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Urban Subterranean Space: A link between a ground level public space and underground infrastructure

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Urban Subterranean Space

A link between a ground level public space and underground infrastructure

by

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Underground Subterranean Space: A link between a ground level public space and underground infrastructure
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I. Abstract

The global trend of urbanization requires an increased demand for reliable infrastructure in urban land. The lack of buildable space in urban areas has been resolved traditionally by skyscrapers and sometimes, the location of new development is shifted to the outside of the central city due to the lower density and property values. However, longer distance between the traditional city center and the new developed area requires additional infrastructure to support the networks.

Urbanization allows economic and social development as well as an opportunity to lessen the impact of consumption and production on the environment. However, the urbanization and denser city plans do not always create the successful sustainable urban development. The key function of a city is to enable exchange, interaction and the combination and recombination of people and ideas. Although denser cities are more productive, innovative and energy efficient, when buildings become so massive, this key function of the city can disappear (Florida). While skyscrapers can be the significant element of the big cities, it can be intriguing to consider buildings downwards instead of upwards because it saves ground space by providing extra spaces as well as bringing visibility back to the pedestrian level.

This thesis will argue how necessary it is to develop the subterranean space within the urban contexts which will establish an alternative solution for urban design problems. This research will create a design framework for subterranean public space which leverages existing underground spaces, such as subway stations in New York City, to create a space that contributes to its aboveground environment that is currently neglecting a significant relationship with above ground spaces. The result of this thesis is to design a subterranean public space that provides an extra space with an access to multiple services.

II. Introduction

This section provides background knowledge which helps to understand the current urban environment and needs for public spaces. In addition, it includes the usage of underground spaces as well as basic formations of them by function and configuration.

1. Population Growth and Urbanization

According to the World Urbanization Prospects report by the UN, 54% of the world's population lives in urban areas and this worldwide movement of people from rural areas to urban will continue to grow. The report states that by 2050, 66% of the world population will live in urban areas (United Nations 31).

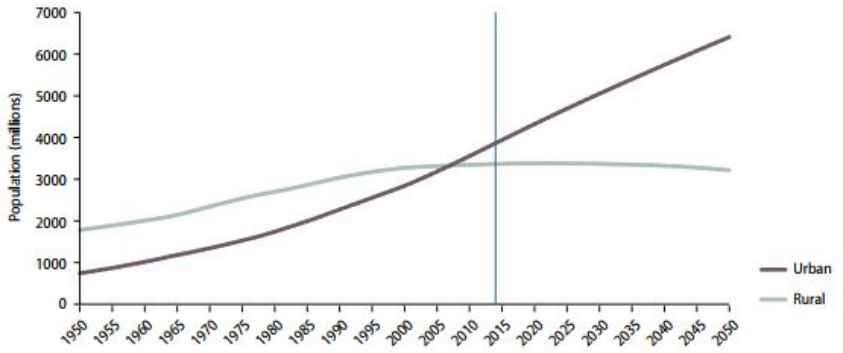

Figure 1. Urban and rural population of the world, 1950-2050

Source: United Nations

Figure 1. shows that in 2007, the global urban population surpassed the global rural population and the world urban population is expected to continue to increase (United Nations 31). This exceptional attention of population into urban areas comes from its sustainable and convenient values of urban environment yet without considerate urban design and planning, it resulted in urban sprawl and congestion. As infrastructures in urban areas continue to grow and

buildable space become limited, it is significant to respond by creating buildings that considers environmental conditions.

This urbanization trend requires continuous improvements in sustainable and resource efficient urban environment. Sustainable urban environment can be described as a city where it provides the quality of life to residents with the capacity of resource to support its activities (Basiago 148). To be more specific, the value of urban environment and urban sustainability can be explained in terms of economic, environmental, and social perspectives.

First, the idea of sustainability pursues the way to satisfy the present consumption levels without compromising future needs (Basiago 148). Conventional economists believed that economic growth would allow the technological development in which replaces the natural resources destroyed in the production process and the economic sustainability restrained resource use for the sustainability of natural capitals. Therefore, economic sustainability was not achieved at the cost of environmental sustainability. Yet, currently, qualitative growth has adapted to common practices of understanding the economic sustainability rather than quantitative growth. Providing needs for the general public is a practical sense to realize the economic sustainability (Basiago 150-151).

For instance, urban environment offers various services including public transportations, business, stores, and recreational parks that keep people to stay within the city so people can save their time and money to travel. In other words, urban areas attract more people by fulfilling all the requirements for living. Jane Jacobs mentioned in the book, *Economy of cities* that only cities add new activities to existing activities and believes that this is the engine for human and economic growth (Jacobs 249-250). Hence, as more people live in the city, the conventional role

of the city will be re-emerging as a marketplace and it will invigorate the economic activities. This is the main motive of urban population growth and a reason that the urban environment allows to be much more convenient to live in than rural areas.

These days, cities no longer generate smoke and pollution as they did in the industrial revolution period. Enormous energy consumption, uncontrolled waste and contamination led cities to separate from natural ecosystems and this disrespectful attitude towards environment caused settlements to sprawl. Climate change is one of the main environmental issues today and CO2 emission relates to vehicles in which impacted on urban environment. ("Greenhouse Gas Emissions"). The attention to the environmental impacts of the urban promotes the importance of urban planning to address the global environmental challenges in growing cities. Transforming a city form has become a tool to address many environmental issues and a new type of city stimulates compact and walkable communities which covers the major environmental concerns (Rudin and Falk 76).

There are worldwide sustainable schemes such as the British BREEAM for Communities, the Japanese CASBEE for Urban Development and the American LEED for Neighborhood Development, and they have been used for the certification and benchmarking for various architectural projects in urban areas. Emphasizing on community well-being is the common idea among those schemes and specifically, compactness, centrality, density, porosity, complexity, path size, land consumption per capita, land-use mix and accessibility are the primary indicators to exam and describe the relationship between urban form and environmental sustainability (Säynäjoki et al. 6623).

Since the use of motor vehicles is one of the major impacts on urban environmental issues, combining high population density with compactness of urban structure has an important role in developing environmental sustainable societies (Säynäjoki et al. 6623). Therefore, investment in short distance walking, pedestrian friendly environment, cycling and public transportation is now necessarily to be considered for urban development. In addition, denser development allows less heating systems for housing, cost and eco efficient centralized sewer systems, waste collections and material recycling which also brings huge benefits to the urban economy (Säynäjoki et al. 6624). Living in downtown or an urban area might have been quite rough due to empty buildings at night and poor environmental quality also, many cities have been struggling with the fast-growing urban sprawl. However, transforming a city form with dense planning has become a new trend in urban and this movement has provided a new perspective towards both environmental and economic sustainability in urban areas.

The value of the community is considered as one of the most significant elements of social sustainability in urban. It is not too much to say that the successful urban environment can be determined based on the existence of a strong community. According to the research project "The value of urban design", the social benefits of good urban environment are particularly focusing on well-designed public spaces (Carmona et al. 78). Based on the well-designed open areas and amenities for public, urban environment has a better understanding on social activities by less need for high profile security arrangements.

The sense of comfort in public spaces with associated facilities adds social well-being and civic pride to the city. As a result, physical design, distribution of uses and levels of activity during the day and at night help people to decide whether they want to stay in the city or not (Carmona et al. 80). In addition to a sense of safety and civic pride, urban environment pursues

health benefits to residents by improving connectivity within the city. It encourages people to walk and cycle more to generate greater physical activities in their daily life.

Convenient physical connections certainly allow mixed use developments as well as smaller scale of development throughout the city thus, it improves the accessibility to essential facilities. (McIndoe et al. 3) When people have a better accessibility to social services, residents or an isolated group acquired the social equity which means people have the same status in the society such as civil rights, freedom of speech, property rights and equal access to certain social goods (“Social Equality”).

Urban environment suggests denser and mixed-use developments which enhances better social connections between communities and people. In addition, it encourages diversity of housing form such as apartment living. Therefore, urban areas tend to respect individuality as well as public realm by developing different architectural forms and living patterns.

Urban areas possess distinctive physical and social characteristics. In addition, it supports public realms in which strongly relates to managing of urban environment. More people tend to live in an urban due to its convenient life and strong civic pride. People appreciate easier access to variety of services and activities. This trend brings new vitality to the urban environment and enhances economic status as well. All things taken together, these benefits in terms of economic, environmental, and social promote new patterns in urban development and positively attract more people.

2. Land Scarcity

While urban environment is accompanying with economic advancements and easier access to services, urbanization faces some challenges including pollution, rapid sprawl, and environmental degradation. Along with those issues, both vertical and horizontal growth of urban environment needs to be re-evaluated for the further development.

2.1. Skyscrapers

Urban environment takes a lot of advantages from skyscrapers and these great edifices are the evidence of advanced technology of modern civilization. However, there is a strong argument over the dynamics of the cities and the consequences of living in high rise buildings. Some urban areas spread out consistently, others remain concentrated around the urban center. According to the Demographic Partitions, the term urbanization is a result of the physical growth of urban areas, be it either horizontal or vertical and when it considers the rise of urban centers, infrastructure, modernization, sustainability, and public services are mainly discussed ("Urbanization in 2013"). Therefore, the key of urban development is how successfully a city combines the buildings with transportation, energy efficient grids and public spaces.

How do we measure the urban area? The United States Census Bureau distinguishes urbanized areas of 50,000 or more people and urban clusters of minimum 2,500 and less than 50,000 people. Both urban area and urban cluster refer to densely developed land in which includes residential, commercial, and other non-residential urban land uses ("How Do We Measure"). Due to the dense and limited land, the urban areas have been focusing on mixed-use development consequently, the buildings have been getting more massive and higher.

Since 1860s, tall buildings with iron skeletons began to be built and in 1885, the first ten-story building was built in Chicago by William Le Baron Jenney[1], followed by Sullivan's Wainwright Building [2]five years later. Since that, millions of people have been living in high-rise buildings (Gifford 2). There has been an ongoing argument over vertical growth of urban environment that cities may need more skyscrapers since high rise buildings have been considered as the most suitable solution to response to the shortage of urban lands. Therefore, a lot of developed urban areas are characterized by compact city plans with skyscrapers because they provide more interior spaces than low rise buildings on a given property. However, having a "high" downtown with full of skyscrapers does not always mean a bright future to the urban life since there is a disconnection to a greater infrastructure and isolated occupants from the street level. Even though, many skyscraper developments provide some solutions to promote pedestrian and social life at ground level, from an urban design perspective, those issues still remain and the environmental impact assessment is required for any new projects (Ali and Kodmany 387).

There are some opinions against tall buildings in terms of economic, environmental, and social aspects. First, from the economic perspective, their construction requires extra cost because of their extra sophisticated foundations, mechanical systems for vertical circulations and structural systems to carry high wind loads. Moreover, depending on a location and economic circumstances, while skyscrapers could create higher property values in their neighborhood, in difficult economic times, they may not make enough sales or rental values to recover the

[1] William LeBaron Jenney (September 25, 1832 – June 14, 1907) was an American architect and engineer who is known for building the first skyscraper in 1884 and became known as the Father of the American skyscraper. (Source: Wikipedia, https://en.wikipedia.org/wiki/William_Le_Baron_Jenney)
[2] The Wainwright Building (also known as the Wainwright State Office Building) is a 10-story, 135 ft. red brick office building in downtown St. Louis, Missouri. The Wainwright Building is among the first early skyscrapers in the world. (Source: Wikipedia, https://en.wikipedia.org/wiki/Wainwright_Building)

expensive construction costs (Ali and Kodmany 386-387). Without a great care in different situations, unconditional increased property prices by skyscrapers make housing and services in urban environment are unaffordable for urban residents (Ali and Kodmany 387).

In addition, there are environmental concerns generated by growth of high-rise structures in some big cities. In 2011, in Leeds, England, due to the wind tunnel effect near by the Bridgewater Place which was the highest building in the city, a man died and 25 people were injured. Since that accident, the city has suggested establishing a law for skyscrapers in which considers the risk of street winds (Parkinson). The high wind speed caused by tall buildings deviates wind at higher elevations towards street level making uncomfortable and unsafe to the pedestrian environment as shown in Figure 2 below (Moonen et al. 200).

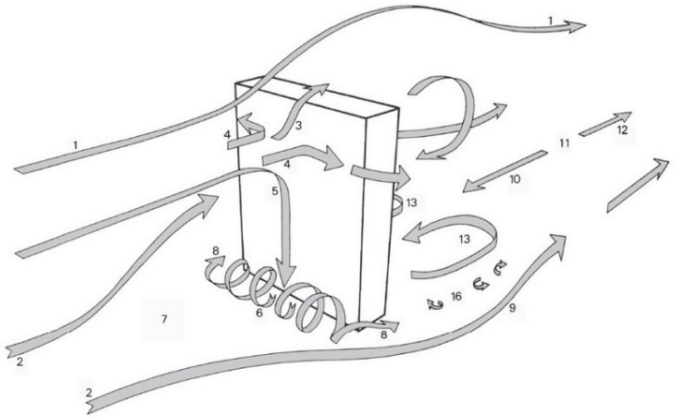

Figure 2. Schematic representation of wind flow pattern around a high-rise building

Source: Urban physics: Effect of the micro-climate on comfort, health and energy demand, (Moonen et al. pp 201)

To be more specific, According to Nada Piradeepan, an expert on wind properties at engineering consultancy firm Wintech, the accelerated winds near skyscrapers are caused by the "downdraught effect" in which happens where the air hits a building with no space to escape, then the air is pushed up and down, and moves around the sides. As a result, the air is forced

downwards increasing wind speed at the pedestrian level. In addition, if there are several skyscrapers near each other, an effect called “channeling” will occur. Channeling occurs when wind accelerates and causes to squeeze air in a narrow space in between buildings. The different effects can be combined to create faster moving wind effects (Parkinson).

In addition to the accelerated wind effect, skyscrapers are source of Urban Heat Island effect. Temperatures in urban areas are generally 2-4 °C higher than suburban areas due to trapping of heats between large buildings (Meggers et al.3072). In addition, the heat emitted from the buildings is greater than its footprint and this allows warmer temperature around tall buildings (Meggers et al.3072). As a result, buildings start using more A/C systems consuming more energy and generating unnecessary heats throughout the city.

Social and cultural impacts also play an important role to decide the high-rise building in urban development. Visual impact of skyscrapers gives a strong impression to people and builds a character of the city. One the other hand, skyscrapers generate some unpleasant impacts both for residents and adjacent communities. According to *The Consequences of Living in High-Rise Buildings* by Robert Gifford, the social relations in high-rise buildings can be divided into two: relationships within a dwelling and relationship among neighbors in the building.

Gifford stated that most social relationships occur among residents of the same floor and if so, people who live in tall buildings have a few friends and connections for the typical resident and rest of residents from other floors would be strangers (Gifford 10). The point of the social relations in tall buildings that residents of high-rise buildings see many more other residents but have a fewer close connections in the building per person than residents of low-rise buildings.

This may influence withdrawn behaviors which associates to loss of community and social support (Gifford 13).

The “vertical gated communities” bottle up the activities of residents which might be associated with the public realm. Keeping public realm is the most significant factor of urban environment. Also, various interactions with other people create safe and productive urban communities however, limited interaction with people detriments cultural activities in which may impacts on long term on civic quality.

2.2. Urban sprawl

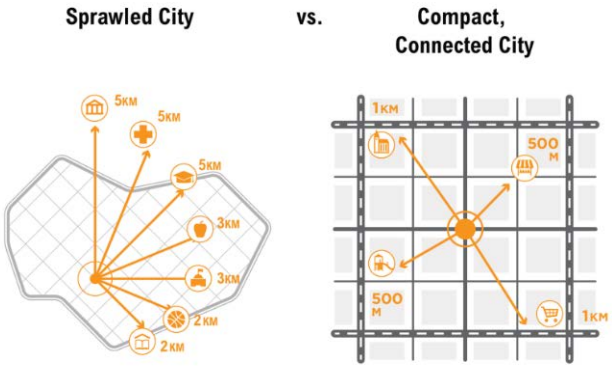

Figure 3. Sprawled city vs. Compact, Connected city

Source: Cities Safer by Design (Welle et al. pp 26)

While skyscrapers represent the result of ‘vertical’ urban development, urban sprawl is the most common result of ‘horizontal’ urban development. Urban sprawl shown in Figure 3 is another outcome of urbanization as it refers the outspread of the urban center towards a less populated land. It is a pattern towards low density areas and is a development that is highly dependent on automobiles therefore, it refers to the way land is used and the way people travel. As a result, the different types of lands such as residential, commercial, office and recreational

facilities are separated from each other. They are accessible only by cars, and relatively small parts of the city are dedicated for walkable town centers and public open spaces (Frumkin et al. 2). Oliver Gillham provided his own definition of sprawl in *The Limitless City* that *"a form of urbanization distinguished by leapfrog patterns of development, commercial strips, low density, separated land uses, automobile dominance, and a minimum of public open space* (Frumkin et al. 2)*."*

The current urban population is about 3.9 billion and it expected to grow 6.4 billion by 2050 out of the total global population of 9.5 billion (Swilling). If the city continues to grow without alternative solutions, the doubling of the urban population will requires doubling of the natural resources to maintain the cities (Swilling). As cities continue to advance, they have been sprawled outwards taking up valuable farmlands. In 2010, the total area covered by asphalt that refers to the world's urban settlement was about 1 million sq. km. If the urban population and long-term urban sprawl trend continue without changes, the area of urban settlement will be more than 3 million sq. km by 2050 (Swilling).

According to Swilling, in general, farmlands close to the city intensively cultivate the bulk of food due to the higher rate of food consumption and this additional 2 million sq. km is the most productive farmland. However, if the current urban sprawl remains, the global food supplies could be threatened especially, when food production is already not keeping up with the population growth (Swilling).

One of the key factors of rapid urban sprawl in North America was the relatively low oil prices, however, when oil prices hit the highest point in 2008, the capacity to afford urban sprawl reduced. For example, from 1960, Detroit city built more ring roads to suburbanize the middle

and upper classes and since the city went to bankrupt, their urban center was no longer able to manage the economic impact of its giant car factories (Swilling). In Detroit, out of the city's 300,000 buildings, 70,000 were unoccupied and lost their functions.

Rising oil prices and restricted carbon foot are not the perfect solutions for the current urban sprawl. It should be controlled by accessible, multi-centered and high-density city form such as New York City and Seoul. They created a network of high-density neighborhoods connected by efficient and affordable mass transit systems. By doing so, they could avoid sprawl and increase the number of people using public transportation and finally, the mass transit has become financially feasible (Swilling).

The impacts which associate with sprawl is often considered to be negative. The impacts include ("Smart Growth"):

- Conversion of forests, crop land into developed land: Approximately 34 million acres of forest land, cropland and other undeveloped land in the U.S. were converted to developed land,
- Degradation of natural habitat and reduction of food resources for wildlife,
- Increase in the costs of municipal public services such as water, sewage systems, landscaping and so on,
- Increase in automobile and traffic congestion,
- Increase in greenhouse gas emissions which associates with both transportation and building efficiencies.

3. Need of Urban Planning and Design: Urban Design Principles

Since we realized that there are needs for better solutions regarding the future urban development, the attention to the urban planning and design in current urban conditions is getting increased. However, without accurate understanding on the urban design and planning, it is impossible to build a future urban environment. The first step to approach to the urban planning and design will be knowing significant factors of urban environment and applying the principles to the urban design practices.

3.1. Value of Public Space in Urban

'Urban' includes not only the city and town but also villages and hamlets. The term 'design' is much more of an affective problem solving and/or the process of development rather than referring aesthetic actions (Carmona et al. 3). Definition of urban design can be changed depending on the unique urban settings and it should be approached in flexible manners.

Over the past several decades, the core concept of urban design was to create a place for people (Carmona et al. 7). Contemporary urban design considers not only a design of space but also a behavioral setting. Particularly, a successful urban design focuses on the diversity and activities taking place there. Therefore, essential notion of urban design is to create spaces for the public which can establish a relationship between people and their environment (Carmona et al. 7). The meaning of public realm includes the 'physical' (space) and 'social' (activity) dimensions and the physical public realm addresses the space and settings which support or facilitate public life and social interaction (Carmona et al. 109). The physical quality of public realm such as streets, boulevards, parks, squares, plazas, and water front establish the image of a city. While one architectural landmark can be an icon of a city, public spaces represent the quality of overall public life in which makes a city more livable and memorable (Paumier 3).

Public space provides a platform where people can, interact, and experience the social world. It is a space that offers an opportunity to see something new, learn and to be inspired. Together with a strong and expanded economic market place, public spaces in urban draw the future investments and they help to sustain and enhance the economic and social features of the city (Paumier 3). However, rapid growth of urban population and world urbanization trends require more housing and infrastructure which will make less public spaces throughout the city therefore, it is valuable to explore solutions to create more public spaces that symbolize the identity of the city and address user needs.

3.2. Qualities of Urban Public Spaces: Experience (Emotional) and Physical Qualities

The public space requires both physical and social aspects of urban environment and the space itself is considered and evaluated by urban design principles. As one of the essential elements of the urban environment, public space should reflect an emotional attachment or meaning of a space. It also needs physical qualities to generate an identity of the space and make it to be a part of the urban environment. The clear identity of place makes a strong connection between the city and its residents. Therefore, emotional connections to the space and physical qualities of public spaces are two types of identity.

Figure 4. Cheong-gye Stream, Seoul, South Korea, Left: After restoration, Right: 1950~60

Source: Seoul Solution (https://seoulsolution.kr/ko/content/3250)

Inhabitat (https://inhabitat.com/how-the-cheonggyecheon-river-urban-design-restored-the-green-heart-of-seoul/)

Peter Buchanan said that *"urban design was essentially about place making, where places are not just a specific space, but all the activities and events that make it possible* (Carmona et al. 7)*"*. This perspective explains that the urban space should be designed not only for the specific purpose but also for the various experience within the space. The space can be used for multi activities so it can be reminisced not just by the name of it but also by the moment when the event was occurred. Many people will make a connection to the space by interacting and memorizing the personal or group experience in it therefore, the space creates a place where it reflects the city from the past to the present day. *"Every citizen has had long associations with some part of his city, and his image is soaked in memories and meanings* (Lynch 1)*"*. The experience in the space can be memorized by either personal or group activities and all these experieriences can be incorporated and create connections to the historical, cultural and social elements. Hence, the public space truly represents the heart of the city.

For example, in Seoul, South Korea, Cheong-gye Stream Restoration project (Figure 4.) converys a lot of meanings. Cheong-gye Stream area used to serve as water resource for nearby neighborhoods and industrial roads. The stream was extremely polluted during the 1950s and 60s due to the urbanization and industrial development. In 2002, Seoul Metropolitan Government established the stream refurbishment project and in 2005, the restored stream and linear park were opened to the public inviting more people into the city. This project brought a lot of benefits such as reduced urban heat island effect, enhanced tourism, economic vitality, enriched wildlife habitat and a great pedestrian experience ("Cheong Gye Cheon"). On the other hand, there were some issues regarding traffic congestion and economic loss to business during the construction phase. The traffic concerns were treated by the new multi-modal transportation policy along with a strong focus on public transportation systems.

In terms of existing economic loss, the city provided a stability fund to business relocation. The project team had to have 4,000 meetings with residents in order to make this project work ("Cheong Gye Cheon"). This case shows that creating public space is not a simple architectural work. It is more focused on people who currently live and or work in the area. Some people may have good memories from their childhood in the old stream, others who own businesses in that area have a strong attatchment as their livehood. One of the successful parts of this project was that the project team and the city worked hard for the residents who have a strong sense of attachment in this area thereby, this public space truly managed and planned both for current residents and future visitors.

Today, old generations take a walk reminiscing about the past experience in this neighborhood and younger people enjoy this new place for various activities. Incorporating a familiar feature into public space in urban environment creates the strong sense of attachment as well as a positive image of the city.

Improvement of public space can influence people's views toward the image of the city. This is due to the fact that the physical qualities of a public space demonstrate the city's economic health and progress for the better future. In addition, the physical development is able to attract more potential investments and users (Paumier 3). The physical quality of a space takes a large portion in identity of the space. People perceive and use the space by physical qualities and these qualities strengthen a sense of attachment.

There are number of qualities to define the successful urban spaces. Kevin Lynch, in his book, *"The image of the city"* explored the three qualities to create the environmental image: identity, structure and meaning (Lynch 8). First, the identification of an object distinguishes one

from other things and as a recognition, it separates one from entity. Second, the image must include the spatial or pattern relation of the object to observer and to other objects. Lastly, the object requires to reflect some meaning for the observer (Lynch 8). These three elements together draw a definition of 'imageability' which is a quality in a physical object that gives a strong image to any observers (Lynch 9).

Imageability is a quality that can be applied in the public space in urban to make the space a significant component of the city. Lynch seperated meaning of the space from physical form and explored the physical characters which relate to indentity and structure of the space (Lynch 46). According to Kein Lynch, physical forms can be classified into five elements: paths, edges, districts, nodes, and landmarks. These five elements cannot exist by a single element in the real case (Lynch 46-47). They are interconnected and contribute to define the quality of public space. Following paragraphs are the brief explanations about five elements.

First, paths allow movement in the city. They can be streets, walkways, transit lines, canals and railroads. The environment is observed by moving along the paths. According to Lynch, as a major element in the city, other elements are arranged and related along the paths (Lynch 47).

Second, edges are boundaris and linear breaks in continuity such as shores, railroad cuts, edges of development and walls. Lynch defined them as " lateral references" rather than coordinate axes. They are linear elements which are not considered as paths by users. They are not as dominant as paths however, they take an important role as elclosure or organizing features such as outline of city by water or wall (Lynch 47).

Third element is districts. Districts are the medium to large sections of the city. They are recognizable section and people have a sense of entrance with distinctive characters. They are recognizable not only from inside but also from outside as a reference (Lynch 47). Texture, space, form, detail, symbol, building type, use, activity, inhabitatant and topography are some components which determine the physical characteristics of districts (Lynch 67).

Fourth element is nodes. Nodes are the strategic poits. Typically, they are some concentration points when obsever is traveling. They can be junctions, places of a break in transportation, shift point from one to another structure (Lynch 47). Even though, their conceptual images are small scale, in reality, they can be large scales such as squares, extended linear shape or entire central districts (Lynch 72).

Last element is landmarks. Simply, they are references to the observers. They are easily identifiable so they contain satisfying qualities of recognizability as a reference as well as symbolic with visual importance. Usually, they are simple physical objects such as building, sign, store or mountain (Lynch 48). According to Lynch, singlularity is the key characteristic of a landmark which is unique or memorable in the context. Not only that, when they have a clear form or contrast with thr backround, that spatial prominence allows the element as landmarks (Lynch 78).

In this thesis, the five types of elements will be addressed in several sections in order to evaluate the urban public spaces and analyze their physical characteristics. In addition, these five elements will be used to create a framework of final design work.

Establishing an identity is important to create a public space. The space should transfer a meaning to both users and the surround environment. The meaning can be history, cultural

activities and individual or group experience which enhance the sense of attachment to the space. In addition, the public space needs to be identified by providing physical characteristics including paths, edges, districs, nodes and landmarks. Based on these principles, the framework for the successful urban public space can be established.

4. Underground Space

Underground space has been considered as a space which is separated from ground environment. In addition, it is treated as a non-habitable space which is used for mechanical space, storage and transportation in general. However, since the demands for extra spaces in urban have increased, the use of urban underground space has reconsidered as a part of urban development.

4.1. Need of Urban Underground Space

Since urbanization has become a popular trend with the growing population, the concerns regarding response to the built environment have been increased. The limit of buildable areas in urban encourages more high-rise buildings and urban sprawl phenomenon. The intense growth of urban population density is often related to weakening of the quality of urban life. The growing concerns regarding both land conservation and quality of life slow down the developments at ground level (Goel et al. 1).

Urban underground space gradually has become a part of urban development in order to accommodate a large population and density in the city. Even though, the concept of underground space in urban environment is not something new, the level of social environment of subterranean structure is not advanced enough (*A Psychosocial* 1). The term Urban Underground Space (UUS) is defined as a space beneath urban areas which has a potential to

provide direct services to a city (*Livable Cities* 8). The use of underground space is expected to increase in spatial dimensions, depth and architectural requirements also, it involves to integrate with above ground developments (*A Framework* 32).

Although, some developed cities already explored underground spaces, the use of underground is still limited in terms of quality and diversity. Most of them are exploited for the transportation system and utility services. One of the problems of the existing underground space is that the underground has lower recognizability compared to the buildings on ground level. Moreover, most of the time, it is hard to access to the information or maps about the underneath of the city. This poor knowledge of the urban underground puts a long distance between the public and subterranean spaces. Therefore, it is important to open the underground space and bring it into our daily activities. By doing so, it helps to solidify the urban communities and build a sustainable region without territorial expansion.

The Figure 5 shows the Gaussuan curve in which represents economic growth of the major cities with the development of one central area. However, the greater utilization of land tends to follow the Inverted dome pattern in which incorporates large-scale public open space with deeper underground development (Goel et al. 8). The current land use in urban environment needs more efficient way for planning in order to meet the cities' demand on open space. The inverted dome pattern can be preferred in the future urban planning due to the fact that it allows not only a room to breathe in towering buildings but also a space for public realm (Goel et al. 8).

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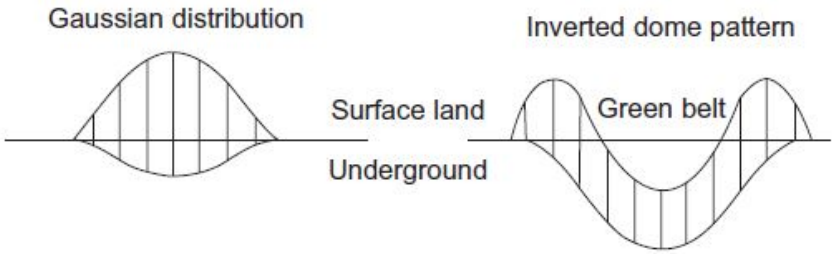


Figure 5. Gaussian distribution curve and Inverted dome pattern

"A Gaussian distribution curve represents a typical urban space use configuration, whereas an inverted dome distribution curve represents the goal of planning of urban space use." (Goel, Singh and Zhao)

Source: Underground Infrastructures; Planning, Design, and Construction, (Goel et al.8)

4.2. Configurations of Urban Underground Space

Building an underground space in urban environment provides a new perspective in urban design and it requires meeting urban design principles to make the space both habitable and thriving. Underground spaces have been used in many ways. While some cities may have a long history of integration of underground space in urban development, others may have just started. When the underground space is applied in urban area, it is often treated as an individual space which supports large buildings. The application of underground in urban areas are limited than suburbs mainly due to the existing adjacent structures. When the underground space is applied to the urban environment, the form of space reflects various scales of development and relationships to the ground level as well as land use of patterns (Carmody and Sterling 64). Thus, the form of the urban underground space can be restricted by existing conditions. Figure 6 through 8 shows a range of urban underground concepts based on the different settings of existing environments.

Figure 6 presents cut and cover space which utilizes a minimal level of underground space. It is the most common settings in urban environment and mostly the space is used for utility lines under the streets and basements levels for buildings. Figure 7 illustrates more

intensive use of shallow underground space than Figure 6. In general, this low subsurface space is used for commercial and other pedestrian-oriented functions. This shallow subsurface allows some potential development for open spaces on the ground level as well as a link between underground and street level. Figure 8 shows the most intensive underground development. It extends several levels below. In this case, it takes a quite large portion of space in the city and increases opportunity for dense development and more efficient utilization of valuable urban land. It also allows less compact surface with more open space. It is a natural process to build foundations for the above ground structures and these subsurface spaces should respond closely to the pattern of existing ground development (Carmody and Sterling 64).

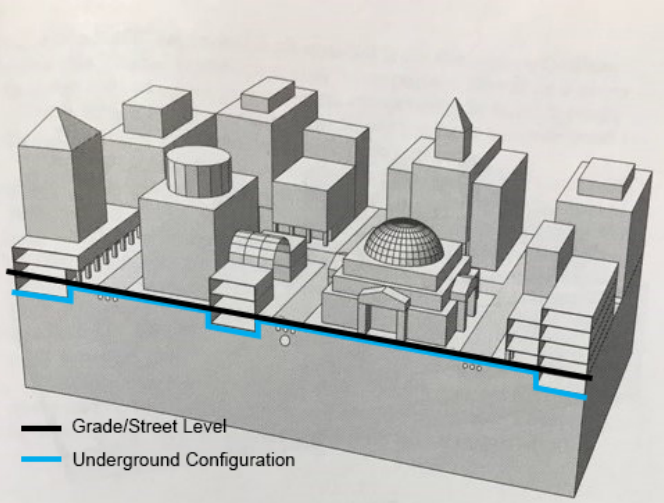


Figure 6. In most urban setting, underground space is utilized to a minimal degree. Utilities and some isolated basement are beneath buildings.

Source: Underground Space Design by Carmody and Sterling, pp 65, Recreated by author of thesis, 2017

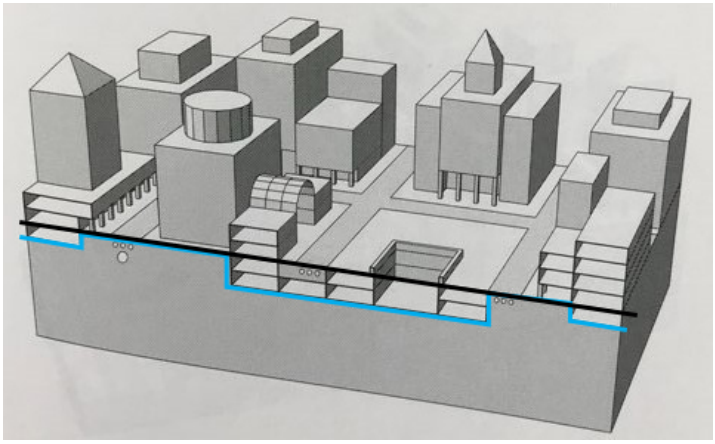


Figure 7. Use of shallow underground space allows increased surface open space. Connection between underground space and basement of building can create a pedestrian network.

Source: Underground Space Design by Carmody and Sterling, pp 65, Recreated by author of thesis, 2017

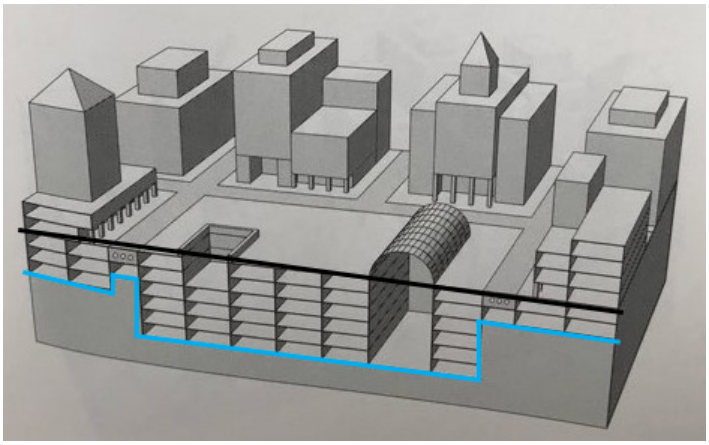


Figure 8. Deeper and several levels below grade can provide opportunity to increase the density of urban development as well as a large open space on street level.

Source: Underground Space Design by Carmody and Sterling, pp 65, Recreated by author of thesis, 2017

4.3. Taxonomies of Underground Space

Underground space can be classified into several categories and it mainly depends on its functions. The different uses of underground can be: space used by public, traffic space, technical maintenance facilities, industrial and production facilities, and special use facilities (Goel et al.53). In addition, different functions of space can be determined by depths and site

conditions. This taxonomy analysis is divided into two sections in terms of function and geometry. Also, different functions in underground space is subcategorized into different depths to see the possible activities in different levels which is significant in urban environment. This analysis allows to understand a wide range of design approaches and help the final proposed design to fit into the right context.

4.3.1. Classification by Function

	Primary Use	Function	Example of Use
Residential	Single Family		Dwellings
	Multi Family		
Non-Residential	Religious		Church, Mosque
	Recreational	Sports, Culture, Leisure	Swimming pool, Sports facilities, Theater, Museum
	Commercial	Office, Retail	Office, Shopping mall, Restaurant
	Institutional	Educational facilities	Classroom, Lab, Library
Infrastructure	Transportation	Tunneling for transportation use	Pedestrian path, Train, Subway, Car tunnel
	Utilities	Non-vehicular transport	Water pipes, Gas, Electric, Telephone wires
	Storage	Hazardous material	Radioactive waste, Chemicals
		Food	Wine cellar
		Natural resources	Gas, Oil
		Other goods	Warehouse, Archives, Parking
Military	Defense	Civil defense	Shelters, Strategic defense center, Prison

Table 1. Classification of Underground Space use by Function

Source: Underground Space Design by Carmody and Sterling, chapter 3

The major functions of underground space with subcategories of use is presented in Table 1. Primary uses which associates with people are separated from its usages which are not due to the different design approaches (Carmody and Sterling 47). The space for people require special consideration otherwise, the space cannot be successful. Since, the purpose of this thesis is to make a successful subterranean public space, the human acceptance factors must be considered (Goel et al.53).

4.3.1.1. Classification by Depth

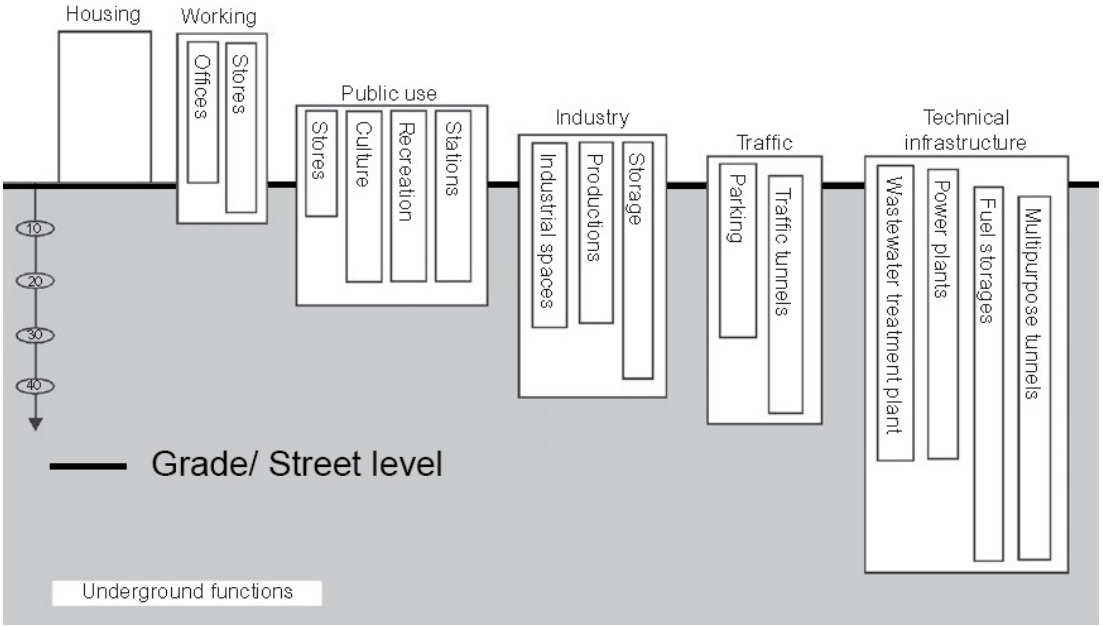


Figure 9. Feasible depths of different activities in urban structure

Source: Underground Infrastructures; Planning, Design, and Construction by Goel et al. pp 54

Figure 9 represents optimal uses of underground space depending on various levels. The lower (deeper) levels may have more challenges than upper levels in terms of construction and access points form ground level but it is important to build all levels that can fulfill roles adequately (Goel et al.53). When it considers urban environment, different configurations should be evaluated to make it more beneficial to existing urban environment.

4.3.2. Classification by Geometry

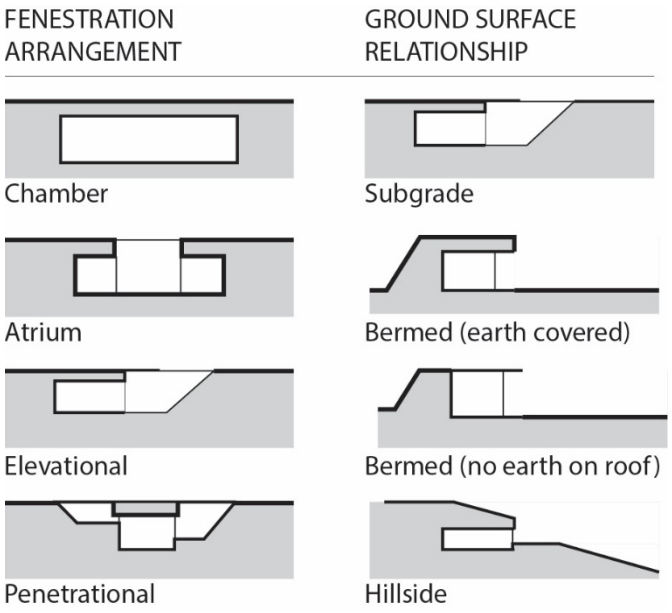


Figure 10. Classification of underground space use by fenestration and ground surface relationship

Source: Underground space design by Carmody and Sterling, pp 49, Recreated by author of thesis, 2017

Geometry classification helps understand different configurations in accordance to the various site conditions. The formation of underground space (Figure 10) can be determined either by naturally-occurred areas or construction operations (Carmody and Sterling 49). When the space is used by people, the configuration of the building is very important since it closely associates to fenestration and relationship with ground level. Building an underground space in urban environment has more challenges due to the limited space and close distance to the other infrastructures.

III. Problem Statement

There are several cities that have developed the underground space, oftentimes, the space has not been completely utilized as a part of the city. The lack of connection to its above ground level appears that the urban environment wastes its precious land and it neglects the underground space, in which loses its potential for an effective urban development and use of space.

While there are a lot of advantages of underground space, when the underground space is occupied with people and placed in the urban context, there are several challenges that should be addressed. From the urban design perspective, the lack of exterior image of underground space easily loses its identity and is hard to be considered as a part of urban context. In addition, a lack of exterior ambiance and image lead to a result of absence of interior spatial orientation (Carmody and Sterling 151). Therefore, the underground space is relatively hard to create since it cannot fully replicate the same sensation and livelihood compared to the above ground environment.

While the underground space cannot mimic the same environmental settings compared to the ground level, with careful planning and execution on design, it will attract the general population to learn and support the underground space. Interior design will play a big role to provide the adequate requirements and needs for the people to create a positive experience within the space. Limited access to the outside and natural light generates a sense of isolation from the ground level thus, the underground space does not have a strong impression that this is a safe and comfort space to walk in. Improving underground space will be valuable only when it meets the basic human needs and quality within the space.

This study will explore how the underground space can contribute to the current urban environment by analyzing the relationship between the ground environment and below ground level and then it will propose a subterranean public space design which provides extra platforms for the dynamic public realms. This thesis expects to make the subterranean public space can be a part of current urban design practice.

IV. Literature Review

This literature review section demonstrates and support the development of the urban subterranean spaces. This chapter is divided into four sections. The first section provides existing theories associate with public space in urban design and it also includes projects showing positive effects of urban public space. The second section covers social sustainability associate with urban environment. The third section addresses the theories regarding urban underground space. The last section are case studies presenting the theories in urban environment.

1. Urban Design and Public Space

"Making places for people." is the main idea of urban design and it addresses the aesthetic entity and a behavioral setting in the place. This wide range of concept focuses on the functions and activities occurring in the place and the official notion of urban design embraces making a place and management of public realm (Carmona et al. 7). Therefore, urban design does not only improve the city form but also improves the quality of life in urban environment by connecting people and places. The traditional visual art approach to urban design is an earlier approach and is more architectural understanding of urban design. It emphasizes the visual qualities of buildings and spaces rather than cultural, social, economic, and spatial factors of urban places. On the other hand, the social usage approach focuses on the user experience such as social qualities of people, places, and activities (Carmona et al. 7).

Kevin Lynch is one of the pioneers of the social usage approach. Lynch focuses on the social usage of urban design through examining people's perceptions and mental images rather than examining the physical and material form of urban environment. In his book, *The Image of the City*, Lynch mentioned *"Nothing is experienced by itself, but always in relation to its*

surroundings, the sequences of events leading up to it, the memory of past experiences" (Lynch 1). This perspective supports his standpoint that the architectural element is not the only factor to compose the city. People and their activities are also part of the city and they are important as much as physical objects in the city. His book focuses on the visual quality of the city by exploring mental images which is held by citizens because legibility has a potential depth and intensity of human experience (Lynch 4).

According to Lynch, a good environmental image is closely related to a sense of emotional security and it allows a harmonious relationship between human and the outside world (Lynch 4). The environmental image is a result of a two-way process between the observer and the environment and, there are three components to construct the environmental image: identity, structure and meaning. First, identity is a uniqueness in which makes an object as a separable unit. Second, the image includes spatial or pattern relation of the object which affect to observers and other objects. Third, the object must embed some meanings for the observer. Together, these three components contribute to the definition of imageability which is a quality in physical object. This quality gives a strong image to any observer (Lynch 8). Therefore, referring to Lynch, the notion of imageability is,

> It is that shape, color, or arrangement which facilitates the making of vividly identified, powerfully structed, highly useful mental images of the environment. It might also be called legibility, or perhaps visibility (…) but are presented sharply and intensely to the sense (Lynch 8).

Lynch classifies five elements that bring out the city image: path, edge, node, district, and landmark (Lynch 8). The imageability of the city depends on how strong these elements are and the stronger city image can provide more memorable experience to people.

Another social usage approach based on people and experience is by Jane Jacobs. Her perspective on the urban design is in accordance with the social interaction and use. In her book, *The Death and Life of Great American Cities*, she stands against the modernist city planning and rebuilding. Her approach to the urban design comes from understanding the activities taking place in the city. *"Cities are thoroughly physical places. In seeking understanding of their behavior, we get useful information by observing what occurs tangibly and physically, instead of sailing off on metaphysical fancies* (Jacobs 96)."

Her detailed suggestions for city design is carried from successful streets. A well-used street is a safe place to be because the side walk with eyes upon the street could be the natural proprietors of the street. In addition, people on the street allows to entertain people inside of the building by watching street activities (Jacobs 35). Jacobs emphasizes the fact that socio-functional aspects of street, sidewalks, and parks play an important role as containers of human activities and places of social interaction. The qualities of city streets can be incorporated into the qualities of public spaces because they need the same qualities of safety and interpersonal relations between strangers.

It has been mentioned that quality of environment is the major factor that encourages all kinds of outdoor activities. Physical environment is one of the factors influences activities in the public space. When the public spaces are poor quality, only minimum activities occur (Gehl 11). Public spaces such as pedestrian streets or traffic free zones where it has been established in exiting urban areas show the significance of quality improvement in terms of daily and social activities in cities (Gehl 33). Figure 11 shows the entrance area of an office building and the difference of activity between before and after quality improvement is clear (Gehl 34).

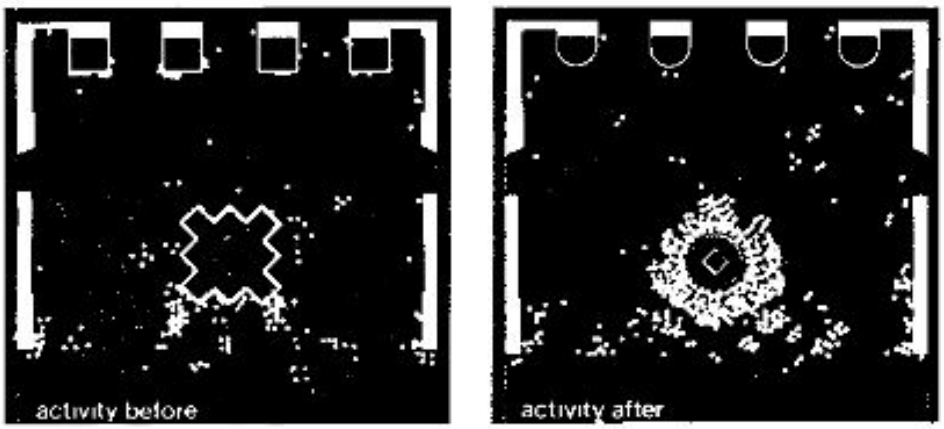


Figure 11. Entrance area to New York office building

Source: Life Between Buildings by Gehl, pp. 34

Therefore, enhancing the quality of public space allows one to be among, to interact with others and to experience diversity in a city (Gehl 34). In other words, creating places for people naturally bring more activities into the city and by connecting people and spaces, the city becomes an active and enjoyable place to live.

In 2007, New York City started a plan: the *PlaNYC 2030, A Greener, Greater New York*. The purpose of this plan is to make New York City become more sustainable and provide a better environment for residents and millions of people who are expected to move to the city in the years between 2007 to 2030 (Gehl and Svarre 132). The plan includes providing a better quality of life to residents, improving city street, reducing private car traffic, and rethinking public space (Gehl and Svarre 132). Broadway was selected for this project since it represents the most dynamic picture of the city and it is the gathering place for people from all over the world. According to the calculation of examine the percentage of area for cars and people in Time Square, 89% of area was dedicated for cars and only 11% of area was used for pedestrians (Gehl and Svarre 132). Time square along Broadway converted to pedestrian friendly street by changing the area to a car free public space. In addition, the city created 322 kilometers of

bicycle paths. The new Time Square (Figure 13) includes tables with simple folding chairs for seating and temporary flower boxes. Figure 12 shows the headcounts which were made before and after changing. This result shows that Time Square has become a place for stationary activities. *"Pedestrians walking in the space for traffic on 7th Avenue between 45th and 46th Street, that is, at Times Square, before and after the area was closed to through traffic. Headcounts were made between 8:30 a.m. and 1:00 pm* (Gehl and Svarre 132)*."*

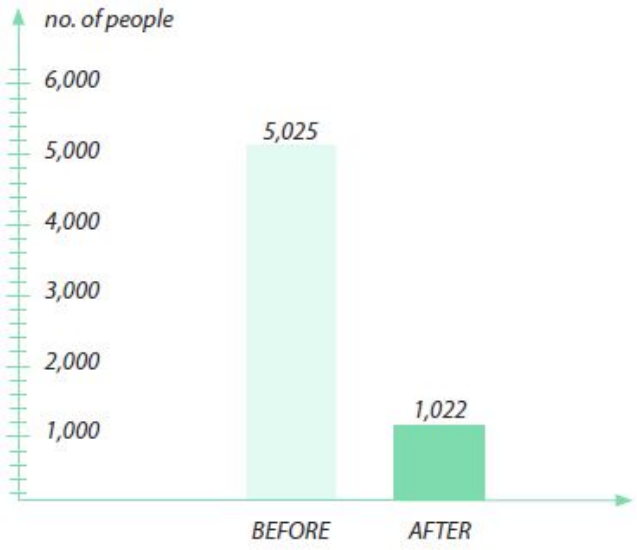


Figure 12. Pedestrians in the street

Source: How to study public life by Gehl and Svarre, pp.132

This study is a part of the rapid changes that are made in New York City and used to measure the other projects and changes in the city. The Department of Transportation in New York City, Janette Sadik-Khan mentioned that *"Until a few years ago, our streets [in New York] looked the same as they did fifty years ago. (…) We're updating our streets to reflect the way people live now. And we're designing a city for people, not a city for vehicles.* (Gehl and Svarre 133)*"*

Figure 13. Time Square before and after, Left: Time Square spring 2008, Right: Time Square summer 2009

Source: How to study public life by Gehl and Svarre, pp. 134,135

Designing a public space is based on where people are expected to go and to stay (Gehl and Svarre 15). It is necessary to understand the movement of people and how they stay in the space to make a smooth pedestrian flow and create an inviting public space (Gehl and Svarre 15). In addition, considering activities in the space allows to have a knowledge of the type of activities and the requirements for them (Gehl and Svarre 17). The activities in public spaces can be almost endless and it is meaningful to make multiple activities occur at the same time. There are two types of activities in public space: Necessary and optional. Necessary activities include shopping, walking to and from a bus stop or working as a police or postman. Optional activities include strolling, jogging, sitting on a stair step or chair, reading, or simply walking around (Gehl and Svarre 17). Social activities in public spaces are determined by both necessary and optional activities because by looking and passing each other in the same place, they can create connections with other activities (Gehl and Svarre 17). Therefore, to make the public space as a meeting place, it is necessary to understand the public life. When a public space functions as a

place for meeting place, first, it can be a destination for meeting others. In addition, it heavily influences individuals to understand the social context of life because meeting with other people can be stimulating and interesting experience.

2. Social Sustainability and Urban Environment

The term sustainability is no longer focus on the environmental concerns only. The range of sustainability now embraces economic and social dimensions (*The Social* 289). The concept of social sustainability is a wide range of concepts which leads to the following question: 'What are the social goals of sustainable development?' According to the 'Bristol Accord' which details a common European approach to a sustainable community, the definition of sustainable community is 'places where people want to live and work, now and in the future (*The Social* 290). The communities need to achieve diverse needs for the current and future residents who are sensitive to their environment and pursue a better quality of life. These communities are safe, well planned and offer equality of opportunity and good services for all (*The Social* 290).

Sustainable development has been studied throughout the years but only during the last decade the idea of social sustainability is applied into the urban environment seriously. There are two important concepts have emerged in the field of social sustainability: sustainable development and compact city (*The Future* 234). Since cities are the main "collaborators" of unsustainable development, it is necessary to examine the future development thoroughly. Building a compact city strategy is one of the possible way to lead to a sustainable city form (*The Future* 234). So, how do we relate the social sustainability and the compact city form?

According to the journal, *Compact city development: High ideals and emerging practices,* compact cities where are densely built with mixed land use can provide a better quality

of life by offering more social interaction, community spirit, and cultural vitality. They also provide an easier access to work, shops, public transportation, and opportunity to walk and cycle that are only available in the compact city form (*Compact City* 6). Therefore, the social sustainability can be measured within the urban context by providing a better access to several services that residents need locally and daily. By doing so, the community can achieve a healthy and active society as well as social equity.

3. Urban Underground Space

As population grow and infrastructure is becoming more complex, demanding on extra spaces in urban environment directly affect the quality of life in urban environment. Buildings and roads are developed rapidly and this development leads the horizontal expansion and deterioration of urban environmental quality. (*The Future* 233). According to a journal, *The future of the underground space* by Sanja Durmisevic, there is a need to make a city more compact to create a city as a cultural, social, and economic center. Recreation and social activities nearby residential areas can be achieved by placing some functions in underground space such as transportation system, shopping mall, restaurants, museums, and movies (*The Future* 235). By doing so, the vertical line of the city can be fully utilized by integrating aboveground level and underground (*The Future* 235).

Next, the topic of attachment relation to urban underground space is addressed by a journal, *Urban underground space: Solving the problems of today's cities.* The world-wide trend of urbanization with population growth increase needs for reliable infrastructure, more energy efficiency development, and a higher environmental awareness of pubic (*Urban Underground* 245). The demands on a higher quality of living in existing urban environment faces challenges since they need more spaces for adding new functions or relocating and

improving existing ones. Use of underground space provides opportunities to place new facilities in urban center while remaining compact city form however, oftentimes, underground solutions are only considered when the aboveground options have been exhausted however, if the underground solutions are considered from beginning of planning, there would be more optimal solutions for urban development (*Urban Underground* 245).

Effective planning for underground space can be established by careful consideration of both benefits and drawbacks of underground development. According to the *Underground Space Design* by Carmody and Sterling, there are three major issues associate with underground space. The advantages and disadvantages of underground space can be distinguished by three major issues: physical and institutional, life cycle cost and societal issues. The physical and institutional issues are divided into five subcategories: location, isolation, preservation, layout and institutional. Among those five subcategories, location, isolation, and layout have the biggest impact to this project.

First, the biggest benefit of underground space is that it can be built close to the existing structure or under unbuildable site. It means that the underground space has more flexibility to use the land. In addition, the lack of buildable surface in urban area can be solved by developing underground spaces (Carmody and Sterling 27). On the other hand, underground constructions could face more challenges than traditional building constructions. Creating facilities under grade level needs more interaction with the local geological environment than regular surface construction It may have to deal with unfavorable geology or uncertain geology conditions which increases both construction time and cost (Carmody and Sterling 38).

Second, isolated space is the most distinguishable physical characteristic of underground facility. This unique condition provides moderate temperatures compared to the ground surface. In addition, its slow reaction of the large thermal mass of the earth allows better conditions for energy conservation and energy storage. For example, the heat loses conduction from building envelope in cold climates can be reduced. In other words, there is less chance to gain heat by radiation and conduction through the building envelope in hot climates. Moreover, energy consumptions for peak heating and cooling can be decreased. Isolated conditions also provide better protections for noise, vibration by absorbing the shock and energy through earth (Carmody and Sterling 27).

However, being isolated from ground environment has negative psychological issues and it is the most pervasive drawback in underground facilities. In general, the idea of being below grade facility is a negative reaction because its association with darkness, humid and musty air. In addition, the feeling of being lost and disoriented in underground space is caused by lack of reference points such as the ground, sky, sun, and adjacent objects which cannot be seen. Most psychological issues in underground space are related to the lack of natural light and poor ventilation. Designers and researchers have been forced to attempt to solve these problems (Carmody and Sterling 39).

Third, in terms of layout, underground facilities have more freedom than surface structure. Especially in urban environment, it allows three-dimensional planning rather than being controlled by topographic and existing land use restrictions (Carmody and Sterling 32). On the other hand, underground construction must maintain stability of surrounding geologic conditions. While the ground can be supported by itself up to certain span limitations, when support is used, there would be a limitation of opening sizes based on the increasing cost of

supporting larger openings. In addition, even though underground spaces have less restrictions in terms of topography, the location of access points is limited by surface land and topography. Also, the number of entrance is restricted by high cost of shafts (Carmody and Sterling 32).

The future expansion or adaptability of underground space have potential problems because in general, underground spaces are harder to modify than surface structures and it is costly (Carmody and Sterling 41). Table 2 below shows the benefits and drawbacks of underground space.

MAJOR ISSUES	SUBCATEGORY	POTENTIAL BENEFITS	POTENTIAL DRAWBACKS
PHYSICAL AND INSTITUTIONAL ISSUES	LOCATION	Proximity Lack of surface space Service provision Status	Unfavorable geology Uncertain geology
	ISOLATION	Climatic thermal, severe weather fire, earthquake Protection noise, vibration, explosion fallout, industrial accident Security limited access, protected surfaces Containment hazardous materials, hazardous processes	Climatic thermal, flooding Communication Human issues psychological acceptability physiological concerns, fire safety, personal safety
	PRESERVATION	Aesthetics visual impact interior design Environmental natural landscape, ecology, run-off Materials	Aesthetics visual impact, building services skillful design Environmental site degradation, drainage, pollution
	LAYOUT	Topographic freedom 3-dimentional planning	Ground support Span limitations Access limitations Adaptability Sewage removal
	INSTITUTIONAL		Easement acquisition Permits Building code Investment uncertainty
LIFE CYCLE COST	INITIAL COST	Land cost savings Construction savings no structural support, weather independent, scale Sale of excavated materials or minerals Savings in specialized design features	Confined work conditions Ground support Limited access Ground excavation, transportation, and disposal Cost uncertainty geological, contractual, institutional delays
	OPERATING COST	Maintenance Insurance Energy use	Equipment/ materials access Personnel access Ventilation and lighting Maintenance and repair
SOCIETAL ISSUES		Land use efficiency Transportation and circulation efficiency Energy conservation Environment/ aesthetics Disaster readiness National security Less construction disruption	Environmental degradation Permanent changes Embodied energy

Table 2. Benefits and drawbacks of underground facilities

Source: Underground space design by Carmody and Sterling, pp 26, Recreated by author of thesis, 2017

Next, the topic of attachment relation to underground public space is addressed by the book *"Urban Design Manhattan"*. According to the book, the public square among tall buildings should be located below street level where the pedestrian flow from the underground train (Okamoto et al. 9). To be specific, the space should separate between grade pedestrians and vehicles on the streets. Also, the space should integrate the space below with the above ground to encourage a use of three-dimensional city development. By doing so, underground space gets sunlight and air from above ground and the sunlight provides spatial orientation and identity. In addition, it creates a more interesting cityscape for pedestrians by looking lower and upper levels (Okamoto et al. 10).

This approach on the subterranean public space is considered based on the horizontal transportation by train, vertical transportation by elevator and the pedestrian link. Moreover, it suggests the entire urban infrastructure should be interchangeable which means above ground urban structure should be consistent and continuous. Hence, the notion of urban design should be "guts" of the city rather than focusing on the surface and individual buildings (Okamoto et al. 10).

4. Precedent Study

The goal of an urban design is to establish a public wellbeing by concentrating on the economic, social, and cultural events into the daily life. Public space is one of the main elements in urban environment as it allows a wide range of people, ages, and activities into the city. A successful urban environment provides some great public spaces to make a strong connection between residents and the city. These public spaces help the city to maintain its reputation as a thriving urban center ("Great Public"). The following places mentioned below are the great examples of public spaces and they are categorized in respect to positions and configurations to establish a framework for underground public space in urban.

4.1. Urban Public Space Within the Context

Public space is one of the valuable indicators to show the quality of urban life since it is a place where major cultural events occur. A successful urban public space reflects its contexts to satisfy different groups of people, activities, and time periods. New York City contains various types of public spaces and among those spaces, Bryant Park and Washington Square Park stand out as successful examples of public space due to their response to these contexts.

4. 1. 1. Bryant Park

Bryant Park is located in between Fifth and Sixth Avenue and between 40th and 42nd Street in Midtown Manhattan. The New York Public Library is located on the park and it provides the functional eastern boundary of the park allowing Sixth Avenue as the primary entrance (*Bryant Park*). By the 1970s, the park was not active neither as an urban feature nor an historic site. Although, thousands of people walked by the park every day and the park was surrounded by office buildings, only a few people went inside of the park due to its poor maintenance and accessibility from streets. The park was positioned three and a half feet higher

than the street level. However, the main issue was that there were no activities for people and the park was used to buy illegal drugs in the past ("Great Public").

Since its restoration in 1979, the park started adding new programs including markets, cafes, landscapes, and entertainments in which brought vitality and life back to the park (*Bryant Park*).

Figure 14. Bryant Park in Winter Season, New York

Source: Author of thesis, 2017

In the 1990s, the actual people who visited the park during lunch hours reached a range of 4,000 people and later there were no more drug dealers in the park ("History"). Since the park reopened in 1992, it became one of the most popular and comfortable city park in the city. The rental value around the park increased by 60 percent and now it is considered the prime public asset in Midtown Manhattan ("Great Public").

The activities taking place in the park are varies and flexible enough in different times and seasons. The park includes an outdoor reading room, summer arts series, ice skating rink and more which help the park to become vibrant all throughout the year (Figure 14). The park hosts about 1,000 free activities, classes, and events (“Thigs to Do”). As one of the urban amenities, the park provides a place to stretch out and relax for people who work around the park and tourists from all around the world.

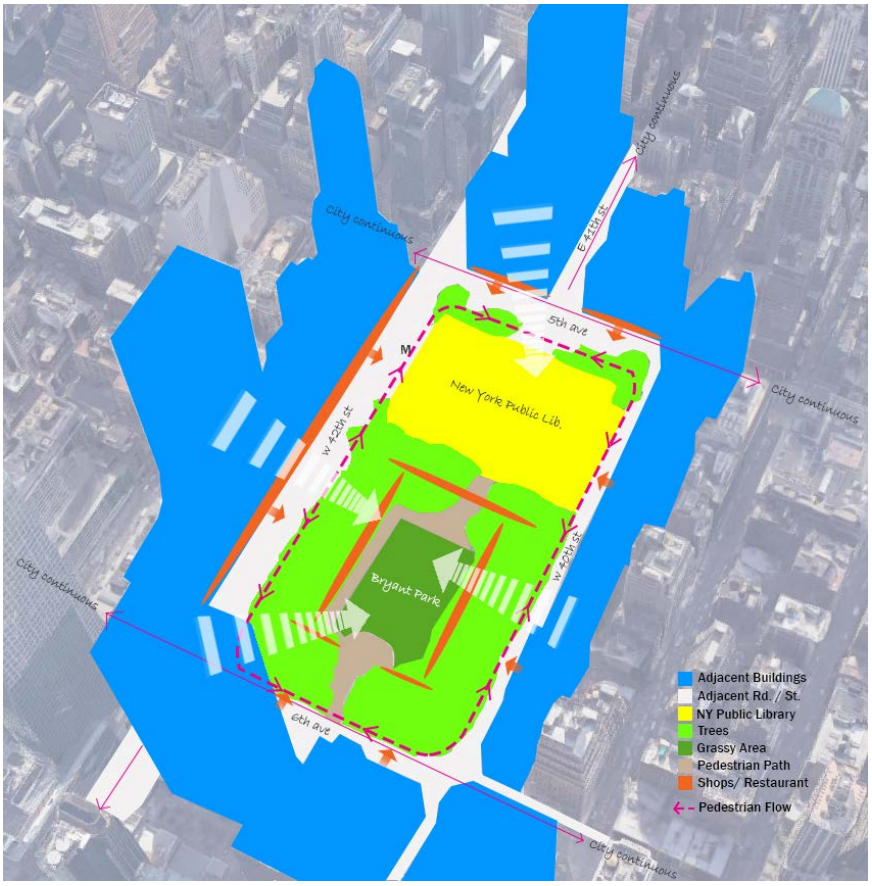


Figure 15. Diagram of Bryant Park, New York

Source: Created by author of thesis, 2017

Nowadays, Bryant park is constantly filled with people due to its connectivity to adjacent services and public transportation. The overall layout of the park reflects its immediate contexts. The grass area on the west side of the park fully functions as an outdoor garden for the adjacent buildings and it is equipped with moveable chairs within the property so people can freely

arrange their comfortable seating areas. As shown in Figure 15, the park is enclosed by buildings creating not only an open space at ground level but also providing a clear view for people in tall buildings. In addition, the small kiosks along the walkway in the park continues shopping flows from fifth avenue and it provides a shortcut with pleasant experience.

Since the park is sited on the higher platform than the streets, it naturally creates a clear edge helping to organize the pedestrian movement. The visible boundary of the park acts as a barrier but it also works as a seam to link different major blocks together (Lynch 65). The adjacent streets and avenues of the park carry heavy traffics with various scales of stores. Fortunately, the park contains the activities in which associates with the surroundings and it attracts not only the residents but also tourists from all over the world. The park ambiguously works as a node, edge, or path for various situations (Lynch 65).

4.1.2. Washington Square Park

Washington Square Park is in Greenwich Village in lower Manhattan, New York City. It is well known with the Washington Arch by Stanford White ("History"). The Washington square Arch is an icon of the park and represents the northern gateway to the park. The park is surrounded by New York University buildings, apartments, and small studios for artists ("Washington Square"). The park is mostly visited by people from surrounding neighborhoods, also tourists all over the globe visit the park to experience the NYC life. In figure 16 shows the users from different regions.

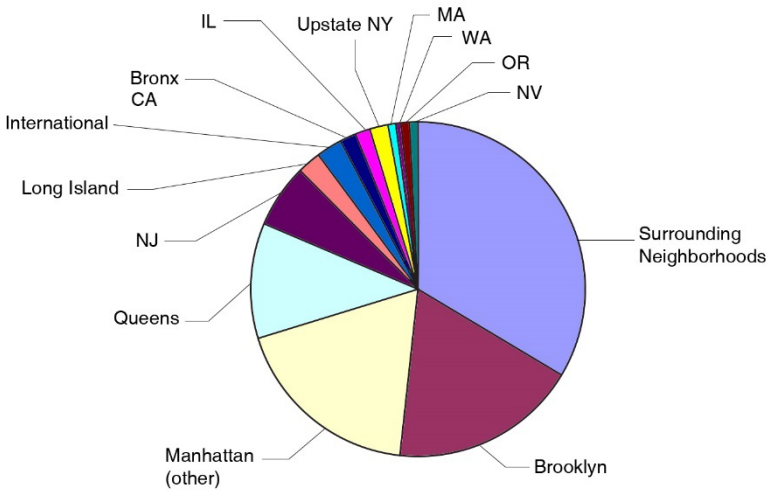


Figure 16. Survey question: "Where are you from?"

Source: Project for Public Spaces, Wahington Square Park:
A User Analysis and Place Performance Evaluation

The results in Figure 16 indicates that the park is a destination of both locals and international users (*Washington Square* 4). Therefore, the park is populated with residents, tourits and visitors, it has become one of the iconic attractions in New York City.

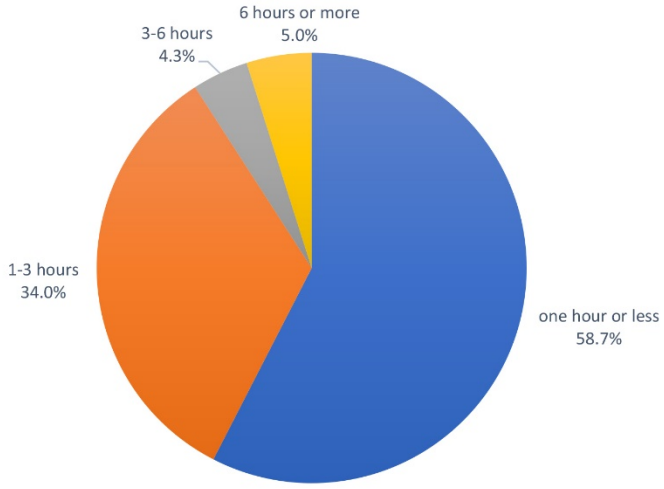


Figure 17. Survey question: "How long do you plan to stay in the park?"

Source: Project for Public Spaces, Wahington Square Park: A User Analysis
and Place Performance Evaluation

Figure 17 shows that more than half of the visitors sit in the park for over an hour or less which is assumed that the park can be used for daily activities such as lunch, breaks, or a pathway to other surrounding areas. In addition, 34% of people responded that they stay at the park from one to three hours which means people dedicate pretty long hours in the park doing other activities. These results describe that the park is a comfortable place to spend time, enjoy activities and get along with people *(Washington Square* 4*)*.

What kind of activities do people enjoy in the park? Activities taking place in the park can be different depending on the day and time. In weekdays, the park is used mainly for students, office workers or people who socialize, eat and dog runs *(Washington Square* 6*)*.

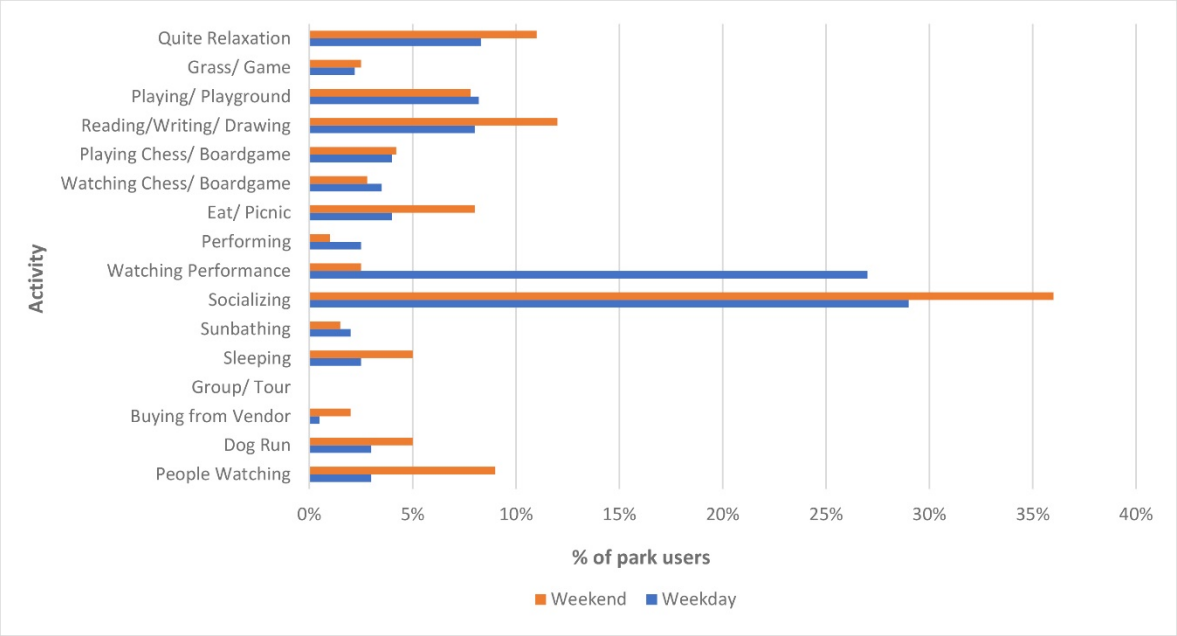


Figure 18. Park activities, weekday vs. weekend

Source: Project for Public Spaces, Wahington Square Park: A User Analysis and Place Performance Evaluation

On the weekends, the activities are more focused on cultural events (*Washington Square* 6). Figure 18 displays various activities on weekdays versus the weekends. Socializing and watching performances are the first and second major activity that takes place in the park. Therefore, with various programs, the park is always busy with people and the events makes it as a safe and enjoyable to stay. As it shows, most activities occuring in the park reflect the neighborhood contexts. Relaxation, reading, dog run and playing are based on the residents' daily activites. Performance, boardgames and watching performances are refleting lively vibes from college and arts studios around the park.

Both Bryant park and Washington Square park include various activities in which help these places be busy for the entire week and year around. These parks provides various platforms for different activities and it naturally invites people to do activities which are suitable within the contexts. A park in the urban environment represents a place where people can engage with each other, network, and attract stakeholders for future construction in the area where is densely populated in order to enrich the land and culture.

Based on the analysis of Bryan Park and Washingyon Square Park, the ideas that should be applied to this project are the following:

- The place should reflect adjacent contexts by continuing pedestrian flows and user needs such as shops, seatings and entertaining elements,
- The place should be enclosed by buildings or surroundings so that the open space is placed within the city context reflecting the grid of streets and organizing the sidewalk,
- A wide range of activities are requred; from daily activities to special occasions so that the space can be utilized all year around,

- The space provides various access points; entrances from different sides.

4. 2. Current Use of Underground Space in Urban

Due to the needs of improvement of the urban environment, city planners, designer and engineers have a great responsibility to build a better environment for all kinds of activities at the ground surface (Goel et al. 2). Underground space is a great opportunity to support the existing built environment with new transportation, communication, and utility networks (Goel et al. 2). Underground metro system is the most common feature of adapting underground space into urban environment.

4. 2.1. Subway stations in New York City: 34th Street-Herald Square Station

The subway lines in New York City connect the entire city together increasing horizontal transportation connections throughout the city. There is no relationship between the underground subway systems and above ground environment except the surface entrances which only have the potential connection between the two different environments (Lynch 57*). "The buried paths of the Boston subway could not be related to the rest of the environment (…). The surface entrance of the stations may be strategic nodes in the city, but they are related along invisible conceptual linkages"* (Lynch 57). The lack of visibility of underground transit systems cannot be fully integrated into the urban environment and without enhancing a connection between the above and below ground worlds, it remains as a separated infrastructure in the city.

Figure 19. Underground Subway Station, 34th Street Station in New York City

Source: Author of thesis, 2017

Figure 19 is a typical view of underground subway station in New York City. While it is highly functional as a transit system, it is hard to see the relation with the above ground. Some people already know where to exit but others, especially cities like New York City where is heavily populated with people and tourists; 60.5 million tourists visited in 2016 ("NYC Travel"), they need an effective way to guide the general public. Without seeing any contexts on the ground level, there is no sense of direction and oftentimes, people need to go back and forth to find the right exit.

Figure 20. Underground Passage, 34th street station in New York City

Source: Author of thesis, 2017

The primary concern of underground space are darkness, poor ventilation, and a feeling of lost or disoriented. This is because there are less reference points such as the ground, sky, sun, and adjacent objects (Goel et al. 23). Figure 20 shows the underground passage of subway station in NYC and it doesn't provide the natural light and clear view to exit. Poorly conceived artificial light in the space doesn't provide any positive effect throughout the space. The narrow and linear corridor increase the negative experience in underground space including claustrophobia and lack of connection with the outside world.

Figure 21. Entrance to Subway Station, 34th Street Station in New York City

Source: Author of thesis, 2017

Figure 21 is the most common subway entrance design. It functions as a path to the underground with information of subway lines. Like the interior of the subway station, the entrance doesn't reflect any relationship between the underground and ground level. The opaque walls and rails around the entrance don't allow neither any visibility nor natural light into the underground space. The entrance to the underground space affect the entire image of the rest of the space. It is not able to change the fact that it is a downward vertical movement; however, this

negative experience can be changed to positive with a different entrance configuration (Goel et al. 31).

4. 2.2. Underground Pedestrian Network in Montreal, Canada

Montreal, Canada is well known for its underground pedestrian network (Figure 22). It covers about 30 km of corridors, tunnels, and public spaces. This underground space is a great example of integration of aboveground buildings and underground spaces both functionally and structurally (*The Future* 236). In Montreal, the traffic line is located ground level and the entire "indoor city" is dedicated to pedestrians. In this way, it can avoid direct contacts of different groups; pedestrians and vehicles (*The Future* 236).

Figure 22. Underground Pedestrian Path Map, Montreal, Canada

Source: Go!Montreal (http://gomontrealtourism.com/montreal-underground-city-map/)

The underground path also includes commercial and shopping centers. These underground shopping centers contain not only the most expensive and fashionable shops in the city but also small booths and shops in underground transit stations. This continuous and

integrated system stimulated more investments in the extension of the underground connection system and encouraged various pedestrian activities (Carmody and Sterling 80-81).

The severe climate of Montreal is the main reason to locate the underground pedestrian path with a protected environment. Cities with extremely cold winter need more underground passages where it serves as pedestrian paths as well places for businesses so that the cities can be vibrant for all seasons. Most underground spaces including metro stations are accessible through aboveground buildings. Providing entrances through the halls of buildings on aboveground such as office buildings, hotels or shops allows better controlled of safety, well maintained facilities, and better psychological effect such as reducing a sense of downward (*The Future* 236).

Based on the analysis of the current subway station designed in New York City and Underground path in Montreal, the ideas that should be considered in this project are the following:

- The underground space should be integrated with its surrounding urban environment by connecting adjacent services,
- The entrance should be easily recognizable from both inside and outside,
- The entrance should capture the natural light as much as possible to generate a positive sense and attract users,
- Signs for tourists and new visitors to guide a direction to go,
- The underground space should provide various programs for comfortable and convenient pedestrian experience.

4. 3. Relationship Between Belowground Space and Aboveground

The fully submerged underground space comes with many significant issues regarding its relationship to the above ground level. Some of the most recognizable issues are that underground space lacks building image and boundaries. These issues are highly related to the principles in quality of urban public space.

4.3.1. Sunken Plaza: Rockefeller Center

Sunken Plaza provides significant benefits including natural light, view, connection to the outdoors and improved orientation within the facility (Carmody and Sterling 204). In terms of orientation, sunken plaza provides a visual connection between underground and below ground level. In addition, the spaces surrounding the sunken plaza can easily improve the feeling of confinement and lack of stimulation in underground space (Carmody and Sterling 204). The lack of imageability of underground space is one of the big concerns regarding quality of urban design. The sunken plaza can contribute to improve imageability and it can be a landmark or contain a landmark or be an activity node (Carmody and Sterling 205).

Rockefeller Center in Midtown Manhattan, is located between Fifth Avenue and Sixth Avenue. Rockefeller Center is composed of two parts which is the original center and the others are International style buildings (*Rockefeller Center*). The rectangular shape of the sunken plaza (lower plaza) is planted with shrubs and provides a sense of enclosure and privacy. 200 flagpoles surround the perimeter of the plaza at ground level and the plaza is surrounded by a walkway that is several steps lower than street level (*Rockefeller Center*). This outdoor plaza provides a room for natural light and air flow in the skyscraper canyon.

The lower plaza is accessible from the underground concourse which is an underground network of retails and stores at Rockefeller Center. The underground passageway connects all buildings to the Rockefeller Center and it expands to 7th Avenue providing convenient and entertaining experience ("The Concourse"). The underground commercial strips along the pedestrian paths not only hold the entire Rockefeller plaza together but also keeps people inside making the plaza as a gathering and destination point in the city. Therefore, the sunken plaza

Figure 23. Rockefeller Plaza, Ice Rink

Source: Author of thesis, 2017

Figure 24. Rockefeller Plaza, The Summer Garden

Source: Rockefeller Center (https://www.rockefellercenter.com/blog/2017/05/04/summer-garden-open/)

continues the physical activities at the ground level with the sense of connection to the outdoor environment. In addition, the exterior walls at underground level do not follow the edge of the sunken plaza. They are pushed into the interior side so that the sunken plaza has some extra outdoor spaces but they are covered by the balcony at the above level.

The sunken plaza is utilized all year around with outdoor bars, restaurants and lounges during the summer time and the ice rink in the winter. Especially, the ice rink in the winter is one of the most popular place to start to the holiday season in New York City. Figure 23 and 24 show different settings in different seasons. Due to its various activities in the outdoor plaza, the stores

in underground level are busy all year around attracting people. In addition, the open plaza allows the natural light and a visual connection to the underground space so that users do not get the feeling of darkness and separation from the ground level.

4.3.2. The Oculus (World Trade Center Transportation Hub)

The Oculus is located in lower Manhattan, New York City and it was designed by architect Santiago Calatrava. It is adjacent to the World Trade Center site, known as "Ground Zero". As the World Trade Center Transportation Hub, it provides accesses to Port Authority Trans-Hudson (PATH) trains to New Jersey and New York City subway lines (*The Oculus*). The Oculus meets boundaries by Fulton, Greenwich and Church Streets to the North, West and East connecting the procession of green and urban spaces ("World Trade").

The exterior elliptical structure on the street level is approximately 350 feet long, 115 feet of its widest point and 96 feet height above grade at its apex. The steel ribs that form the Oculus extend upward to create a pair of canopies with a maximum height of 168 feet above grade ("World Trade"). The various access routes from different sides allow the Oculus to become a node which links and concentrates the pedestrian travel flows.

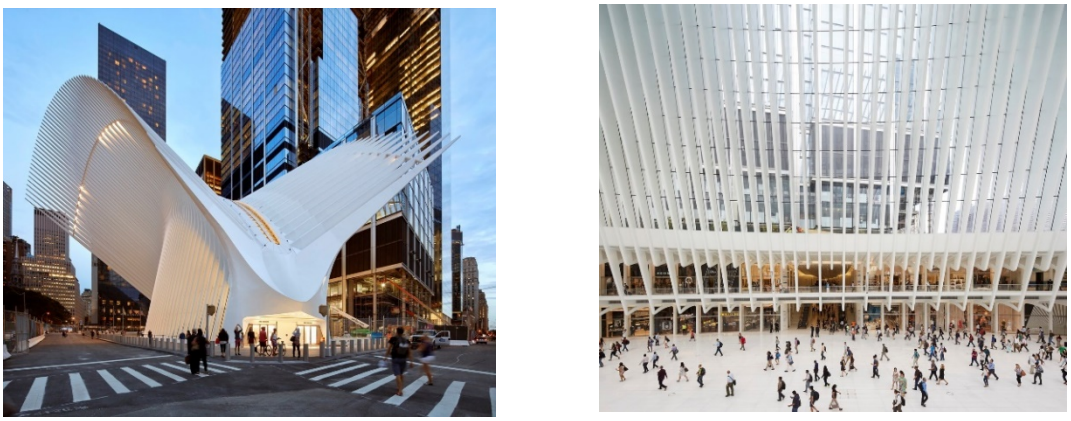


Figure 25. The Oculus, Left: Exterior, Right: Interior

Source: Hufton + Crow (https://www.architecturaldigest.com/story/santiago-calatrava-explains-designed-oculus-for-future-generations)

In terms of building scale, it is an intermediate scale (Figure 25, Left) between its immediate context of towers and pedestrian scale. According to Santiago Calatrava, it is the secret beauty of the skyline of New York since the building is hidden by skyscrapers around it and the structure can be recognized when people walk close to it via pedestrian path (Calatrava). The exterior structure looks like a freestanding sculpture which has become a landmark in Lower Manhattan.

Figure 25 (Right) displays the interior space which is below street level so when people come into the building, they need to use the stairs, escalators or elevators that lead them to the upper and lower concourse levels. These multi-levels provide various retail stores and restaurants supporting 250,000 daily commuters and millions of visitors from around the world ("World Trade"). The lower concourse is approximately 34 feet below the street level called the Transit Hall (Figure 26). The entire hall is approximately 350 feet long by 115 feet across at its widest point ("World Trade").

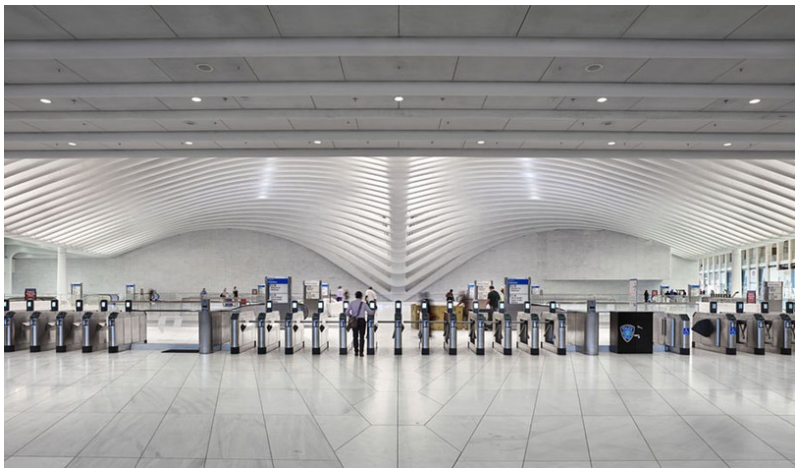


Figure 26. The PATH Station Train Platform in the Lower Level Concourse of The Transportation Hub

Source: Karchmer, Alan (https://www.architecturaldigest.com/story/santiago-calatrava-explains-designed-oculus-for-future-generations)

Even though, the interior space is below the street level, the space doesn't have the issue with the daylighting in which most underground spaces struggle with. Figure 27 shows the transparent glass sections between the steel ribs which allow natural day light all the way down to the lower levels illuminating the entire space. In addition, a skylight which is along the length of the Oculus spine helps to bring natural light in to the lower levels (*The Oculus*). The inside space is larger than the outside in which gives the impression of a large plaza. People get the almost same light condition inside of the structure as they walk outside on the streets (Calatrava).

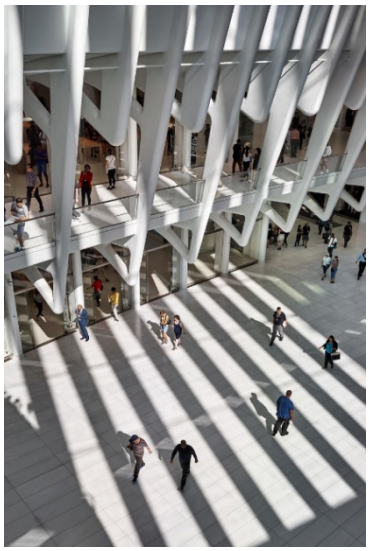


Figure 27. Natural Daylighting from Outdoor

Source: Karchmer, Alan (https://www.architecturaldigest.com/story/santiago-calatrava-explains-designed-oculus-for-future-generations)

In addition to its physical characteristics, the Oculus preserves memories from September 11th terrorist attacks. It is not only a physical connector for underground transit systems but also a symbol of hope in which people can overcome the tragedy (Calatrava). The skylight of the Oculus is operable and opens every September 11 to honor the memory of the victims. It has become a landmark as well as a monument to the community in New York City in which they mourn and honor the victims of the tragedy (Calatrava).

The Oculus is now an important landmark in New York City where it provides multiple functions. It can be a freestanding sculpture which creates pedestrian paths along the structure and provides a positive walking environment. It also can be a vertical connector that links multiple underground transit lines to the existing urban environment above. This connecting space supports commuters with numerous commercial services making the space more convenient and comfortable to stay. Finally, The Oculus conveys the memory of site with the form of the structure representing hope and the operable skylight which brings a sky of New York city into the building.

Based on the analysis of the sunken plaza in Rockefeller Center and the Oculus, the ideas that should be considered in this project are following:

- The space should have a physical or visual connection to create a transitional space between underground and above ground level,
- The space should have multiple access points that link pedestrian flows,
- The space should provide retail spaces and some other convenient services to support different activities all year around,
- The central atrium/ open space on the lower levels can capture the natural light and maximize the daylight in the underground space,
- Creating a link to the existing underground transit system is necessary to create a natural path to the above ground.

5. Summary

The design case study provides significant strategies that need to be considered in this project. It establishes the characteristics of underground public space in urban context. To sum up the strategies considered above, the urban underground public space needs to reflect the notions stated below:

- The space should be surrounded or enclosed by buildings where it requires an open space for better air flow and pedestrian path,
- The space should continue the pedestrian activities such as walking, shopping and cultural events that keep the space busy all year around,
- The space should reflect its context to be a significant connection between underground space and existing built environments so it can be a part of daily activities,
- The space should connect to the existing underground transit lines to create a natural path to the ground environment,
- The space should have multiple access points in which can be a node, path, or landmark in respect of imageability by Kevin Lynch,
- The entrance should be easily recognizable both from inside and outside to make a positive image of below ground space,
- The space should provide a visual connection to the above ground with an open space to capture and maximize the natural light as much as possible,

Even though, these ideas are from different archetypes, they can be combined to create a framework of this project. It means that the urban subterranean public space needs to establish its own guidelines. Therefore, the principles of underground public space include the unique sense of the underground conditions with a strong connection to its above ground urban environment.

V. Theory and Method

This section includes quantitative and qualitative researches that support the needs of subterranean public space in urban environment. The principles of urban public space and design guidelines of subterranean space will be used to create the final design of this thesis.

1. Quantitative Research

1.1. How Many People Use Public Transportation in New York City?

"With population of 8,550,405 in July 2015, New York City is the most populous city in the United States, more than twice the size of the second largest city, Los Angeles" ("New York").

"As one of the major cities in the U.S. New York City has the highest population density with 27,000 people per square mile" ("New York").

"Over 200 languages are spoken in New York City" ("New York").

These facts above show the population facts in New York City that diverse group of people live together within the dense urban land. Based on the population facts above, New York City could be a place where needs the public amenities the most and can effectively maximize the public realms.

In terms of public amenities, the public transit system is one of the great public assets in New York City. Approximately 55% of commuters use public transportation to work (Figure 28), compared to 4.9% nationally ("The New York").

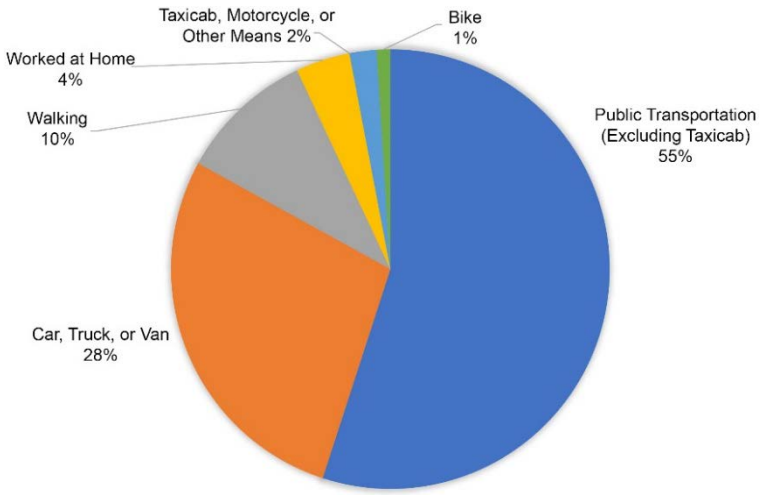


Figure 28. NYC Commuting

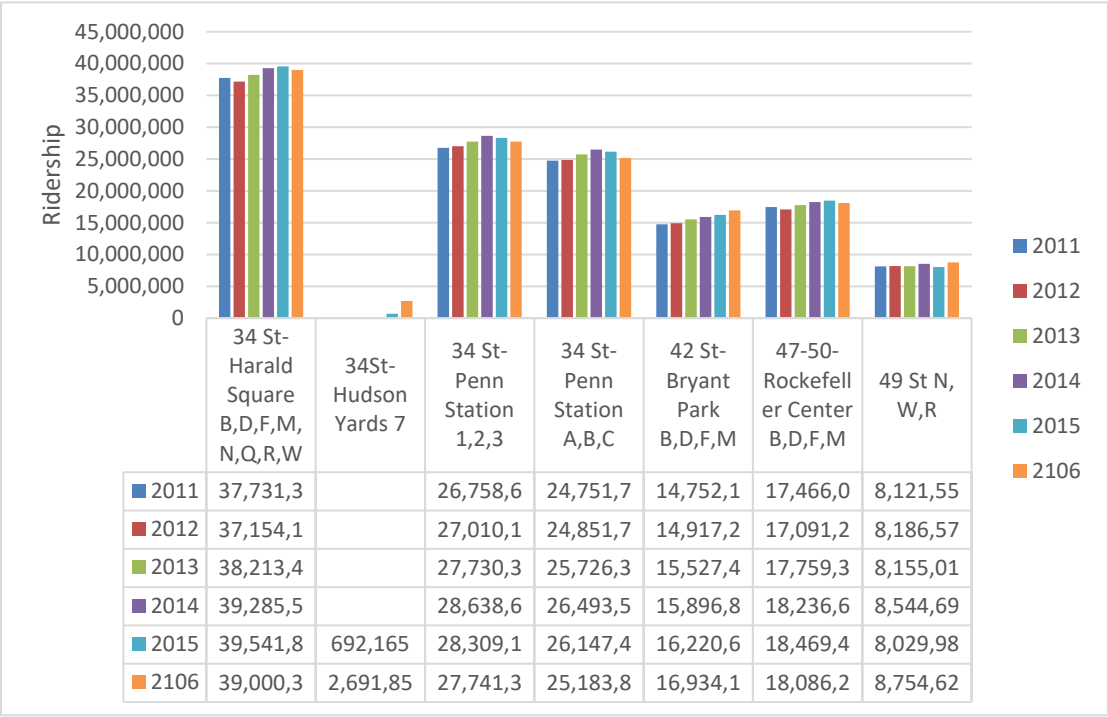
Source: NYCEDC, https://www.nycedc.com/blog-entry/new-york-commute

In addition, there are millions of tourists who visit New York City. According to the NYC travel & Tourism Visitation Statics, 60.5 million of people visited New York City in 2016 ("NYC Travel"). Along with this data, Table 3 shows number of ridership of subway in New York City[3]. The number of ridership continues to change but the stations receive a steady stream of riders. Especially, the number of riders of 34th Hudson Yards station is dramatically increased (288.9%) since it was operated ("Annual Subway").

Moreover, 34th Harald Square station is used by more than 35,000,000 people which ranked in 3rd busiest station in Manhattan in 2016 ("Annual Subway"). Since the Midtown Manhattan represents the central portion of Manhattan with the largest business district, it has a lot of commuters and residents who work in offices, hotels, and retail stores (*Midtown Manhattan*). The station leads riders to the Harald Square in which consists of two sections; Herald Square to the North side and Greeley Square to the South side (*Herald Square*). This

[3] The graph was created by the author of this paper, the information was based on the Annual Subway Ridership table provided by the MTA. It only includes stations in midtown Manhattan (34st-59st) adjacent to the project site.

open square is well used as a rest area and is fully occupied by many tourists and midtown office workers all the time.



	34 St-Harald Square B,D,F,M, N,Q,R,W	34St-Hudson Yards 7	34 St-Penn Station 1,2,3	34 St-Penn Station A,B,C	42 St-Bryant Park B,D,F,M	47-50-Rockefeller Center B,D,F,M	49 St N, W,R
2011	37,731,3		26,758,6	24,751,7	14,752,1	17,466,0	8,121,55
2012	37,154,1		27,010,1	24,851,7	14,917,2	17,091,2	8,186,57
2013	38,213,4		27,730,3	25,726,3	15,527,4	17,759,3	8,155,01
2014	39,285,5		28,638,6	26,493,5	15,896,8	18,236,6	8,544,69
2015	39,541,8	692,165	28,309,1	26,147,4	16,220,6	18,469,4	8,029,98
2106	39,000,3	2,691,85	27,741,3	25,183,8	16,934,1	18,086,2	8,754,62

Table 3. Annual Subway Ridership

Source: MTA, http://web.mta.info/nyct/facts/ridership/ridership_sub_annual.htm

Altogether, the demand for public transportation will be continued and the city needs to improve theses public services to support this high demand. Since the public transit system connects different boroughs throughout the city, public spaces adjacent to the transit stations have a great potential to improve the quality of public life in New York City.

1.2. Community District Profiles: Manhattan Community District 5

Manhattan is composed of 12 districts (Figure 29) and the midtown Manhattan area is in the district 5 ("Manhattan Community"). As a heart of the New York City, Midtown Manhattan is always busy with thousands of people. District 5 includes Flatiron, Gramercy Park, Herald Square, Midtown, Midtown South, Murray Hill, Time Square and Union Square. Population in

midtown Manhattan was 44,000 in 2000 and 51,700 in 2010 which shows a 17% increase ("Manhattan Community"). Since the total population in Manhattan have been growing, the population in midtown is expected to follow the growing trend. In terms of built environment in District 5, commercial and office use takes the largest portion of the land with 64.21% and then mixed residential and commercial follows by 13.54% (Figure 30). In addition, accessibility to the park, 94% of residents live in walking distance of the park or an open space which is quite high compared to the Citywide target, 85%.

Midtown Manhattan includes many successful public spaces such as Bryant Park, Union Square Park, and Madison Square Park. These places allow people to enjoy various activities all year around. For example, The Bryant Park offers birdwatching classes and ping pong tournaments. District 5 put a lot of effort to create a better quality of public life by creating more pedestrian plazas to sit, mingle and play. Times Square, Herald Square and the Flatiron Plaza provide opportunities for better public activities. Recently, District 5 opened Plaza 33 which is located on 33rd street ("Parks and Public").

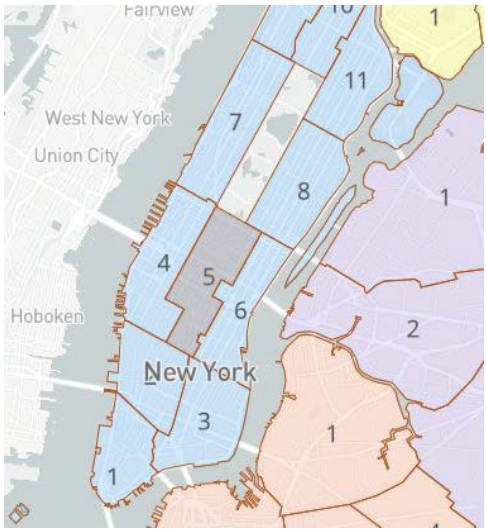


Figure 29. Manhattan Community District

Source: NYC Planning, https://communityprofiles.planning.nyc.gov/manhattan/5

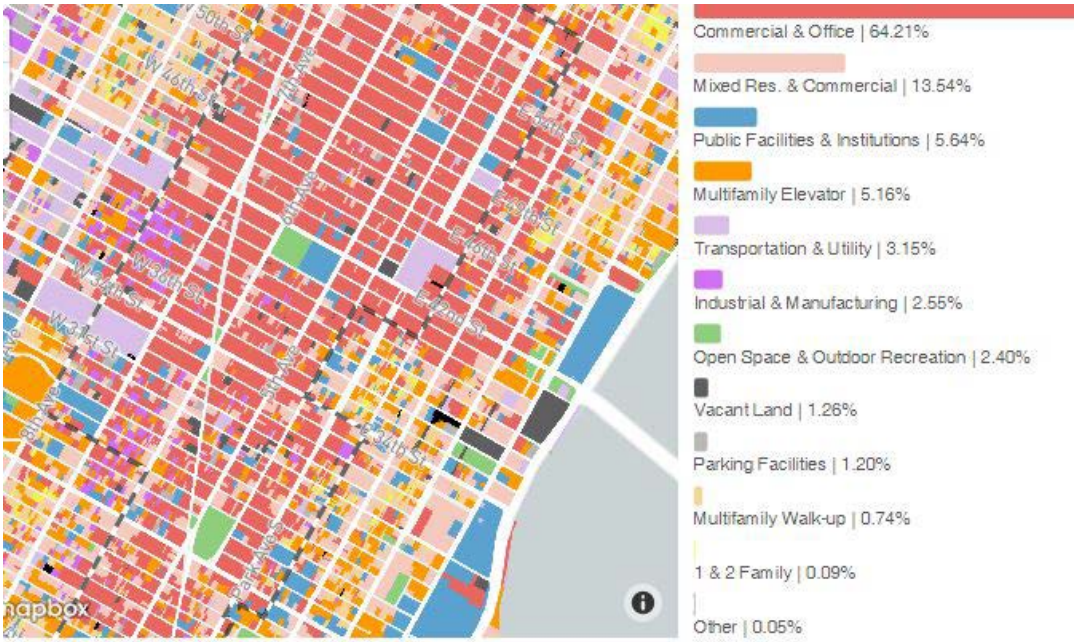


Figure 30. District 5, Land Use

Source: https://communityprofiles.planning.nyc.gov/manhattan/5

1.3. Social Impacts of Public Space and Quality of Life

New York City has been trying to improve the quality of public life in the city. PlaNYC and the Department of Recreation and Parking has created approximately 182 acres of parkland since 2007 (“New York”). The goal of this plan is to make New Yorkers live within 10 minutes of walking distance from a quality open space. Due to its high population density, New York city has smaller green space per person than other major cities in the U.S. As population continues to grow, New York City needs to add more parks and open spaces expecting the public spaces can be valuable assets to improve the quality of life in the city (“New York”). Along with this program, The NYC Plaza Program by NYC Department of Transportation (DOT) collaborated with community organizations in which they have been working on creating more attractive and safe public spaces for people of for all ages (“The Public”).

Since DOT started the NYC Plaza program, they have created over 70 new public plazas for areas where it needs open spaces (Gehl Studio et al.). According to Gehl Institute which is a nonprofit organization working for urban livability in New York City, seven NYC plazas were analyzed to study the connections that impacts public life and public space. The evaluation focuses on how public spaces contributes to quality of public life and greater social justice (Gehl Studio et al.).

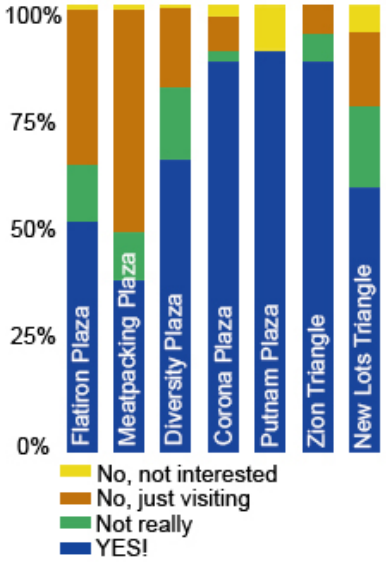


Figure 31. Is this your plaza?

Source: Public Life in NYC's Plaza (Gehl Studio et al.) https://gehlinstitute.org/work/nyc-public-plazas-public-life-and-urban-justice-in-nycs-plazas/

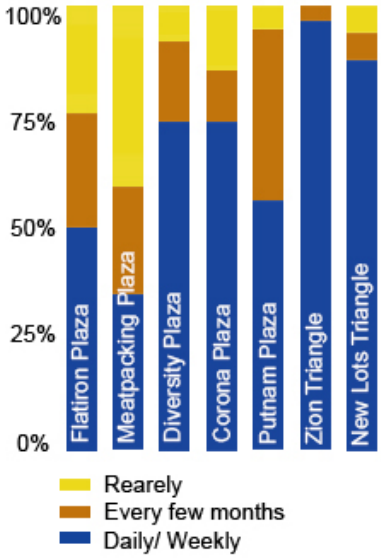


Figure 32. How frequently do you visit the plaza?

Source: Public Life in NYC's Plaza (Gehl Studio et al.) https://gehlinstitute.org/work/nyc-public-plazas-public-life-and-urban-justice-in-nycs-plazas/

Figure 31 shows that on average, more than 50% of people have a strong sense of ownership on their plaza and Figure 32 shows that these plazas have regular and frequent visitors (Gehl Studio et al.). These two figures describe that these plazas contribute to improve the public pride and attachment to the public assets. In addition, with more daily and weekend visitors, these public spaces have become a part of the daily life.

Figure 33. What income groups are represented on the plaza versus the neighborhood demographics?

Source: Public Life in NYC's Plaza (Gehl Studio et al.) https://gehlinstitute.org/work/nyc-public-plazas-public-life-and-urban-justice-in-nycs-plazas/

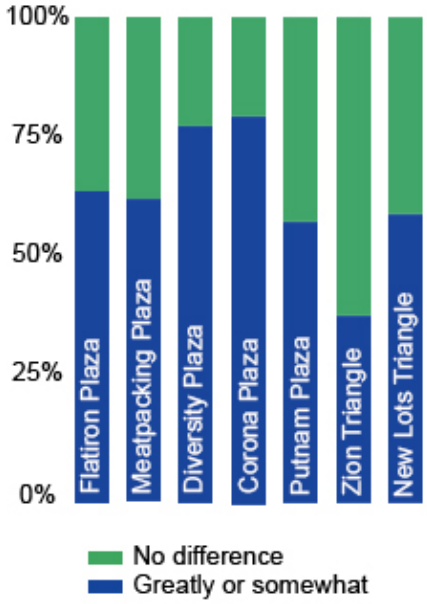


Figure 34. Has this plaza increase the amount of time you spent outside?

Source: Public Life in NYC's Plaza (Gehl Studio et al.) https://gehlinstitute.org/work/nyc-public-plazas-public-life-and-urban-justice-in-nycs-plazas/

Figure 33 and 34 shows how open plazas encourage social interaction. Figure 33 describes that compare to the neighborhood demographics, lower income groups are more represented at the public plazas which means the plazas are used by socio-economically diverse group of people (Gehl Studio et al.). Not only that, as more people spend their time at the plaza (Figure 34), the chance to interact with people and participate in neighborhood events increases.

Figure 35 shows that on average, 70% of people have recognized people in their neighborhood due to new built plazas which correlates with higher social interactions and recognition in the plaza. In addition, people who make less than $50,000 (Figure 36) tend to make new connections in the plaza which means public space have a great opportunity for social equality by inviting diverse group of people (Gehl Studio et al.).

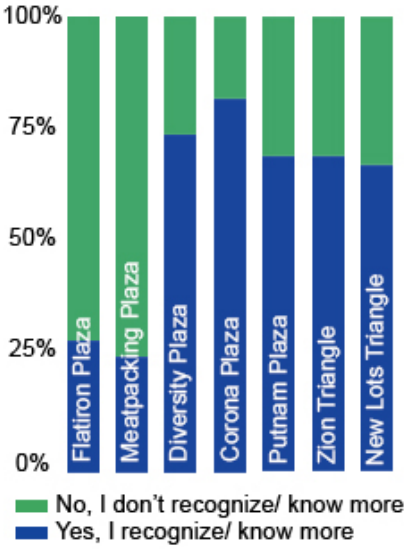


Figure 35. Do you recognize more people in the neighborhood since the plaza opened?

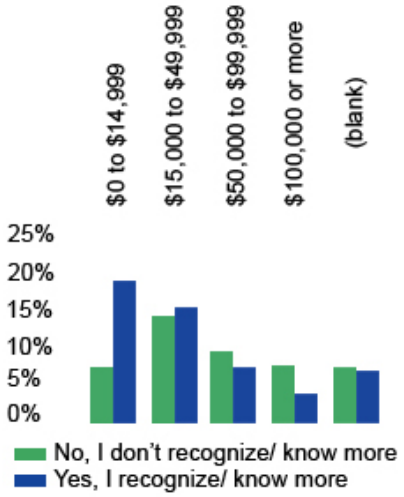


Figure 36. Who recognize people on the plaza, by income group

Source: Public Life in NYC's Plaza (Gehl Studio et al.)

https://gehlinstitute.org/work/nyc-public-plazas-public-life-and-urban-justice-in-nycs-plazas/

Open plazas encourage people to come outside and interact with other group of people. Each people has different backgrounds and the public space is the place where supports social and cultural events. These events help to build a stronger community in which helps bond people from different social classes, ethnicity and religion.

Based on these quantitative data above, this study has established the necessity of creating more public spaces in urban environment in which will help to enhance not only the quality of public realm but also the quality of individuals life in urban.

2. Qualitative Research

2.1. Urban Design Principle

2.1.1. Quality of Public Space

One of the fundamental elements of urban design is the public space. Once the urban environment realized the needs of public space within the city, it is important to understand the relation between the environmental images and urban life at the level of urban design principles. Kevin Lynch mentioned in his book *The Image of the City* that the elements which indicate the physical forms of the city image can be classified into five: paths, edges, districts, nodes, and landmarks (Lynch 46). If the five elements are strong enough, the imageability of the city can be also strong and memorable. Imageability is a quality that can be applied to a public space and can make it an important part of the city.

In this thesis, those five elements above will be applied to determine the design framework of urban subterranean public space. They will help to analyze the characteristics of urban public space and see the impact of the public space and its relation to the urban environment.

Paths

Paths allow all kinds of movement within the city. As one of the major city elements, the hierarchy of paths can be vary based on the degree of familiarity with the city (Lynch 49). For those people who know more about the city have a better idea of specific paths and their interrelationships (Lynch 49). Concentration of special use and different activities taking place along the paths create characteristics of the street in which strengthen the image of paths. Also, paths are important since they lead people to different part of the city. Therefore, paths are not only distinguishable and continuous throughout the city but also have a directional quality which make people to think of origins and destination points. Once the paths have a directional quality, they can have different scales. The scale of path in the overall image of the city can be vary. It can be a sense of one's position along the total length of path or it can be determined by a sequence of landmark or nodes along the paths (Lynch 55).

Edges

Edges are linear elements in which is different form paths. They are boundaries of different areas acting as lateral references (Lynch 62). Although, mostly edges give a sense of enclosure to users, other times, they are not necessarily impenetrable. Many edges join different areas together creating interesting effects (Lynch 65). Sometimes, edges can be paths due to their directional qualities. For example, Charles River edge in Boston has clear the side-from-side distinction of water and city and the end-from-end distinction by Beacon Hill (Lynch 66). The scale of edge can be gigantic with great buildings, parks and private beaches which go along the entire length of it like the Lake Michigan in Chicago (Lynch 66).

Districts

Districts take a quite large portion of the city so people can go into it. Since each district has a unique character, people can recognize them internally. Also, they are used as an external reference points to direct people (Lynch 66). There are several elements that determine the physical uniqueness of districts such as texture, space, form, detail, symbols which can be all kinds of clues to distinguish each district (Lynch 68). Lynch called these elements as the "thematic unit" since these typical features help to draw an image and recognize the characteristics. There are different types of boundaries of districts: hard and soft (uncertain). Hard boundaries are definite and precise such as boundaries of Back Bay at the Charles River in Boston. On the other hand, soft boundaries are uncertain such as the end-point of downtown shopping and the office district which is estimated location (Lynch 69). While some cities can stand alone in their own zone, others are joined together creating a continuous distinctive district such as shopping districts, financial and market regions and they can be combined together. The contrast of each area helps to enhance their own thematic strength (Lynch 72).

Nodes

Nodes are the strategic foci that can be junctions, paths, or concentration. Even though the conceptual image of a node is small, when they are applied in reality, they could be a large squares or even entire districts (Lynch 72). Nodes are important points as it is a place where people make their directional decision. For example, junction is a place of a break in transportation and people make decisions at this point. People tend to pay more attention at junctions as well as its nearby elements (Lynch 73). Nodes are important without the clear physical form. Subway stations are invisible path systems. Park street, Charles river or Copley

stations in Boston are important in the city map. These key stations often have close relationships with some key surface elements (Lynch 74).

Landmarks

Landmarks are physical elements which can vary in scale. There are two ways of making landmarks in the city: By making the elements recognizable from other locations, or by making the nearby surroundings contrast to the elements (Lynch 80). Historical associations attached to objects also enhance the value of landmarks. For example, Faneuil Hall or the State House in Boston are historically meaningful and the meanings strengthen them as landmarks in the city (Lynch 81).

The image of the city cannot be created by one single element. Even though, the scale of each element can be varying depends on the location and user needs, when those five elements are combined, they contribute to identify the overall image of the city.

2.2. Principles of Subterranean Space

Subterranean space design needs to consider several problems mainly caused by a lack of exterior configuration and windows. These concerns are more relatable to the environmental psychology and architectural design rather than an engineering problem (Carmody and Sterling 154). Moreover, since the nature of subterranean space, the ambiguous exterior form conflicts with the quality of public space discussed in previous sections. Therefore, urban subterranean space should be approached in a different manner to maximize the use of underground space and make it as a part of urban development. The design principles of urban subterranean space need to find a point between the quality of urban public space and principles of subterranean space.

The set of design guidelines have developed by *Underground Space Design; A Guide to Subsurface Utilization and Design for People in Underground Spaces.* The organization of the design guidelines are categorized into five sections; Exterior and entrance design, layout and spatial orientation, interior design elements and systems, lighting, and life safety (Carmody and Sterling 155).

2.2.1. Description of Design Guidelines for Subterranean Space

Exterior and Entrance Design

- Building Image

  Compare to the traditional building design, the subterranean space always includes challenges regarding lack of building image. Uncertain building image cannot contribute to the overall environmental image in which conflicts with the urban design principles. Kevin Lynch mentioned in his book, *Image of the City* that *"A good environmental image gives its possessor an important sense of emotional security.* (…) *Indeed, a distinctive and legible environment not only offers security but also heightens the potential depth and intensity of human experience"* (Lynch 5). The undefined building image limits and interrupts people to draw a meaningful image which may associates with the past experiences or it could make people think of negative images such as death and burial, dark and humid basement (Carmody and Sterling 170). Therefore, a new way of approaching is required to lessen those drawbacks and contribute to the environmental image.

- Entrance Design

Along with exterior image, building entrance plays important role because it provides a sense of arrival and strengthens the orientation of the exterior and interior of the building. It

also shows the physical and psychological transition between the exterior and interior world (Carmody and Sterling 172). The entrance of subterranean space requires special attention because in general, the entire space is in below grade so it does not have a distinct form or opening as traditional building design. In addition, since it is a transition point from above and below grade, its downward movement contains negative feelings and fears (Carmody and Sterling 173).

Layout and Spatial Orientation

Layout and spatial orientation represents the most fundamental interior configurations such as circulation system, arrangement, size, and shape of spaces within the facility (Carmody and Sterling 191). Designing a subterranean space requires a fundamentally different design approach from conventional above grade buildings to make it acceptable to people. Due to its invisible overall configuration of the building and the lack of reference points to the exterior, there can be a sense of confinement as well as losing stimulation (Carmody and Sterling 193). Disoriented feeling within the space is not only an inconvenience but potentially stressful for occupants (Carmody and Sterling 193). Kevin Lynch emphasized the negative impact of disorientation as:

> (…) let the mishap of disorientation once occur, and the sense of anxiety and even terror that accompanies it reveals to us how closely it is linked to our sense of balance and well-being. The very word “lost” in our language means much more than simple geographical uncertainty; it carries overtones of utter disaster (Lynch 5).

Although, Lynch's concept primarily focuses on the design of urban environment, the same concept can be applied to individual building design in terms of negative impact of being lost. The lack of orientation in subterranean space is mostly caused by lack of openings and connection to the exterior environment (Carmody and Sterling 195). Therefore, in addition to the effective use of interior materials, spatial size and arrangement should be carefully designed (Carmody and Sterling 196).

Interior Design Elements and Systems

Well-designed interior space can be used to offset some negative effects of subterranean space. While layout and spatial orientation addresses size and shape of the space, interior design elements cover more visual factors such as color, pattern, materials, furnishings, and other notable elements such as plants and fountains (Carmody and Sterling 224). Other negative associations include coldness, dampness, and poor air quality. Even though, the underground space is mechanically ventilated as conventional buildings above ground, these negative qualities still need an attention.

The lack of spatial orientation has been discussed in the interior layout of subterranean space. Well-designed buildings include the architectural legibility such as wayfinding system because regardless of the building design, occupants tend to rely on signs or maps to choose their direction and understand the overall space (Carmody and Sterling 229).

Lighting

Lighting is the fundamental element in the design of subterranean space because it associates with the most common drawbacks of below grade spaces such as darkness, windowless and natural light. Lighting controls all kinds of visual experience within the space

thus, it provides definition and character of the space (Carmody and Sterling 261). Even though, artificial lighting can illuminate the underground space, it does not have the same quality of sunlight in which associates with psychological concerns such as s sense of confinement (Carmody and Sterling 262).

Life Safety

Life safety is particularly important design issue because most underground spaces have some physical limitations that need a special feature to guarantee occupant's safety in an emergency (Carmody and Sterling 285). One of common negative aspects of being in subterranean space is that fear of entrapment from fire, flood, or other disaster. Compared to the regular building design, underground space has less windows and has a different layout pattern with unfamiliar egress systems therefore, it could require longer evacuation times and increase fear and anxiety to escape (Carmody and Sterling 286). The subterranean space needs a special attention to offset a sense of fear with open and legible space plan.

3. Method

The principles of urban design discussed above will be combined with the principles of underground design and all of values contribute to a framework for the successful design of subterranean urban public space.

3.1. Five Elements of City Image: Application to Urban Public Space

Even though, Lynch's five elements more focus on the city scale, they can be applied to the scale of public space as public space can reflect the quality and image of the city.

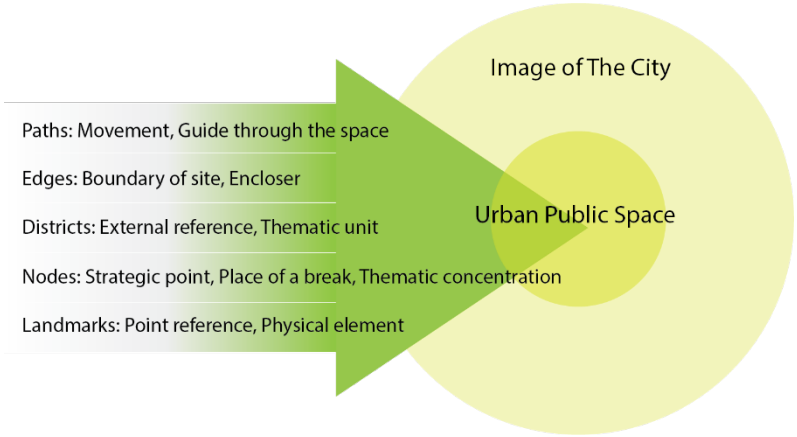


Figure 37. Five elements of city image

Source: Kevin Lynch, Image of the City, Created by author of thesis, 2018

Creating a clear identity is the main component of urban design and the concepts so far studied, a sense of attachment[4] and the physical elements of space (Figure 37) are the major components. Even though, there are other influences on creating an identity of the space, since the objective of this thesis is creating an actual design form, this study will specifically focus on the five physical qualities of imageability. The final design of this thesis expects to reinforce not only the visual elements of the site but also the meaning of the space as well. Following section is a description of how the design frame work would proceed according to the spatial qualities in urban design principles.

- Paths: Creating a clear passage along with the entrance and the passage should be more than one. The passages are in different scales based on the hierarchy of connected adjacent streets.

[4] Refer to the section 3.2. Qualities of urban public spaces: Experience (emotional) and physical qualities

- Edges: Creating defied edges by physical elements such as fence or kiosks. The edges between the site and the surrounding roads should protect the activities taking place in the site and provide access points from different sides.
- Districts: Creating a site with a unique theme so the site can be distinguishable from surroundings. The uniqueness can be achieved by texture, form, detail, symbol, building type, activity, or topography (Lynch 67).
- Nodes: Creating a site as a destination of multiple activities so that people come into the site for a certain reason. It can be a spot for meeting up, eating or transportation.
- Landmarks: Creating a design feature in which can be a symbol of the site. The design feature should be related to the history, culture, or people in which carries a strong connection between the city and public space.

3.2. Subterranean Space Design Guidelines

Among the five categories of subterranean space design discussed earlier, this thesis will only adapt three major principles which are; the exterior and entrance design, layout and spatial orientation, and natural light. This is because they are the major principles in which can be applied to both subterranean space and ground space. Not only that, the lighting and life safety principles can be addressed by spatial orientation and interior design elements.

Exterior and Entrance Design

- Exposed building boundaries and related architectural elements help to recognize the building image from the ground level.
- Make a visual connection between the exterior space and the interior space.
- Create a clear and legible entrance which can be easily recognized from the major pedestrian path.

- Create a spacious vertical circulation showing clear direction.

Layout and Spatial Orientation

- Create a legible and stimulating environment.
- Design spaces with manipulating room size and shape to enhance a sense of spaciousness.
- Design the underground space by hierarchy to divide the entire space.
- Provide visual connections between the interior and exterior so the space can receive natural light as much as possible.
- Provide a clear and attractive signages and map to facilitate orientation.

Natural Light

- Create a stimulating and warmth indoor environment to avoid negative aspects such as cold and damp below grade space.
- Provide natural light as much as possible.

3.3. Diagrammatic Analysis of Subterranean Space

While the design framework established in previous section provides a clear idea of creating a subterranean public space, it does not provide a particular form of the space. Following examples present several design approaches showing how they lessen the design issues in the subterranean space. The examples focus on the five design objectives in accordance in the design guidelines by *Underground Space Design; A Guide to Subsurface Utilization and Design for People in Underground Spaces.*

3.3.1. Entrance Through a Sunken Courtyard

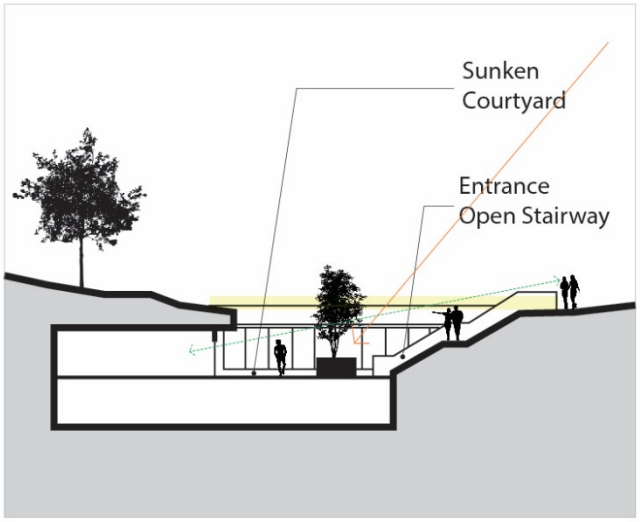


Figure 38. Entrance Through a Sunken Courtyard

Source: Underground Space Design by Carmody and Sterling, pp. 180, Recreated by author of thesis, 2018

Figure 38 shows a subterranean building under a flat site with an entrance through a sunken garden. The exterior courtyard not only serves a gradual entrance to the subterranean space but also defines the shape and exterior of the building below (Carmody and Sterling 180). Although, the courtyard shows only a part of the building, it makes the underground building more understandable with a connection to the interior and exterior environment. In addition, it helps to bring natural light into the below space reducing darkness and sense of confinement within the space. By joining the sunken garden to the ground level, it avoids a downward transition to the entrance allowing people to walk into the building through the façade (Carmody and Sterling 181). The open courtyard attracts people on the ground level and provides a view to people on both below and above ground levels.

3.3.2. A multilevel Sunken Exterior Courtyard

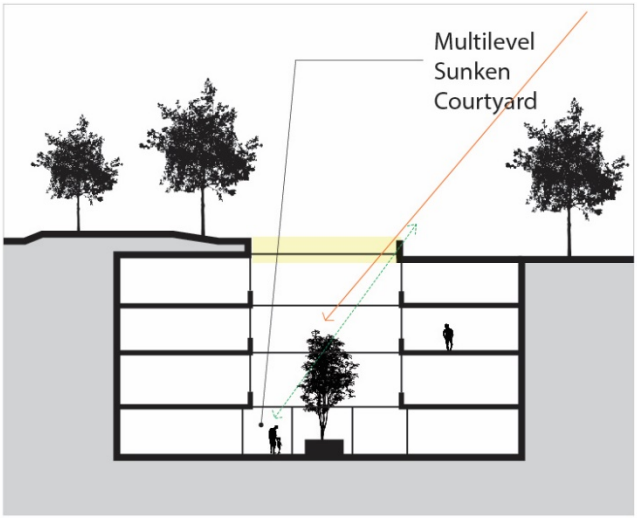


Figure 39. Multilevel Sunken Exterior Courtyard

Source: Underground Space Design by Carmody and Sterling, pp. 205, Recreated by author of thesis, 2018

In a multilevel building, the exterior courtyard helps to connect the interior and exterior environment. Especially, the lower floors have a chance of getting natural light through the open courtyard making the subterranean space more appealing. In addition, by extending an access to the exterior courtyard, it naturally enhances building circulation and public areas. The main circulation path along the courtyard with multiple entrances help to organize the movement within the facility and make it easier to understand the overall space (Carmody and Sterling 205).

3.3.3. Covered Interior Atrium Space

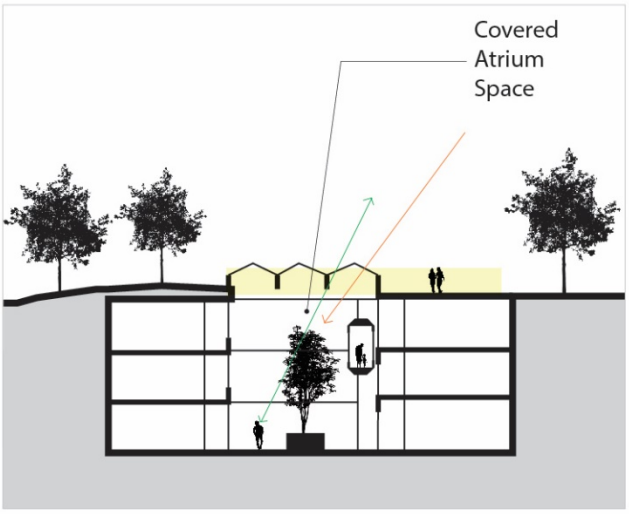


Figure 40. Covered Interior Atrium Space

Source: Underground Space Design by Carmody and Sterling, pp. 206, Recreated by author of thesis, 2018

Multistory interior atrium[5] spaces in subterranean spaces extends views, visual stimulation, a sense of orientation, natural light and focus of activities (Carmody and Sterling 206). As one of the most significant and versatile design elements in the underground facility, with respect to orientation and image, the interior atrium space works as the central landmark and creates the major image of the building (Carmody and Sterling 206). In terms of imageability by Kevin Lynch, the interior atrium can be a major path, activity node. Moreover, it includes a landmark or can be a landmark itself.

The covered interior atrium has significant benefits not only for the interior space but also for the exterior environment. The covered part can be a unique architectural element and it establishes a characteristic of the building in which improves the weakest point of the

[5] The term atrium generally refers to an interior or covered courtyard space (Carmody and Sterling 206).

subterranean building. With some safety and privacy treatments, the covered part can be used for a great public space on the ground level extending usable area on the ground level.

3.3.4. Transmitted and Reflected Exterior Views

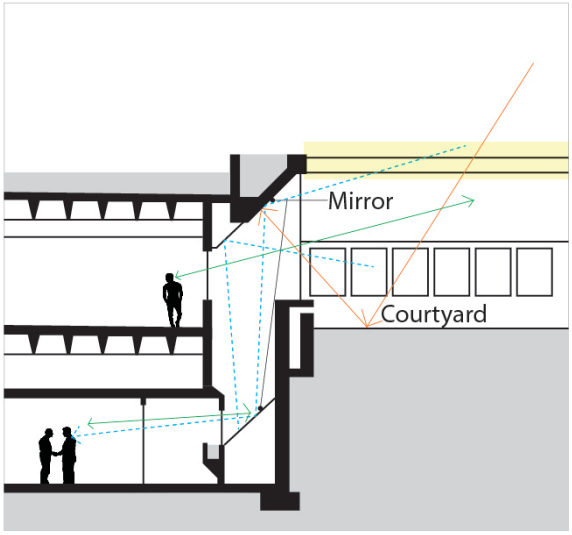


Figure 41. Fort Snelling Visitor Center in Minneapolis

Source: Underground Space Design by Carmody and Sterling, pp. 251, Recreated by author of thesis, 2018

Providing exterior views is not easy for isolated subterranean spaces. In addition to the architectural solution, it needs extra device to overcome the issue regarding the windowless space. "Surrogate windows[6]" can help an isolated underground space to receive the current immediate exterior views (Carmody and Sterling 251). Figure 41 shows a simple solution by installing a reflective device in the isolated subterranean space. People in the lower floor where there are two levels below, they can see the outside environment through a large angled mirror in which shows an imaged reflected off the mirror above (Carmody and Sterling 251). This system can be applied in different situations. A more complex system is applied in a building at University of Minnesota (See Figure 42). The lowest floor is located over 30 meters (98.5 ft.)

[6] Surrogate windows provide an actual outside view of the exterior by either optically with lenses and mirrors or electronically with video transmission (Carmody and Sterling 251).

below grade level. The exterior view is provided through a series of lenses with mirrors from the top of the building to all the way to the lower floor. While, this reflected exterior view helps to reduce a feeling of a windowless within the subterranean space, this complex periscope system provides the exterior view only at a viewing position so people need to go to the certain point to see the view.

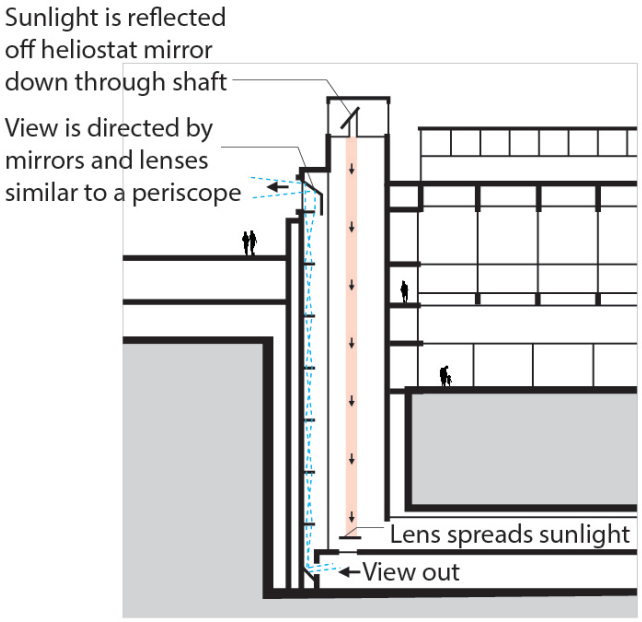


Figure 42. Civil and Mineral Engineering Building at University of Minnesota

Source: Underground Space Design by Carmody and Sterling, pp. 251, Recreated by author of thesis, 2018

There are more options to provide the exterior views such as a camera system on the surface providing various views from the ground level. This technology has been installed widely for security purpose but not for the "surrogate window" yet. This is because it requires an extremely high-resolution image and it only provides two-dimensional look. Even though, these systems have some limitations, they are all helpful to reduce some critical issues within the subterranean space (Carmody and Sterling 252).

3.3.5. Interior Lighting

In addition to the natural light in the subterranean space, interior lighting is important to enhance spaciousness. Indirect lighting of wall and ceilings is one of the effective techniques to increase the perception of spaciousness in a room because higher illumination level helps to enhance the feeling of openness (Carmody and Sterling 280).

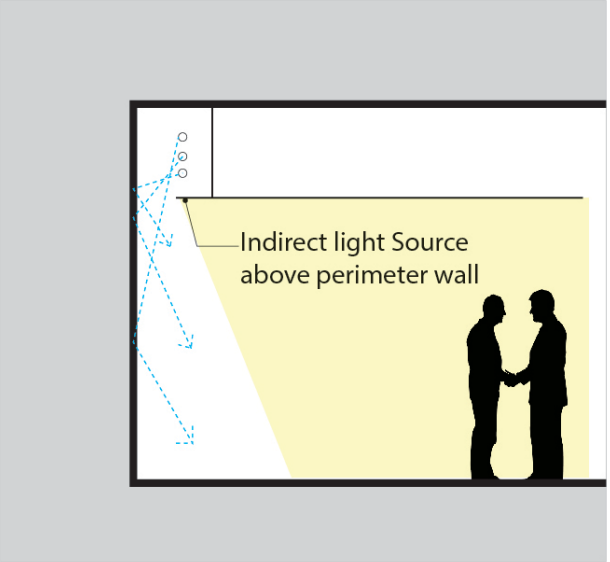


Figure 43. Uniform Indirect Lighting

Source: Underground Space Design by Carmody and Sterling, pp. 280, Recreated by author of thesis, 2018

Figure 43 shows indirect lighting in a room. This diffused lighting makes the space larger by brightening the perimeter of the space. Moreover, indirect lighting contributes to create a positive image of the underground space. For instance, higher level of illumination within the space can offset the associations with darkness and the invisible light source makes walls and ceilings are lightened naturally.

3.3.6. Life Safety: Clear Internal Organization and Egress System

Occupant's safety is the most important criteria in the building design and it must be guaranteed. The building should provide a clear egress path by using a simple interior layout.

Especially in a subterranean building, due to the sense of confinement and lack of windows, the egress path should be created in respond to a familiar circulation patterns. One important aspect of designing safety egress is that reading an exit door or a place of safety (Carmody and Sterling 294). Most underground facility can provide safe egress like conventional building designs. The subterranean space may have some physical constrains to make a simple egress path because a lack of spatial orientation with unfamiliarity could be a potential issue within the space (Carmody and Sterling 294). However, shallow underground building can provide a simple egress circulation as a conventional building design.

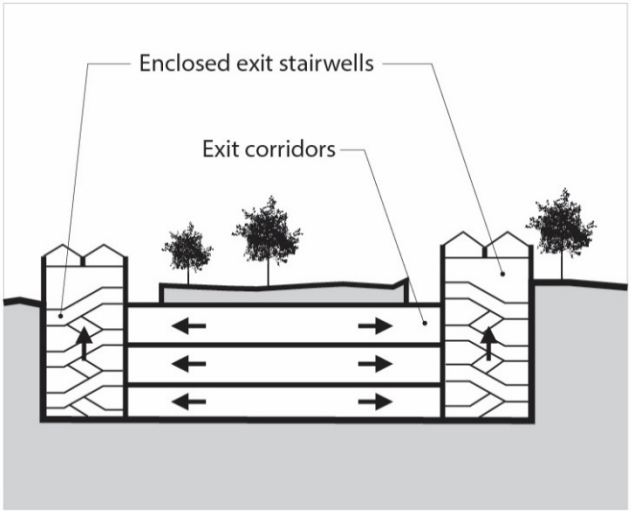


Figure 44. Egress System

Source: Underground Space Design by Carmody and Sterling, pp. 294, Recreated by author of thesis, 2018

Figure 44 shows shallow subterranean building with conventional egress design. People can pass through the central corridor to reach to the stairways to exit to the ground surface. Although, deeper underground facility may require more complex systems such as longer shaft and tunnels to evacuate occupants from the building, with a careful and simple layout with effective emergency system, subterranean space can be utilized and include various activities as much as conventional buildings.

3.4. Design Framework for Subterranean Public Space

The final design framework is divided into two major categories: Principle of public space and Principles of subterranean space and both of which are subdivided into specific elements. First, based on the researches above, principles of public space contain five major categories that should be achieved in the final design phase to create a clear identity in urban public space. These five elements will reflect two major aspects of public space in which have been discussed previously: spatial identity and sense of attachment (experience). The five elements are:

- Movement (Paths)
- Enclosure (Edges)
- Thematic unit (Districts)
- Activity (Nodes)
- Symbol (Landmarks)

Each category has its own uniqueness yet they overlap each other. The second category of design frame work is the design guidelines for subterranean space. Based on the subterranean space design guidelines developed by *Underground Space Design; A Guide to Subsurface Utilization and Design for People in Underground Spaces*, three major categories will be applied in this project. They will be:

- Building Exterior and relation with the ground level
- Spatial orientation and circulation
- Natural light

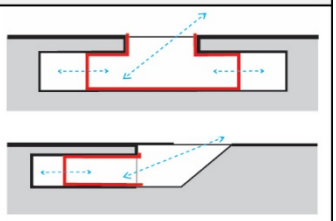
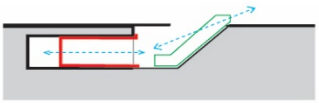
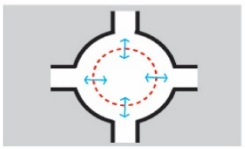
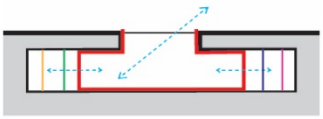
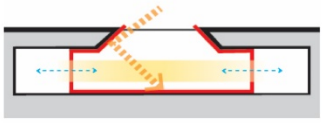
Underground Space Design Guidelines			
Main Issue	**Design Principle**	**Design Guidelines (Application)**	**Diagram**
Building Exterior			
Lack of Building Image	Exposed building boundaries and related architectural elements help to recognize the building image from the ground level. Make a visual connection between the exterior space and interior space.	Use either **Atrium** or **Elevational** fenestration arrangement to make a exposed exterior to the ground level. **Subgrade** configuration enhances the relationship with the ground level. **Sunken** courtyard provides a exterior view to the underground interior space.	
Unclear Entrance	Create an entrance which can be easily recognizable from the major pedestrian path. Create spacious vertical circulation showing clear direction.	Create an open and wide ramp (15' wide) to direct pedestrian flows to the subterranean space. **Entrance Through a Sunken Courtyard** to minimize the downwards movement and make a familiar entrance way to users.	
Layout and Spatial Orientation			
Poor Circulation	Design spaces with manipulating room size and shape to enhance a sense of spaciousness.	Use the **Sunken Courtyard** as a central circulation space to direct people in the underground space. Circular configuration provides a simpler spatial orientation.	
Lack of Legibility	Create a legible and stimulating environment.	Use shallow **Atrium** fenestration arrangement to create a visual connection between ground and below ground space. Provide a clear signage and map to facilitate orientation. Zoning (Color code) help to create a distinctive image within the space.	
Natural Light			
Lack of Natural Light	Create a stimulate and warmth indoor environment to avoid negative images such as cold and damp below grade space. Provide natural light as much as possible.	Use subterranean **Atrium** space to capture the natural light so the underground space can have the same daylight effect as ground level.	

Table 4. Underground Space Design Guidelines

Source: Underground Space Design by Carmody and Sterling, Created by author of thesis, 2018

Table 4 describes the details of underground space design guidelines. Further details will be provided in a schematic design process. The design principle of subterranean space should be established in response to the negative aspects of the space. This set of basic design framework does not finalize a physical form of subterranean public space yet it will inform to make a design decision of subterranean public space. This set of design framework (Figure 45) will lead a way to achieve the physical form of subterranean public space.

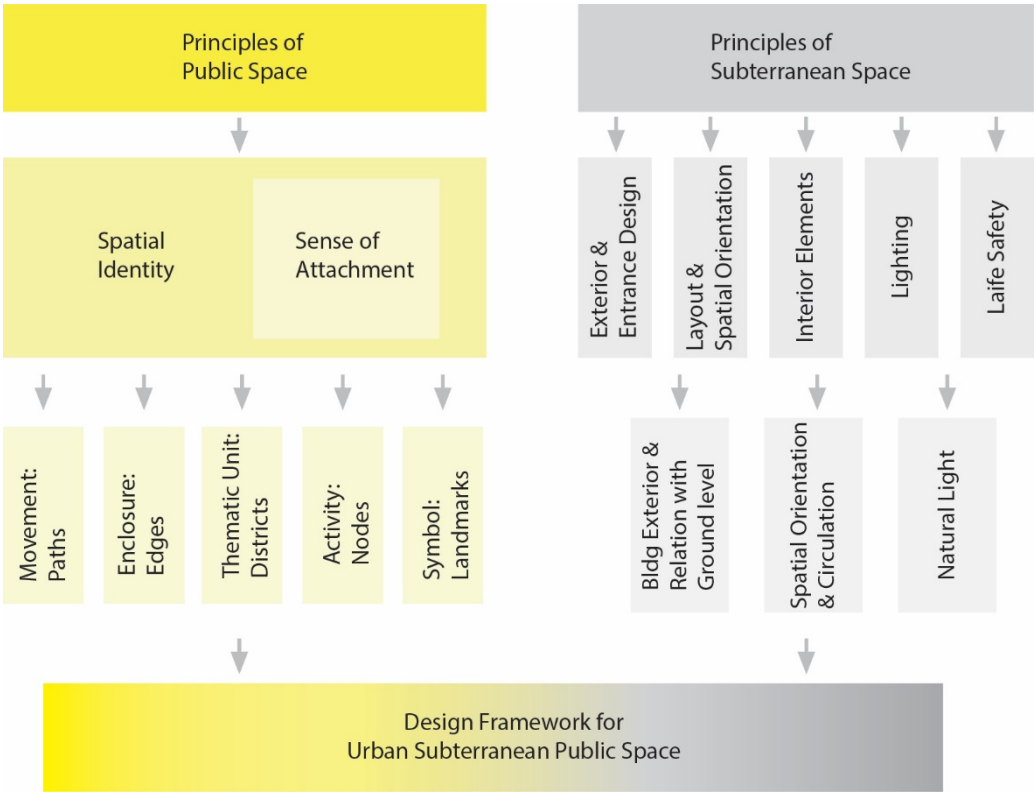


Figure 45. Design Framework

Source: Created by author of thesis, 2018

Following is a description of a design framework explaining how the design work would reflect and proceed in accordance with the framework.

1. The project site is in an area where it requires a public space with diverse uses.
2. The project site is in a heavy populated area and the surrounding environment components should reflect urban context.
3. Design qualities include:
    a) Create a clear pedestrian path from the streets and the path should provide a sequential experience to people throughout the site,
    b) Create distinct edges to give a sense of enclosure by integrating different materials and physical barriers,

c) Design the site with a distinct concept to improve legibility and make the space more attractive,

d) Provide various programs to make the space as destinations of different activities,

e) Create a symbolic element to provide a unique identity of the space. The landmark can be related to the history or culture of the city,

f) The subterranean space should increase the actual useable area of public space without expanding boundary/perimeter of the site boundaries on ground level,

g) The subterranean space should provide some exposed sections to the exterior environment (e.g. courtyard or open stairway),

h) The design should minimize the downward movement as much as possible,

i) The subterranean space should provide clear passages to different directions within the space.

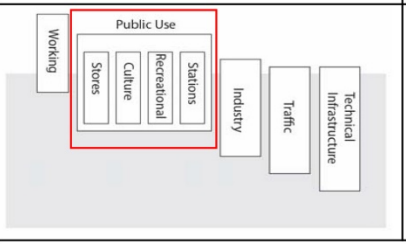
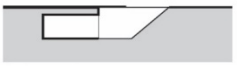
Primary Use/ Function	Use	Depth	Fenestration	Ground Relationship
Non-Residential/ Culture, Commercial	Public Space, Gathering, Event, Stores		 Atrium	 Subgrade

Table 5. Proposed design classification

Source: Created by author of thesis, 2018

VI. Schematic Design

This section shows how this thesis applies design principles into the actual site in New York City. The design process starts from site analysis which includes location, history, zoning code, surrounding context, and climate of the city. Based on the site analysis, this thesis develops programs and specific design works.

1. Site Analysis

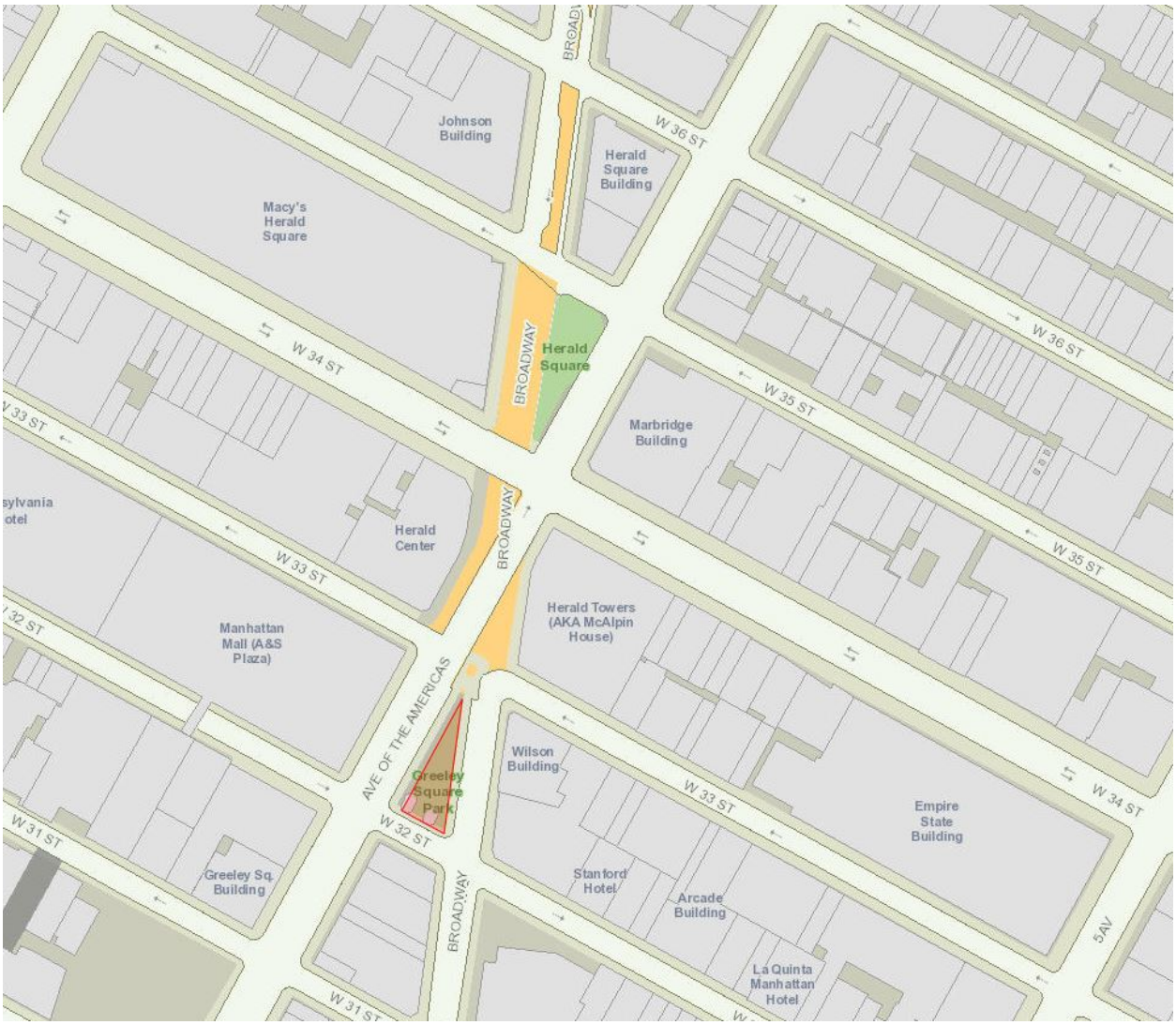


Figure 46. Site: Greely Square (Highlighted with Red Line)

Source: NYC Planning (ZoLa: Zoning and Land Use)
http://gis.nyc.gov/doitt/nycitymap/template?z=8&p=987486,212016&a=ZOLA&c=ZOLA&s=l:Manhattan,834,1,PLUTO

1.1. Location

Greely Square (Figure 46) is located in between West 32nd street and West 33rd street and between Broadway and Sixth Avenue in Midtown Manhattan, New York. It is on the south (downtown) part of the Herald Square which is formed by the intersection of Broadway, Sixth Avenue and 34th street. The intersection is a typical Manhattan bow-tie square that consists of two sections: Harald Square to the north (uptown) and Greely Square to the south. It is a small triangular shape park that is planted with trees and shrubbery (*Herald Square*).

It is located within the 34th street district which includes 31 busy blocks in Manhattan. As the business district, over 100,000 of office workers come into this area daily. Since this district is accessible by several public transportations such as subway, bus, LIRR[7] and New Jersey Transit trains, it serves as a gateway to the city for visitors from New Jersey, Long Island, the entire eastern seaboard as well as tourists from all over the worlds. In addition, it is one of the greatest shopping districts in New York City offering over 175 department stores including, specialty shops and national chain flagships ("The Neighborhood").

On the site, there are two entrances that directly connect to the underground PATH and subway stations: 33rd street and 34th Herald Sq. station. The square is surrounded by Manhattan mall on the West, commercial/office building on the south and Wilson building and Radisson Martinique Hotel building on the east side. North side is facing to the Herald Square with extended open space. Since, the surrounding buildings are quite high with 7-17 stories, the Greely Square provides a nice open area for pedestrian and air circulations.

[7] Long Island Rail Road

1.2. History

Greeley Square is formed by Broadway's diagonal path which forms a bow-tie shape. The northern part of the bow-tie is Herald Square and the southern part is the Greeley Square named after celebrated editor and political leader Horace Greeley. He made the first daily news and launched the New York Tribune ("Greeley Square"). Inside of the park, there is a statue of Greeley created by Alexander Doyle[8]. Around 1990s, the Broadway between 14th Street and Herald Square was the center of the city which was a place for shop, stroll and show off with a line of fancy hotels and theaters ("Broadway at the Turn").

Figure 47.Greeley Square, New York, 1915
Greeley Square and Broadway and the Wilson building, New York City.

Source: Photographer: Chronicle, Contributor: Alamy Stock Photo
(http://www.alamy.com/stock-photo/greeley-square.html)

Since 1992, a Business Improvement District (BID) operated for over 31 blocks in midtown Manhattan by 34 Street Partner Ship (34SP). This project provided benefits of having strong urban parks in the city providing pleasant places for residents, visitors, and office workers to stay (Senville). Urban designer Norman Mintz said, *"Greeley Square used to be a place you*

[8] Alexander Doyle (1857–1922) was an American sculptor. (https://en.wikipedia.org/wiki/Alexander_Doyle)

did not want to go to. Today, you can be hard pressed to find a place to sit during lunch hour."

The 34SP provided sanitary and security services as well as horticultural program. The 34SP also added chairs, tables, and umbrellas to the park (*Herald Square*). Since 2008, a food kiosk has operated by the food vendor, 'wichcraft' serving sandwiches, soups, and salads. In 2009, the Automated Pay Toilet at the park converted into free public facilities which is a rarity in New York City (*Herald Square*).

Figure 48. Greeley Square Park, Greely Square has been extended to northwards Harald Square.

Source: Planners Web (http://plannersweb.com/2010/06/theres-a-good-story-here/)

In 2009, the BID project increased pedestrian space of Broadway between 35th and 42nd streets. By this project, the character of the area had changed dramatically and the pedestrian space provided by Herald and Greeley Square more than doubled. The project also closed vehicular traffic of Broadway between 33rd and 35th Streets to make the pedestrian friendly area (*Herald Square*). By this project, the Greeley Square extended towards Herald Square, northside (Senville).

1.3. Zoning

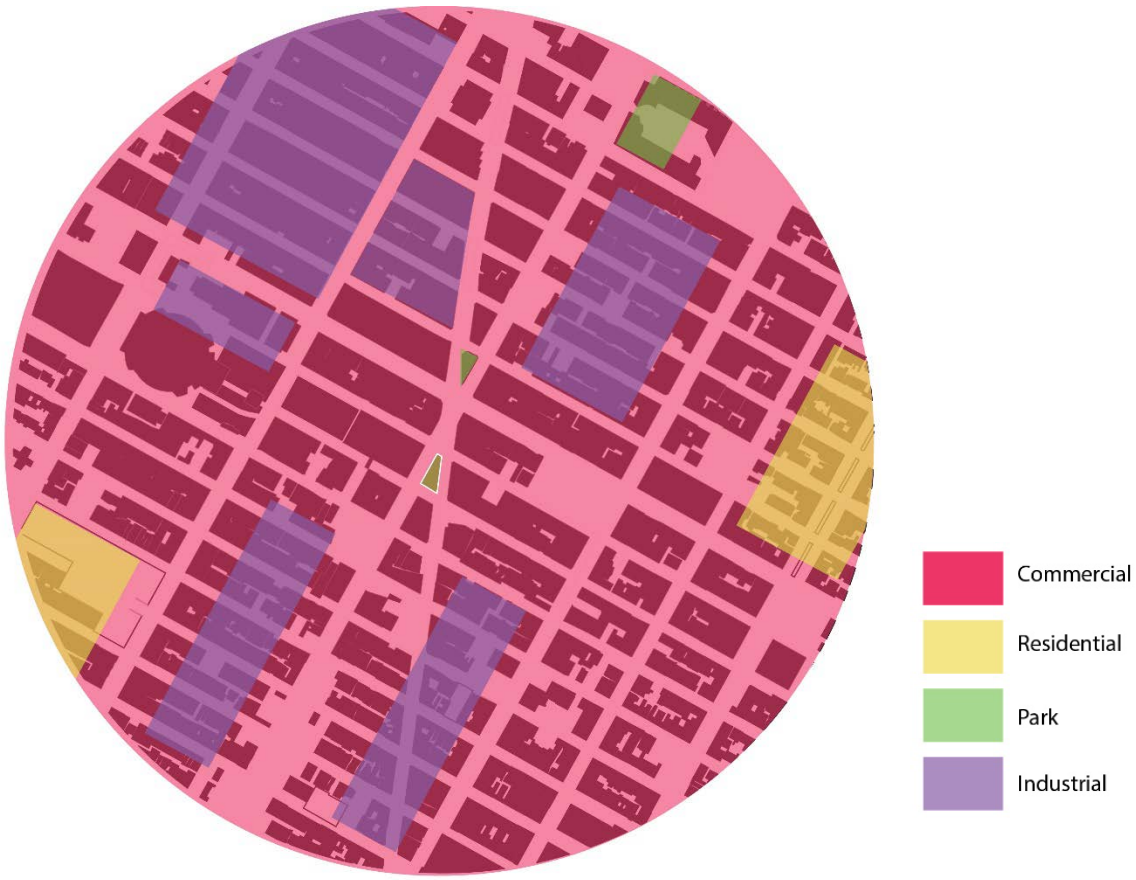


Figure 49. Zoning (Highlighted with white lines)

Source: NYC Oasis (http://www.oasisnyc.net/map.aspx)

Created by author of thesis, 2018

Figure 49 is a zoning map showing 5-mile radius circle around the site. According to the New York City Property Information, the adjacent blocks are mostly under commercial zone. There are some overlapped areas with industry and residential zones. The land use of this area in the commercial and mixed-use categories.

1.4. Urban Context Analysis

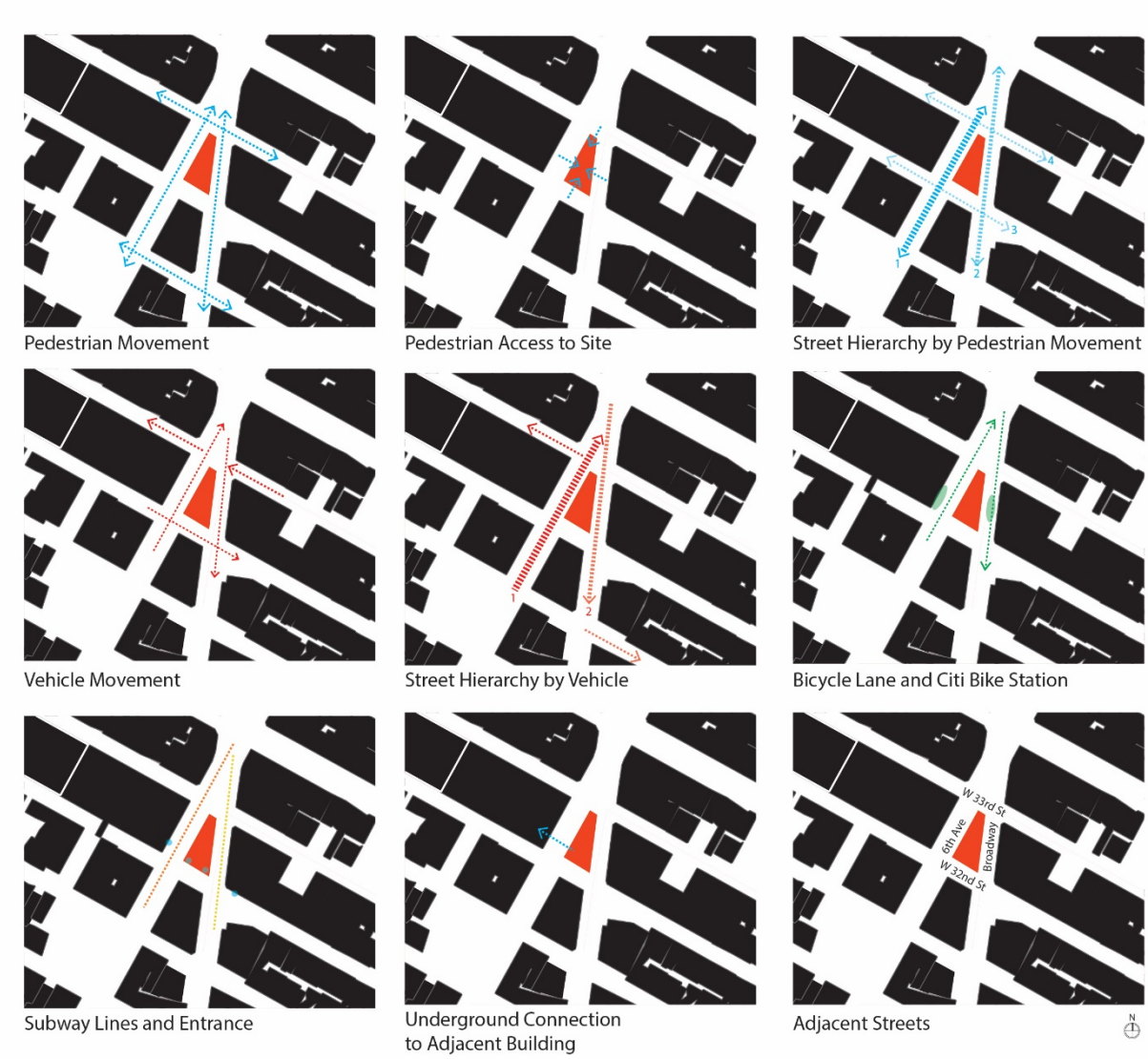


Figure 50. Urban Context Analysis

Source: Created by the author of thesis, 2018

Figure 50 shows the urban context analysis that is mostly focusing on the pedestrian and vehicle movements. First, the site is one of the busiest area in New York City due to the adjacent shopping district and office buildings. Since the BID project in 2009, pedestrian zone has been extended toward northern side so that the pedestrian movement has been increasing. Not only that, this extended pedestrian only zone visually and physically connects the Greeley Square to

the Herald Square Park on north side therefore, the entire area is pedestrian friendly encouraging people to walk and use public transportation. In addition, Greeley Square provides entrances from all adjacent streets which invite more people into the site. While the 6th avenue has the heaviest pedestrian traffic among the adjacent streets, it has the narrowest sidewalk. Therefore, Greeley Square allows people to pass through the park providing safer and pleasant pedestrian experience.

The vehicle movement around the site is also quite busy. With four vehicle lanes, the 6th avenue has the heaviest traffic movement in this area. Since west 33rd street has redesigned for pedestrian only zone, the traffic flows on west 33th street has been reorganized. The vehicle flow from east towards west has blocked so cars from east 33th street are only able to make a left turn to Broadway. Compare to 6th avenue, Broadway has two traffic lanes and narrower sidewalk so the vehicle speed is slower than the 6th avenue. With the vehicle flow from west 33rd street and heavy pedestrian Broadway is always crowded.

The planning of this area encourages people to walk and use bicycles and public transportation more. Both 6th avenue and Broadway dedicate one traffic lane to the Citi Bike station and bicycle lane so bicyclists can travel without sharing lanes with vehicles. In addition, there are two subway entrances on the site which connect to the PATH trains and MTA subway lines. Most people visiting this area use either PATH trains or subway so the underground subway station has several exits leading people to different directions and one exit directly connects to the Manhattan mall on 6th avenue.

Based on the observations, Greeley Square plays an important role as path, node, or landmark. It provides a place for resting, eating, meeting people and transportation. It is a

valuable public space in urban environment but it needs more space to serve current growing pedestrian flow. In addition, with its proximity to subway station, it has a great potential to develop more programs which can support the existing subway station and public space above. From this urban analysis, this project identified that there is a possibility to develop a subterranean space which connects the existing underground subway station and public space at ground level by adding more space and programs in urban context.

1.5. Climate

New York has a typical continental climate with cold, snowy winters and hot, dry summers *(Climates to Travel)*. New York City is located on the coast but it is also located on the edge of a continent that makes a cold winter and heats up in summer. Due to the cold air from Canada and the warm air flows from the Gulf of Mexico, New York City has an unstable climate with an alternation of bad weather and clear and sunny days. The city receives the abundant rain falls, more than 47 inches per year *(Climates to Travel)*. One noticeable point of climate in New York city is that when it compares to other cities, New York City generates low Greenhouse gas emission on a per capita due to the use of mass transit. However, the urbanization in the city allows an urban heat island effect which raises temperature in all seasons (*Climate of New York*).

During the winter seasons (December to February), the average temperature in New York City is about 32 °F which is just above freezing but the temperature drops to about 5-14 °F normally. New York City also gets a lot of snow with some serious snowstorms. On average, they city gets about 15 inches annually.

Summer in New York City (June to August) is warm with abundant of sunshine. There are some alternative weathers in summer as well with some afternoon thunderstorms. The

average temperature is around 73-77 °F and often times, the temperature rises. When heat waves occur, the temperature reaches to 95-100 °F *(Climates to Travel)*.

Spring in New York City (March to May) is also unstable due to the warm days return to cold days. It can get snow in March and maybe in early April. The temperature become pleasant in May with some cold days and rainy days *(Climates to Travel)*.

Fall in New York City (September to November) is the mildest season among four seasons. In early September, the weather is still close to summer with heat, humidity, and afternoon thunderstorms. Mid October, the first cold day starts and then by the end of November the weather gets cold and receive the first snowfalls. New York City gets abundant rainfall in this season *(Climates to Travel)*.

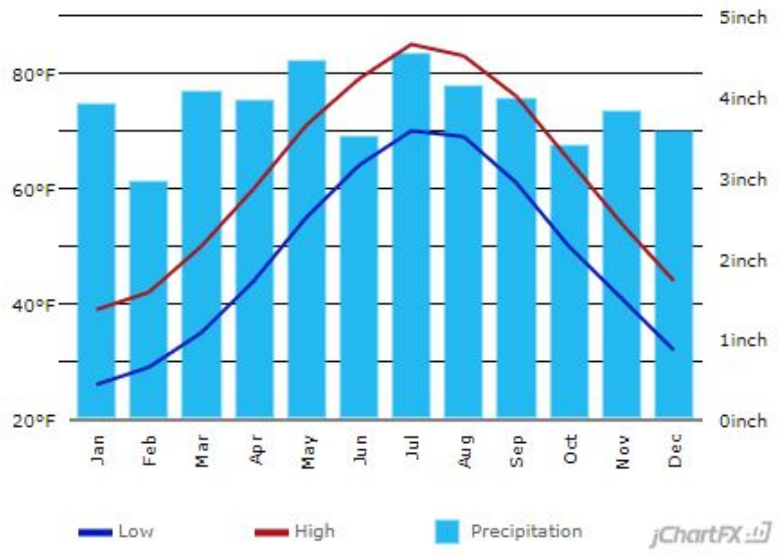


Figure 51. New York Climate Graph - New York Climate Chart

Source: U.S. climate date, https://www.usclimatedata.com/climate/new-york/new-york/united-states/usny0996

Based on the climate analysis, this project considers and reflects the climate of New York City. The underground public space can provide relatively stable temperature with a protection from unpredictable changes such as occasional shower and snow. The central courtyard helps to

ventilate the air during the summer and bring the sunlight in winter to illuminate and heat up the underground space.

2. Background idea

2.1. Abstract diagram

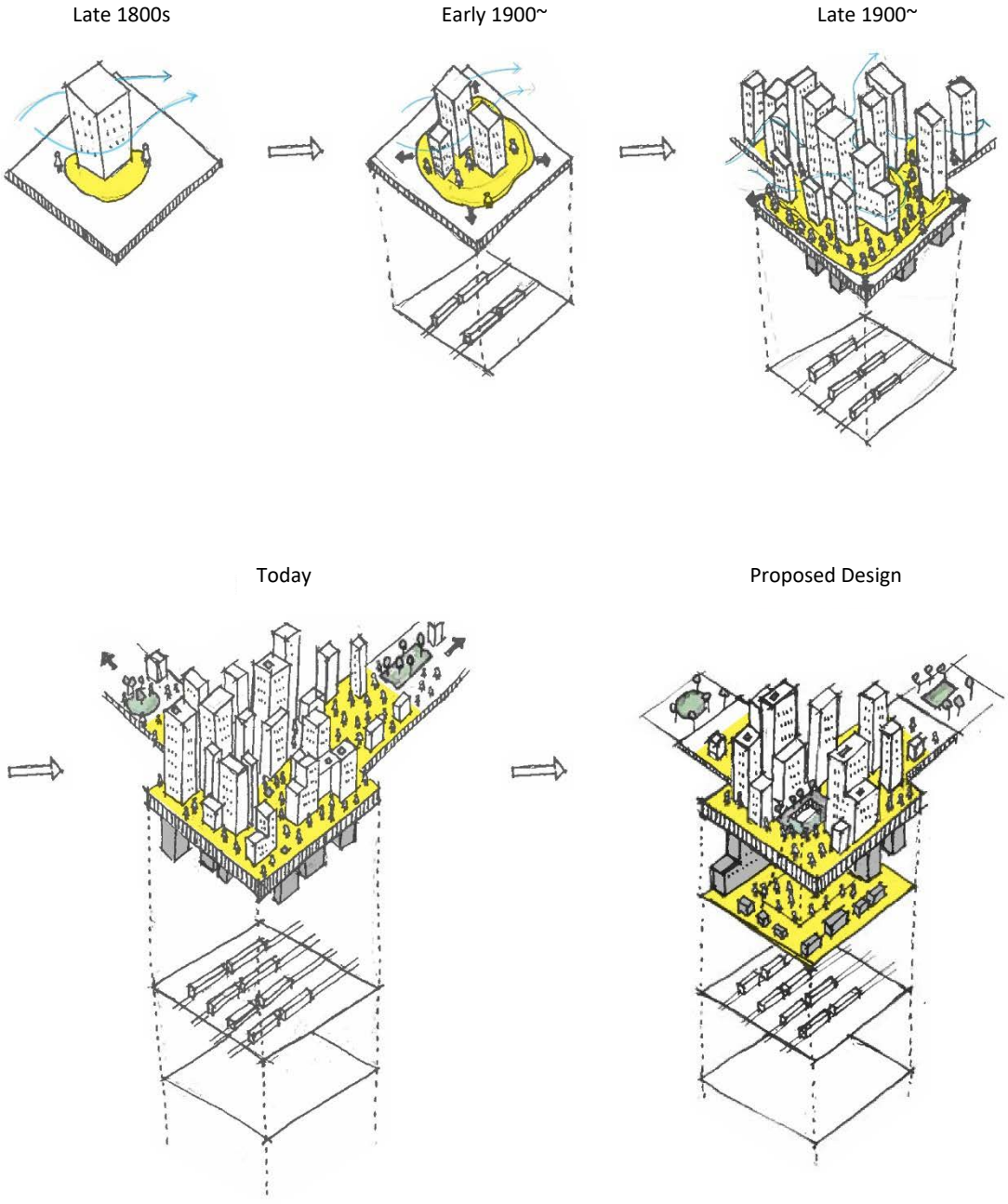


Figure 52. Abstract Diagram

Source: Author of thesis, 2018

Figure 52 presents the fundamental idea of this thesis. According to the 1790 census, 95% of population lived in rural areas and only 5% of Americans lived in urban areas ("Urbanization of America"). Since late 1800s, the industrial revolution has made changes in all kinds of industries and the architecture was also one of the fields have changed in response to the new wave. Since the number of jobs increased in the city, the population in the city increased as well ("Changes in American"). In 1885, the first 10 story skyscraper was built in Chicago. By 1890, industrialization made changes in cities and 35% of American population lived in urban settings. As time goes by cities have been occupied with buildings and people, and by 1990, three out of four people lived in cities ("Urbanization of America"). By 2000, the number of mega cities have nearly tripled since 1990. In 2007, the global urban population surpassed the global rural population and by 2050, 7 out of 10 people will live in urban area (United Nations 31). The rapid growth of urban population has brought a result of urbanization and with this trend, cities expanding its boundaries in accordance with the rising demands for more infrastructure.

This thesis proposed an urban subterranean public space in response to the compact and sustainable urban development. As the quality of living standard gets higher, the city needs to provide a better public life to residents. The urban underground space has a great opportunity to establish both horizontal and vertical city developments with careful considerations.

2.2. Form and program study

2.2.1. Form development

The existing site needs to add an opening to make a physical connection to the underground level. The shape of opening was determined in response to the circulation flow in the trapezoid shape of the site. When the opening follows the trapezoid form, the circulation flow

naturally creates corner spaces which are not usable. On the other hand, when the opening is a circular shape, the circulation pattern can fully follow the edge of opening which allows more natural circulation paths than the trapezoid one. In addition, the circular opening helps to distribute the natural light into the underground space evenly since the sunlight does not hit the corners.

Creating a strong connection between ground and underground levels starts from making a physical connection and this thesis proposed a circular ramp with a low slop stair. The circular shape helps to create a ramp with gradual angle changes. Figure 53 shows circulation flow at the ground level and the possible opening options.

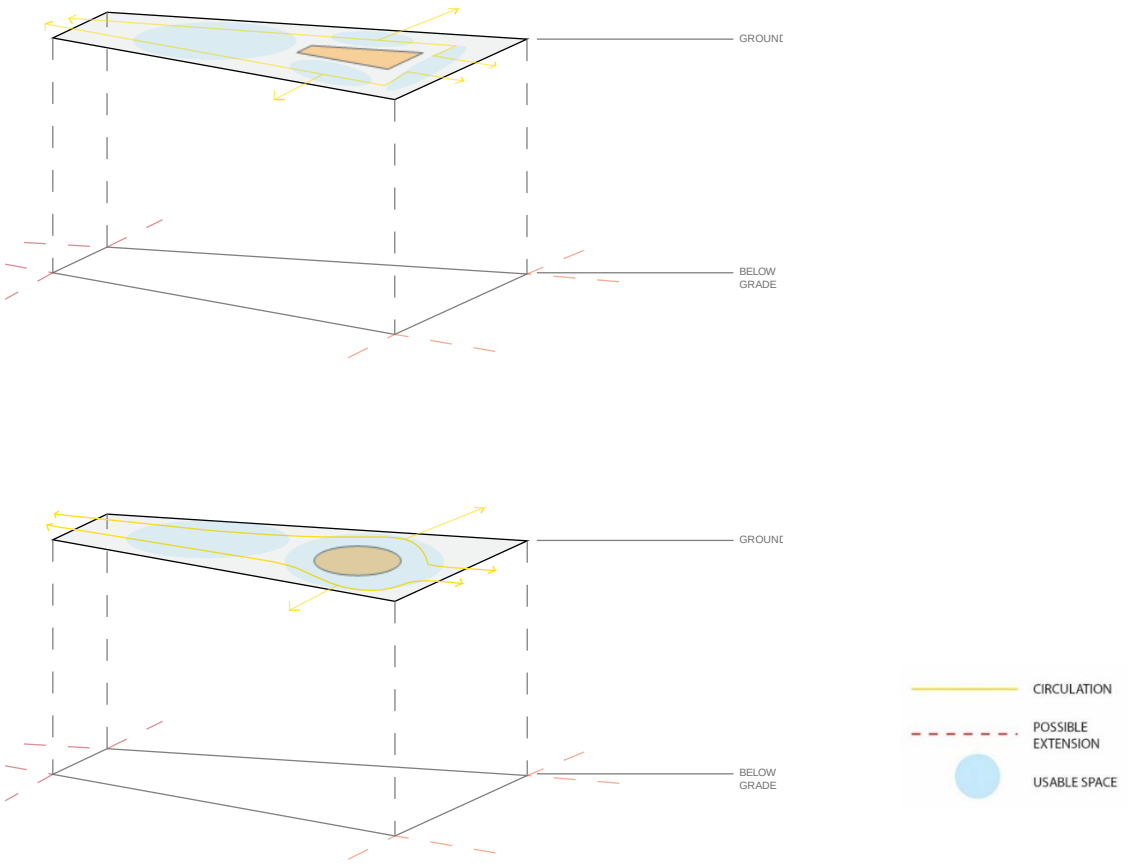


Figure 53. Form Study

Source: Author of thesis, 2018

2.2.2. Programs

According to the zoning map of New York City, current land use of the site is park/ green space. Greeley Square is surrounded by commercial buildings including retail shops, restaurants, and office buildings. As an open public space, it provides a space for lunch breaks, meetings, and other activities. The existing park provides tables and chairs that people can move freely to make their own seating areas. In addition, the site includes PATH train and subway stations on the site, so the Greeley Square is a node that attracts people for diverse activities.

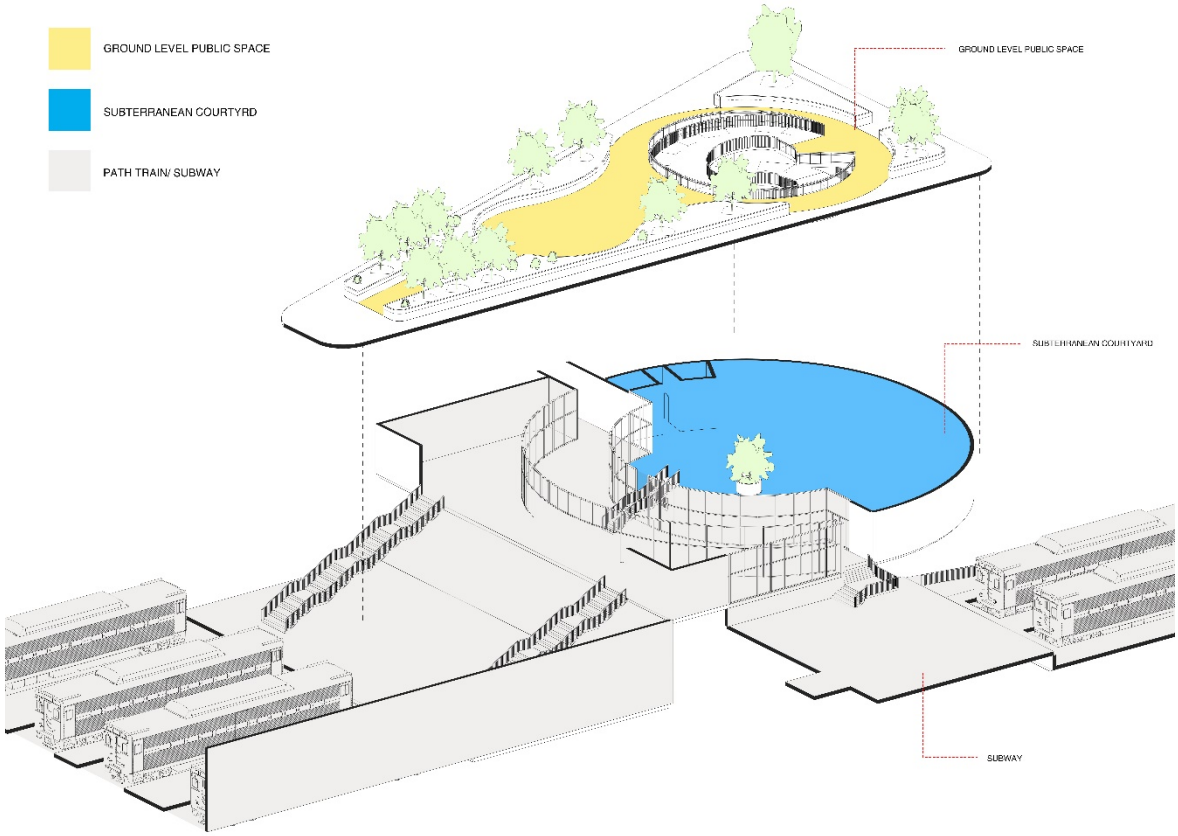


Figure 54. Proposed design by floor

Source: Author of thesis, 2018

Figure 54 shows a proposed design and its composition by floor. The ground level is an existing public space with tables and plants. The underground space is the proposed design which is a transitional space between the ground level and underground train platforms. The underground space reflects the circular opening on the above level to continue the pedestrian circulation and some new programs will be added to continue the same context from the ground level.

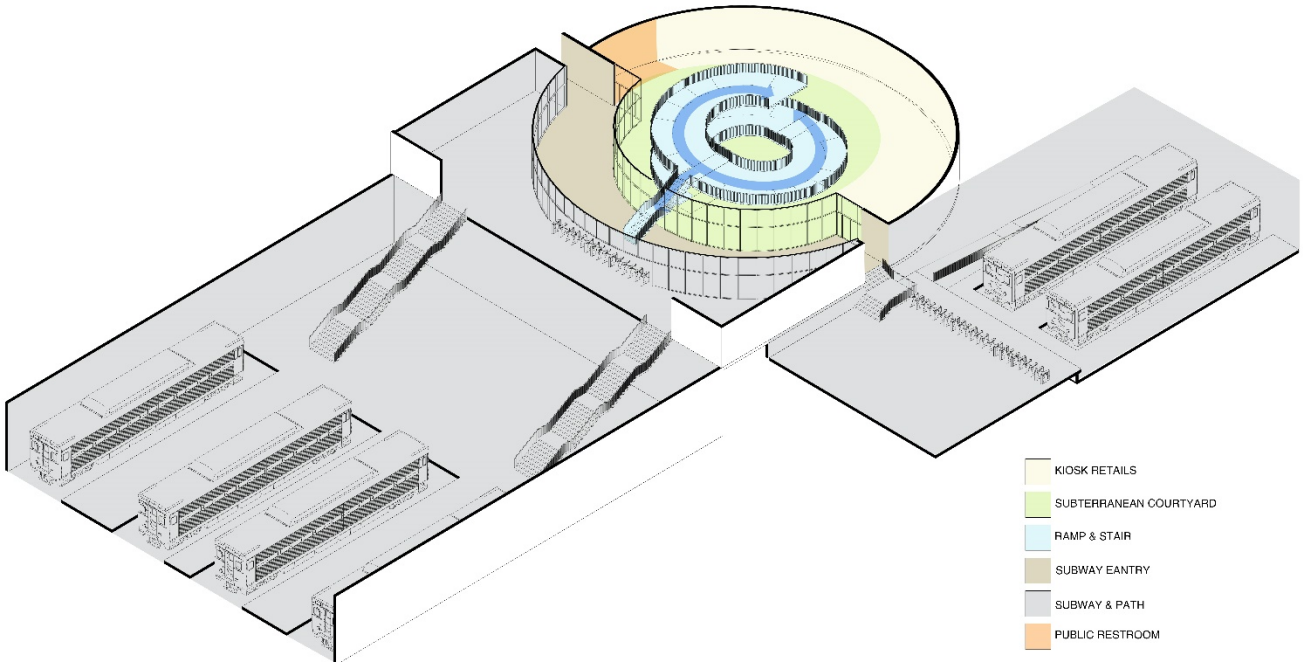


Figure 55. Programs in subterranean space

Source: Author of thesis, 2018

Figure 55 shows programs within the subterranean public space. It includes kiosk retails, open courtyards which are multi-functional, restrooms and entrance to the subway station. The programs are arranged along the ramp making a clear pedestrian flow within the space. The type of kiosk retails varies based on the seasons. They are located under the grade slab which can be classified as semi outdoor space and this helps them to activate all year round with central outdoor courtyard.

Figure 56 shows the composition of programs in a section view. The entire site is the Greeley Square Park which is a pedestrian only zone. The subterranean space located right underneath of the park with combination of existing subway stations and new programs such as open courtyard and kiosk retails.

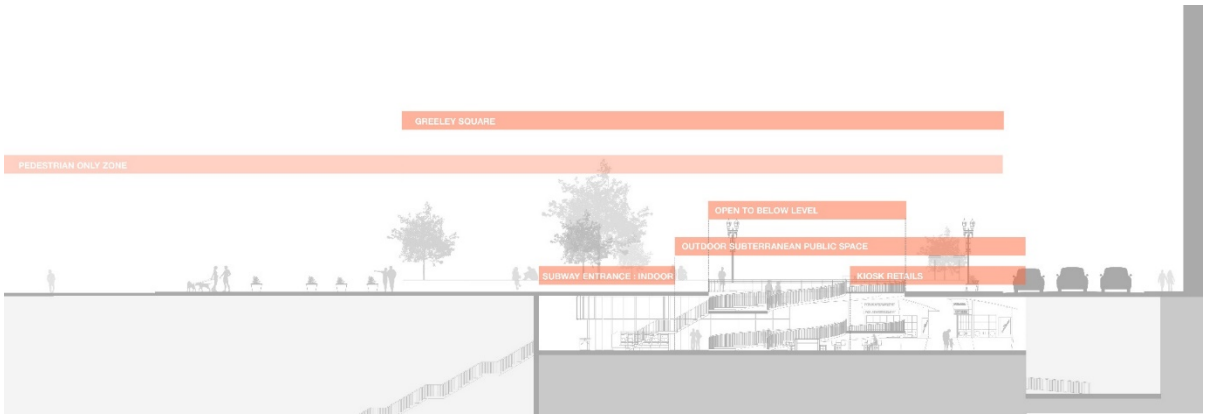


Figure 56. Section view: programs

Source: Author of thesis, 2018

3. Proposed Design

3.1. Site Plan

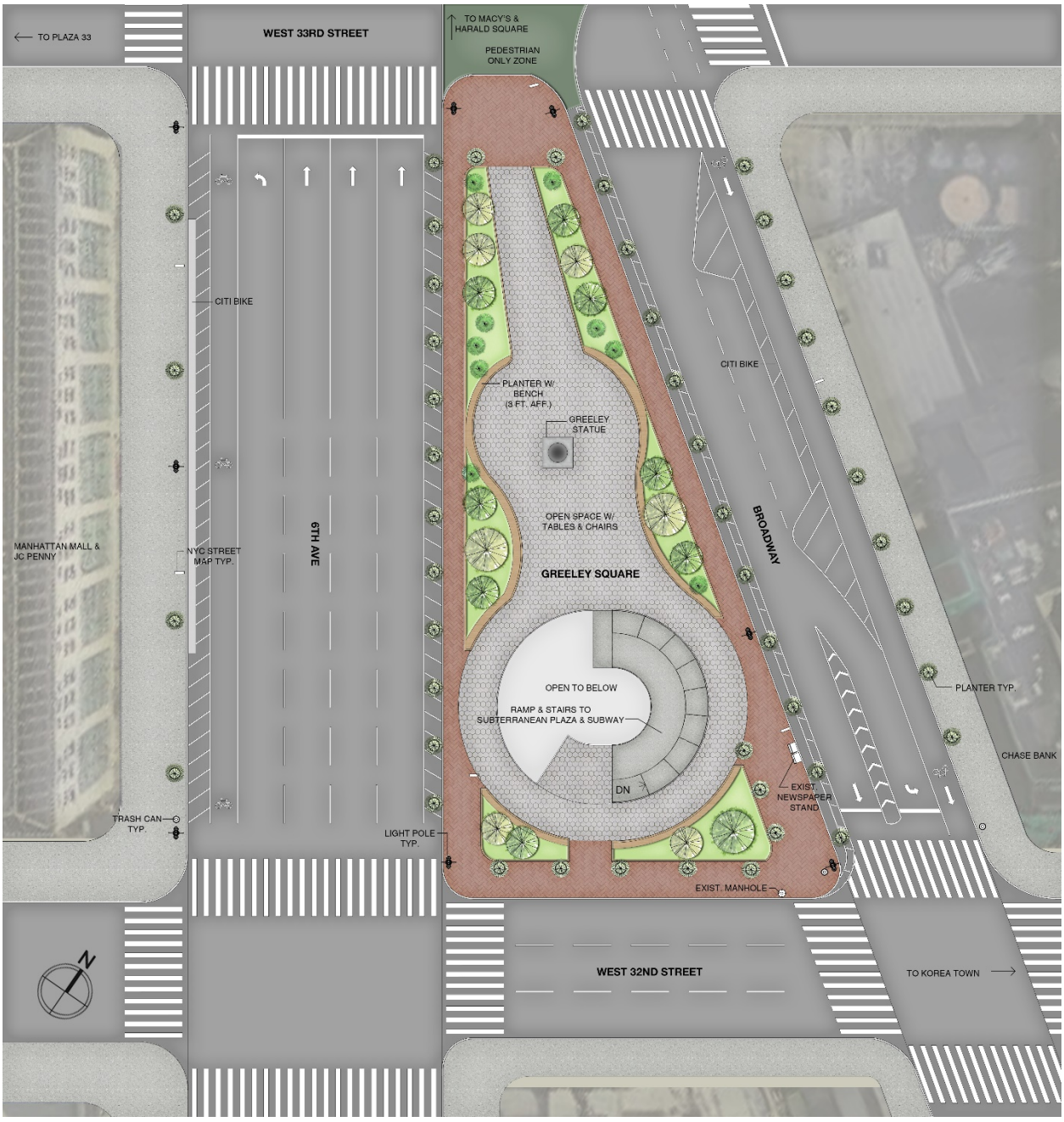


Figure 57. Site plan, N-T-S

Source: Author of thesis, 2018

Figure 57 shows a proposed site plan illustrating the Greeley Square on ground level. It maintains the existing planters on each side to indicate the edge of an open space. In addition, different pavements create a clear edge between park and the sidewalk. The existing Greeley statue is located on the center of the park creating a landmark representing the history of the site. Not only that, it naturally arranges the pedestrian circulation by dividing the pedestrian flows. With the extended pedestrian zone on the West 33rd street, the area has become a safe and an enjoyable walking district. Table 6 describes the application of five elements of the city image by Kevin Lynch.

5 elements of the city	**Paths**	**Edges**	**Nodes**	**Districts**	**Landmark**
Description	Movement	Enclosure	Activity	Thematic unit	Symbol
Application	Pedestrian friendly environment, Pedestrian path on the ground level and transportation path underground,	Physical barrier by landscaping, Visual separation by different pavements, Enclosed outdoor subterranean courtyard	Node for different activities, Multiple activates can occur at the same time: eat, relaxing, performance, selling, buying from vendor, public transportation	The entire site represents pedestrian friendly district, Underground public space, Two different districts in proposed design: ground level and underground level.	Greeley Statue: Symbolic representation, relate to the history of the site

Table 6. Five elements of the city and design application

Source: Author of thesis, 2018

3.2. Subterranean Courtyard Plan

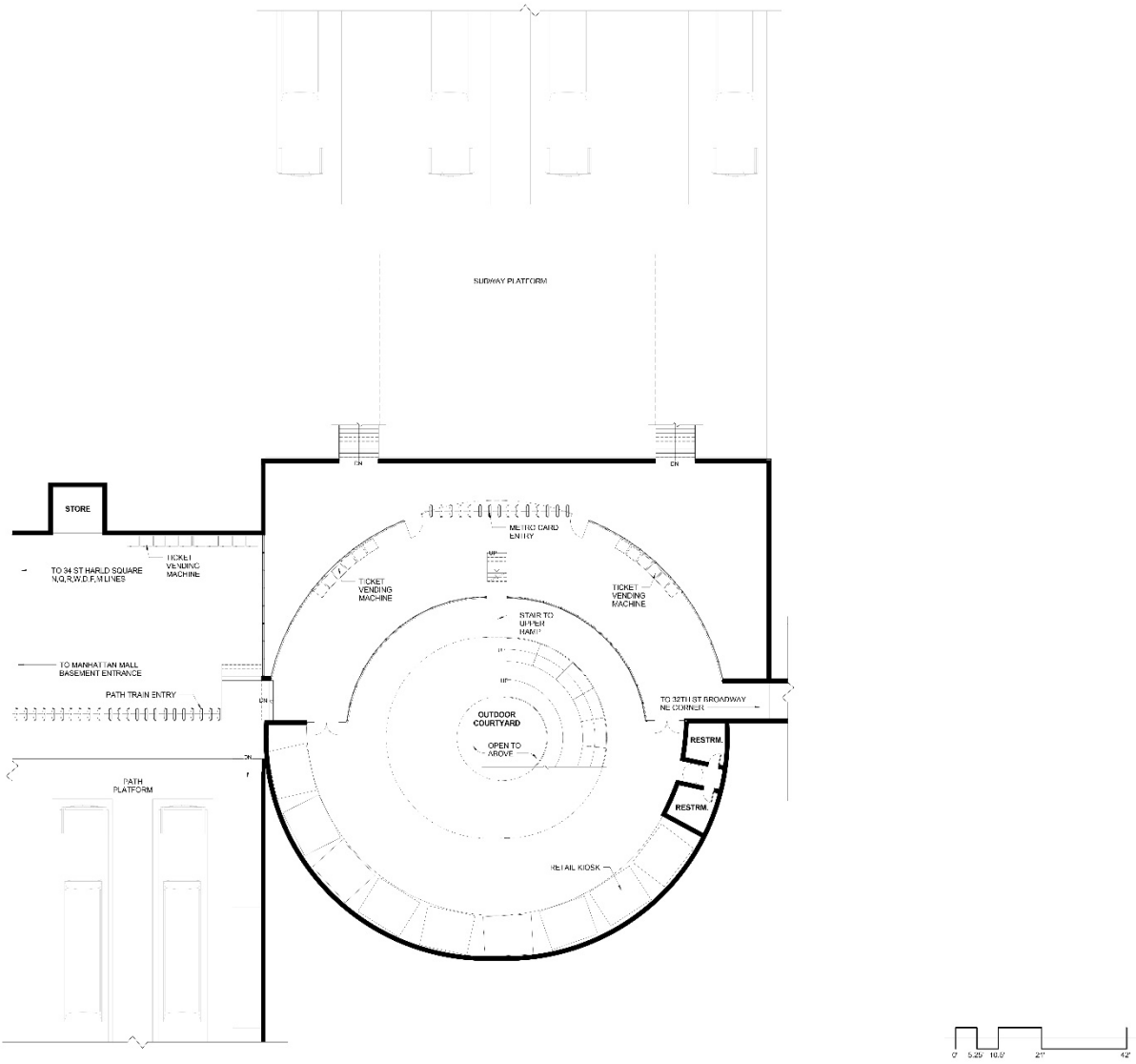


Figure 58. Subterranean Courtyard Plan

Source: Author of thesis, 2018

Figure 58 is the proposed subterranean courtyard plan. The spiral ramp from the ground level is located on the center of the courtyard naturally creating a circular pedestrian flow in the space. The stair from the ramp directly connects to the subway station inside so the subway users

do not need to come all the way down to the courtyard space. By making a secondary entrance for the subway riders, the courtyard space can be less crowded. The subterranean courtyard includes kiosk retails on the opposite side of the subway entrance. They can be food kiosks or miscellaneous item shops. Due to their simple settings, they can change the selling items based on season, time, and themes for special occasions thus, the entire space can be activated all year around. For example, during summer, the center of courtyard can be used for music or art performances and the rest of the area can be used for audiences. During the winter time, the kiosk shops still operate because they can be protected from cold weather by the ground plate.

The open courtyard space not only receive the natural light from above level but also provide a view towards the ground environment decreasing the negative feelings of underground space. The circular shape of space does not create any small corner spots in which can block the travel of light throughout the space. Therefore, daylight can consistently illuminate the subterranean space. In addition, the simple layout of the space lessens some psychological concerns such as sense of lost or isolation in the space. The gradual slop of ramp minimizes the feeling of moving downward and when people arrive the underground level, they can go into the subway station as they walk into the regular building entrance on the ground level.

3.3. Existing Site Section

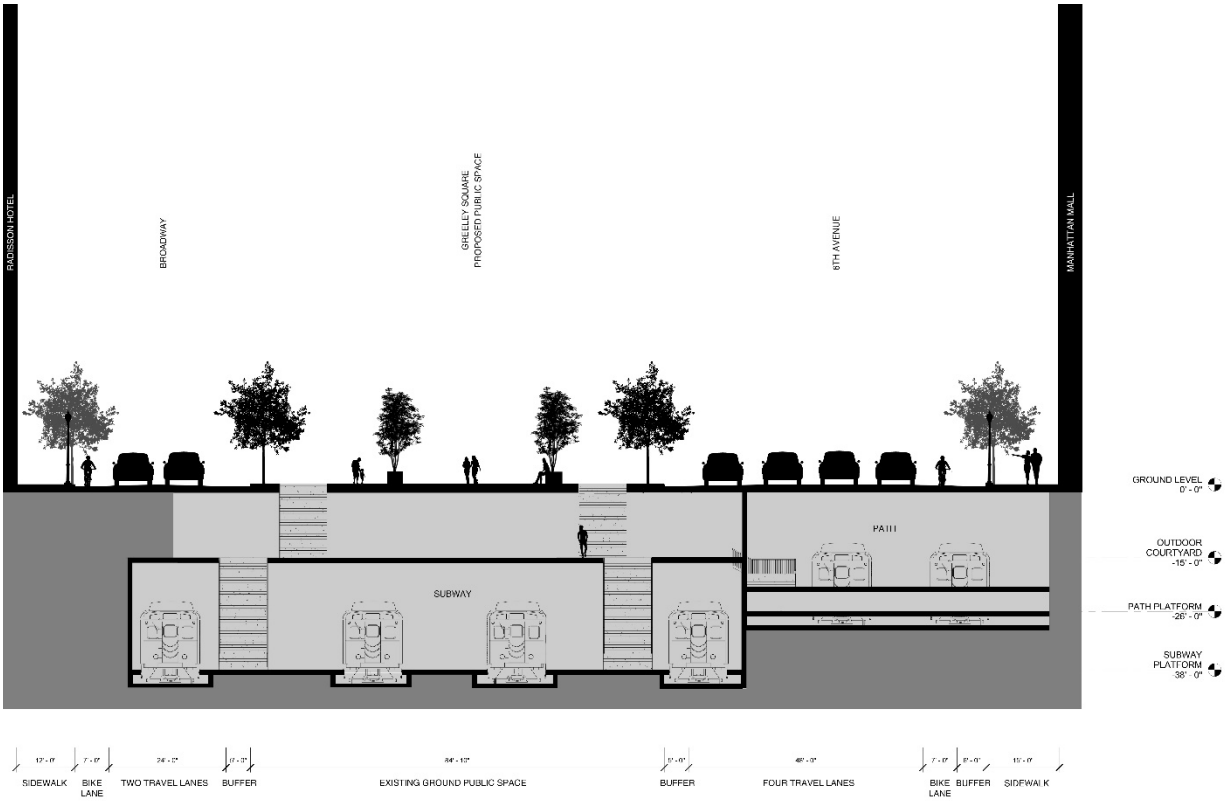


Figure 59. Existing Site Section

Source: Author of thesis, 2018

Current underground space usage of site is mainly for the PATH train and subway systems. It also includes an entrance to the Manhattan mall on the 6th avenue. However, without any relationships with the ground environment except the stairs, the ground environment and underground spaces are completely separated and are treated as two different worlds. The dark and downward movement of stairs do not provide any pleasant feelings of going into the underground space.

The Greeley Square on the ground level provides a great open space for public with some outdoor furniture and trees. It is almost like an island surrounded by tall buildings in midtown

Manhattan. While the Greeley Square is a great refreshing spot within the city, due to its locational benefits, the park is always crowded with people and moveable outdoor furniture. In addition, although the planters and fence along the edge of the park function as barriers from adjacent roads, they also block the views and hide the park from the surroundings.

The existing Greeley Square provides a safe and pleasant pedestrian experience however, it is a relatively small space and it may need some more rooms for other programs. In addition, with a connection to the underground public transportation, the park can be a more active public space.

3.4. Proposed Design Section

Figure 60. Proposed design section

Source: Author of thesis, 2018

Figure 60 and 61 show sections of proposed design. Instead of stairs, with the 15 feet wide ramp, the underground space is connected to the ground level and a part of underground space is exposed to the outdoor environment. As a transitional space between ground environment and subway stations, the subterranean court yard space helps to release some stresses of moving downward. The Greeley square on the ground level still provides a great open space to the public, it adds more spaces underneath of it. Half of open courtyard is surrounded by kiosk retails which make the courtyard space to be more stimulated.

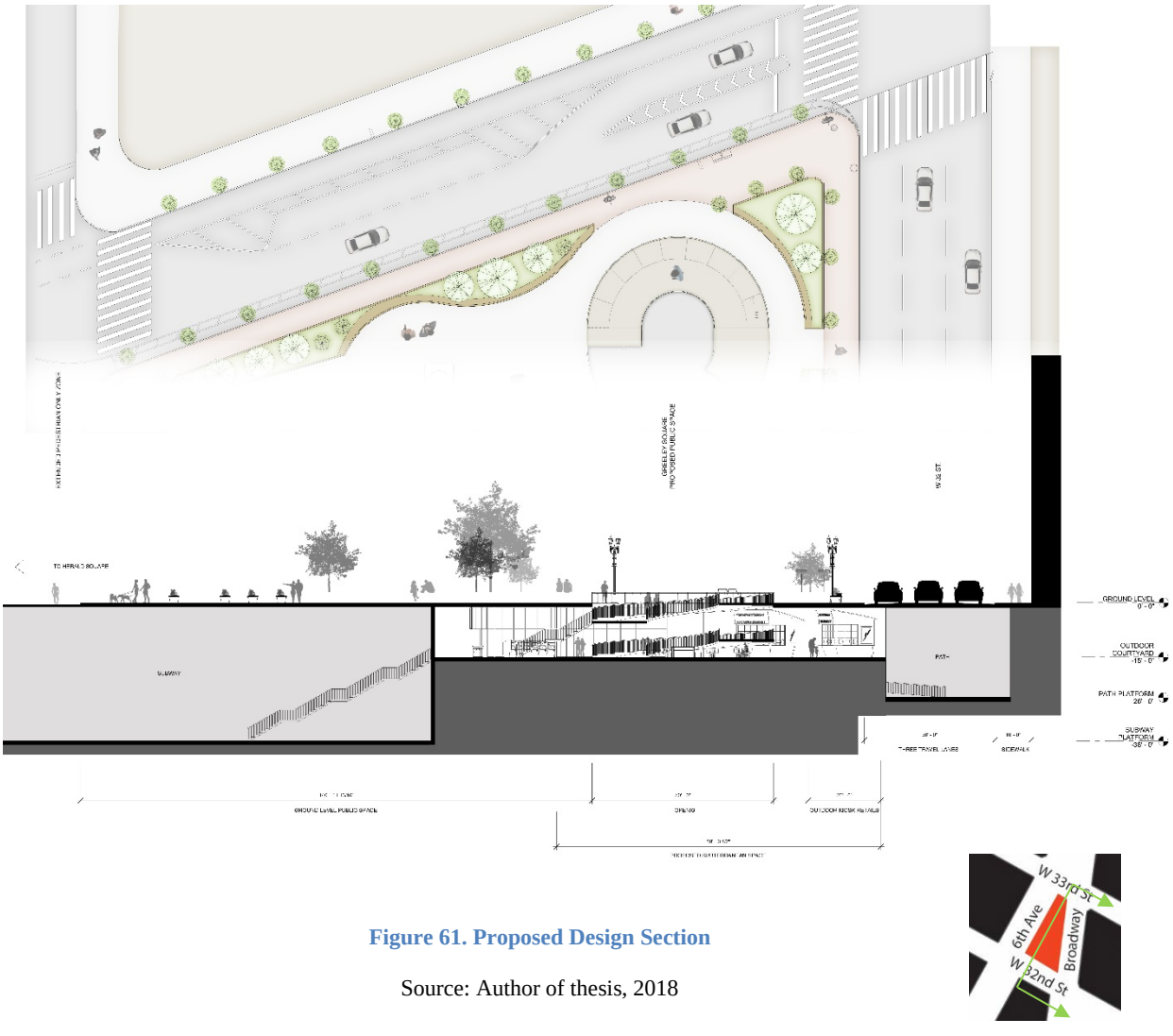


Figure 61. Proposed Design Section

Source: Author of thesis, 2018

3.5. 3D Views

Figure 62. 3D view 1: Ground level public space

Source: Author of thesis, 2018

Figure 63. 3D view 2: Ground level public space

Source: Author of thesis, 2018

Figure 64. 3D view 3: Ground level public space

Source: Author of thesis, 2018

Figure 65. 3D view 4: Subterranean public space

Source: Author of thesis, 2018

Figure 66. 3D view 5: Subterranean public space: summer

Source: Author of thesis, 2018

Figure 67. 3D view: Subterrranean public space: winter

Source: Author of thesis, 2018

3.6. Design Outcome

3.6.1. Existing vs. Proposed Design

	Existing	Proposed Design	Differences
# of Tables	100 (Only ground level)	120 (Ground level: 50, Underground: 70)	(+) 20
Area (SF)	6,300 SF (Only ground level) Source: NYC Oasis map	11,255 SF (Groud level - Opening + Underground Courtyard)	(+) 4,955 SF (80%)

Table 7. Existing vs. Proposed design

Source: Author of thesis, 2018

Table 7 presents the quantitative difference between the existing condition and proposed design. Existing Greeley Square provides tables and chairs that people can move and it will depend on their needs. Based on my observation, the existing site is equipped with about 100 of tables. The proposed design can place about 120 tables based on the BIM model (Revit). While the distance between tables are very close in the actual site, the BIM model it allocates a certain distance between tables. Therefore, the proposed design may add more tables.

In addition, the total area of the actual site is about 6,300 SF (Figure 68) based on the NYC Oasis map. The total area of the proposed design is 11,255 SF which was measured from the BIM model. The results of the proposed design have about 80% more space than the existing site. This area includes ground level public spaces and the entire subterranean courtyard. This result shows that the proposed design can provide extra space for more programs in the site without horizontal expansion. Even though, the actual application needs some more considerations regarding building code, budget and existing site conditions, the underground space can be a strong potential solution to solve the shortage of space in urban environment.

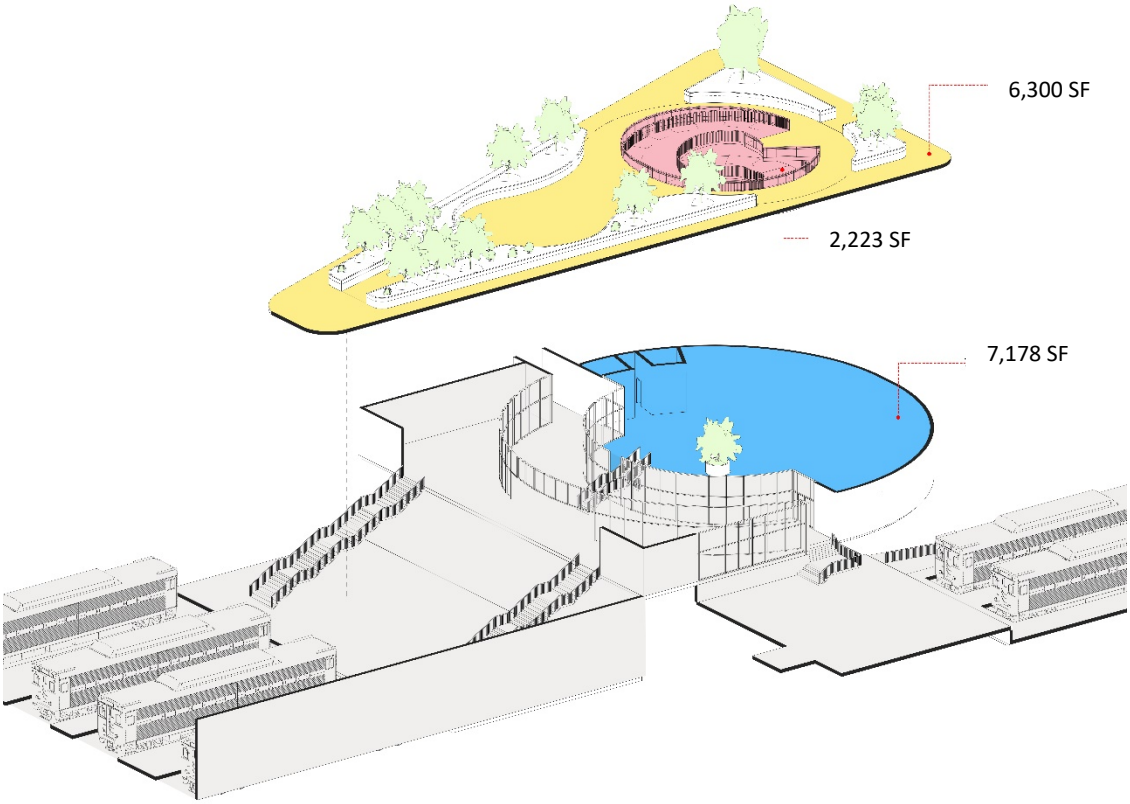


Figure 68. Area of propose design

Source: Author of thesis, 2018

3.6.2. Protection from Surrounding Noise and Pollutant

Figure 69 illustrates the protection from surrounding noise and pollutant. The existing site is surrounded by fence functioning as the physical barrier between and the site. Even though, they can separate the site from adjacent streets, inside of the park is still exposed to the surrounding noise and pollutant from vehicles. The proposed design still has the same condition on the ground level however, the subterranean public space can be separated from the adjacent streets and protect the public space from the surrounding noise and pollutants. In addition, the underground space can be a shelter for unexpected weather conditions in New York City.

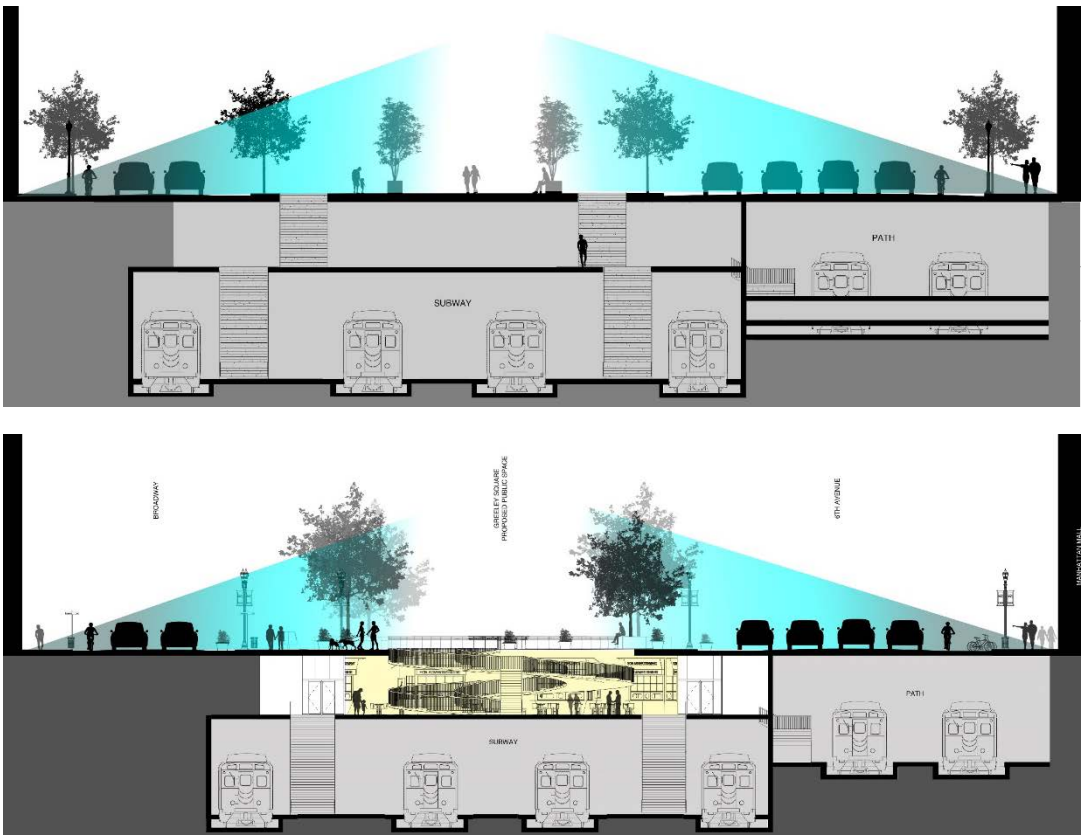


Figure 69. Protection from surrounding noise and pollutant

Source: Author of thesis, 2018

3.6.3. Application of Precedent Study

Based on the precedent study of Washington Square Park, this thesis attempts to apply the survey questions to the proposed design. First, the expected time that people would stay at the proposed space is showed in figure 70. Most people would stay at the park one or less than one hour which means the proposed public space can be used for quick break or lunch spot. Also, it could be a meeting spot or path for underground public transportation. Some people may stay at the park for an hour or more which means the park can be used for special activities such as performance or occasional events. People who stay at the proposed public space for 6 hours or more could be vendors for the kiosk shops. Even though, their kiosks are located underground,

during their work hours, they still can see the ground environment and receive the daylight through the opening.

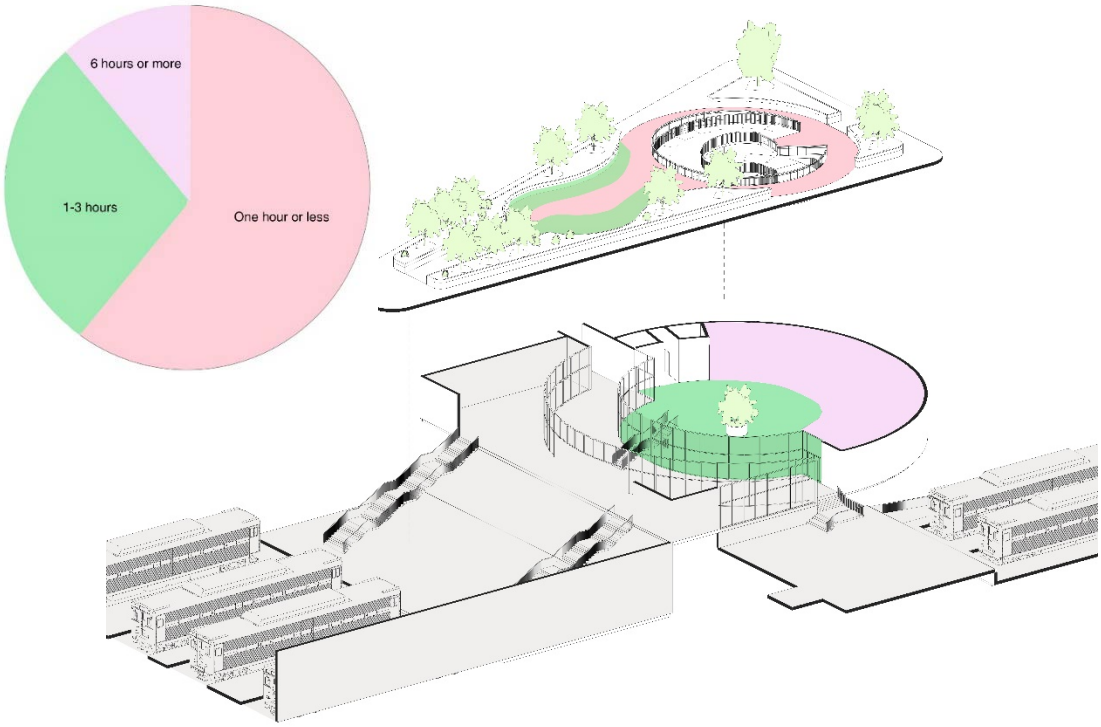


Figure 70. How long do you plan to stay in the park?

Source: Author of thesis, 2018

Next observation are some possible activities in the proposed public space (Figure 71). Socializing is the representative activity that occurs throughout the proposed public space. It is a place for meeting, mingling and communication with others. Other common activities are eating, picnic or watching performances. The proposed design is a node for various activities. It includes spaces for eating, seating or performance so different activities can occur at the same time. Buying from vendor is another important activity that helps the space to stimulate all the time.

While there are some occasional events on the ground level during the summer such as food festival, the underground kiosk shops can open all around year based on season or theme.

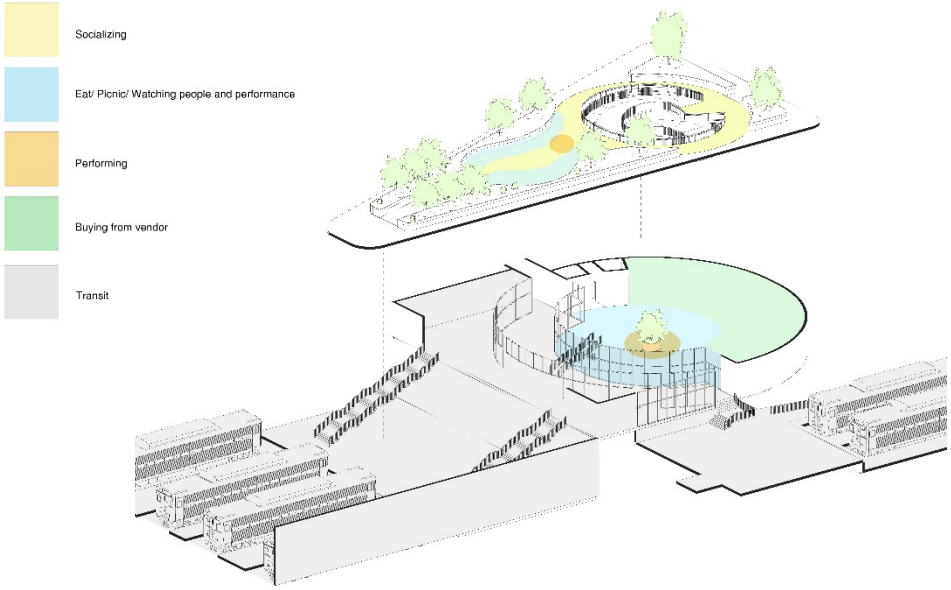


Figure 71. Park activities

Source: Author of thesis, 2018

3.6.4. Possible sites in New York City

Once the concept of urban subterranean public space has established, this thesis looks for other possible sites in New York City that can be applied with the same concept. First possible site is Time Square. It is one of the most popular tourist attractions and public spaces in New York City. Even though the area is quite spacious, pedestrian friendly, it is always crowded with people, shops, restaurant, hotels, and office buildings. Therefore, this subterranean public space can be applied into this area to provide more space for people and to connect the adjacent subway stations, hotels, and shops together in which may help to separate the heavy pedestrian flow. Like the Greeley Square, Time Square also provides movable tables and chairs for public.

If some people sit and stay at the Time Square for a while, then other people may use the underground public space without passing through the crowded ground public space. Another possible site is Madison Square. It is adjacent to the Madison Square Park. If this underground concept is applied to this area, it may add some more programs which connects the park and the ground space and the park can be used during winter seasons. Herald Square is located right above the Greeley Square therefore, it has a great potential to join these two public spaces at both ground and underground levels. Since the ground level is already connected by pedestrian zone, with the underground pedestrian passage, the entire are could be a more dynamic public space. The Plaza 33 is also an existing public space in Manhattan. It is a new public space located on the east side of 33rd street between 7th and 8th avenue. The entire block has been converted to pedestrian zone providing open space for public. With the outdoor plaza of Madison Square Garden building, it is a great relaxing spot for office workers and tourists. It also has some outdoor sculptures making the area more interesting. If the underground public space is applied to this area, it could make a connection to the adjacent Penn station also add more retail spaces along with the Pennsy Food Hall which is a food court in Madison Square Garden building. Moreover, current entertainment programs offering in this plaza are mostly in warm seasons, therefore, with the underground space, the Plaza 33 can be used for all year round.

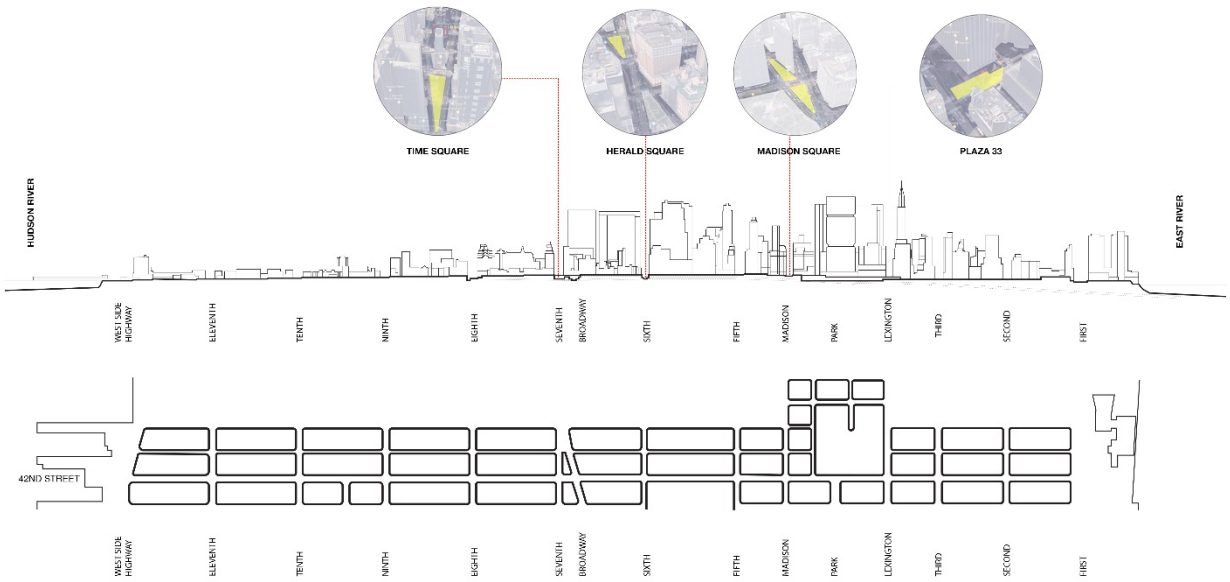


Figure 72. Possible sites in New York City

Source: Author of thesis, 2018

VII. Conclusion

Urban environment has been struggling with consequences of growing population such as lack of space and providing a better quality of public space. There are many efforts to build a compact and sustainable urban environment and the urban underground development can be one of the solutions to deal with the current issues in urban.

This thesis has been established a design framework for urban subterranean space by identifying the principles of urban public space design and underground design. The public space design emphasized making a spatial identity which was based on the five elements of image of the city by Kevin Lynch: paths, edges, nodes, districts, and landmarks. These five principles helped to reinforce the physical quality of proposed design in urban setting. The design principles of underground space were established based on the building image, layout and spatial orientation and natural light in underground level. This design guideline should approach from resolving the issues and limitation of underground space. Therefore, the proposed design focused on taking the natural light into the below grade space as much as possible since it is the most significant factor in designing the underground space.

Another result from the proposed design is providing an extra space in urban environment. Lack of buildable space in urban center has become one of obstacles to keep the compact city form and skyscrapers have been considered as an only solution. As the urban environment requires more infrastructure within the city, there is less space for public realm. Therefore, the proposed design created more space for public use with retail shops. Based on the site observation, the proposed design included 20 more tables than before and increased approximately 80% of area compare to the existing site.

However, this extra space can contribute to the current urban situation only when it is used all year round by the public. According to the design case studies, combination of public space and underground level can make an active space with a unique space planning. The proposed design composed of outdoor, semi-outdoor and interior spaces so that the entire area can be vibrant all year round under various settings.

The advantages and disadvantages of underground space addressed in the literature review shows the further direction of this research as it is necessary to consider the drawbacks of underground space and the fundamental opportunity costs to take this concept to the next stage. Moreover, the value of urban sustainability in this thesis mostly focuses on the social sustainability but further research on economic and environmental sustainability is required.

Despite the fact that there are some restrictions in the current urban environment such as building code, budget and the bias towards underground space, this thesis shows how this concept and design guidelines can be used to create the successful underground public space by making a strong relationship between two different worlds. Following research and application of this concept can be developed and actualized by urban planners with a consideration in earlier stage of urban planning. This thesis expects to consider a wide range of urban development including underground space as a feasible option while the benefits of underground space contributes to the ground environment.

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Figure 15. Diagram of Bryant Park, New York

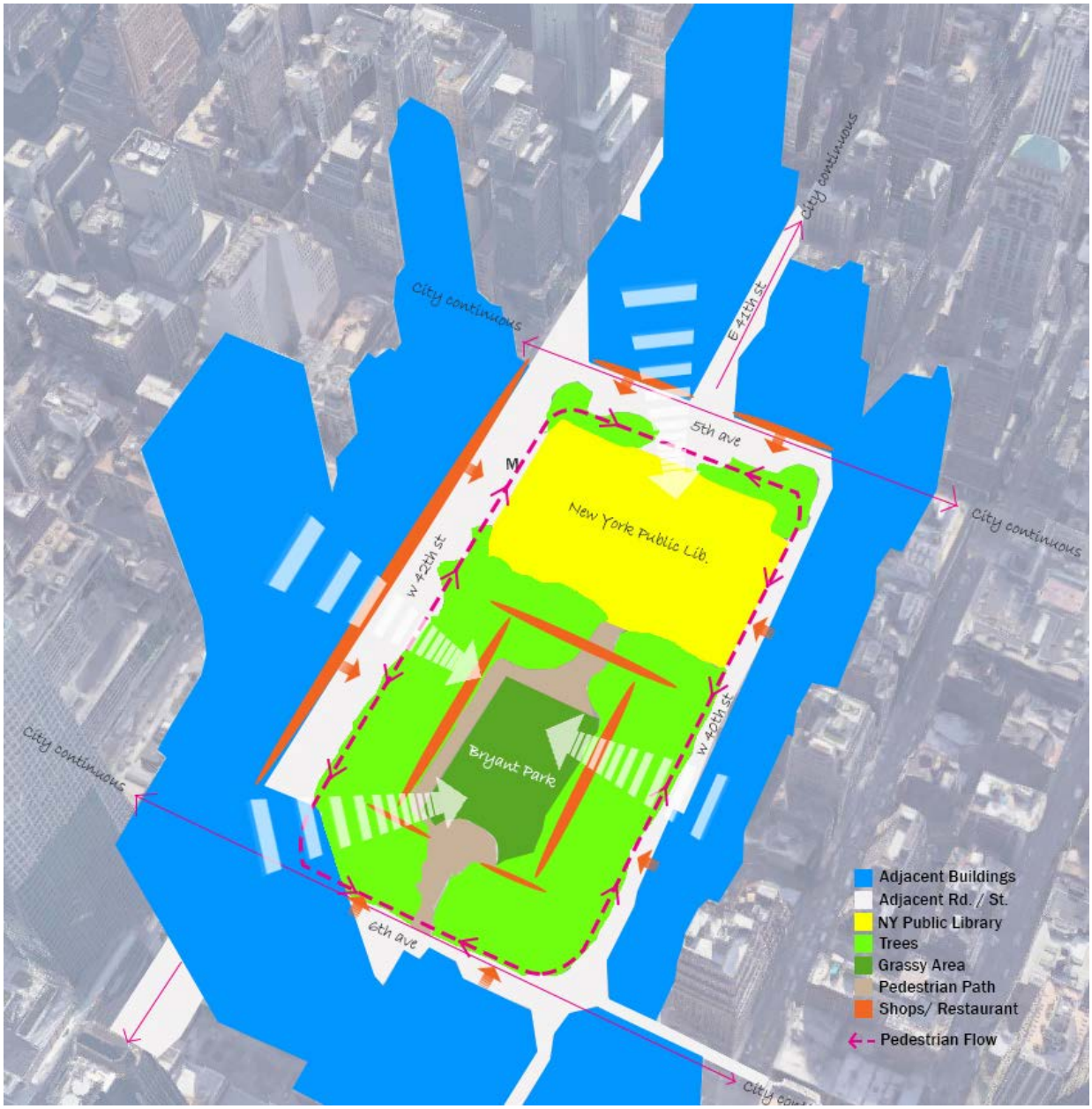


Figure 46. Site: Greely Square (Highlighted with Red Line)

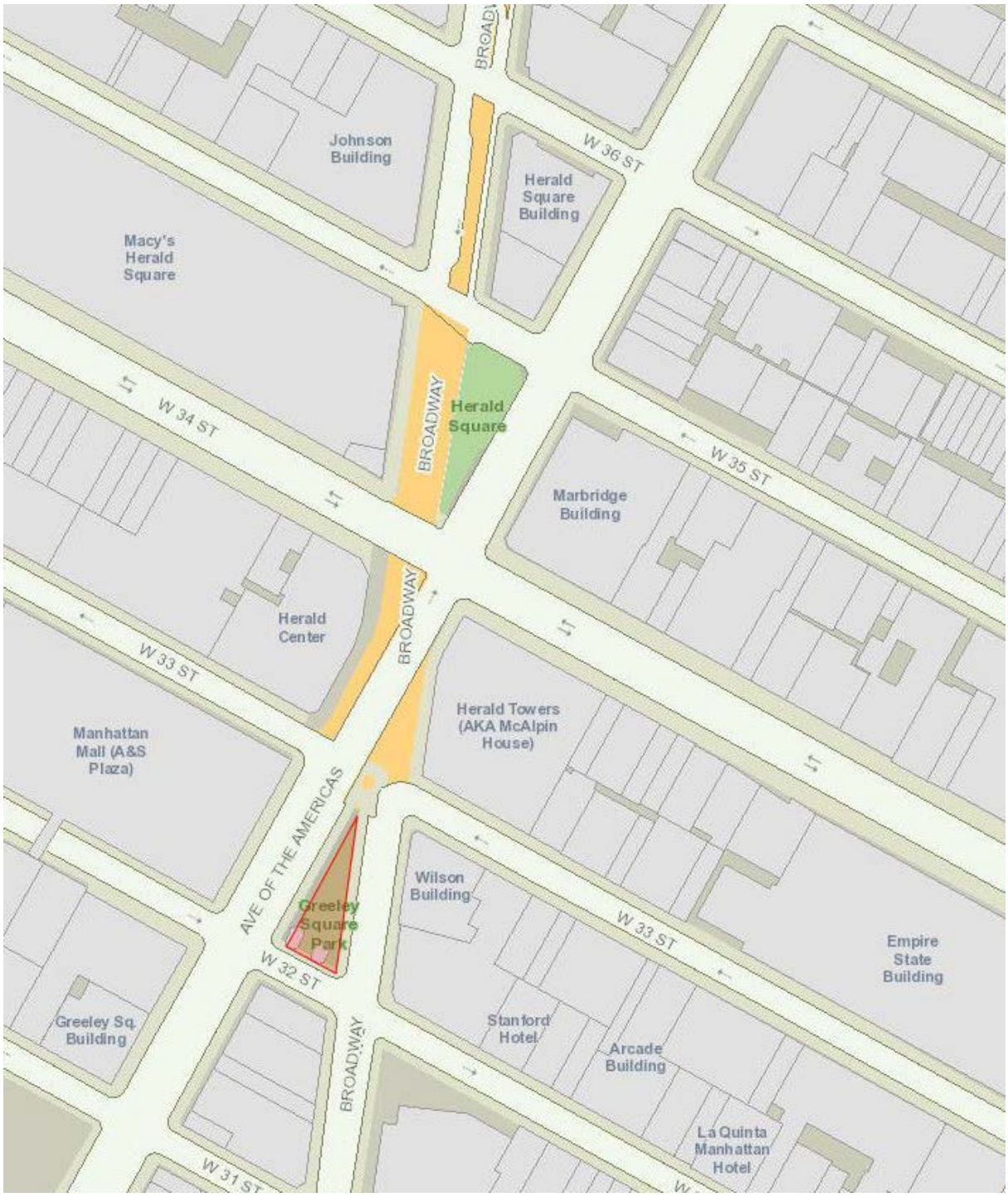


Figure 50. Urban Context Analysis

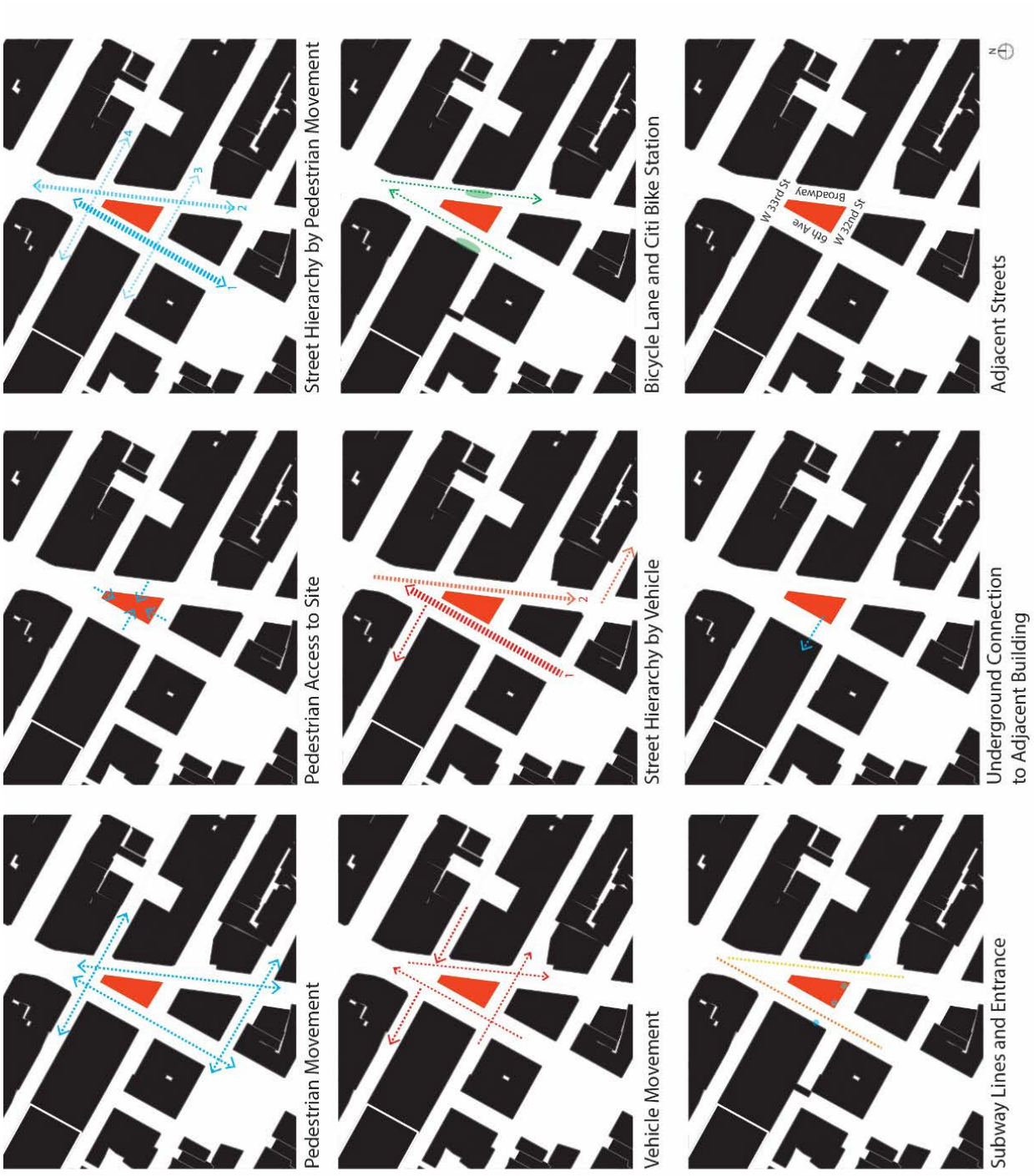


Figure 53. Form Study

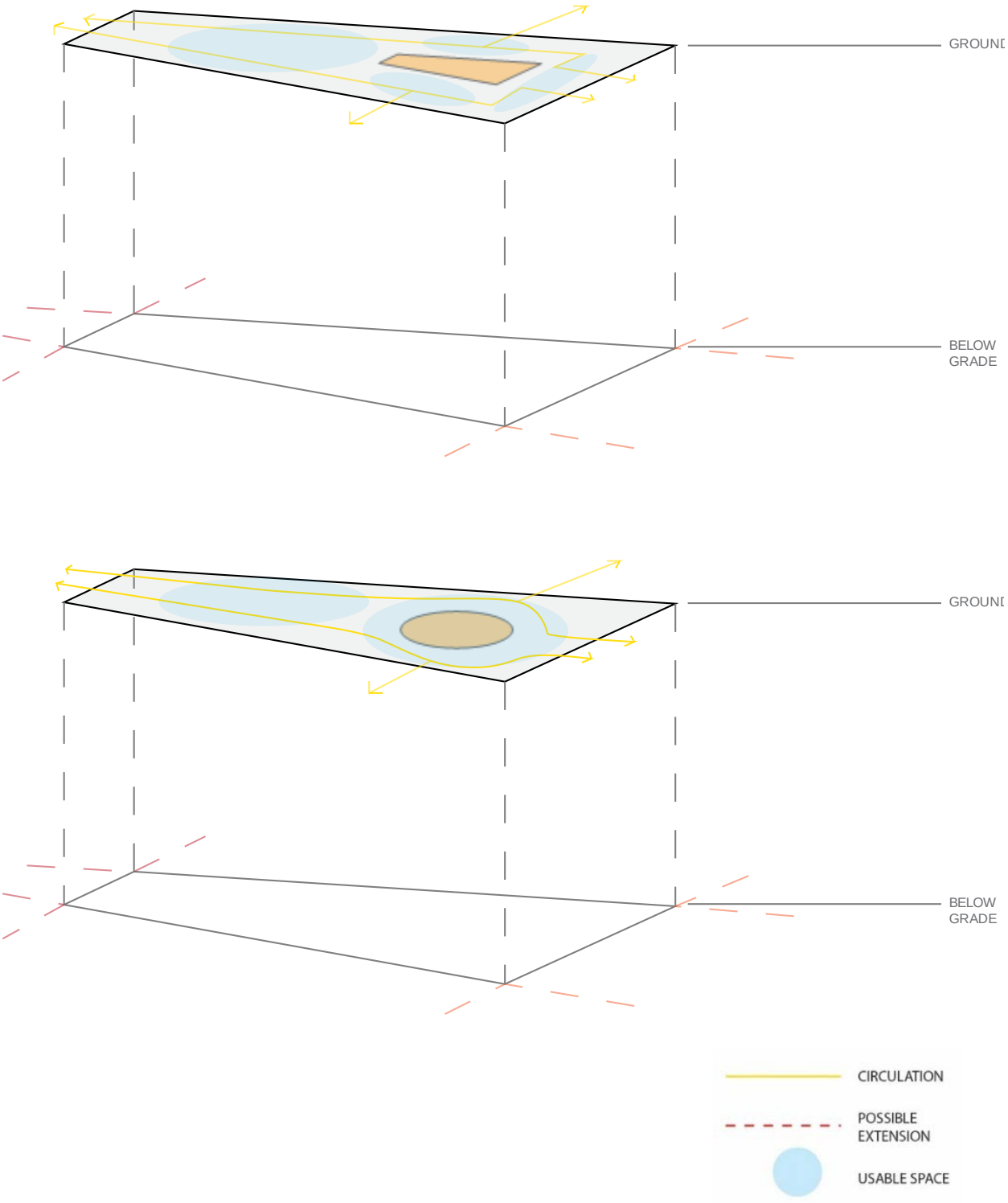


Figure 56. Section View: Programs

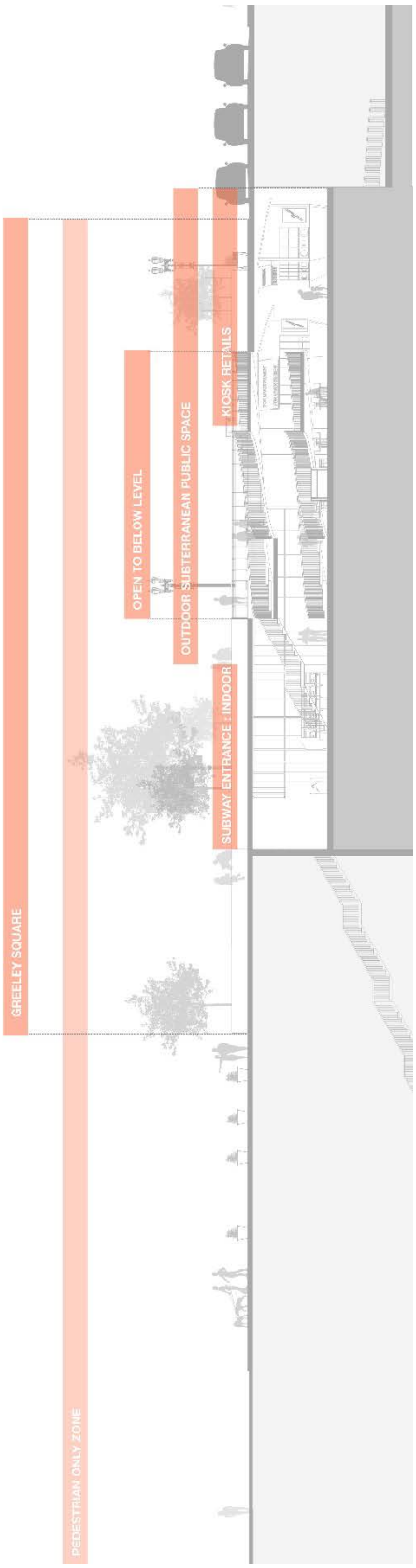


Figure 59. Existing Site Section

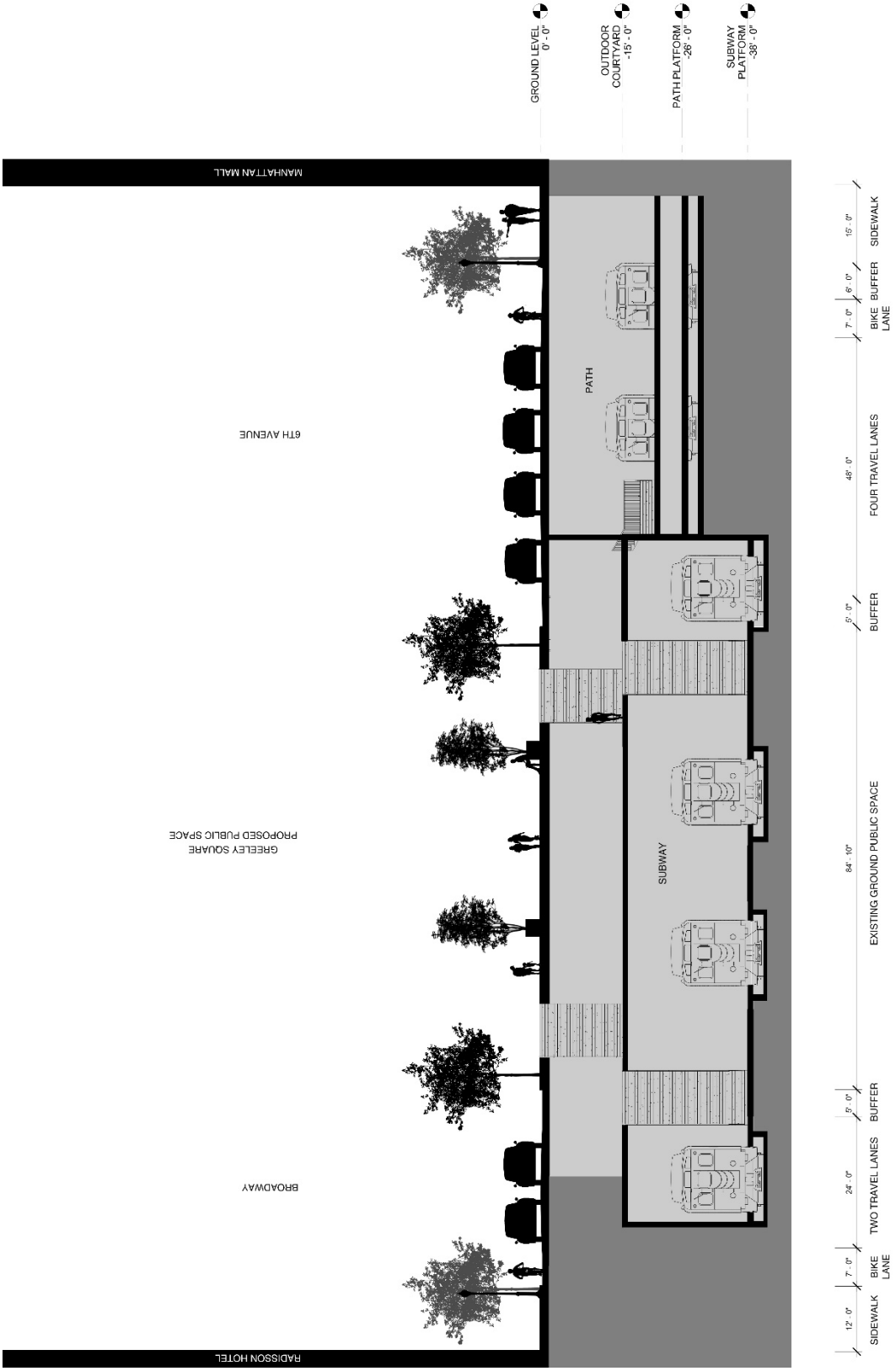


Figure 60. Proposed Design Section

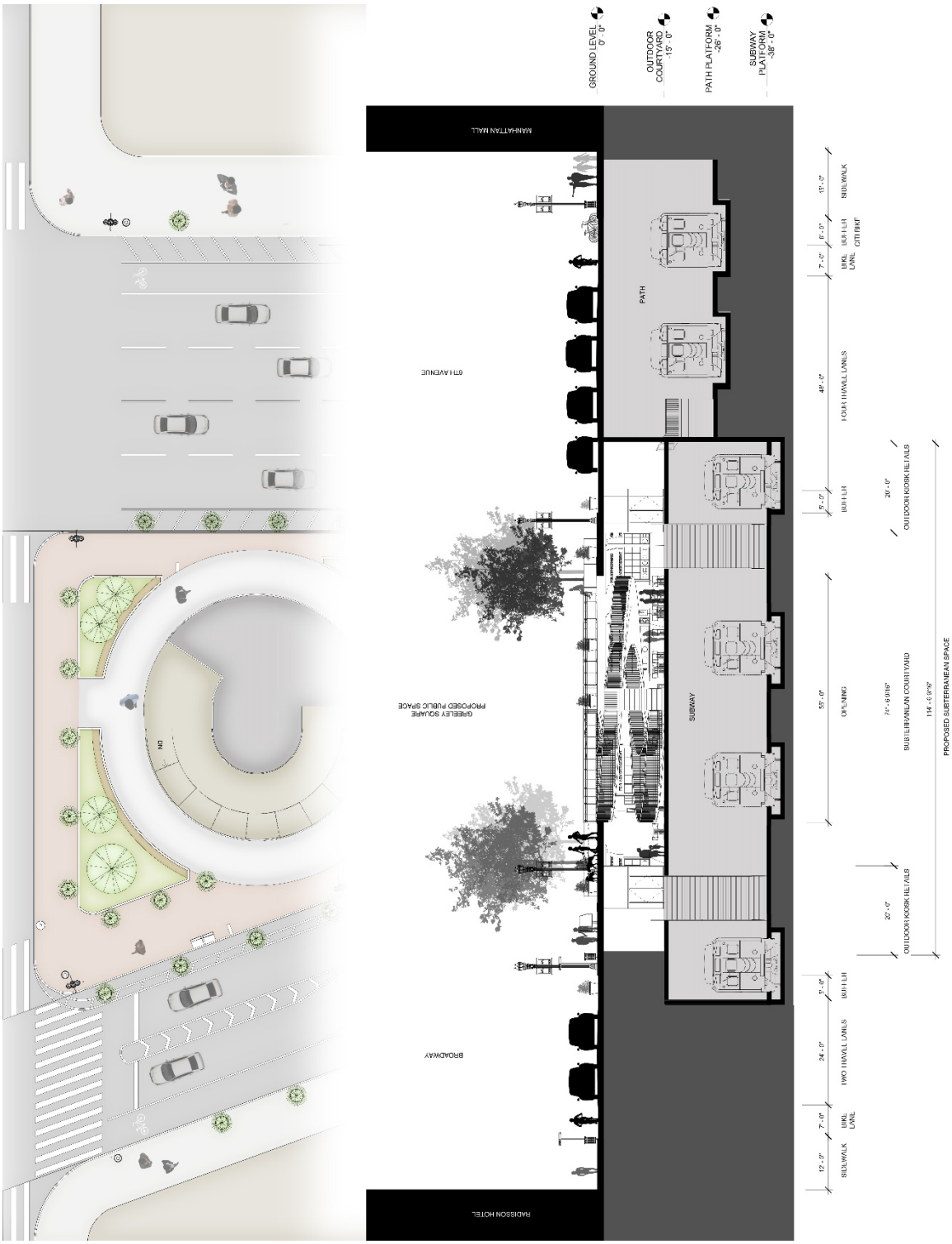


Figure 61. Proposed Design Section

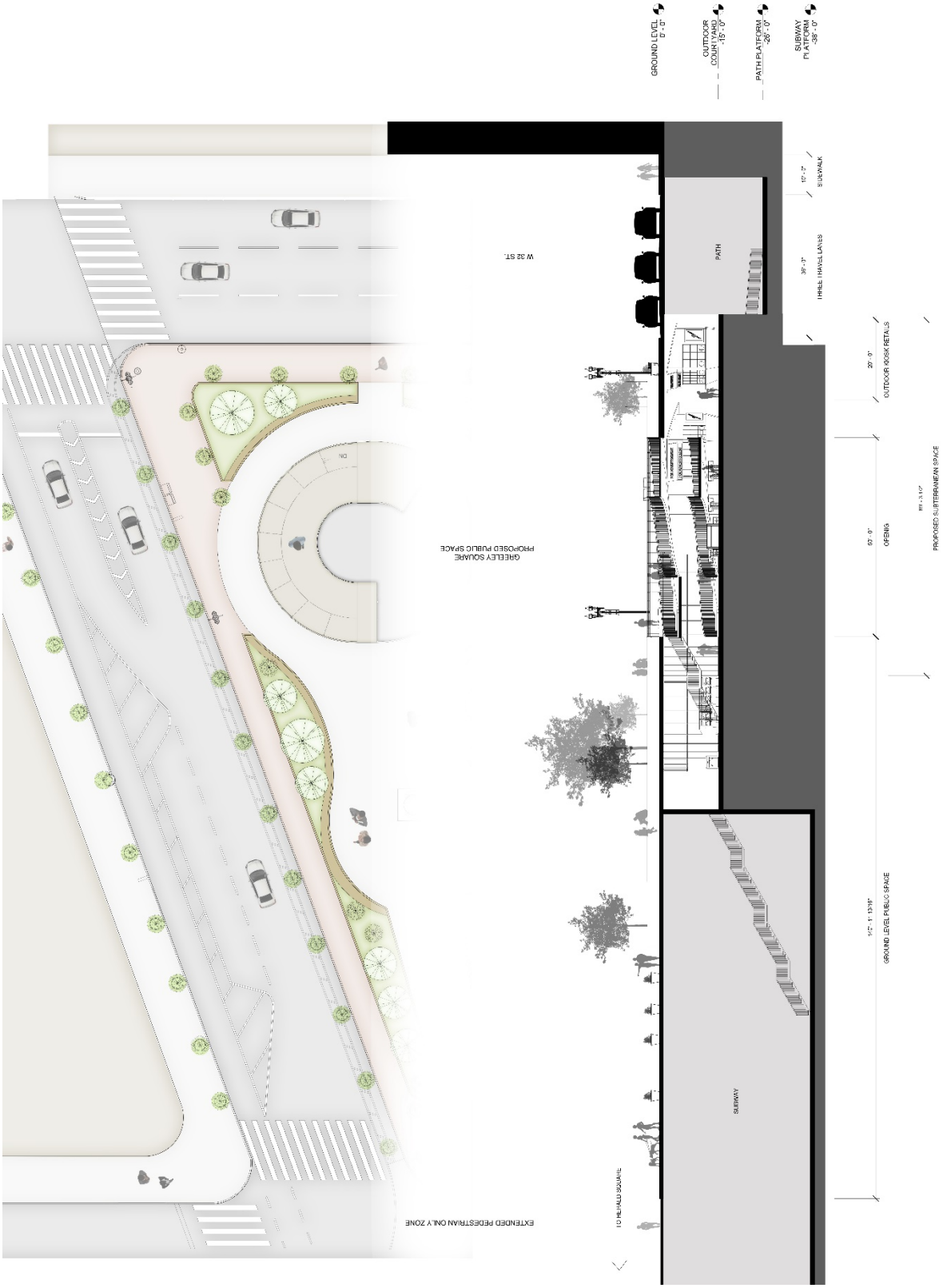


Figure 70. How long do you plan to stay in the park?

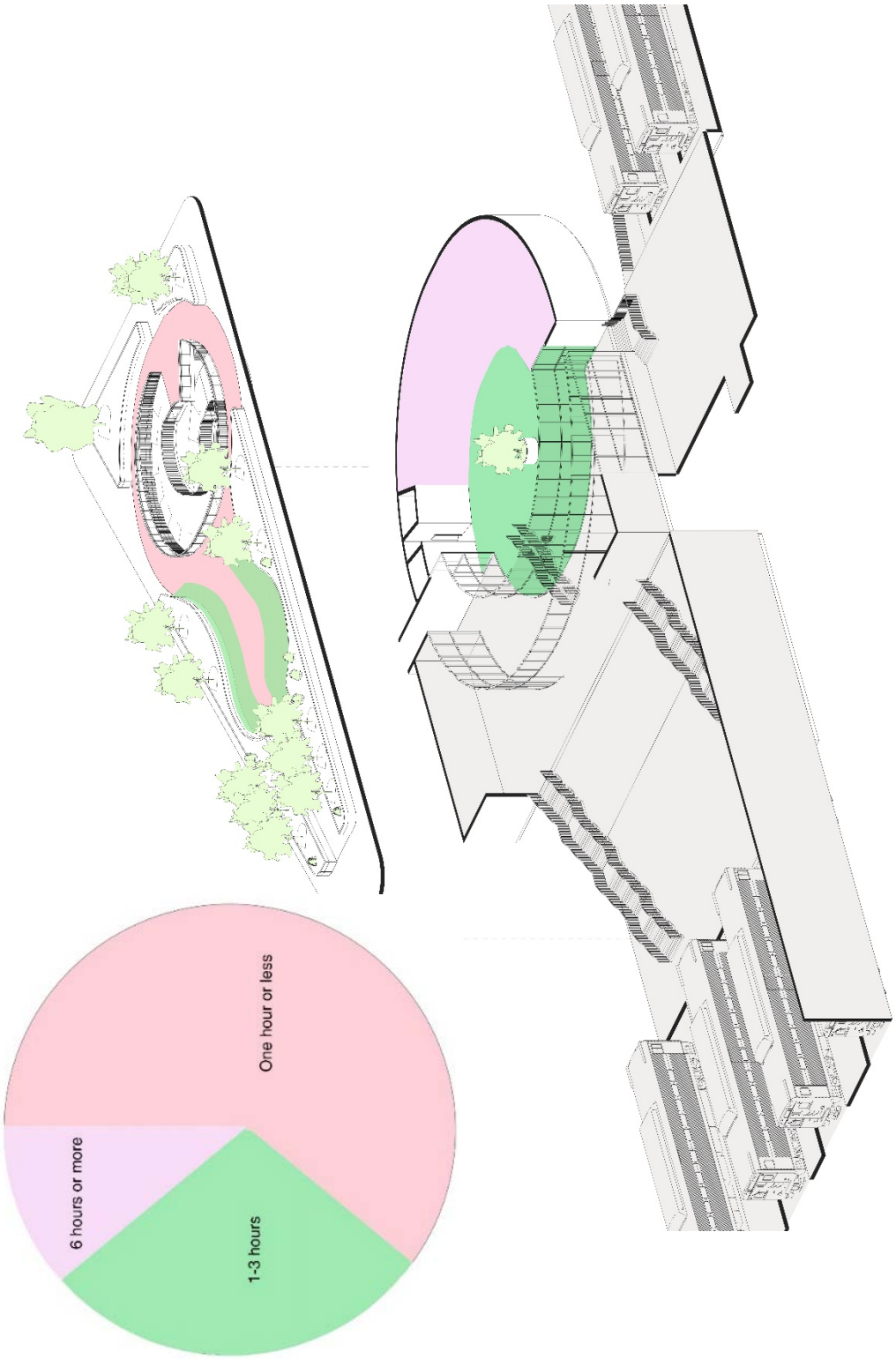


Figure 71. Park Activities

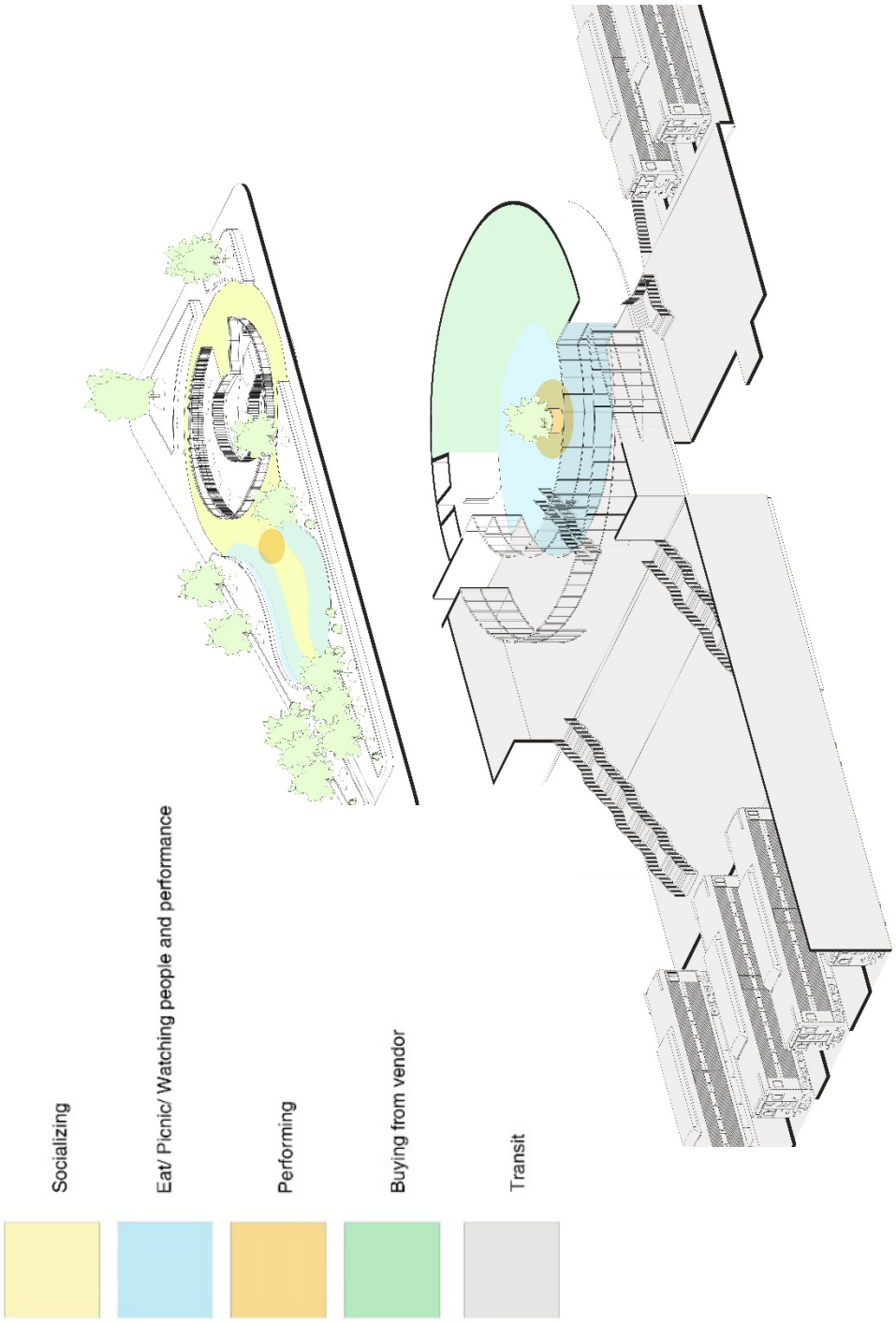
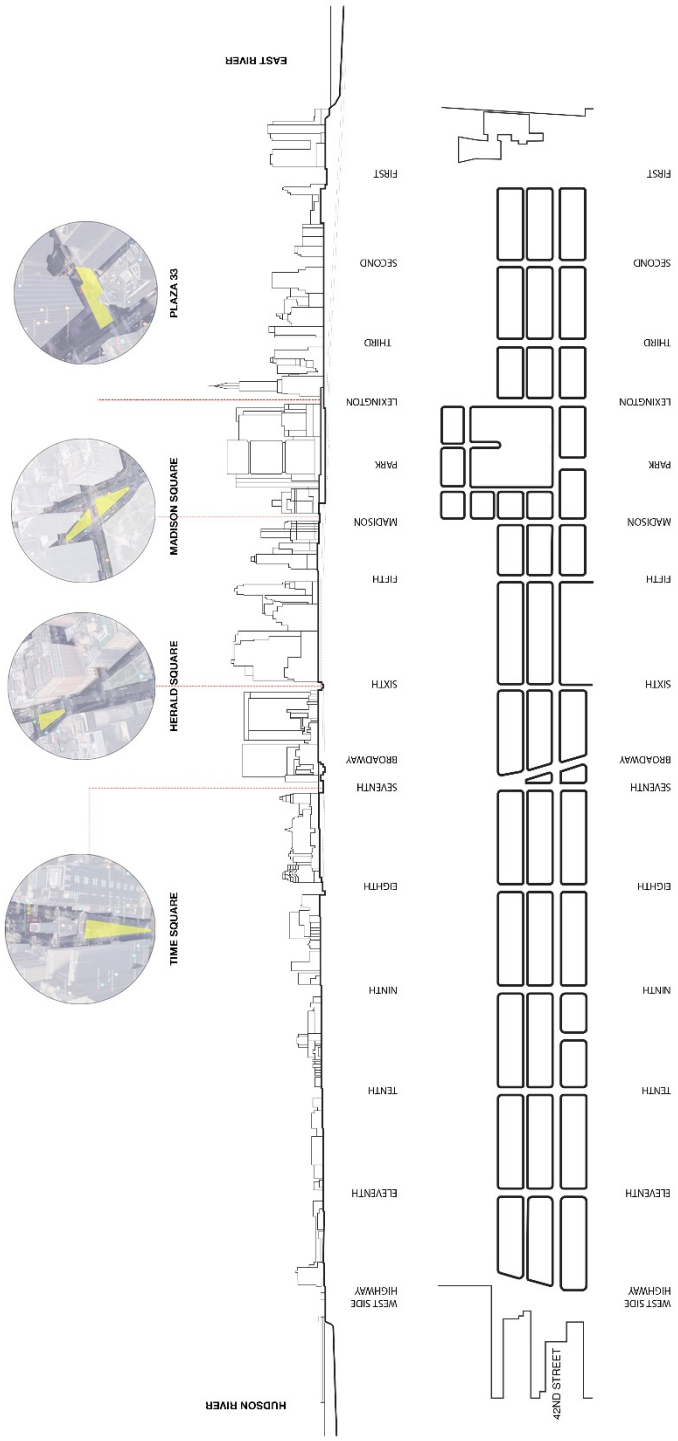


Figure 72. Possible sites in New York City



APPENDIX B: TABLES

Table 4. Underground Space Design Guidelines

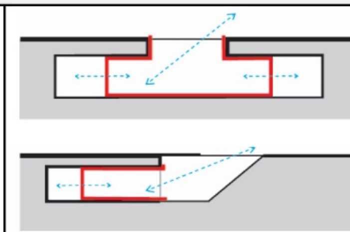
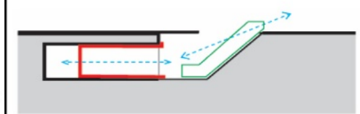
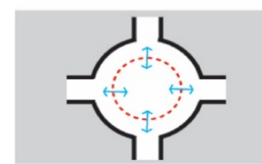
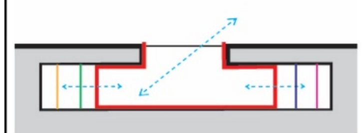
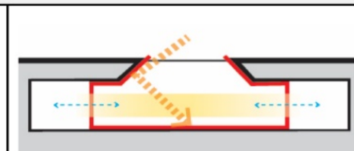
Underground Space Design Guidelines			
Main Issue	**Design Principle**	**Design Guidelines (Application)**	**Diagram**
Building Exterior			
Lack of Building Image	Exposed building boundaries and related architectural elements help to recognize the building image from the ground level. Make a visual connection between the exterior space and interior space.	Use either **Atrium** or **Elevational** fenestration arrangement to make a exposed exterior to the ground level. **Subgrade** configuration enhances the relationship with the ground level. **Sunken** courtyard provides a exterior view to the underground interior space.	
Unclear Entrance	Create an entrance which can be easily recognizable from the major pedestrian path. Create spacious vertical circulation showing clear direction.	Create an open and wide ramp (15' wide) to direct pedestrian flows to the subterranean space. **Entrance Through a Sunken Courtyard** to minimize the downwards movement and make a familiar entrance way to users.	
Layout and Spatial Orientation			
Poor Circulation	Design spaces with manipulating room size and shape to enhance a sense of spaciousness.	Use the **Sunken Courtyard** as a central circulation space to direct people in the underground space. Circular configuration provides a simpler spatial orientation.	
Lack of Legibility	Create a legible and stimulating environment.	Use shallow **Atrium** fenestration arrangement to create a visual connection between ground and below ground space. Provide a clear signage and map to facilitate orientation. Zoning (Color code) help to create a distinctive image within the space.	
Natural Light			
Lack of Natural Light	Create a stimulate and warmth indoor environment to avoid negative images such as cold and damp below grade space. Provide natural light as much as possible.	Use subterranean **Atrium** space to capture the natural light so the underground space can have the same daylight effect as ground level.	

Table 5. Proposed Design Classification

Primary Use/ Function	Use	Depth	Fenestration	Ground Relationship
Non-Residential/ Culture, Commercial	Public Space, Gathering, Event, Stores		 Atrium	 Subgrade