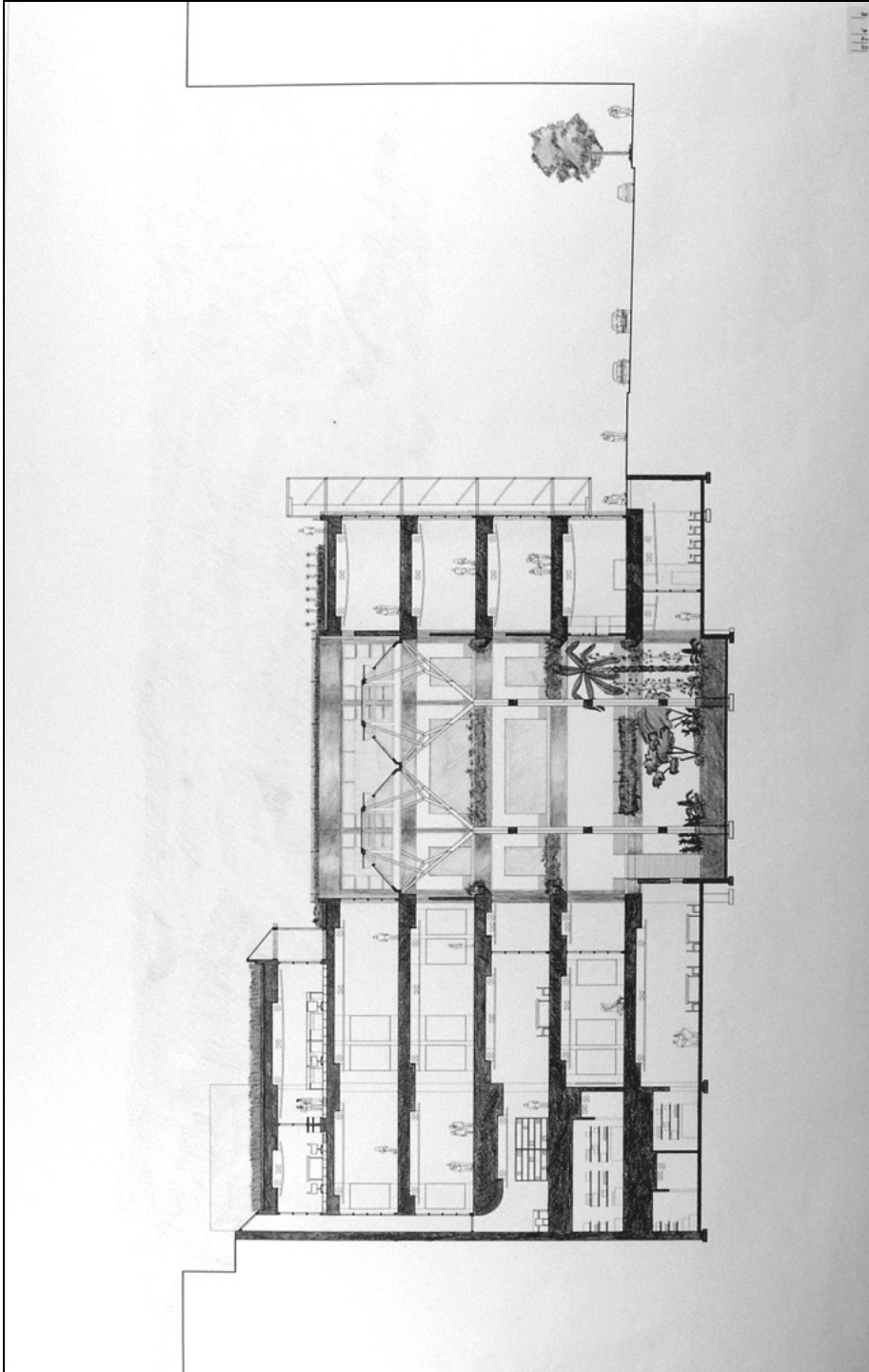
**Figure 73:** The atrium is exposed on the West Façade, allowing views into the atrium space of the treetops and the structural tree canopy.



**Figure 74:** East Elevation.

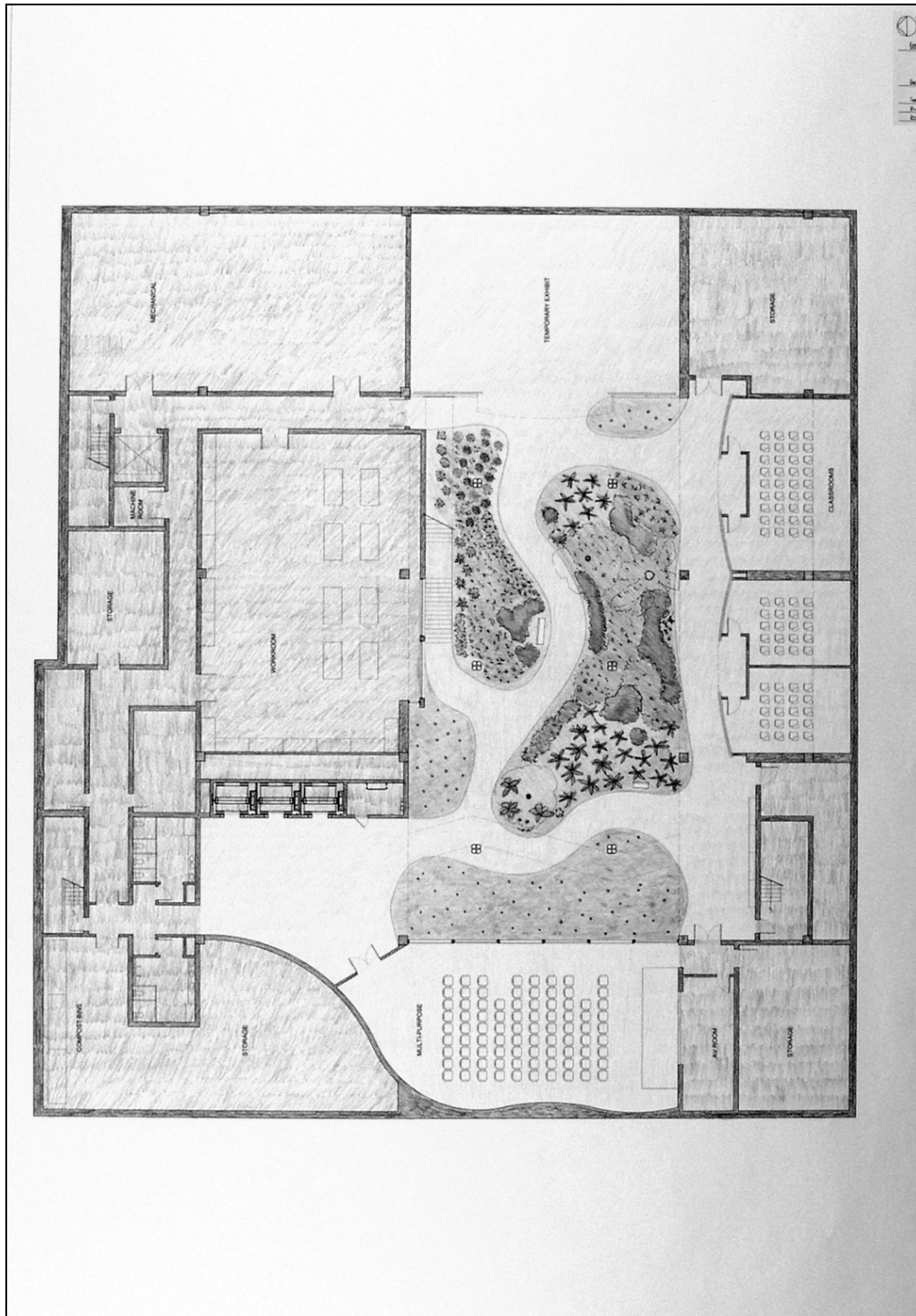


**Figure 75:** East-West Section through building, looking north.

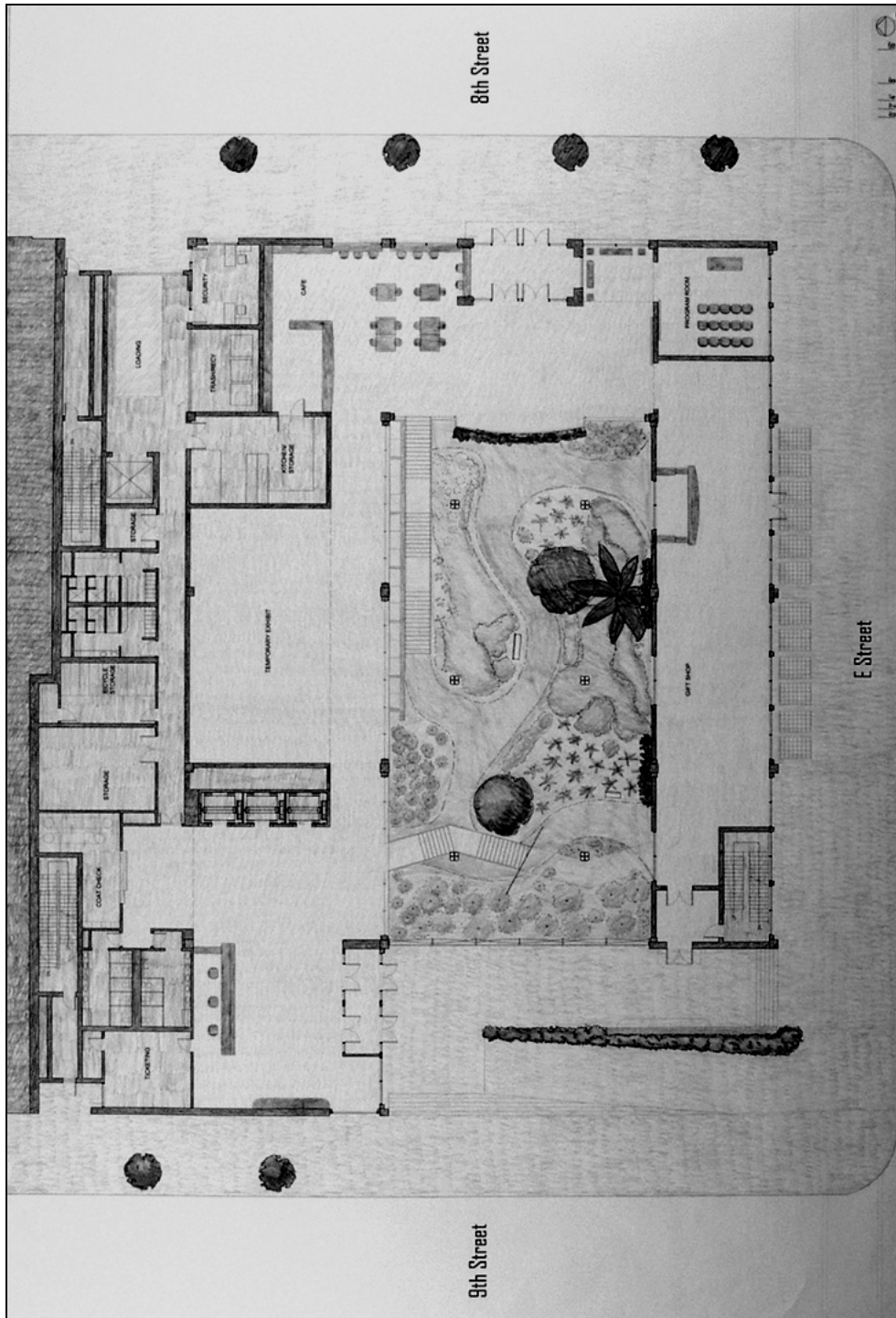


**Figure 76:** North-South Section through building, looking east.



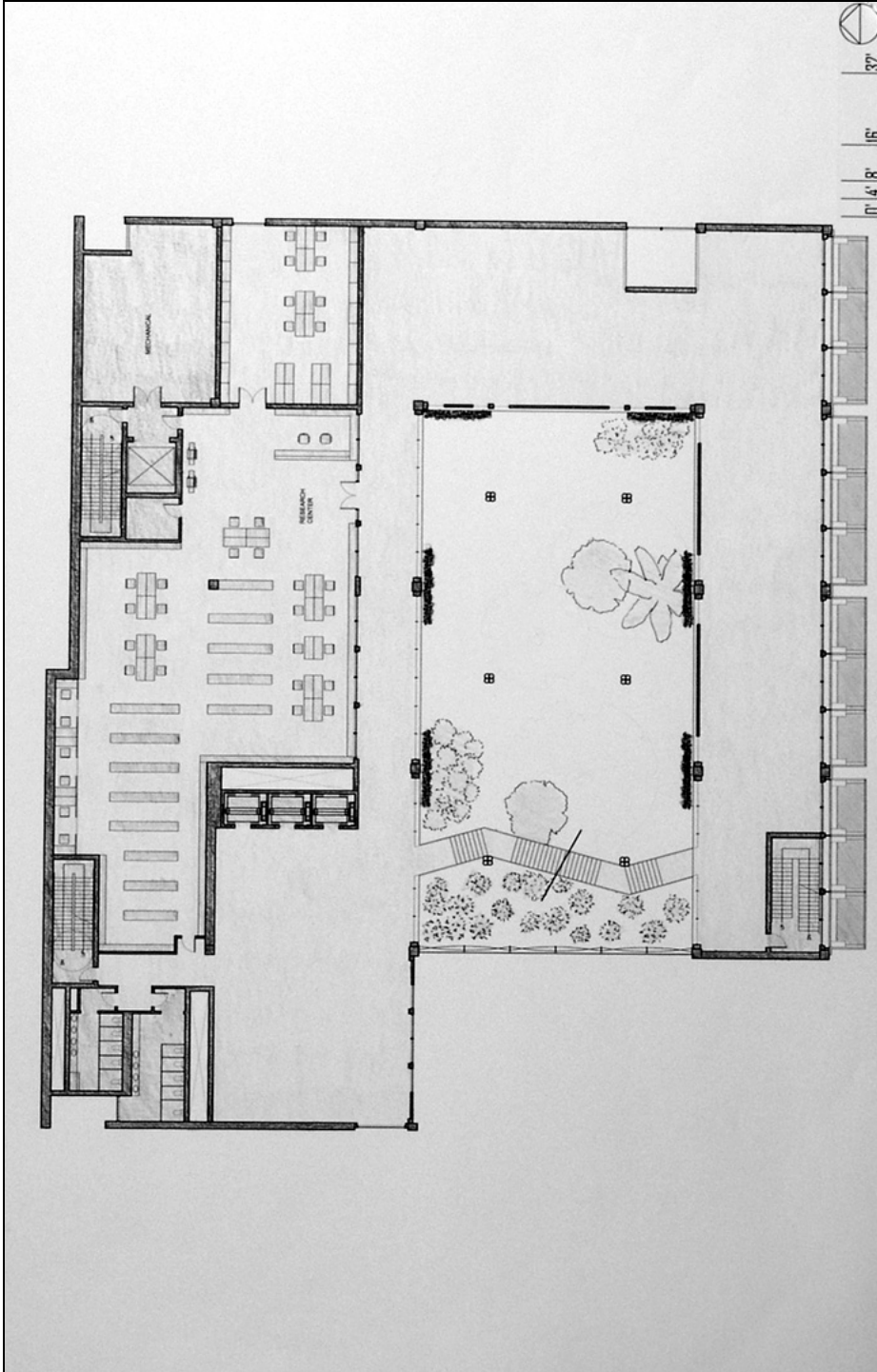


**Figure 77: Lower Level Plan.**

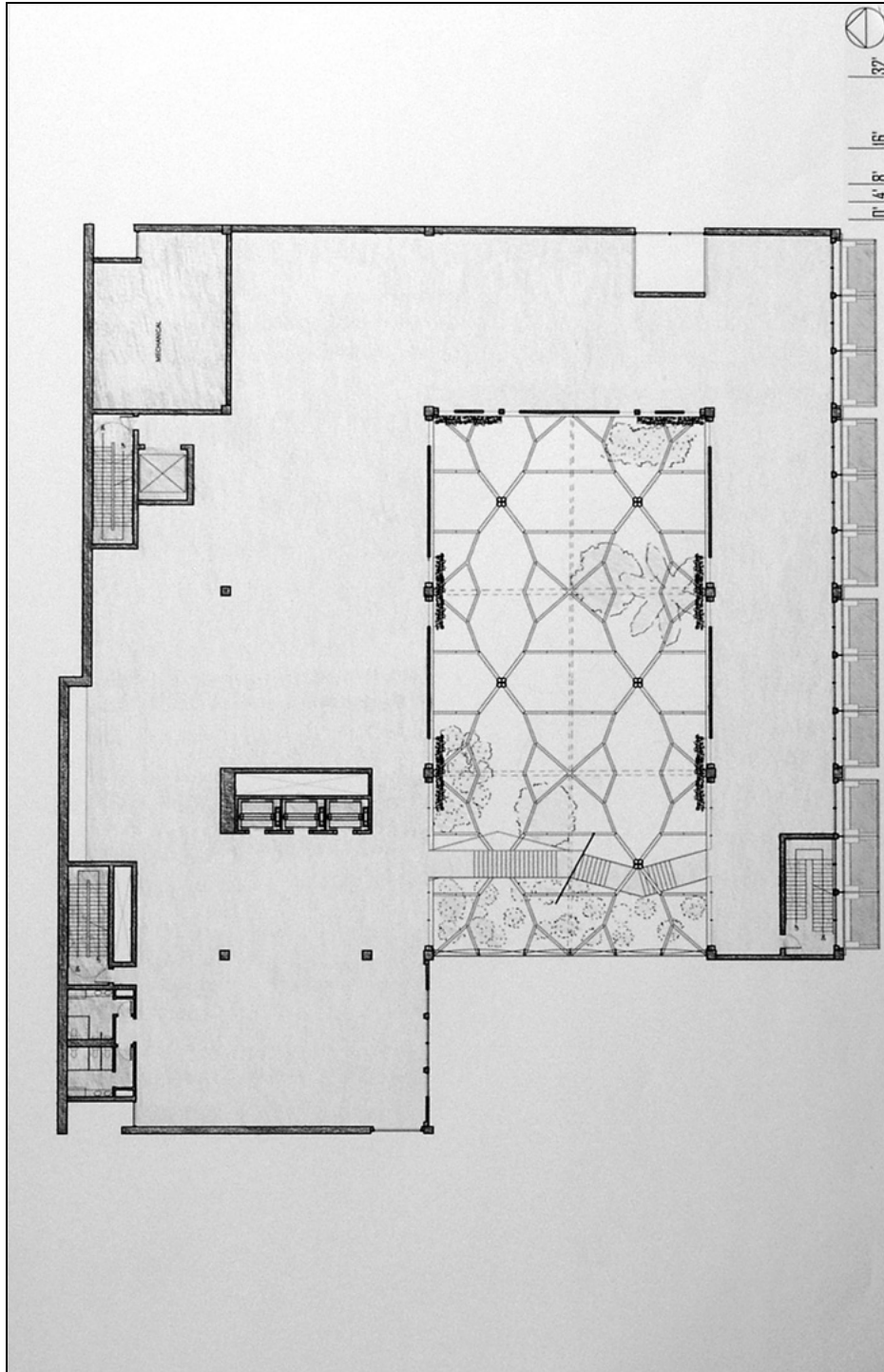


**Figure 78:** Ground Floor Plan

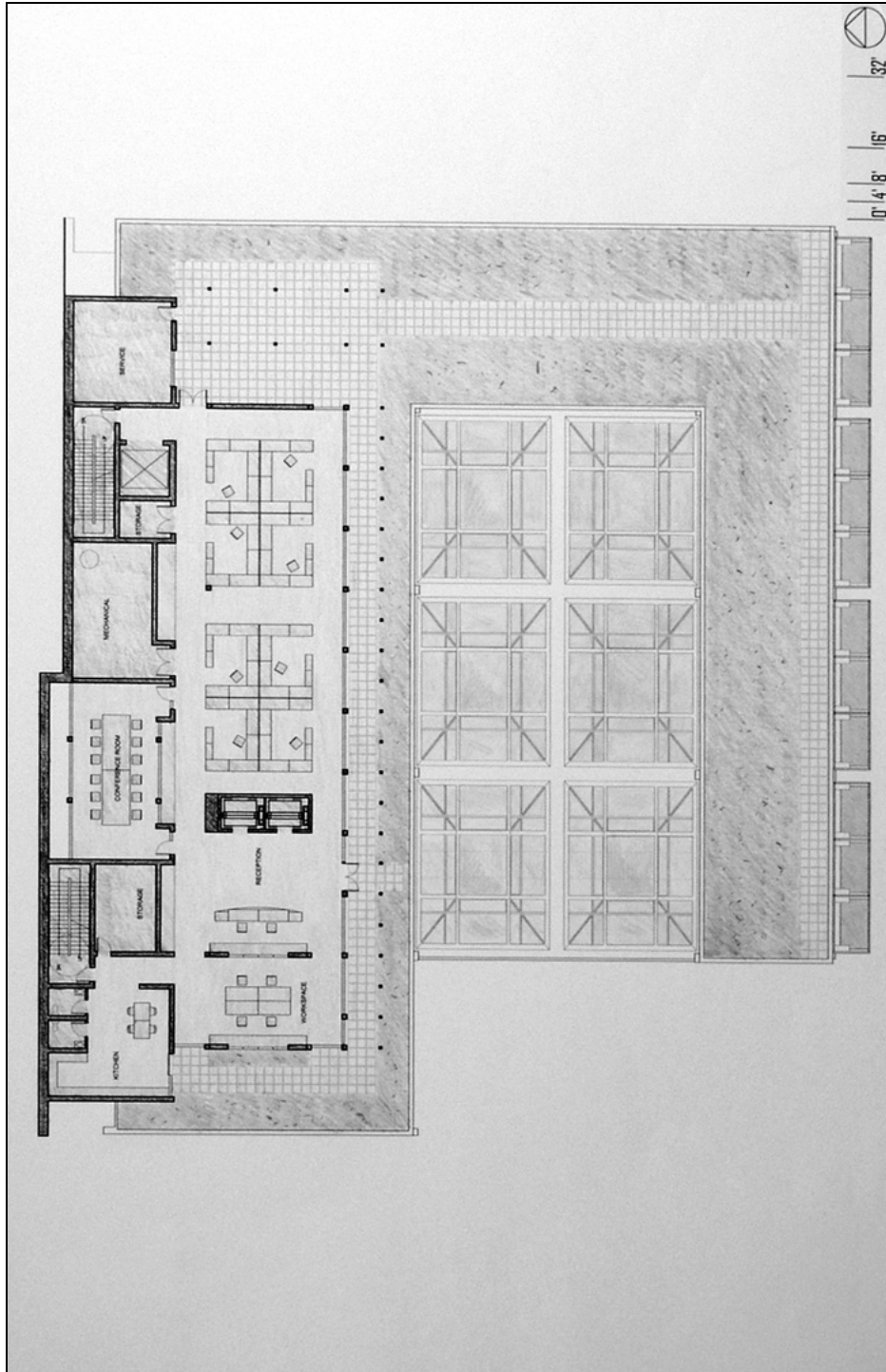




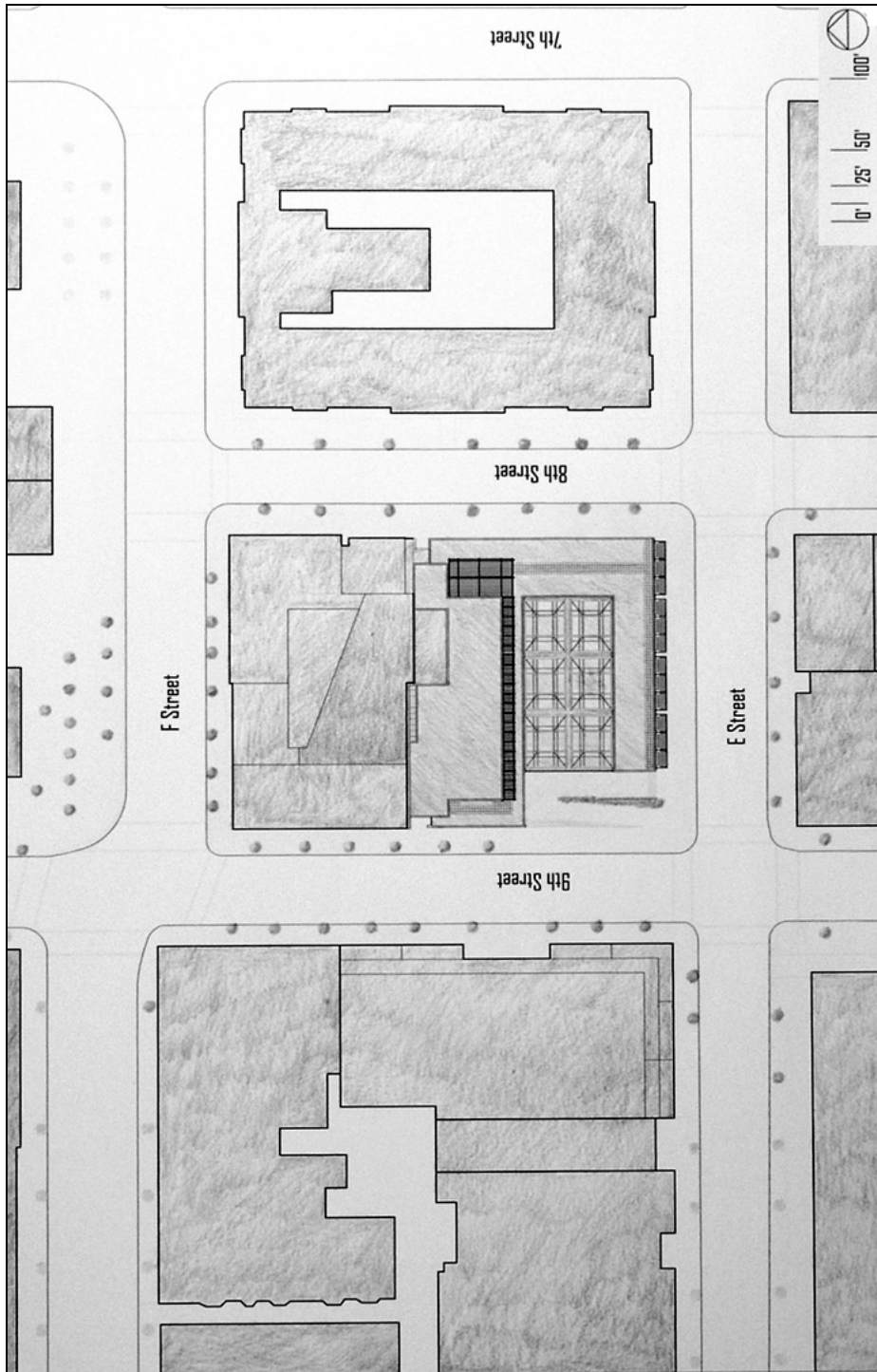
**Figure 79:** 2<sup>nd</sup> Floor Plan. Research Level and Tomorrow's Potential Exhibit.



**Figure 80:** 3<sup>rd</sup> and 4<sup>th</sup> Floor plans. Natural World and Built Environment Exhibits.



**Figure 81:** 5<sup>th</sup> Floor Plan. Administrative Level and Experimental Garden.



**Figure 82:** Rooftop Plan.

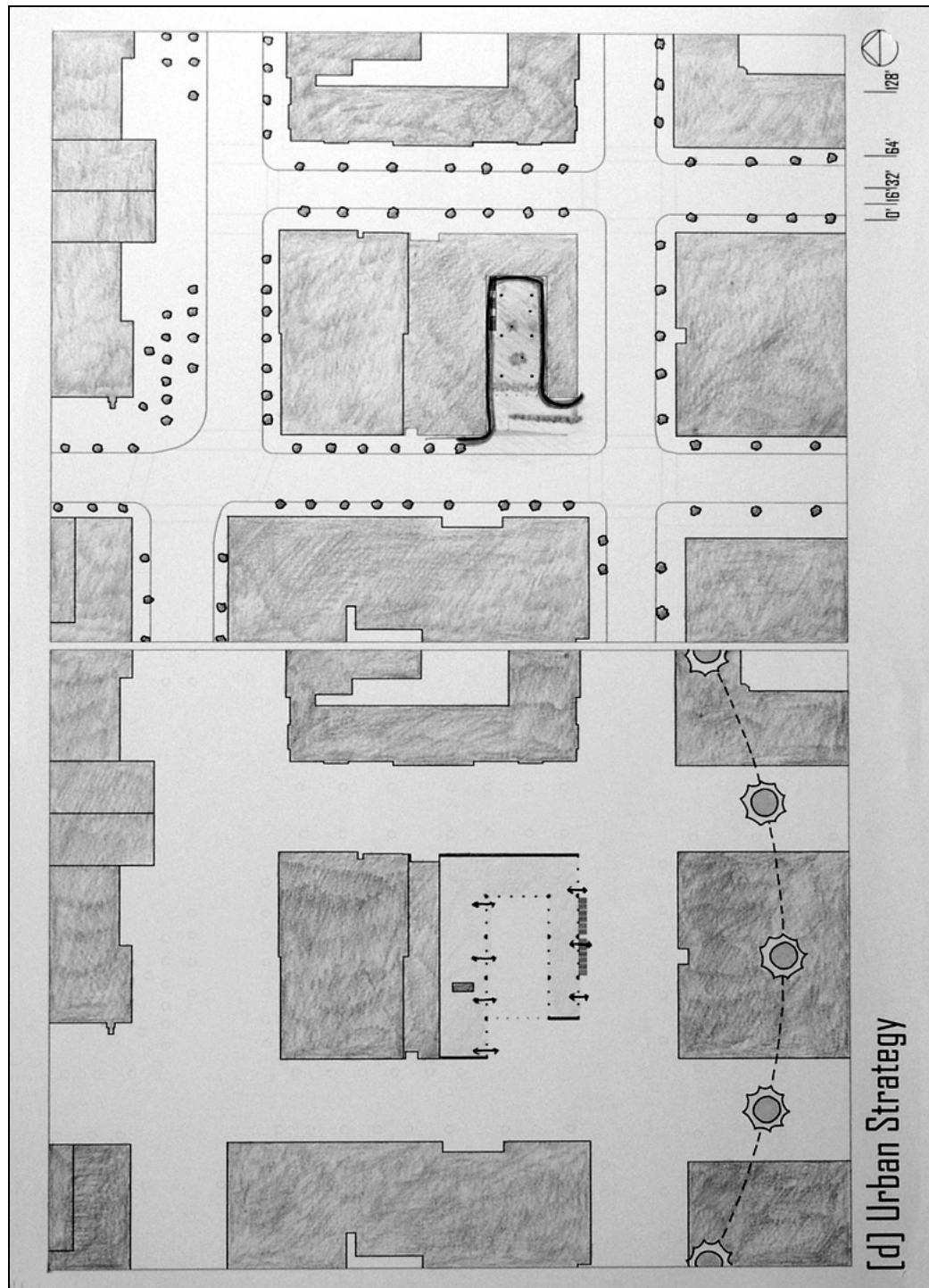
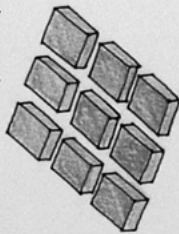


Figure 83.

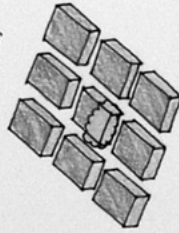
## A Vision of Tomorrow: Greening the City



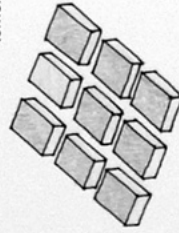
yesterday



today



tomorrow?



One of the important aspects of this thesis is to stress how informed decisions can have a huge impact on our surroundings. The benefits of green roofs are staggering when compared to traditional roofing systems.

Prior to the formation of a city, nature thrives in the landscape. An ecosystem involving animals, plants and microbiology coexist in a self-sufficient community. Birds, and trees are able to develop without the hindrance of pollution.

Development of cities usually has a harsh impact on these ecosystems. City growth, often resulting in successful business practice, is often associated with a disregard for the natural landscape.

As cities expand and become more densely developed, there becomes a strain on natural green spaces. Trees are removed to make room for new construction. With these trees goes animal habitats.

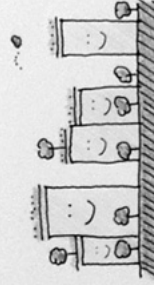
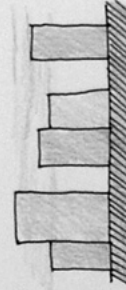
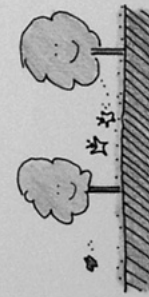
Unhealthy living conditions can also result. Smog and pollution can build up as a result of urban heat islands.

Cities also put a strain on other ecosystems. Rainwater can not be absorbed because of paving and porous surfaces, and must be carried away. This causes an influx of water on other sites, causing erosion and other disruptions. Green roofs can counter this affect by absorbing rainwater.

Working with plants, as well as being around them has many health benefits, including relaxation, lowered stress.

Green roofs provide an aesthetic and functional garden out of something that was not used before. The benefits of are twofold, allowing people to coexist with a new landscape, while improve our quality of life.

Reintroducing plants into the city is a step toward recognizing the importance of greenery in the built environment.



[d] Green In The City

Figure 84.



The Sustainable Design Center is a Living Museum. The museum aspect offers contemplation, learning, and collection - a way to link institutional research back to the public. The living component will be the research part of the program, the content will always be changing and updating itself through time. It addresses the profession of architects and builders, as well as draw attention from schools, families and individuals.

#### [Laws of Nature Gallery]

This gallery talks about the natural environment in terms of how people interact with nature, and principles of nature such as thermodynamics, ecosystems, and nature's "services." It will focus on man's connection to nature and spirituality.

#### [Built Environment Gallery - Yesterday, Today, Tomorrow]

Review of the full life cycle of the built environment from methods of production, to produced items. This exhibit will offer an analysis of what is built and why from the viewpoint of where we've been, where we are, and where we aspire to be. Timeline, value systems, opportunity, and available technology will be considered from a international, national and regional scope.

#### [Tomorrow's Potential - Domestic Scale/Professional Scale]

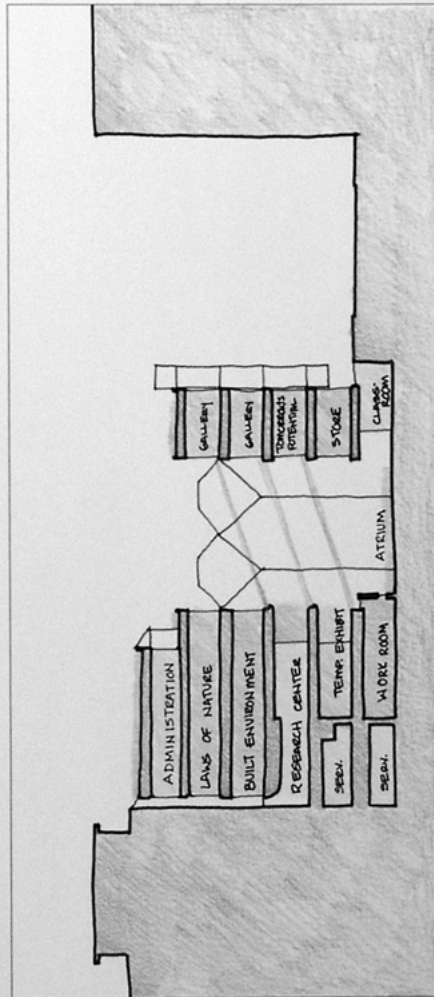
- Encourage individuals to become aware of the effect of their every day decisions.
- Outline ways for individual families to implement sustainable practices in their homes and every day lives.
- Provide a study of building materials, Systems Technology, Rating Systems through samples, models, diagrams, software.
- The building itself will be part of the example:
  - Temperature of different parts of the façade (color, shading devices)
  - Green Roof
  - Solar Panels - energy "produced" during that day

#### [Research Center]

Books, magazines and reference stacks, and design software are located within the research center. Resources continue out into the exhibits, including materials samples, systems diagrams, models, and case studies.

#### [Case Studies- Role of Architecture in a Sustainable Tomorrow]

This gallery displays an in depth study of new buildings, products and projects. This exhibit will be continually updated, with material archived in the Research Center.



[d] Program

The museums attempt to educate and inspire visitors through the experience of place as well as through the exhibits. Movement throughout the building allows you to experience nature in a variety of ways.

1. View of central atrium from street.
2. Enter into building at level of tree tops
3. Arrive at first museum level, looking down into atrium space
4. Juxtaposition of man-made tree canopy to real trees
5. Engage trees from bridge
6. Intimate scale at atrium floor

Figure 85.

[Organization]

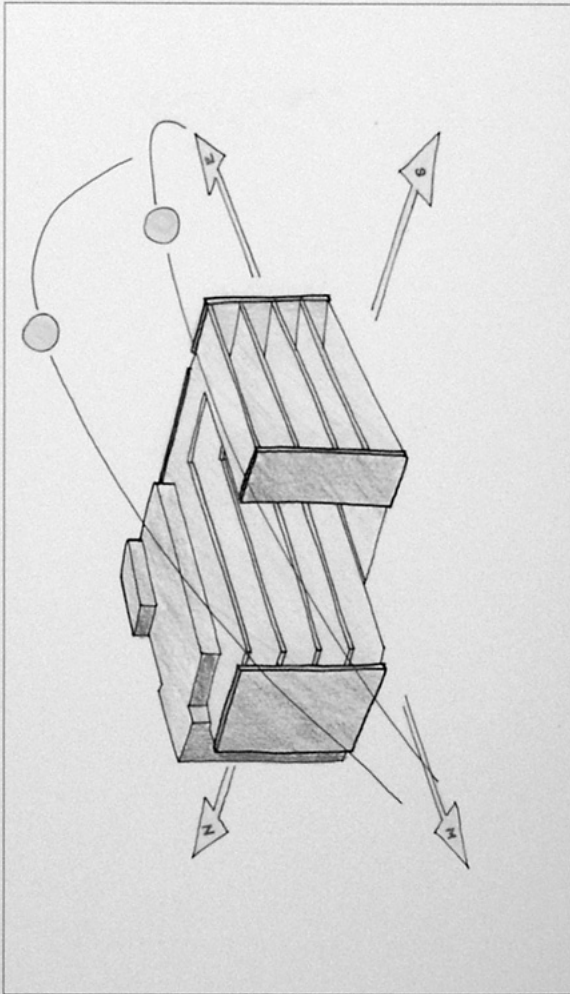
Program Organization in relation to the sun has a significant impact on energy consumption through lighting, heating and cooling loads. Daylighting can provide full illumination to task areas no farther than 12-14 feet from exterior walls, and partial illumination can reach up to 30 feet away. In general, east and west facing facades are difficult to shade from the sun. South facing facades can be monitored with shading devices, whereas north facing facades can be left unconstrained.

The overall organization of the museum offers a variety of spaces to meet various needs. A shallow bar along the south facade allows natural light to illuminate the spaces. Solar panels act as sunshading devices, protecting the building from heat gain and glare. Deeper floor plate allows for larger exhibits and more controlled lighting opportunities. Mechanical rooms do not have a lighting need, do require fresh air. For this reason, mechanical service areas are located to the north, along perimeter walls.

[Structure]

Tree columns are composed of 4 round steel tubes bundled and welded in place. The branches are round steel tubes decreasing in size away from the base.

These branches support the glass roof of the atrium. Loads are shared through regular spacing.



[d] Organization/Structure

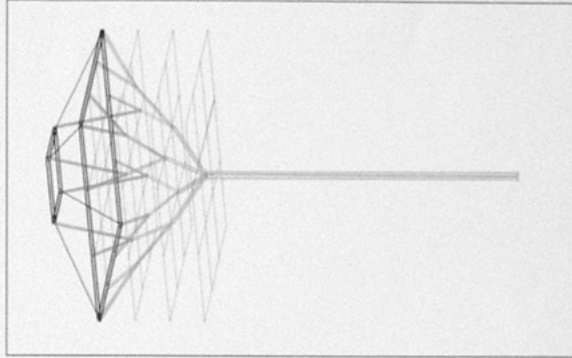
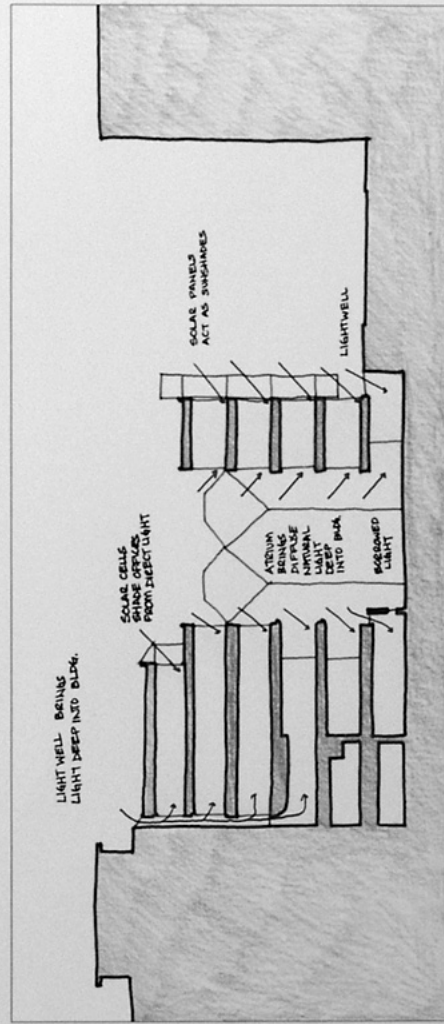
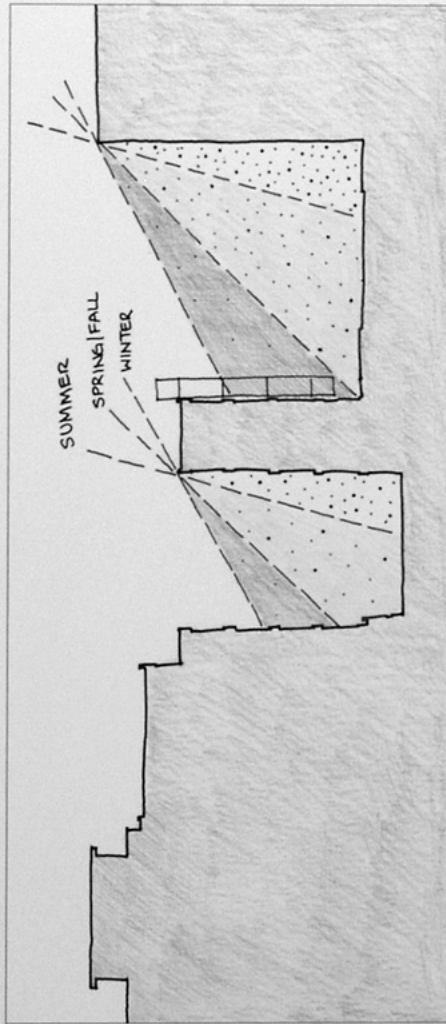
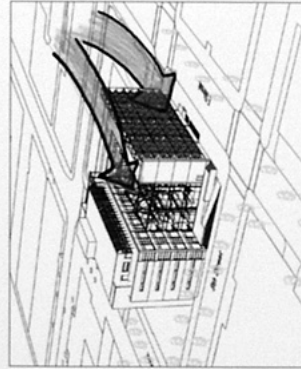


Figure 86.





[d] Light



#### Maximize Daylighting Opportunity

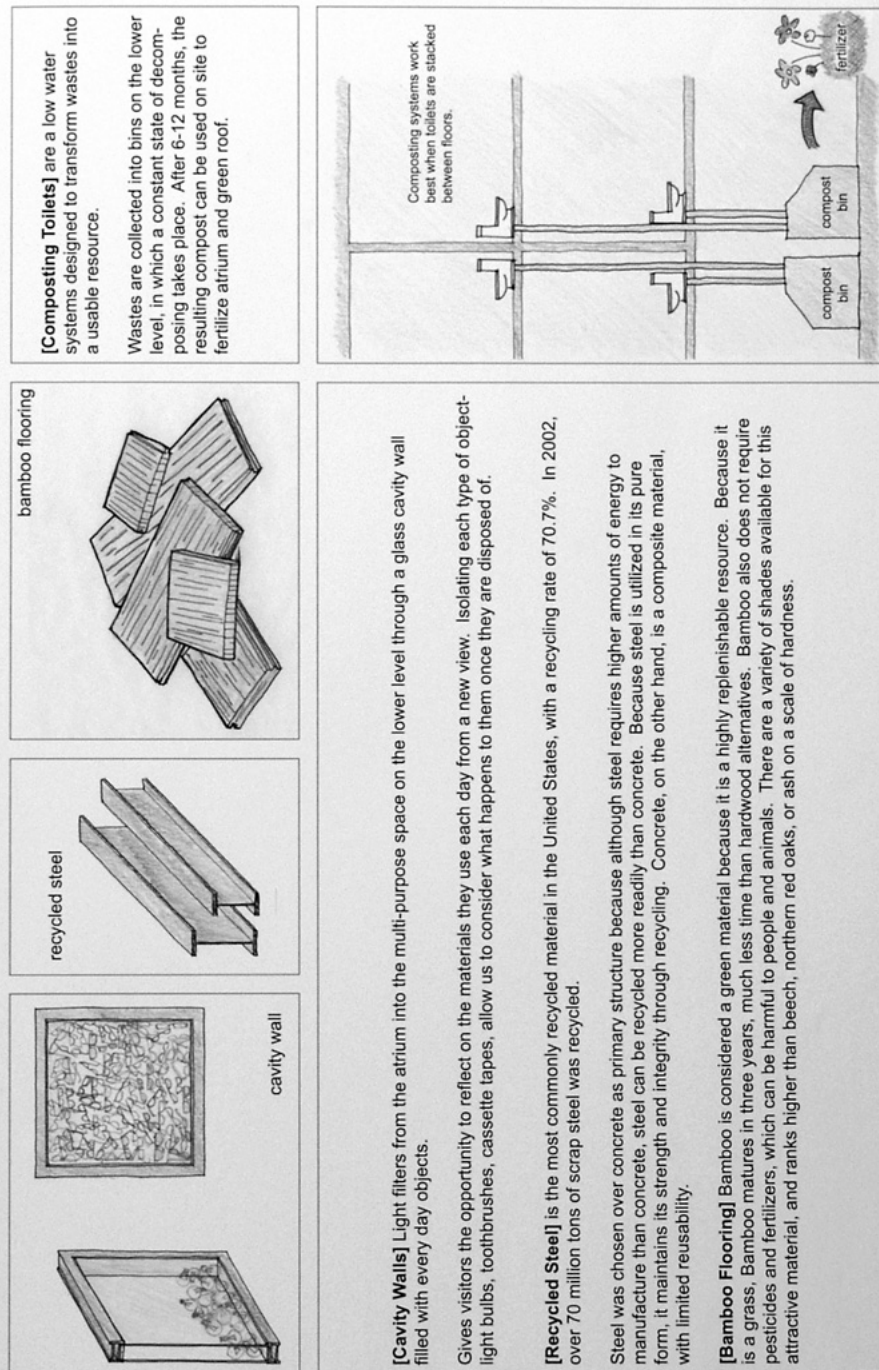
This passive solar design uses natural light to reduce electrical consumption, which also reduces the amount of heat given off by fixtures, reducing cooling load.

Direct sunlight reaches different parts of the atrium and south facade during different seasons. Ambient light is continuous throughout the year.

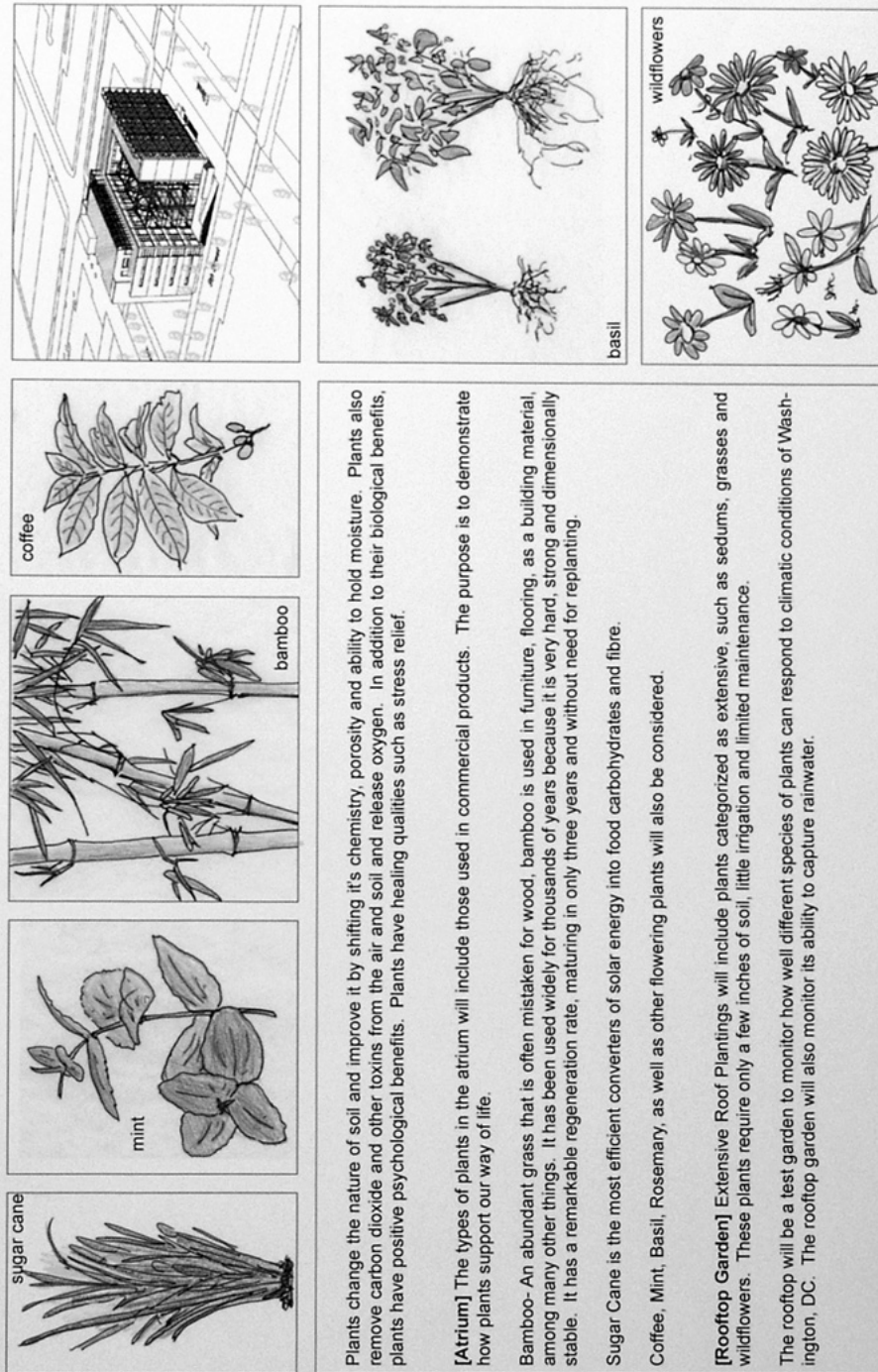
The atrium, the light well along north wall, and the glass block floor over the classroom spaces were designed to borrow light into areas that are not directly located on the facade

Access and exposure to natural light is important for psychological reasons as well. The movement of the sun across the sky is a natural rhythm. It has the ability give us a sense of orientation.

Figure 87.

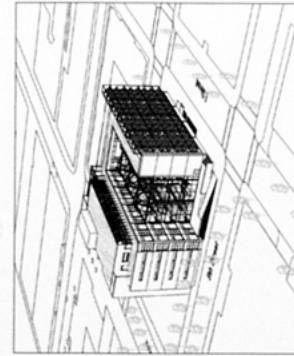


**Figure 88.**

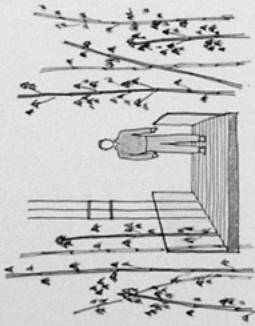


[d] Plantings

Figure 89.



People's feelings about sustainability, at its root, is colored by their attitude toward the landscape. Bridges through the atrium space allow visitors to engage the treetops, and understand nature from a different perspective.

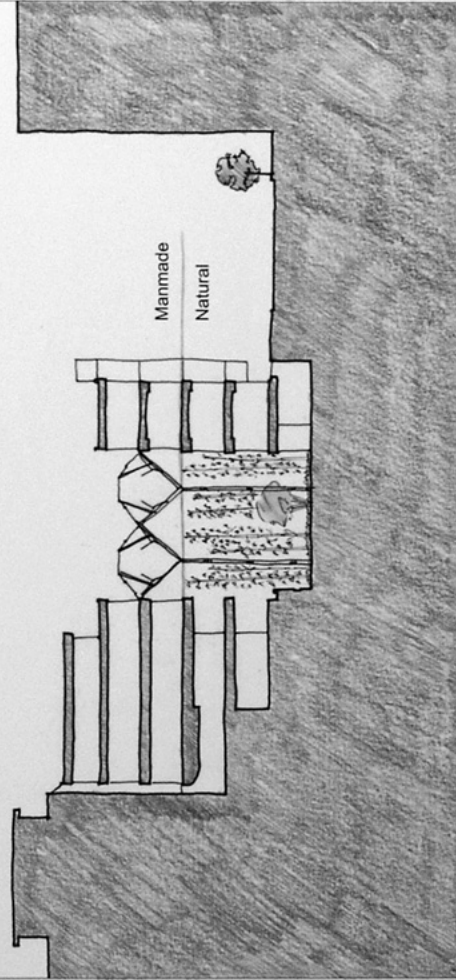


Movement throughout the building allows you to experience trees and plants in a different way.

Visitors can draw comparisons between nature and man-made from juxtaposition of the structural trees against the real trees.

While descending from the fourth floor to the third floor, one experiences the canopy of the structural trees. When moving from the third floor to the second, one winds around the "trunk" of the structural tree, amid the real treetops. At the lower level, dense plantings dominate the atrium floor.

These experiences create memories unique to each person. Visitors can also draw comparisons to past experiences, giving value to these new experiences.



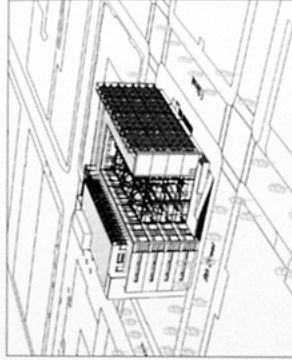
[d]Experience Nature

**Figure 90.**

A green roof – also known as a vegetated or eco-roof – is a lightweight, engineered roofing system that allows for the propagation of rooftop vegetation while protecting the integrity of the underlying roof (Earth Pledge Foundation).

Green roofs have a lot to offer:

- Act as a thick insulation layer, helping to regulate interior temperatures
- Protection from deteriorating UV rays on building surfaces
- Minimize impact of building on site
- Habitat for wildlife
- Reduce storm water runoff by 75%
- Reduce affect of urban heat islands
- Usable space- events place, school groups, etc.
- Test Garden- examine how different species of plants fair in this climate

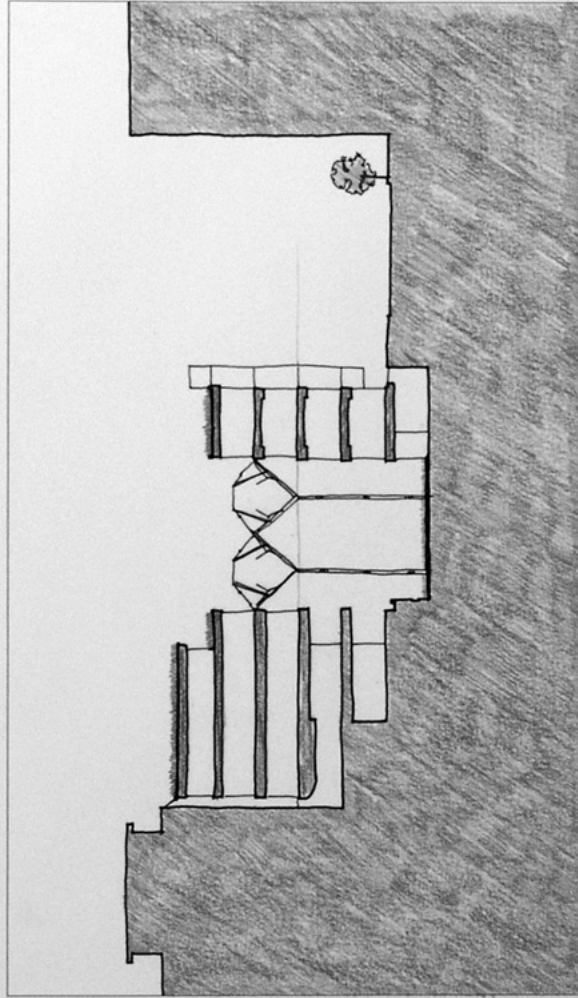


Open space within a city is constantly on demand, yet traditional building practices leave building roofs barren and undeveloped.

Green roofs develop space that has been overlooked or ignored. Rooftop gardens can be integrated into building programs as an amenity.

Green roofs re-establish plantings and landscaping on horizontal surfaces, improving the building's ecological impact on the site. In this case, a paved parking lot preceded the building.

Offices gain the most benefits from the green roof of the Sustainable Design Center. They are provided with constant views of the garden and direct access to the patio where special events, tours and group programs can take place.



[d] Green Roof

**Figure 91.**



Traditional HVAC systems, like the ones commonly used in Washington, DC, are designed to provide a comfortable environment for building inhabitants. This is a hard task to accomplish because each person's perception of thermal comfort is different.

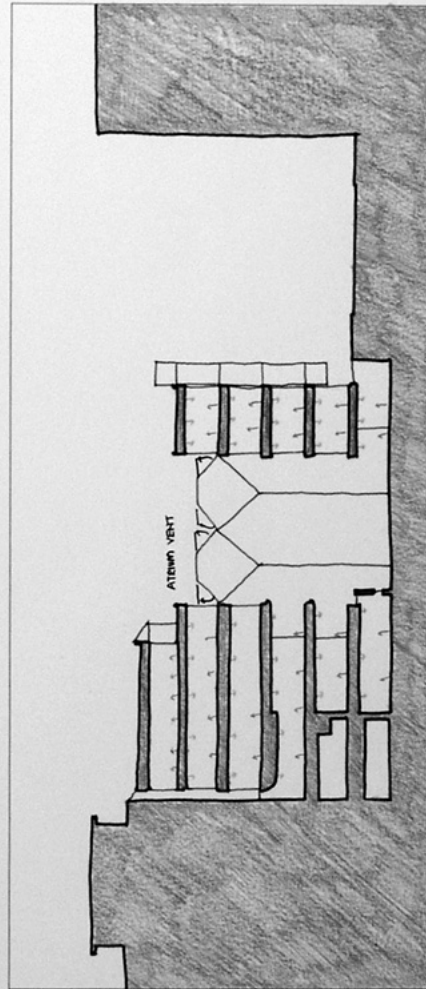
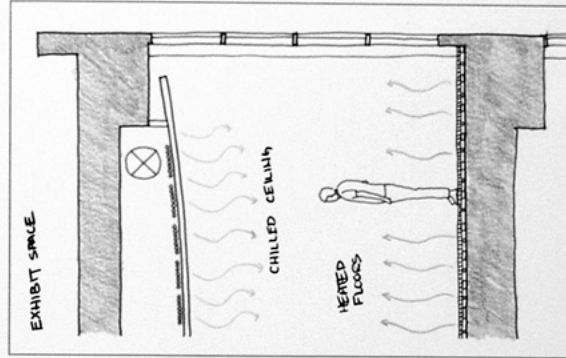
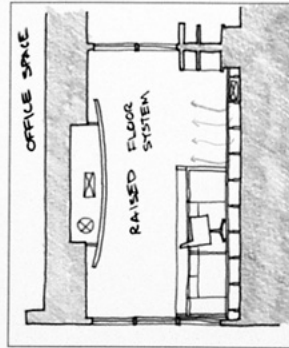
Conventional systems use a high amount of energy to create an even air temperature from which radiant comfort will result. Radiant systems, on the other hand, change the temperature of surfaces in the space, which according to the American Society of Heating, Refrigeration and Air Conditioning Engineers, is a more efficient way to achieve human comfort. (KNECHT)

Radiant flooring is a more energy efficient heating system. People tend to feel comfortable at lower temperatures with radiant systems than, reducing heating loads in cold winter months.

Because the climate in Washington DC tends to be very humid, radiant cooling systems can cause water to puddle on cool surfaces. Desiccant dehumidifiers can be used to take moisture out of the air to address this issue.

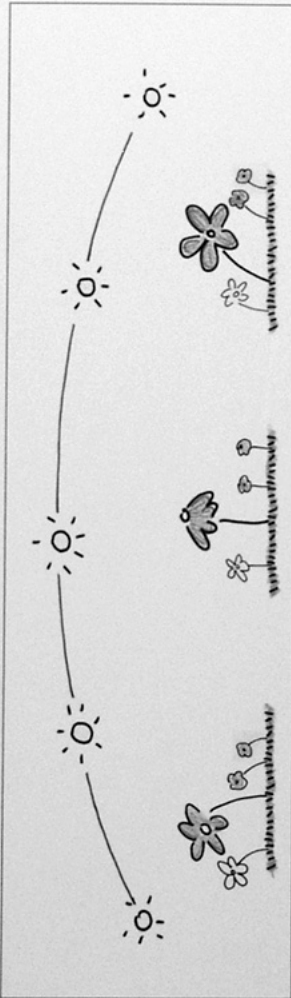
Raised floor system is appropriate for office spaces, delivering heated and cooled air directly to the building occupants rather than the air above them. Occupants also have the ability to personalize temperature controls in their local environment.

The atrium is controlled by an automated ventilation system that opens exhaust windows as needed.



[d] Heating / Cooling

Figure 92.



Photosynthesis is the process by which plants and other organisms use light energy to produce food out of carbon dioxide and water. While their movement is slow, plants generally grow in the direction of light. This allows them to maximize the amount of sun light they are able to use for food.

Phototropism refers to the tendency to move toward light. Sunflowers are unique because in their bud stage, they are highly phototropic. They follow the track of the sun across the horizon throughout the day.

This movement with the sun is a natural reminder of the sun's significance. It makes life possible, providing us with light and energy.

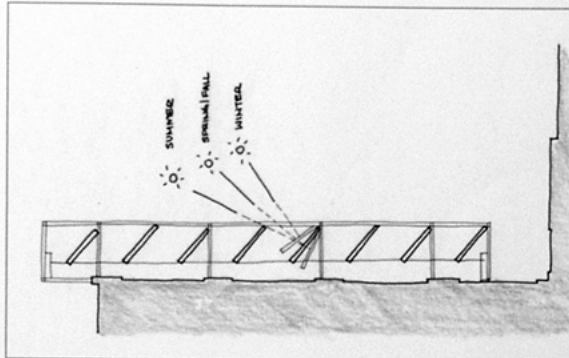
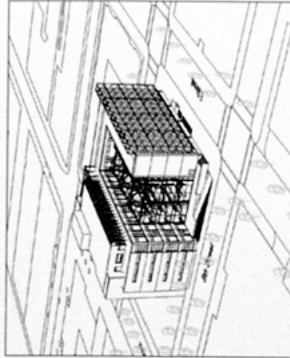
The solar panels located on the south facade of the building are designed to follow the path of the sun as well. A mechanical device changes the position of the panels according to season in order to optimize performance.

**[In nature, there is no waste.]**

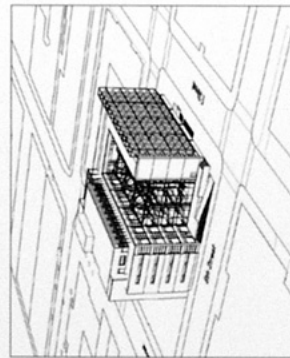
"The overarching design framework we exist within has two essential elements: mass (the Earth) and energy (the sun). Nothing goes in or out of the planetary system except for heat and the occasional meteorite. Otherwise, for our practical purposes, the system is closed, and its basic elements are valuable and finite. Whatever is naturally here is all we have. Whatever humans make does not go away." (McDonough)."

Because our resources are limited, we must be conscious of the way we build. Material preferences will be toward recyclable and reusable materials over hybrid and composites. This allows it to be reused and returned into the cycle of life.

**[d] Learn From Nature**



**Figure 93.**



Target Energy Performance Results (estimated)				View Statement of Energy Design Intent	
Energy	Design	Target	Top 10%		
Score	N/A	100	90		
Site Energy Use Intensity (kBtu/Sq. Ft./yr)	N/A	19.1	37.2		
Estimated Total Annual Energy (kBtu)	N/A	2,615,583.1	5,093,271.7		
Total Annual Energy Cost (\$)	N/A	\$ 52,212	\$ 101,671		

Reducing the initial need for energy is a fundamental part of maximizing a building's performance. This can be achieved through appropriate space planning, specifying high performance equipment, and maximizing daylighting opportunities. The government's Energy Star Target Finder is a free public resource that allows you to determine the annual energy goal of a building design, through a simulation calculated based on building location (climate) and space type. Energy Star estimated that this 137,000 sf building will consume roughly 2,615,583.1 kBtu/year. This translates the energy load to be to 2,103 kWh/day.

The use of solar panels is non-polluting, inexhaustible means to generate electricity. Solar energy can be put into two categories- Light Energy and Thermal Energy. The Sustainable Design Center demonstrates the use of both systems.

**[LIGHT]** The solar panels on the south facade help to offset the building's electrical needs. Solar panels utilize the sun as an ambient energy source. This reduces the strain on the electrical grid and the use of polluting energy sources.

Solar panels are positioned to double as a sunshade for the south facade. Sunshades help to monitor the radiant heat gain, lowering the buildings cooling load, and therefore reducing the overall energy need.

There are 9,300 sf of solar panels arranged along the south facade of this building. Each solar module can generate 10-14 watts/sf. Due to the earth's tilt and rotation around the sun, the number of hours of available sunlight reaching these panels changes throughout the year. The light energy collected has been calculated in the chart based on available light in order to estimate what percentage of the building's electrical need will be satisfied through the solar panels.

**[THERMAL]** Solar hot water collectors located on the roof help to further reduce the building's dependence on the grid for energy. Solar hot water collectors are the most efficient way to heat water. In addition to the use of low flow fixtures and composting toilets, can help to lower the buildings initial load.

280 tubes, each 5' long, with a 1.8" diameter will generate 148,091 Btu/day, satisfying the building's hot water need.

[d] Energy

Month	Avail. Light	% of Need
March	6	34.5%
June	8	46%
September	7	40%
December	4	23%

Figure 94.



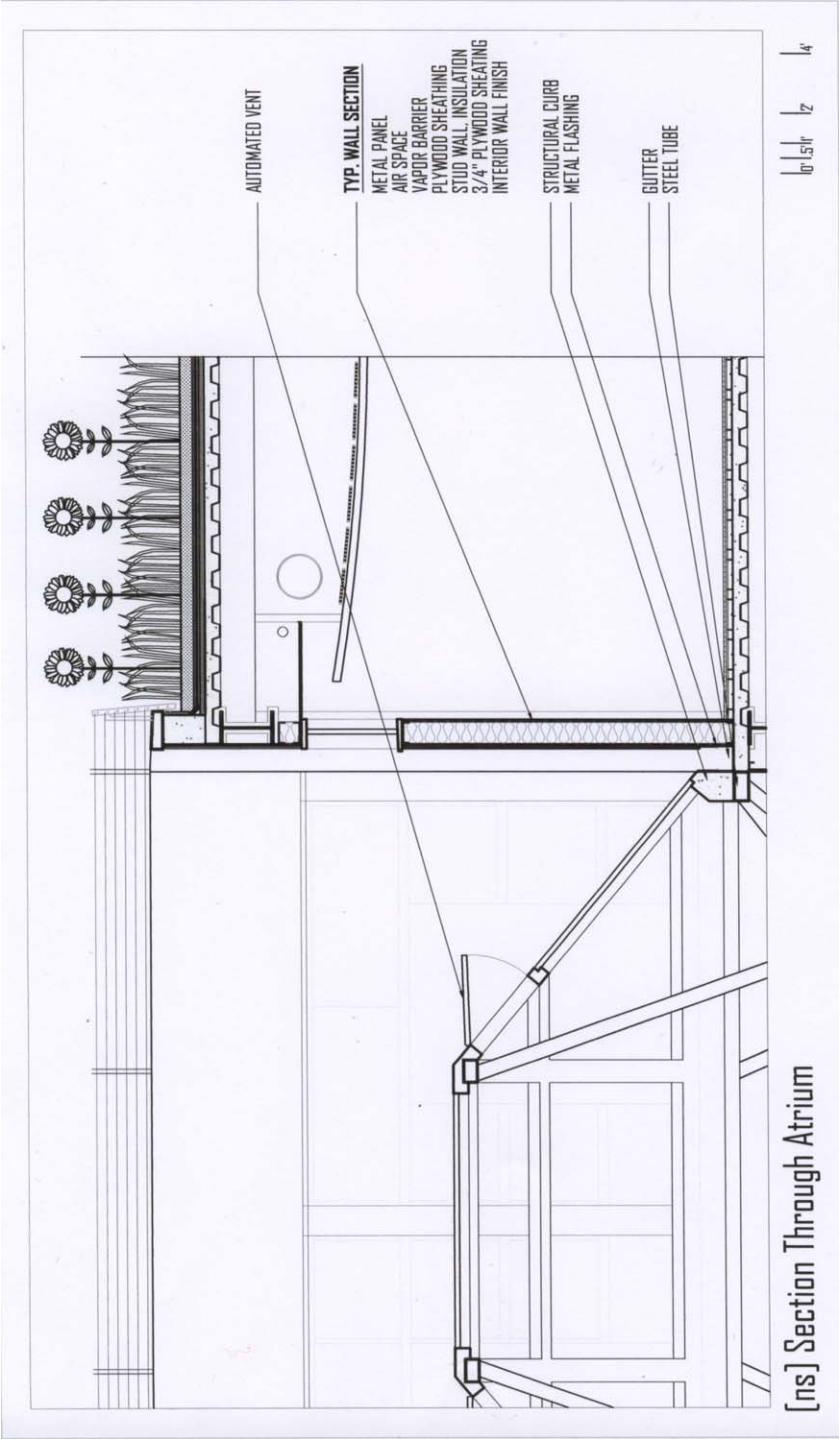
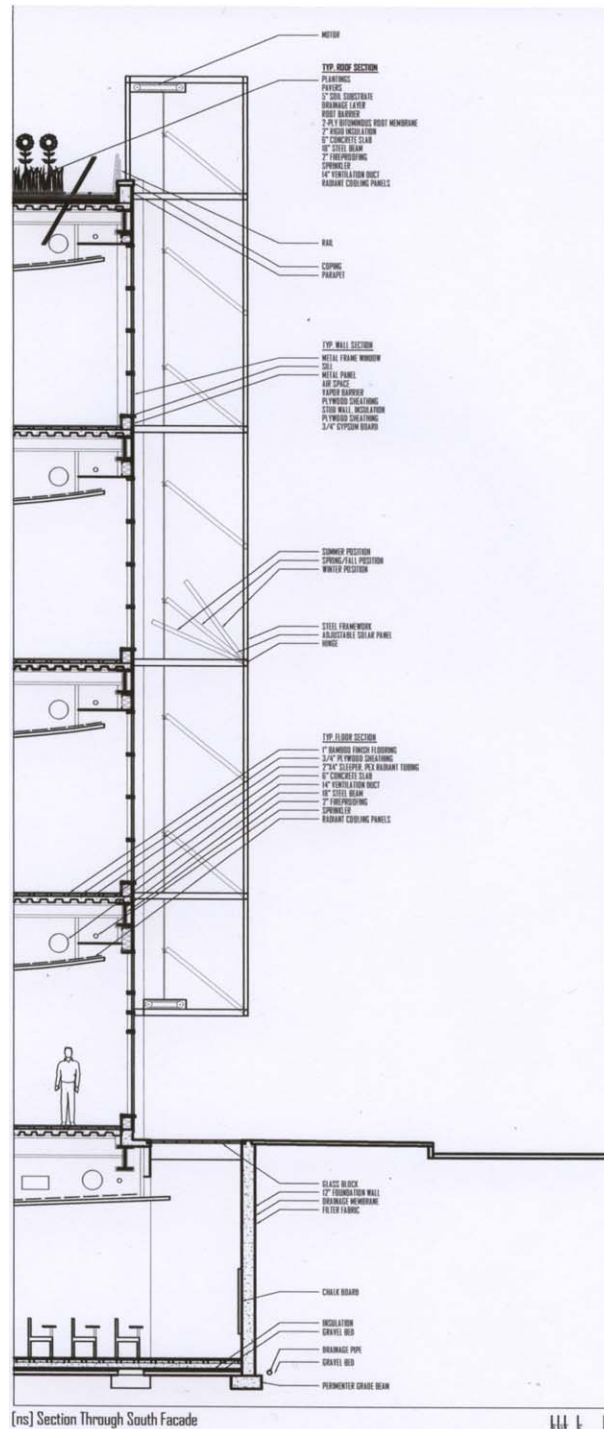
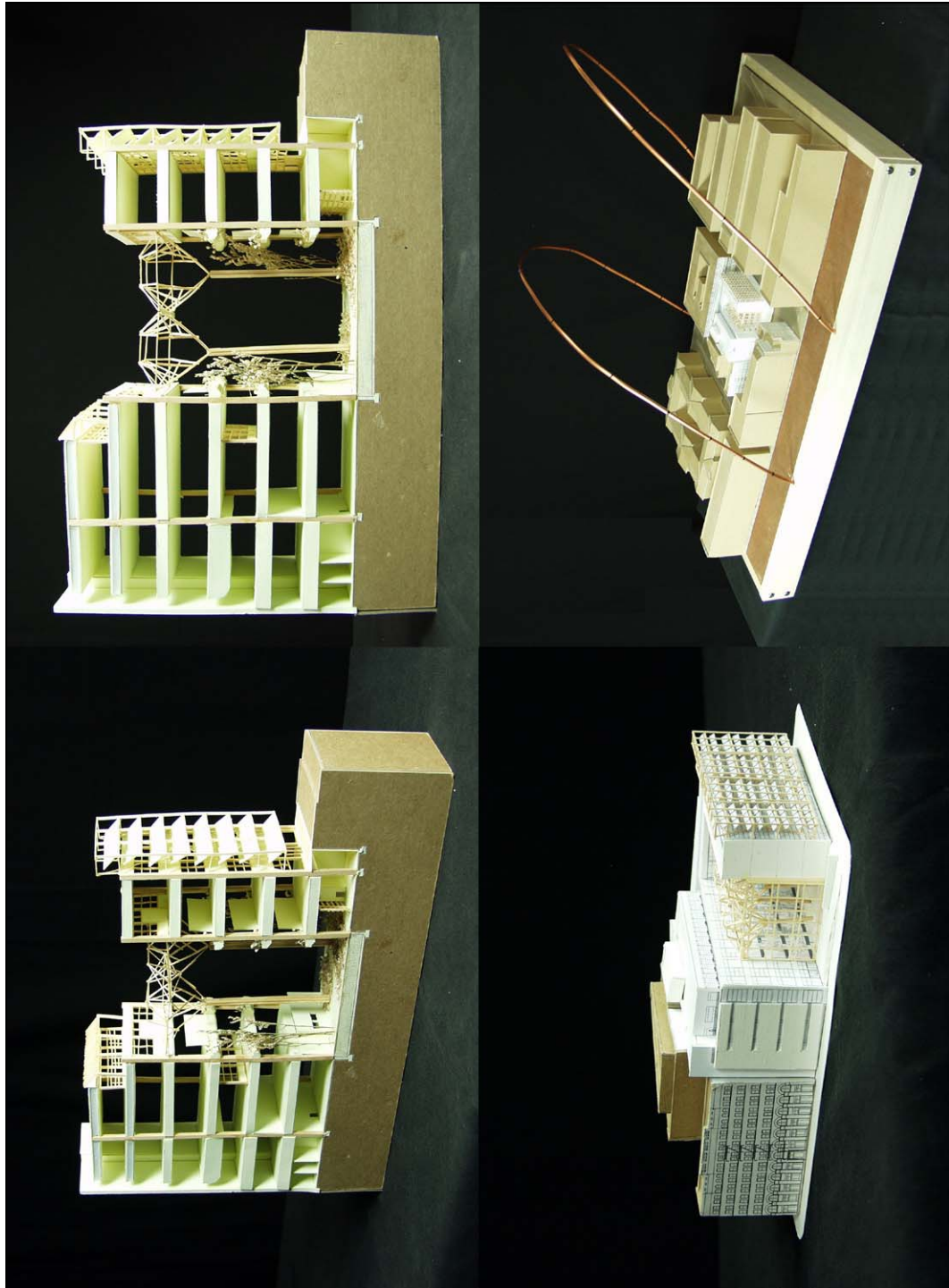


Figure 95.





**Figure 97: Model Images**



**Figure 98:** Model Images.

<sup>47</sup> Quinn, Daniel. Ishmael. Bantam/Turner Books: New York. 1992. P. 250.

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