Recursive Relational Urban Design

by

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ABSTRACT

This thesis proposes a methodology for the act of urban design that is recursive and centered around explicit relational operations, enabled by taking advantage of computation and parametric techniques. It contains iterative experiments aimed to explore and discover the feasibility and potential of computational incremental urban design

The initial idea for this thesis emerged as two urban design conventions are challenged.

The first is the teleological masterplan. Masterplans take a long time to be implemented, causing the majority of them to be only partially implemented. In addition, as the early parts of the design are seeing completion of built development, their surrounding context would have changed and developed as well, rendering the rest of the initial design to be obsolete and out of context, which requires a new design to be created.

The second is a more recent norm: the fact that contemporary designers use generative computation techniques often to generate some form of a masterplan. Sadly, most of the outcomes produce less coherent and intentional designs than what a conventional urban design approach would. Granted, each individual is entitled to his/her own belief on good urban form, but many urban design schemes produced today by computer and parametric techniques are residues of interest and passion for the tools and techniques themselves. Many computation-based urban schemes today, including this thesis, are still early explorations, but I hope to take a step towards bringing our views on computation techniques away from digital obsession and towards a more pragmatic use.

This thesis is a response to my speculation that there are confusions between urban design and architecture at the urban scale. Unlike architecture, urban design cannot afford to take a single set of ideas that aims towards idea clarity, which typically ends up with having a thing as an organizing datum in a single design act, whether it's an axis, a mega structure, an open space, a topography map, etc. This approach is too one-dimensional, regardless of how complex the designer claims his/her project is.

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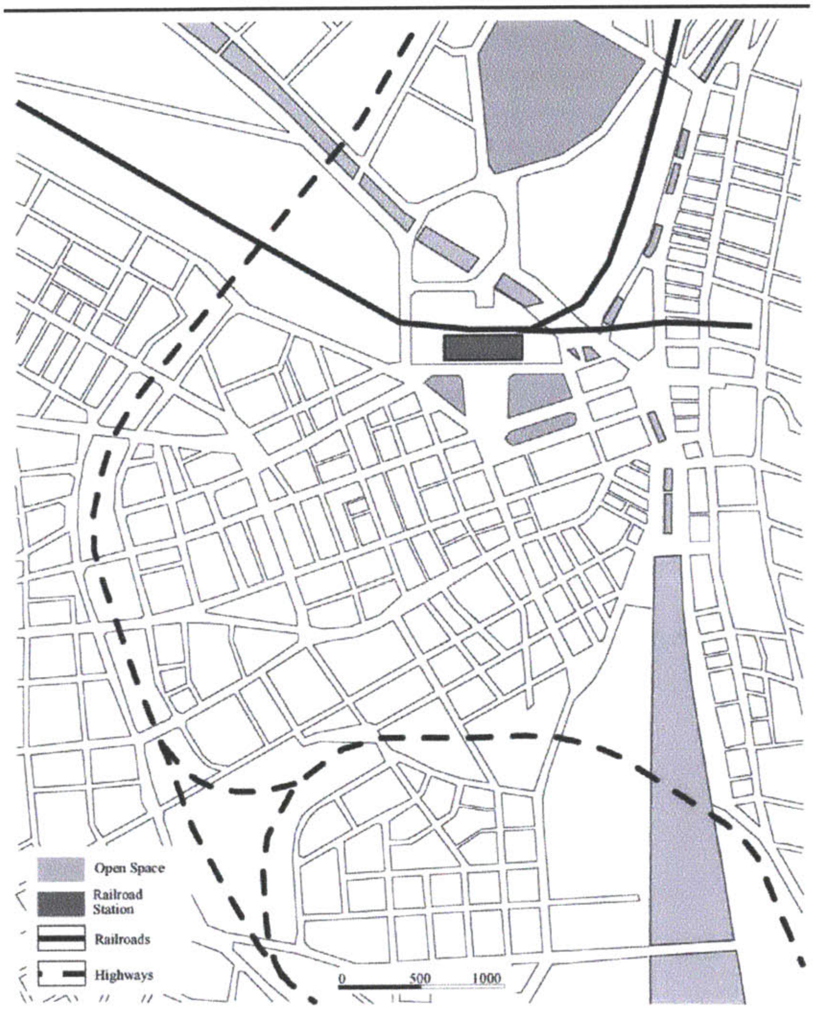
TABLE OF CONTENTS

I. CHALLENGING CONVENTIONS

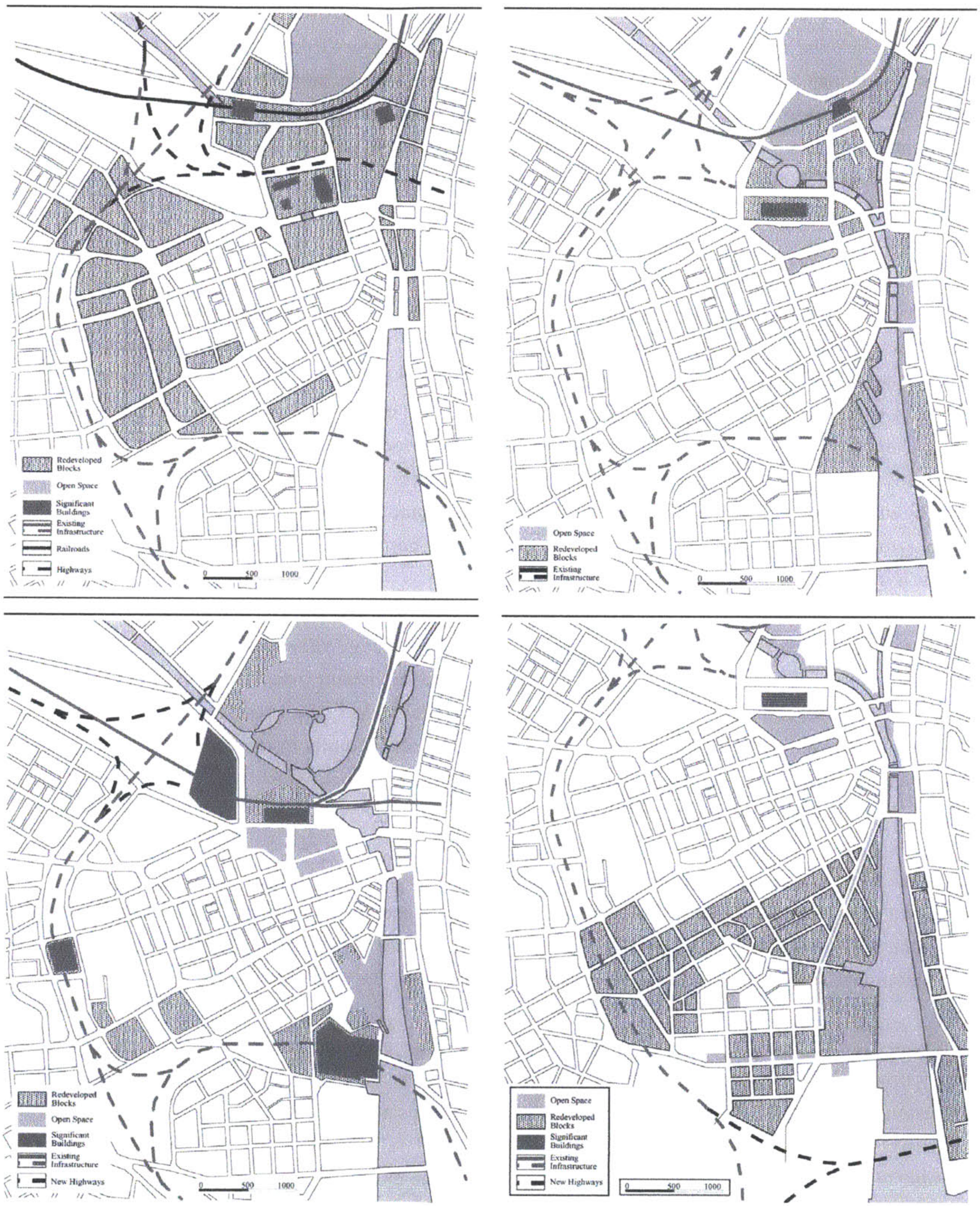
i. Teleological masterplans

The majority of urban masterplans are either never implemented or only implemented partially. Unlike architecture, urban design schemes span over decades in implementation and development, even in a supportive economic and political climate. Assuming uninterrupted developments, urban plans will still take a long time to implement that by the time the early phases of implementations are finished, the surrounding city would have changed to a point where the rest of the design is rendered obsolete.

An example of this is the various masterplans incomplete implementation in downtown Providence between 1960-2000, carefully studied and documented by Brent Ryan (Assoc. Prof. of Urban Design and Public Policy in MIT's Dept. of Urban Studies and Planning as of 2014) in "Incomplete and Incremental Plan Implementation in Downtown Providence, Rhode Island, 1960-2000", published in the *Journal of Planning History*, Vol. 5 No. 1 2006.



Ii.1. Downtown Providence in 1958 (Journal of Planning History, Vol.5 No. 1, 41)



1i.2. Various proposed masterplans for downtown Providence between 1960-2000 (Journal of Planning History, Vol.5 No.1, 45, 48, 52, 55)

In this study, Ryan looked at seven masterplans proposed for downtown Providence from 1960-2000. The study concluded by stating, "This study concluded that Providence's downtown plan implementation, successful as it may have been, was highly incomplete, representing at best the implementation of only a portion of the propositions made by the plans. Second, the study concluded that the city's downtown plan implementation was an incremental process where partially realized plan ideas could be appended by later plans and where each plan's proposals confronted an increasing number of realized elements from previous plans" (Journal of Planning History, Vol.5 No.1, 60).

Ryan's study gives a glimpse of a real case of unintended incremental planning and implementation due to the unfeasibility of teleological masterplanning. He points out that despite Providence's often-lauded effort and success on downtown planning implementation, "less than 25 percent of the individual ideas that had been proposed in Providence's downtown plans since 1960 had been implemented even in part" (Journal of Planning History, Vol.5 No.1, 37). Of the seven plans proposed for downtown Providence, only four actually experienced any implementation. Interestingly, the plans proposed overtime became more modest and conservative, one after another, which can perhaps be an indication of planners and designers noticing past trends in which large ambitious plans often face no implementation. Since modest and conservative plans are more attainable, they may have decided not to waste time coming up with "big ideas" and instead focus on what is immediately at hand.

Ultimately Ryan raised the following key questions to his own study: "Why were certain portions of the plans realized but not others? Were some plan ideas easier to implement than others, or was implementation the result of serendipity?" (Journal of Planning History, Vol.5 No.1, 58). These questions, however, are impossible to answer without looking deeply into the historical accounts of the city in terms of political relationships, economic climate, policy changes, and designs altogether, which are beyond the intended scope of both his study and this thesis.

One of the most critical issues with teleological masterplans is perhaps the fact that if implemented completely, the parts that are developed at the later stages are obsolete. Since masterplans take decades to implement, they are usually developed in phases. By the time the early phases are done, the city around the development site would have changed significantly, rendering the rest of the plan to be out of context.

We may argue that today, cities can be built much faster than even ten years ago. What used to take a century now only takes a decade, which might mean there are more masterplans implemented through completion, negating my argument that teleological masterplans are unfeasible.

It is important to clarify that this thesis does not challenge the existence of the masterplan. Rather, it proposes a different method at arriving to one, accepting the need for a finished masterplan to be given to the client, developer, and contractor. With the speed of development we have today, it is even more critical that we think about the masterplan differently. Otherwise, we may very well end up with a bunch of plan Voisins all over the world.

ii. The use of generative computation techniques in practice

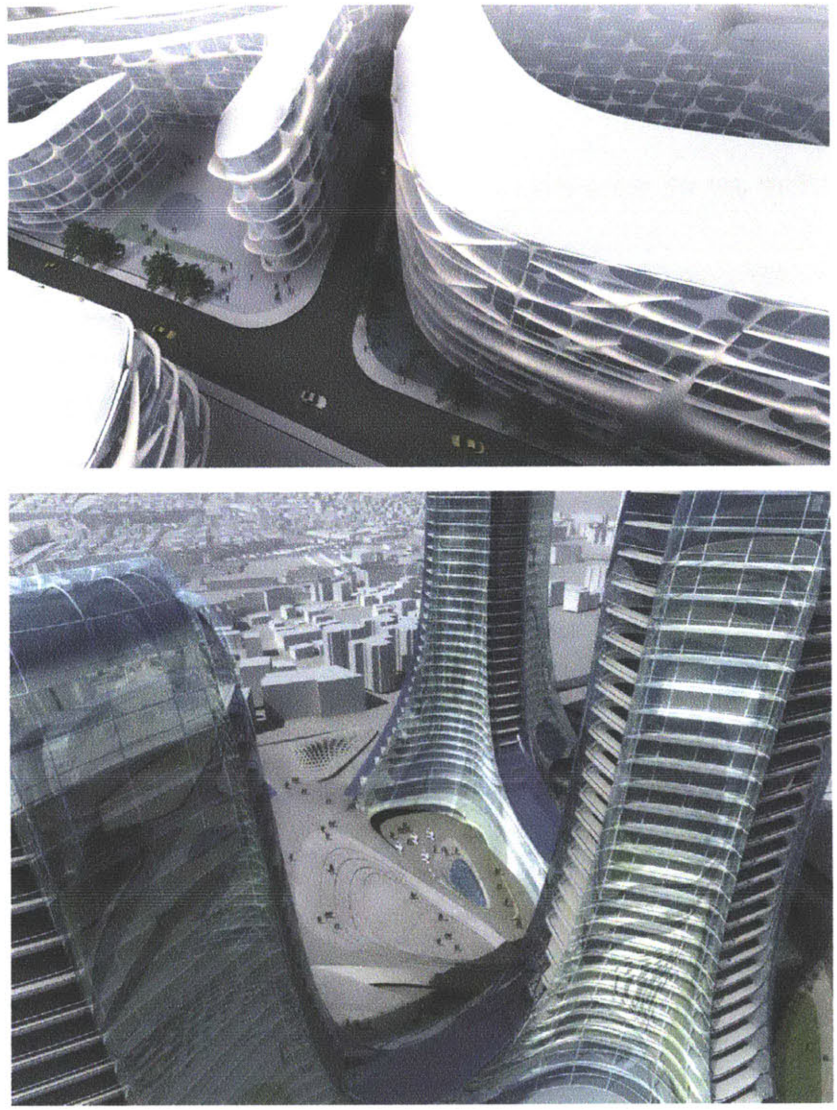
In many contemporary architecture and urban design practices, designers use computers and computation techniques often to generate some form of a masterplan. Sadly, most of the outcomes are in fact much less legible than a Nolli plan and produce less coherent and intentional designs than what a more conventional urban design method would. Granted, each individual is entitled to his/her own belief on good urban form, but many urban design schemes produced today by computer and parametric techniques are residues of interest and passion for the tools and techniques themselves. Many computation-based urban schemes today, including this thesis, are still early explorations, but I hope to take a step towards bringing our views on computation techniques away from digital obsession and towards a more pragmatic use.

One of the most prominent figures in today's parametric design is undoubtedly Patrick Schumacher, whose name is almost synonimous with the word "parametric" in today's design society. He sees parametric design as a style, which he refers to as Parametricism. For him, Parametricism is the next big architectural paradigm after Post-modernism and Deconstructivism. His approach to parametric design is not based on pragmatism. Schumacher accepts that his methodologies are considered to be avant-garde. In his essay "Parametricism as Style – Parametricist Manifesto" (2008), he writes, "The key issues that avant-garde architecture and urbanism should be addressing can be summarized in the slogan: organizing and articulating the increased complexity of post-fordist society. The task is to develop an architectural and urban repertoire that is geared up to create complex, polycentric urban and architectural fields which are densely layered and continuously differentiated."

I ii. I. ZHA's Kartal-Pendik Masterplan (Parametricism - A New Global Style for Architecture and Urban Design)

One of the most important point that Schumacher makes in his approach to parametric urban design is what he refers to as "deep relationality", which he explains is aimed "to integrate the building morphology – all the way to the detailed tectonic articulation and the interior organization. Parametric Urbanism might involve parametric accentuation, parametric figuration, and parametric responsiveness as registers to fulfill its ambition of deep relationality" (Parametricism - A New Global Style for Architecture and Urban Design).

It is clear that Schumacher wants to emphasize his parametric implementation through unmistakably striking visual representation. The drawback here is the emphasis on the pictorial quality of an aerial-view of a city or a city plan over the performance and the actual quality of the city. He approaches urban design the same way he approaches architecture design. Unfortunately, unlike architecture, urban design cannot afford to prioritize visual and formal clarity over function and performance.



I ii.2. Schumacher's monotonous, uniform, and totalitarion parametric urbanism. (Parametricism - A New Global Style for Architecture and Urban Design)

Schumacher has a very strong belief on how architects must dictate what architecture is to non-architects. In an interview titled "On Parametricism" published on his website (patrikschumacher.com), he compares architecture to science in a way that scientists prescribe proper scientific knowledge to the world, and thus "architects – and only architects – who determine through their collective architectural discourse what is good, appropriate contemporary architecture." This view and understanding of architecture carry over to urban design, which is a critical error common to individuals with an architectural background who become involved in urban design.

As mentioned before, Schumacher's primary agenda is visual clarity of parametric design, which means he has, in his mind, deployed a pre-conception of the visual characteristics of parametric design. He mentions that late modernist architects have used parametric modeling to "inconspicuously absorb complexity", whereas he, as a parametricist, "pushes in the opposite direction and aims for a maximal emphasis on conspicuous differentiation and the visual amplification differentiating logics". For him, parametric design aesthetics "is the elegance of ordered complexity and the sense of seamless fluidity, akin to natural systems" (Parametricism - A New Global Style for Architecture and Urban Design). Ironically, Schumacher's criticism of late modernist architects is only supported by his own version of guiding parametric method to achieve his own personal visual agenda which, although happens to be different that that of the late modernists, is still a subjective and personal endeavor nevertheless.

This is not to say that Schumacher is oblivious to the real essence of parametric design. He wrote, "Parametric variations trigger 'gestalt-catastrophes', i.e. the quantitative modification of these parameters trigger qualitative shifts in the perceived configuration. Beyond object parameters, ambient parameters and observer parameters have to be integrated into the parametric system" (Parametricism - A New Global Style for Architecture and Urban Design).

However, Schumacher chooses to focus on the visual changes obtained from tweaking various parameters within a parametric system. He believes that parametric design can address complex urban issues and "articulate them with all their rich differentiations and relevant associations". For him, one of the most significant advantages of designing parametrically is that "the danger of overriding real-life richness is minimized because variety and adaptiveness are written into the very genetic make-up of parametricism". Ironically, while claiming to avoid dumbing down complexity and diversity, his design outcomes are strikingly monotonous and uniform, which is primarily caused by his ambition for "deep relationality" as he attempts to package every aspect of urbanism into one parametric system.

2. URBAN DESIGN VS. ARCHITECTURE AT THE URBAN SCALE

I suspect the term "urban design" is quite ambiguous for many. Many architects who are involved in urban design projects often approach them as if they are architecture, unknowingly or not. In *Urban Design as Public Policy: Practical Methods for Improving Cities* (1974), Jonathan Barnett wrote,

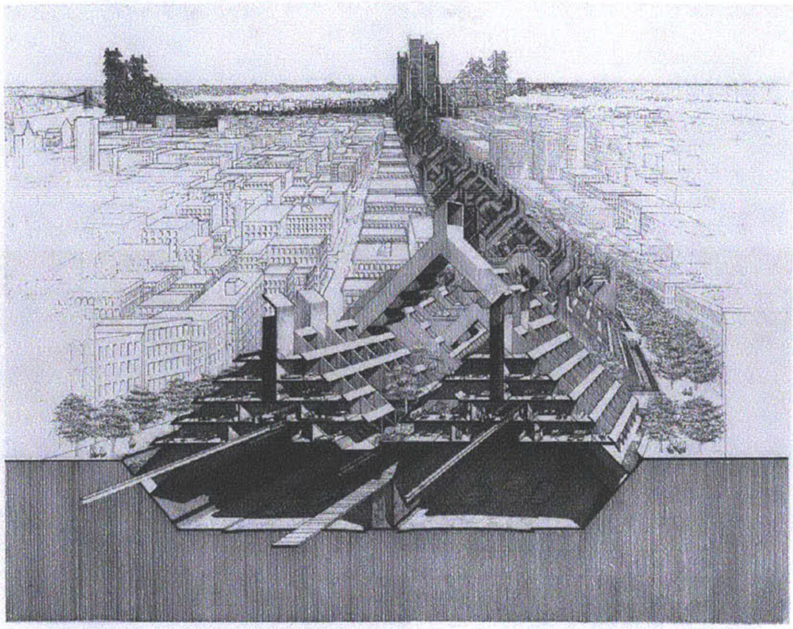
> " A city planner, it seemed to us, was someone who was primarily concerned with the allocation of resources according to projections of future need. Allocating funds for a capital budget is a series of planning decisions, because it involves determinations of need for, as an example, a new school in a particular district, and balancing off that need against that of other areas.
>
> Architects, on the other hand, design buildings. They prepare a set of contract documents so that the building, let us say a school, can be constructed, and they take legal responsibility for the process.
>
> There is a substantial middle ground between these professions, and each has some claim to it, but neither fills it very well." (Barnett, 186)

Unlike architecture, urban design cannot afford to take a single set of ideas that aims towards idea clarity, which typically ends up with having a "thing" as an organizing datum in a single design act, whether it is an axis, a mega structure, infrastructure (a term so loosely used these days), an open space, a topography map, etc. This approach is too one-dimensional, regardless of how complex or well-organized the designer claim his/her project is.

For years, many architects have gained interest in the issues of urbanism. Through architecture, many perceived urban issues are internalized within one holistic structure. There are many early iconic examples of this attitude including Le Corbusier's Unite d'Habitation, Paul Rudolph's Lower Manhattan Expressway, and the theoretical works of archigram. This attitude of internalizing urbanism within large architecture persists until today. Architecture competitions such as eVolo is infested with "vertical city" schemes. Contemporary design practices such as MVRDV and BIG are not exempt from these proposals either. For at least a century now, many architects cannot seem to move away from this idea that urban issues are somehow similar to architecture issues and therefore the two can be combined and approached as one.

Architects are taught and trained to strive for idea clarity in a design scheme. Urban design, if approached this way, becomes too focused on the completed state of the design scheme. Designers often describe their urban design schemes the same way they describe architecture design schemes. A common scenario

2.1. Unite d'Habitation (Photo by Paul Koslowski, 1997. fondationlecorbusier.fr)

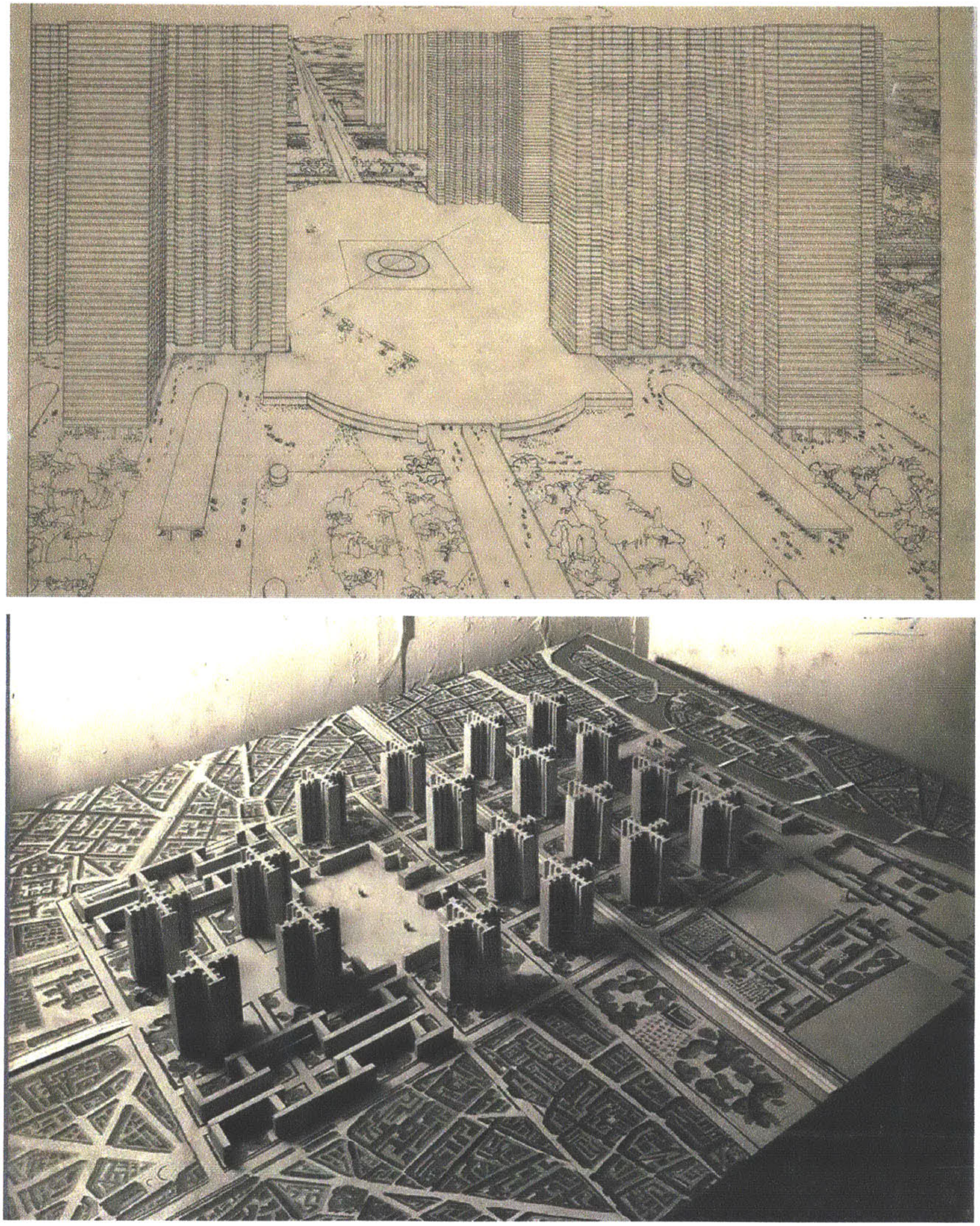


2.2. *Paul Rudolph: Lower Manhattan Expressway (US Library of Congress: loc.gov)*

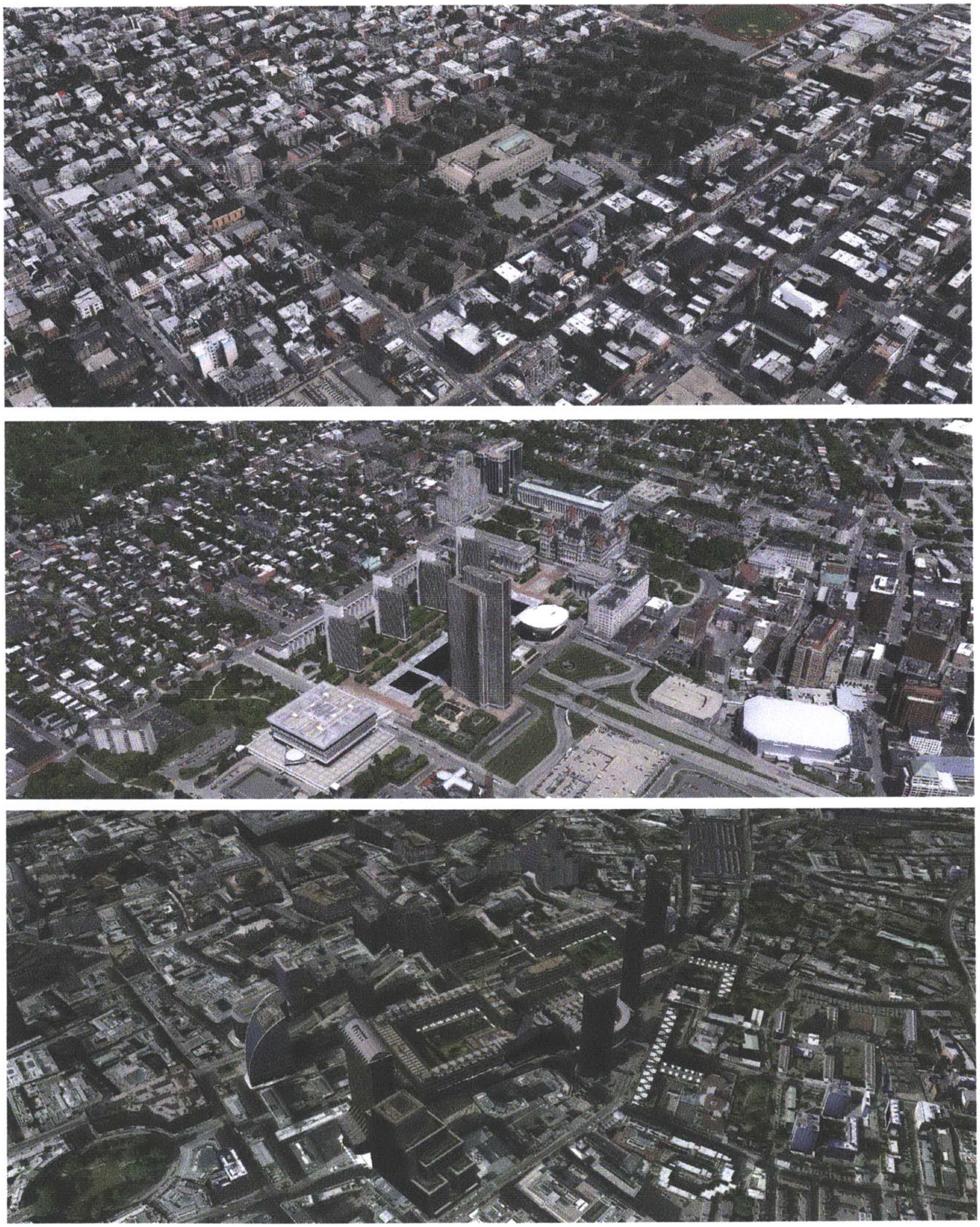
might sound something like this: "*The idea of this design is about the separation of programs. The residentials are clustered around the site with a commercial core in the center of each cluster. In the middle, there is a main street that connects to the rest of the city and branches off to each neighborhood.*" In reality, it is not possible to describe urban areas like downtown Boston, Tokyo, or Paris as being organized by one set of simple ideas. This organizational strategy that stemmed out of architectural discourse is undoubtedly still commonly practiced today in many professional urban design offices.

This attitude that mixes urbanism with architecture has resulted in a few common strategies in urban design. One example that has become a common punching bag for designers and planners as a disastrous urban design strategy is Le Corbusier's Plan Voisin for Paris (figure 2.1). This is a prime example where an architect acts as a totalitarian, imposing his subjective and very personal opinion onto a city. Although this project in particular was never realized, its influence was so powerful that it manifested into reality through many other developments, such as the Barbican estates in London, Ten Eyck housing in Willamsburg (New York), and the Empire State Plaza in Albany (New York).

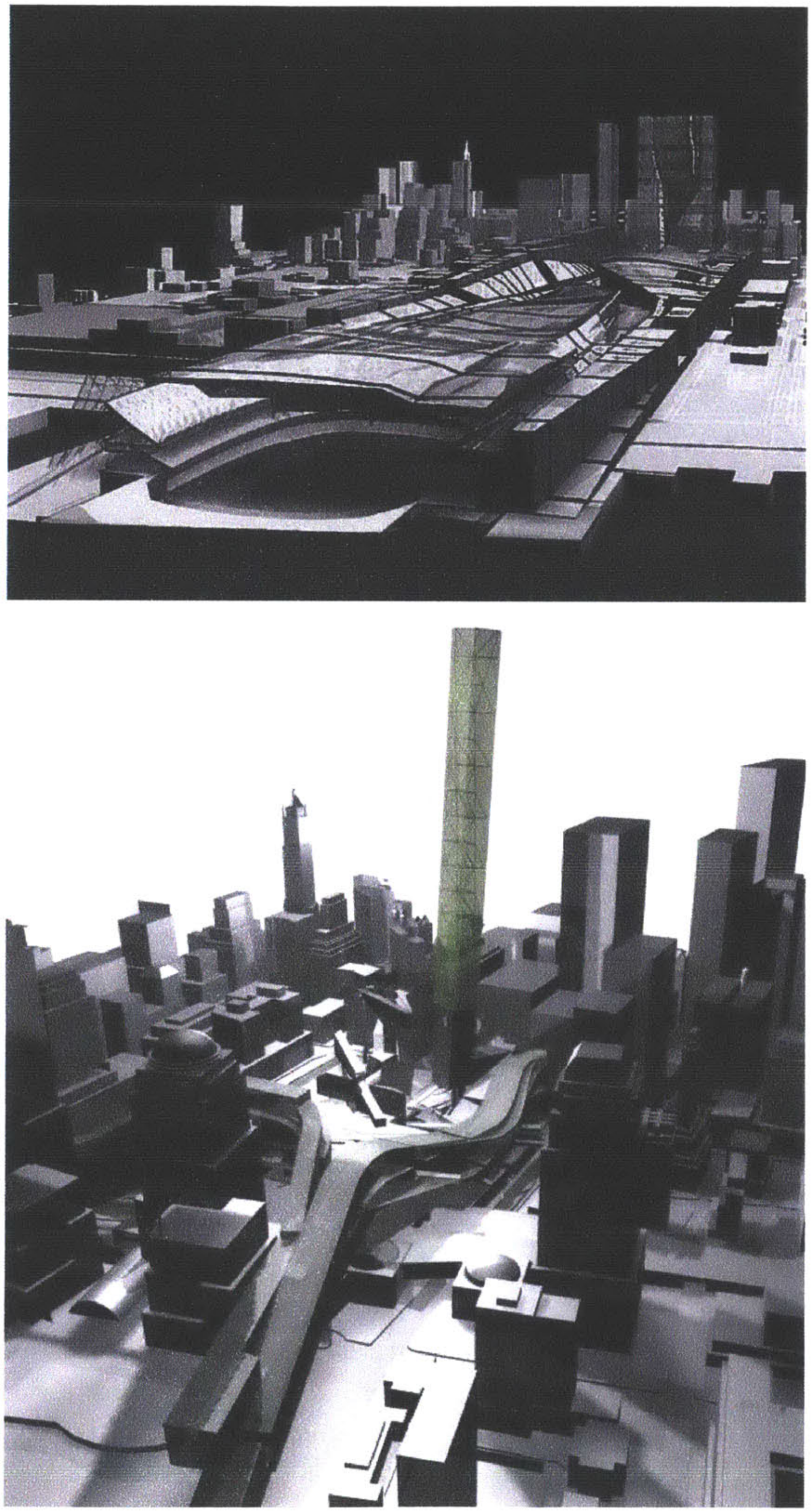
We may categorize this urban design strategy that proliferated from architectural modernism as one that simply aggregates a series of buildings across a city. This approach to urban design results in a scheme that looks like socialist housing blocks, which often carries negative connotations with them for multiple reasons.



2.3. Le Corbusier's Plan Voisin (fondationlecorbusier.fr)



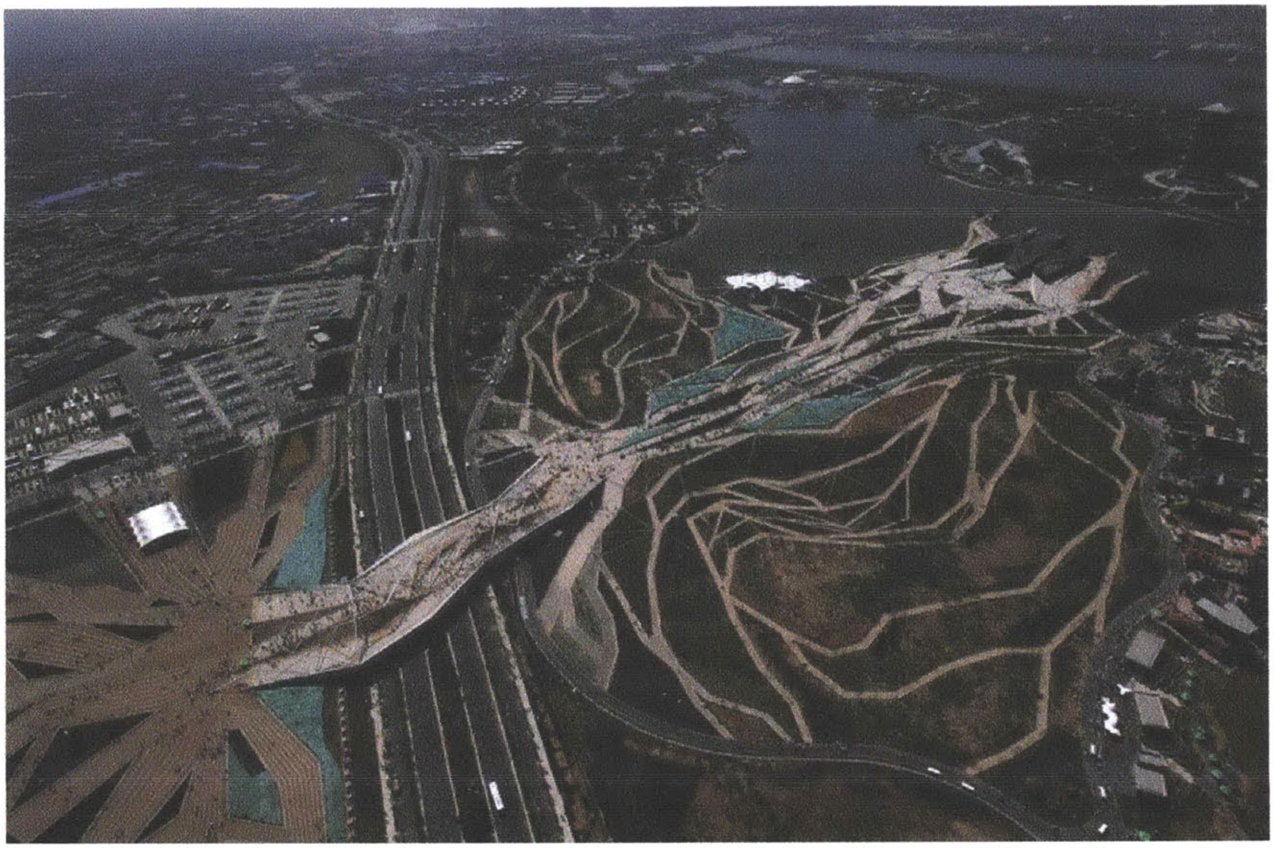
2.4. From top: Ten Eyck housing, Empire State Plaza, Barbican Estates



2.5. Top: Eisenman's Penn Station design proposal (New York's Pennsylvania Stations, 192) and Morphosis' World Trade Center design proposal (morphosis.com)

Another common strategy towards urban design by architects is through the use of large holistic architectural intervention. This includes Peter Eisenman's Penn Station project and Morphosis' World Trade Center design proposal. When one architectural design agenda, which includes a consistent design strategy and visual aesthetics, governs an urban design project, we arrive at projects like these. This strategy believes in the power of architecture as the unifying element in a city that brings multiple elements together into one cohesive design scheme.

The most recent implementation of architectural thinking into urban design utilizing contemporary digital tools and techniques are shown by projects such as Xi'An International Horticultural Expo by Plasma studio, GroundLab, and LAUR Studio (figure 2.4). These projects often result in "incidental" but strong and distinct form and overall plan configuration. Often closely related to landscape urbanism, they are usually influenced by a set of data/information that affect the shape of the design in one way or another. This set of information commonly includes things such as sunlight



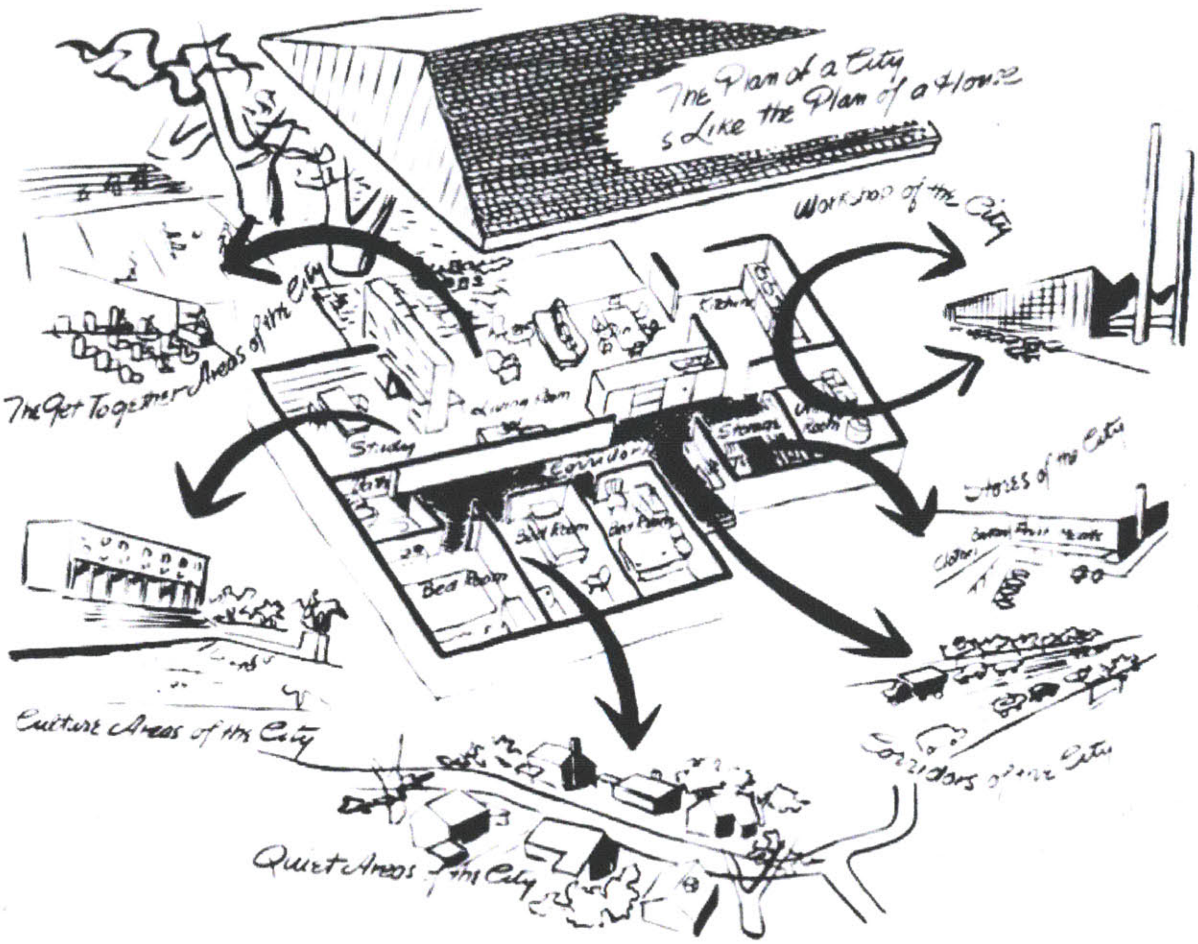
2.6. Xi'an International Horticultural Expo (plasmastudio.com)

information, flood zones map, transportation, circulation (vehicular and pedestrian), topography map, and population density, among many others.

We don't see too many of these designs implemented today. Much like architecture, these large scale designs rely heavily on their full completion in order for them to function properly as intended. As our technology advances, our construction becomes faster and more sophisticated, allowing more of these projects to be built. If we keep addressing our urban issues as if they are architecture, we may very well end up with a world full of theme cities. Thus, we cannot afford to think of urban design holistically, as if it is one large object, one overarching idea, or one consistent design manifestation.

I suspect that this architectural approach to urban design was signified and proliferated by famous modernist architects. Le Corbusier and Louis Kahn thought of cities as if they are architecture. In his sketch, Kahn explicitly wrote," The plan of the city is like the plan of the house", comparing streets to rooms and the sky as ceiling. This attitude towards urban design assumes that a single grand idea can support an entire urban scheme as it does architecture. It believes that a city's structures and systems can be conceived and drawn by a single person as the genius mastermind.

2.7. Xi'an International Horticultural Expo. From top: 2005, 2009, 2011, 2014.



2.8. Kahn's sketch of city to house comparison (Louis I. Kahn Collection, University of Pennsylvania and the Pennsylvania Historical and Museum Commission)

To some extent, the components of a city are somewhat comparable to those of architecture. However, when an urban design is ideologically treated as architecture, it often ends up unrealistic, impractical, and downright ridiculous. This trend of architects generating urban designs has prevailed until today. As a result, designers often manifest their personal design ideologies through urban design the same way they do in architecture design. Modernist architects' urban design schemes revolved around one or a few ideas based on certain observations of the city. For example, Kahn designed a plan for Philadelphia solely based on traffic patterns and speed. Le Corbusier desired to separate different modes of transportation so they do not clash with each other.

2.9 Le Corbusier's Ville Contemporaine: Contemporary City for three million people (fondationlecorbusier.fr)

In *Urban Design as Public Policy: Practical Methods for Improving Cities* (1974), Jonathan Barnett wrote,

> "Architects and planners have inherited some funny ideas about themselves as the keepers of the sacred flame of culture and the guardians of society's conscience. There has been a tradition that a true professional, and, certainly, a true artist, should not be too closely involved in the day-to-day process of government, or politics, or real eastate development. Instead, he has sent his instructions to the policy makers as manifestos or visionary drawings, and, not suprisingly, the policy makers usually find them impossibly idealistic and irrelevant to the problem at hand" (Barnett, 6)

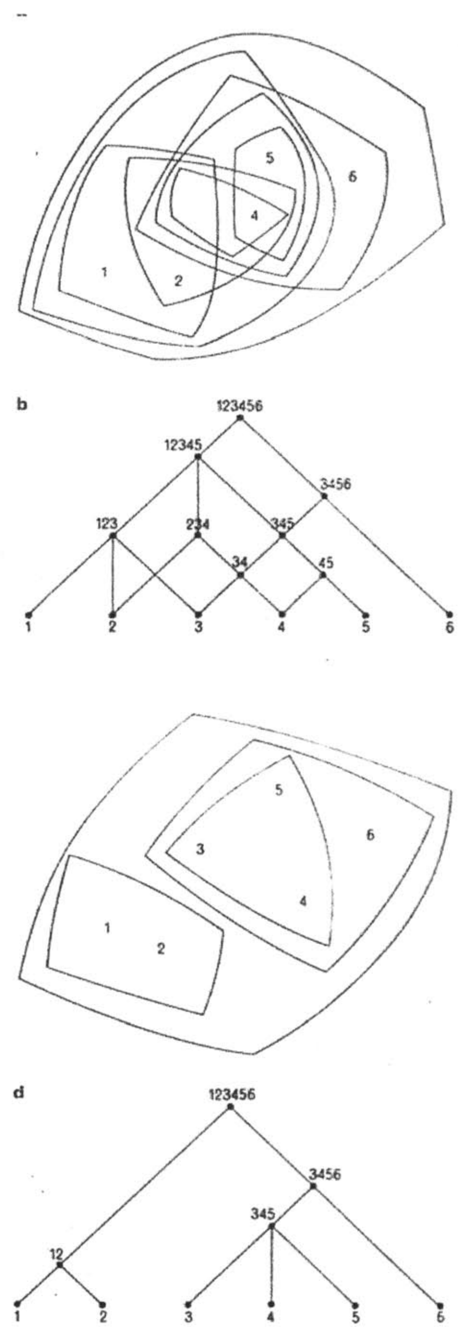
3. PRECEDENTS AND SIMILAR THOUGHTS (INCREMENTAL AND COMPUTATIONAL)

i. Early thoughts in computational and incremental urbanism

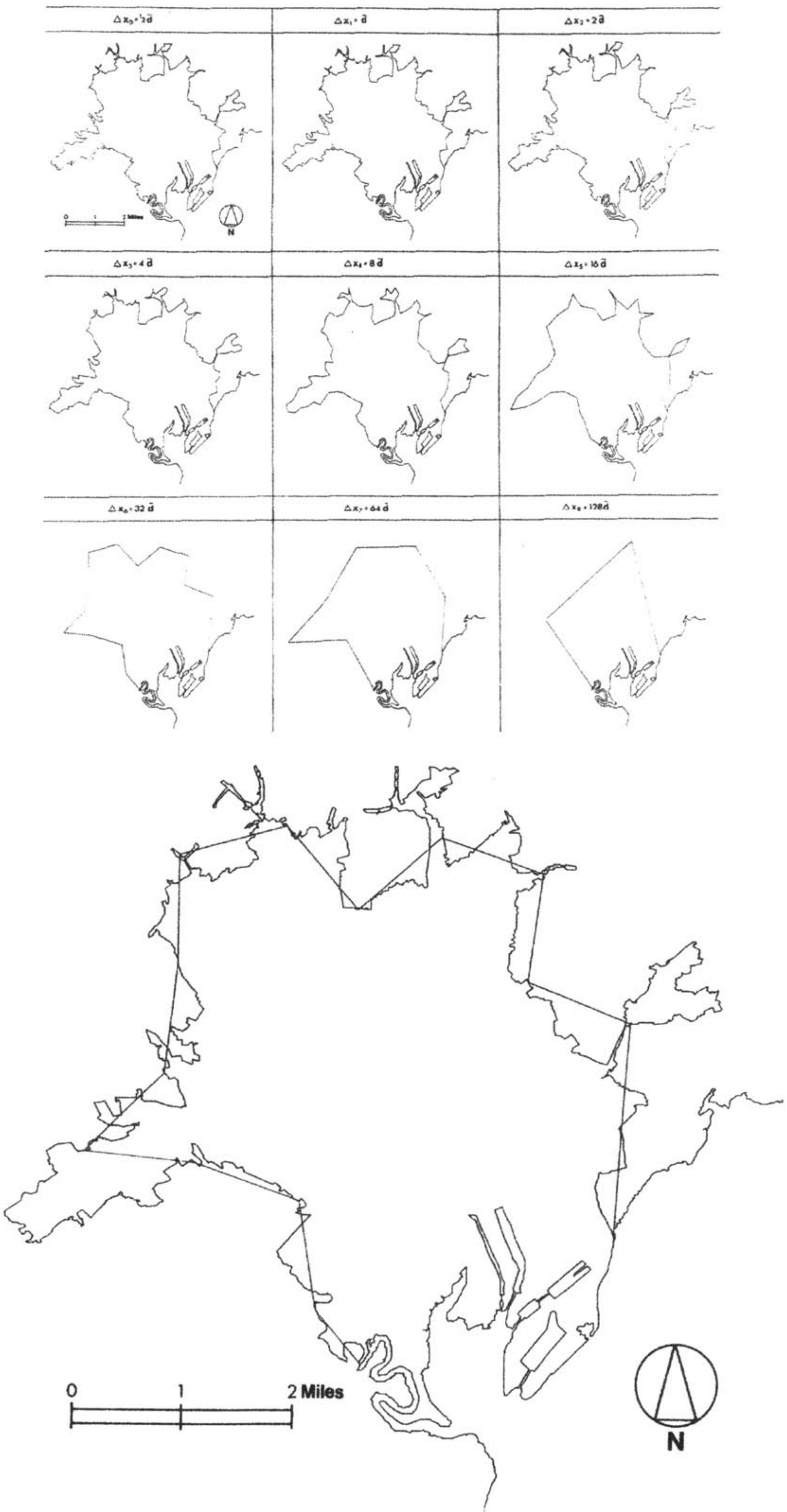
The idea of approaching urban design computationally or incrementally is nothing new. From descriptive to generative rule-based urban design to incremental design and implementation, there are multiple designs and ideas in the past that have attempted to pursue an alternative to the masterplan. So much so that phrases like "death of the masterplan" has become a cliché.

Centuries ago, in *Ten Books of Architecture*, Vitruvius wrote "a logic of a set of performance criteria and their parameters to be balanced in the city. Environmental orientation, exposure, altitude, climate, and flora are set out as the basis for locating the city to create optimal conditions for health. Military defenses, roads, and sea ports are also initial considerations in setting out the position and height of defenses, and the location and design of the buildings and spaces of the city." (Verebes, 68)

Early computation based urbanism focused on describing cities.



3i.1. Semi-Lattice structure (top) vs. Tree structure (bottom)
(Alexander, "A City Is Not A Tree")



3i.2. Fractal-based description of urban form (Batty, 11-12)

In 1965, Christopher Alexander suggested that natural cities, those that have "arisen more or less spontaneously over many, many years", have the structure of a semi-lattice while artifically designed cities, those that "have been deliberately created by designers and planners", have the structure of a tree. (Alexander, "A City Is Not A Tree")

In 1986, Michael Batty and Paul Longley in the University of Wales Institute of Science and Technology published a study on fractals as a way to describe urban boundaries. Derived through mathematics and computation, fractals are shaped through a series of mathematical operations that result in a large complex patter based on simple patterns aggregated through a certain rule/algorithm.

Batty explained that urban boundaries are typically defined through a sruvery. He wrote," Typically, allotments and other urban fringe land uses were excluded, villages linked to the urban area by ribbon development were included, man-made alterations to rivers and coast were included, while large landed estates which subsequently become part of the urban fabric were only included if development had surrounded them." (Batty, 9)

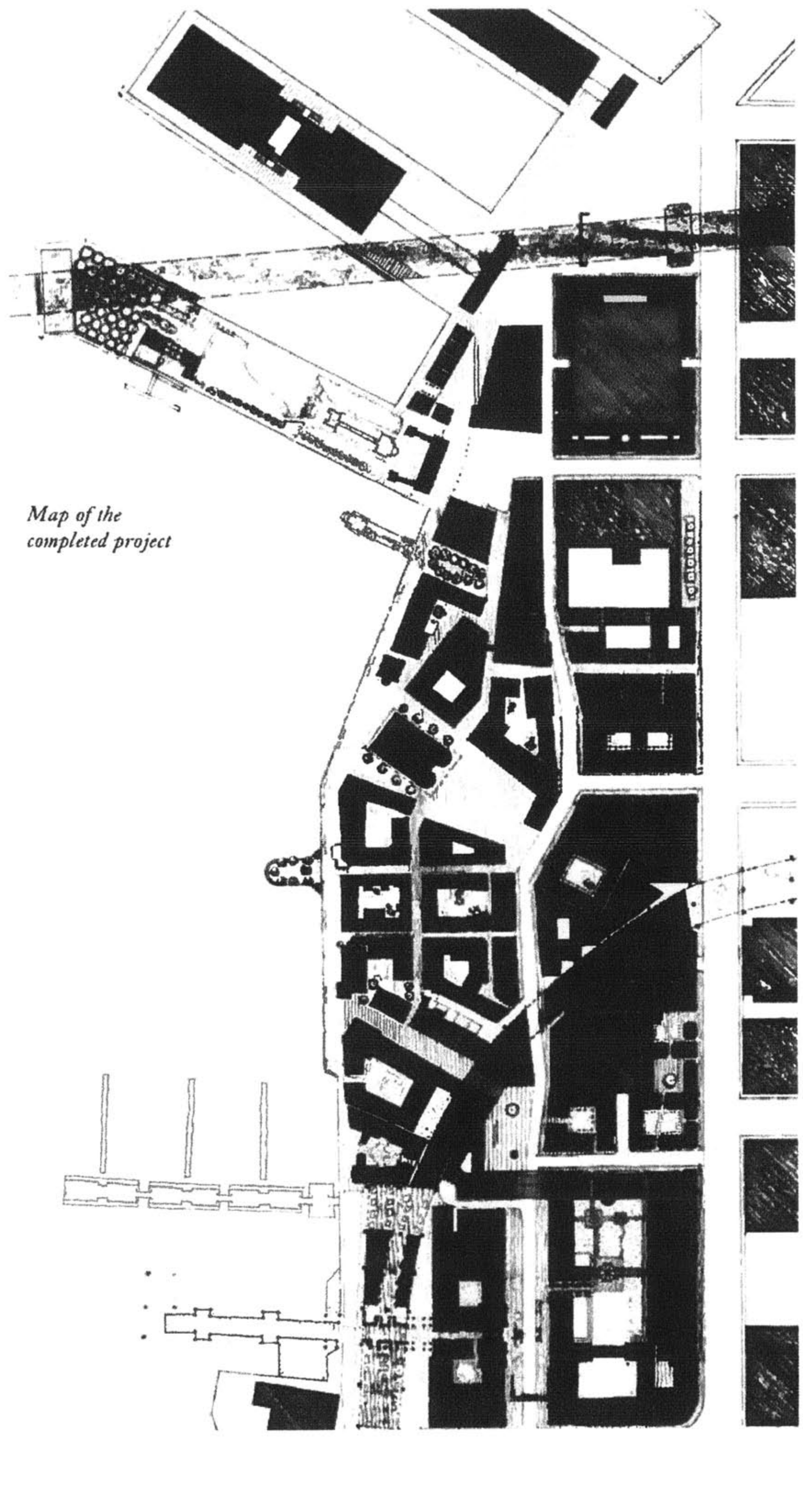
Frustrated and unsatisfied with the inadequacy of methods to define urban boundaries, Batty suggested that fractals can provide a more accurate and natural look at urban boundaries.

The most directly related precedent to this thesis perhaps comes from Christopher Alexander's *A New Theory of Urban Design* (1987). In the beginning of the book, Alexander wrote,

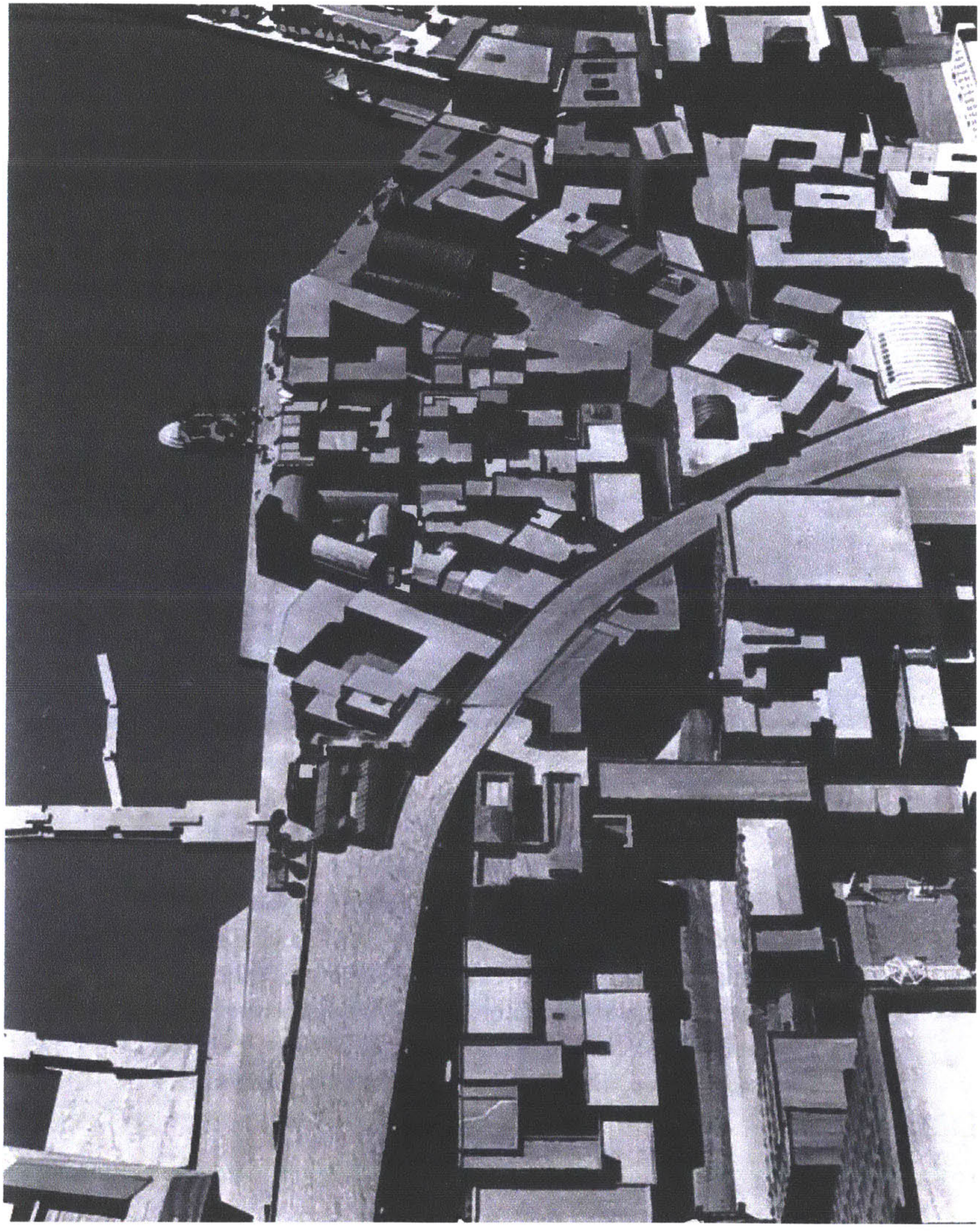
"Urban design has a sense of dilettantism: as if the problem could be solved on a visual level, as an aesthetic matter. However, at least the phrase "urban design" does somehow conjure up the sense of the city as a complex thing which must be dealt with in three dimensions, not two.

We have therefore used the phrase urban design in the title of this book, since it seems to us that urban design, of all existing disciplines, is the one which comes closest to accepting responsibility for the city's wholeness.

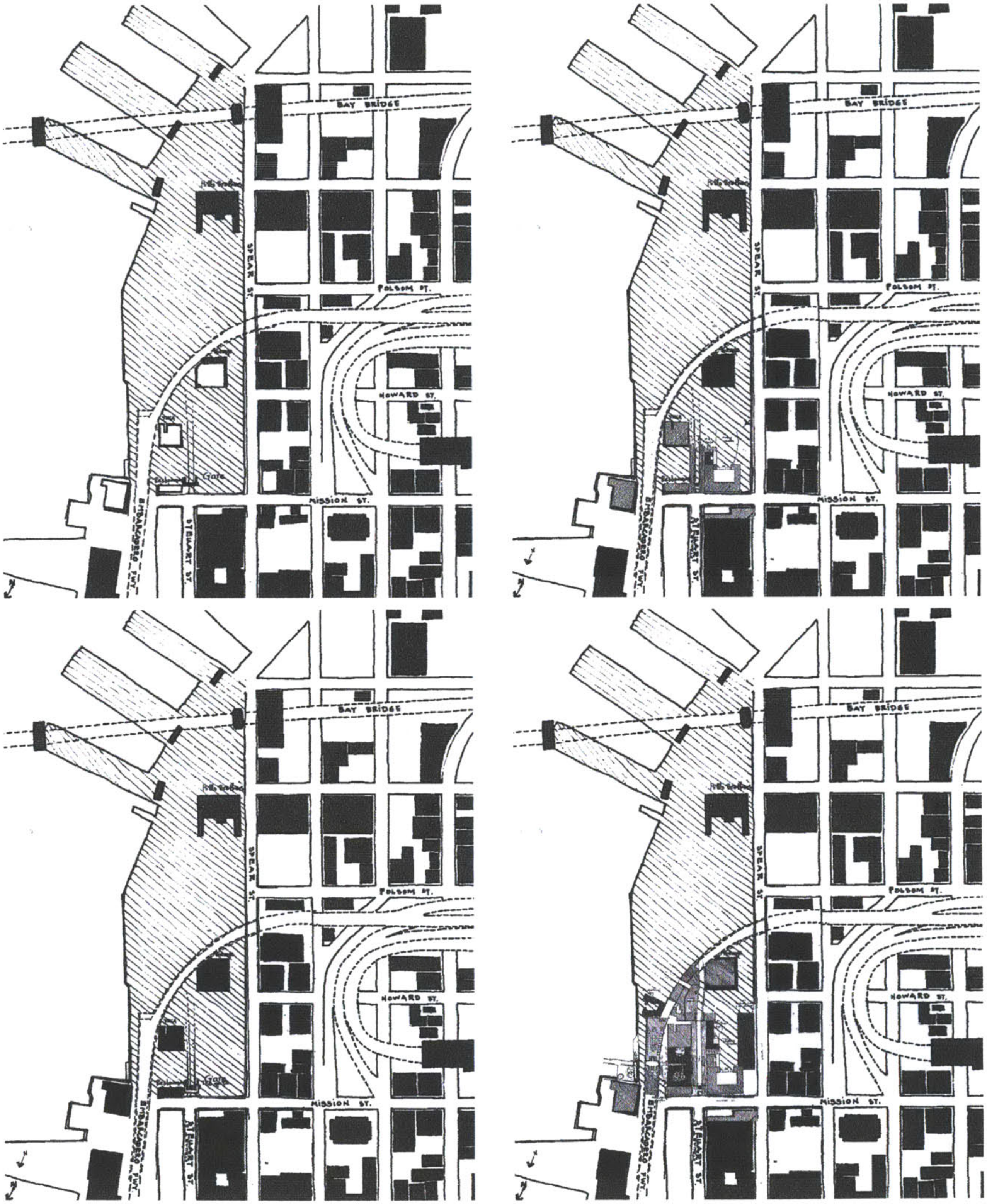
But we propose a discipline of



3i.3. Completed urban plan (Alexander, A New Theory of Urban Design, 106)



3i.4. Completed model (Alexander, A New Theory of Urban Design, 107)


BAY BRIDGE
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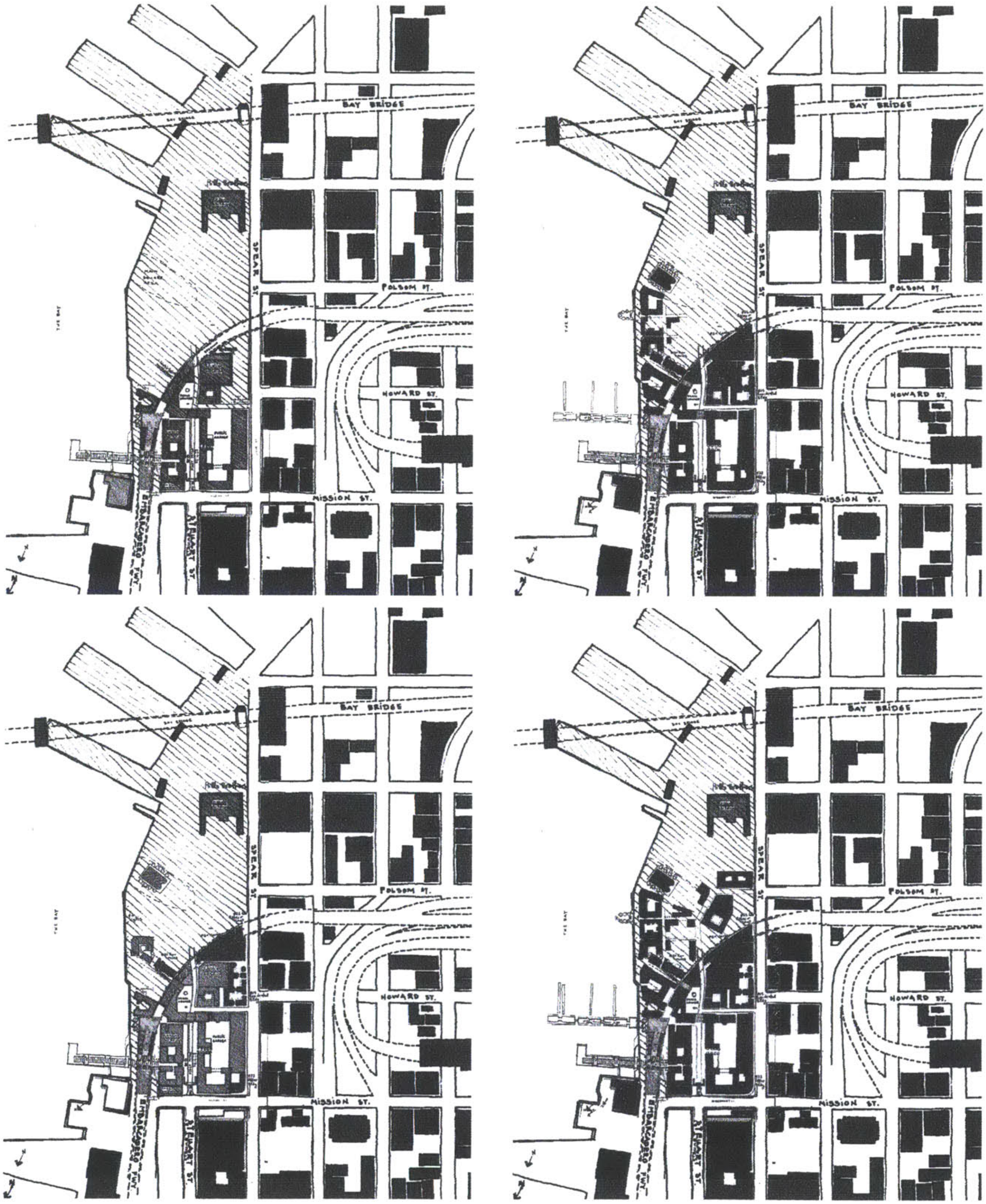


3i.5 Alexander's urban design steps overlaid to better show progression.
(Edited from A New Theory of Urban Design, 104-230)

urban design which is different, entirely, from the one known today. We believe that the task of creating wholeness in the city can only be dealt with a *process*. It cannot be solved by design alone, but only when the process by which the city gets its form is fundamentally changed." (Alexander, *A New Theory of Urban Design*, 3)

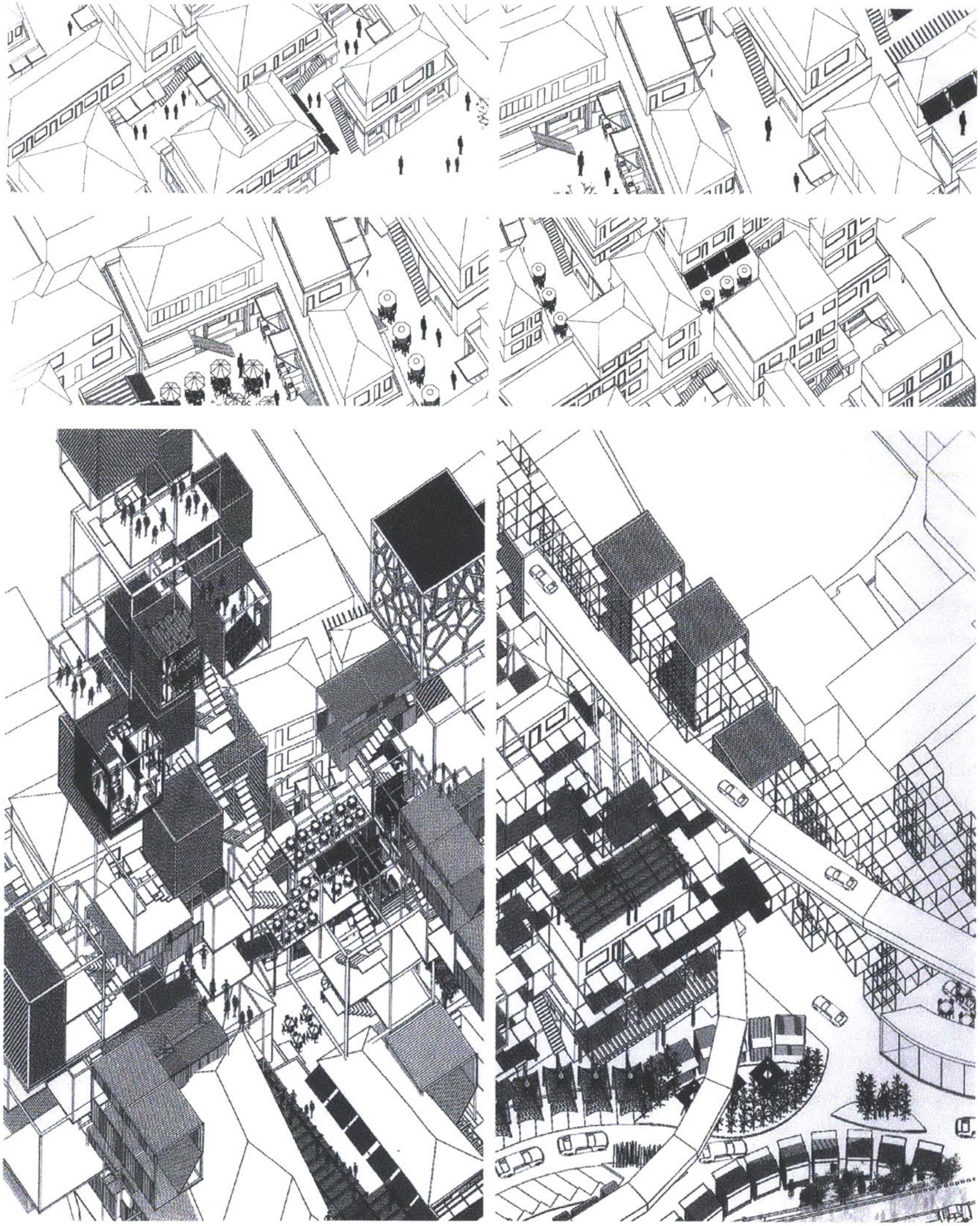
Alexander's primary objective described in this book is to create "wholeness", which he describes as the "feeling of organicness" of a city, similar to the way he described a "natural" city in "A City Is Not A Tree". Alexander's design process, guided by "a series of seven rules", attempts to simulate an imaginary process of city development over a five-year period. Similar to other theories related to urban growth, this one seems to also propose a logic for urban growth that both guide and predict urban developments. Of the seven rules, rule #3 is the most obvious example of this, which serves as "an answer to the fundamental question: *What* shall we build in any given place, where a project is to be undertaken. This question does not ask how it is organized, how it is designed, what character the architecture has... but simply the most fundamental question of all: *What is it? What is going to be there?*" (*A New Theory of Urban Design*, 51-53)

Based on the rules he designed, we can see that Alexander's theory of rules is accompanied by a personal view on what a city should be. Alexander, who is against the machine-like method of urban design, which he claims is often "a result of considered, channeled, information", ends up projecting a classical renaissance city to the site. Acknowledging this, he recognizes the drawbacks of his piecemeal design approach.

However, Alexander points out perhaps the most important thing anyone should keep in mind while designing a city: the fact that the formation of cities is a result of multiple interests that often do not correlate with each other. The irony here is that the rules presented in his theory come as a set of policies that the citizens must abide by, similar to a planning policy, ultimately dictating the subsequent urban forms. Did Alexander simply create a set of planning policy and played a simulation game of what could happen if these policies are implemented in a city? The rules in the policy he created are meant to guide developments. Any developer may choose to build as long as the development falls within the constraints of the rules to maintain "wholeness". In this case, "wholeness" is subjectively, and perhaps conservatively, defined as having similar qualities to those of an old European city.

ii. Recent and contemporary thoughts in computational and incremental urbanism

In recent years, architects, designers, and planners began to gain interest in informal low-income poor settlements. Some are drawn for altruistic reasons, proposing design solutions that can give better living standards for those who live in poverty. Others are drawn to the seemingly random and complex ordering growth logic of these settlements, claiming them to embody bottom-up urban design that possesses the ideal natural growth pattern of a city (decoding the DNA of an urban growth). Naturally, individuals

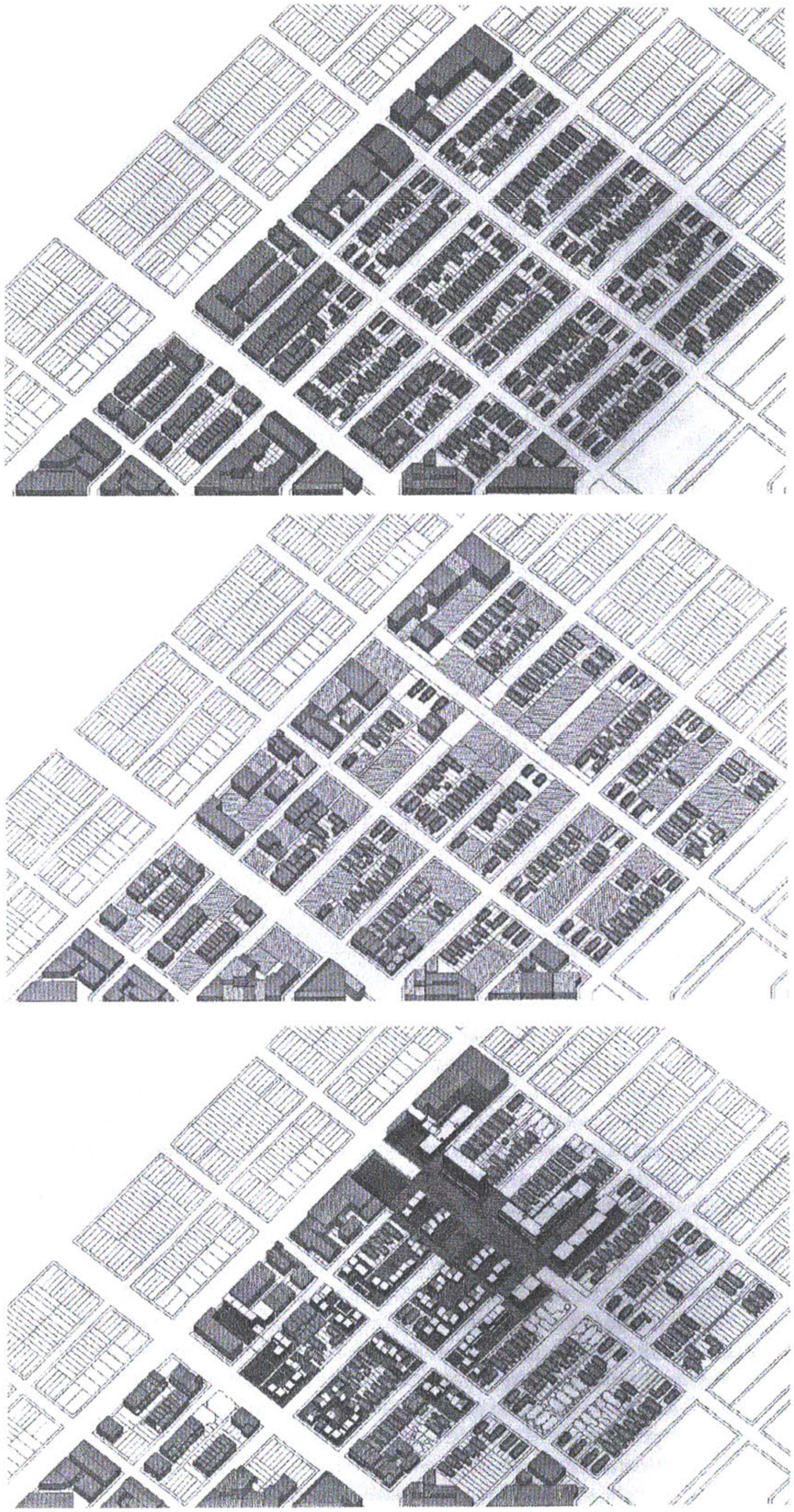


3ii.1 SuperKampung (MVRDV, 356-357)

interested in computational, incremental, and parametric urban design are attracted to informal settlements. One recent study on this topic was published in a book called *The Vertical Village* by MVRDV.

The study looks at East Asian cities and refer to their origins as "urban villages that are built up of small scale, informal, often 'light' architecture" (MVRDV, 6) in response to what they call the relentless "Block Attack", a common phenomenon in Asian cities where massive slab and block towers are erected with repetitive housing units and floor plans without any cultural context.

One of the projects in this study is titled "SuperKampung" (figure 3ii.1), which focuses on bottom-up incremental developments through fictional scenarios. The study looks at Jakarta's Kampungs (villages/small settlements) and assumes an optimistic scenario where "there will be improvements by the central government in the coming years" (MVRDV, 300). Here, the study does not propose a design scheme or an urban plan. Rather, it experiments with incremental growth by assigning each neighborhood a unique identity and



3ii.2 Patchwork Urbanism (Design After Decline, 219-221) imagining a scenario that plays out over the period of ten years. Each scenario is essentially the result of a group of designers daydreaming, pondering, and going bananas at what each neighborhood might become with few simple assumed elements in each neighborhood. It is as much an authoritarive design approach as Le Corbusier's, cloaked in a haze of informal settlements. For what its worth, it is a comic book about a few poor settlements in Jakarta.

On the other side of incremental urbanism, Brent Ryan, through the study of urban planning and policies of post-industrial American cities, proposed an urban phenomenon called "patchwork urbanism". He wrote,

> "The irregular levels of density, habitation, building stock, and open space in the shrinking city are the precise opposite of the level, homogeneous urbanism of the historical industrial city that can still be seen in intact areas of older cities. The new urban patter resulting from shrinkage may be called *patchwork urbanism*. The patchwork is dynamic, shifting and changing over time as abandonment, demolition, and new development each make their mark.
> Patchwork urbanism implies that urban design, rather than acting homegeneously across urban space in the same manner as zoning, acts in a strongly differential mode, influencing certain areas of the city much more than others. This mode of urban design is not unique to the shrinking city; market development is generally far more concentrated in some parts than in others, so parts of cities have historically changed at a greater rate while others changed slowly or not at all." (*Design After Decline*, 213-214)

Based on this, we may imagine an urban design strategy that is more incremental and patch-like. The top image of figure 3ii.2 shows a typical shrinking-city neighborhood before its decline. These neighborhoods are often "moderate-density developments with one- and two-family apartments, with commercial buildings on major streets" (*Design After Decline*, 219). The middle image shows the neighborhood in decline, assuming "a familiar appearance of vacant lots, abandoned houses, and scattered, still-inhabited buildings" (*Design After Decline*, 220). The bottom image shows how a "progressive urban design could reconstruct such neighborhoods with new housing that impoved upon the old, with new public and semipublic open spaces, and with new street patterns" (*Design After Decline*, 221).

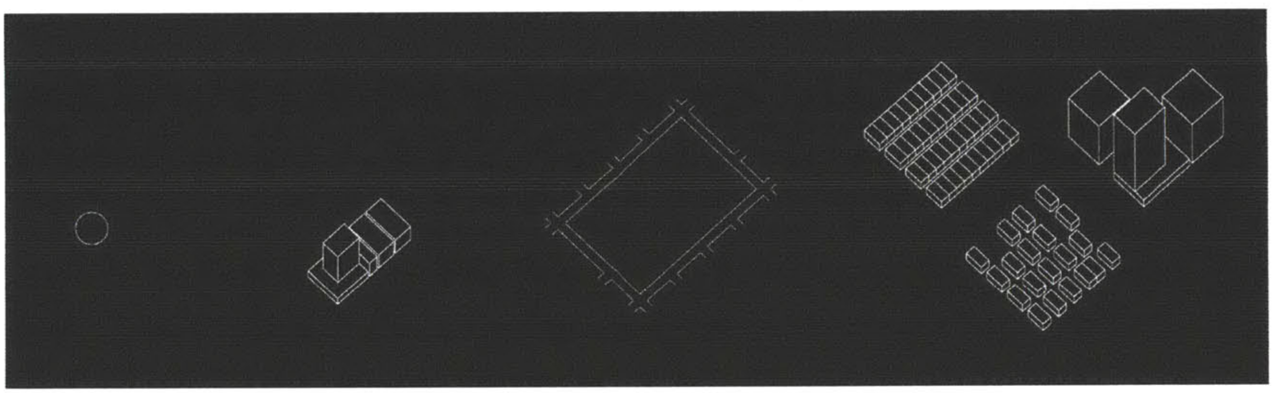
Both examples are equally fictional, though Ryan's tale is told with assumptions grounded in historical and current trends, making it a more serious study. Though not explicit, both examples imply that the final results shown are at least possible realities. I realized telling a story or a scenario of a city's development would be misleading in delivering the arguments of my thesis as it implies a type of prediction. Instead, the scenarios in this thesis are examples of *design processes* that designers would go through while designing an urban scheme using the proposed methodology. They are used as stages for experiments discussed in greater detail in the following chapter.

4. EXPERIMENTS AND REPORTS

i. The basic idea (components and relationships)

As the title suggests, the design methodology proposed in this thesis is recursive by nature. It focuses on the *components* in a city and their *relationships* to each other, contained within an *operation*. An operation contains multiple components and define their relationships. Multiple operations perform together to ultimately create an urban design scheme.

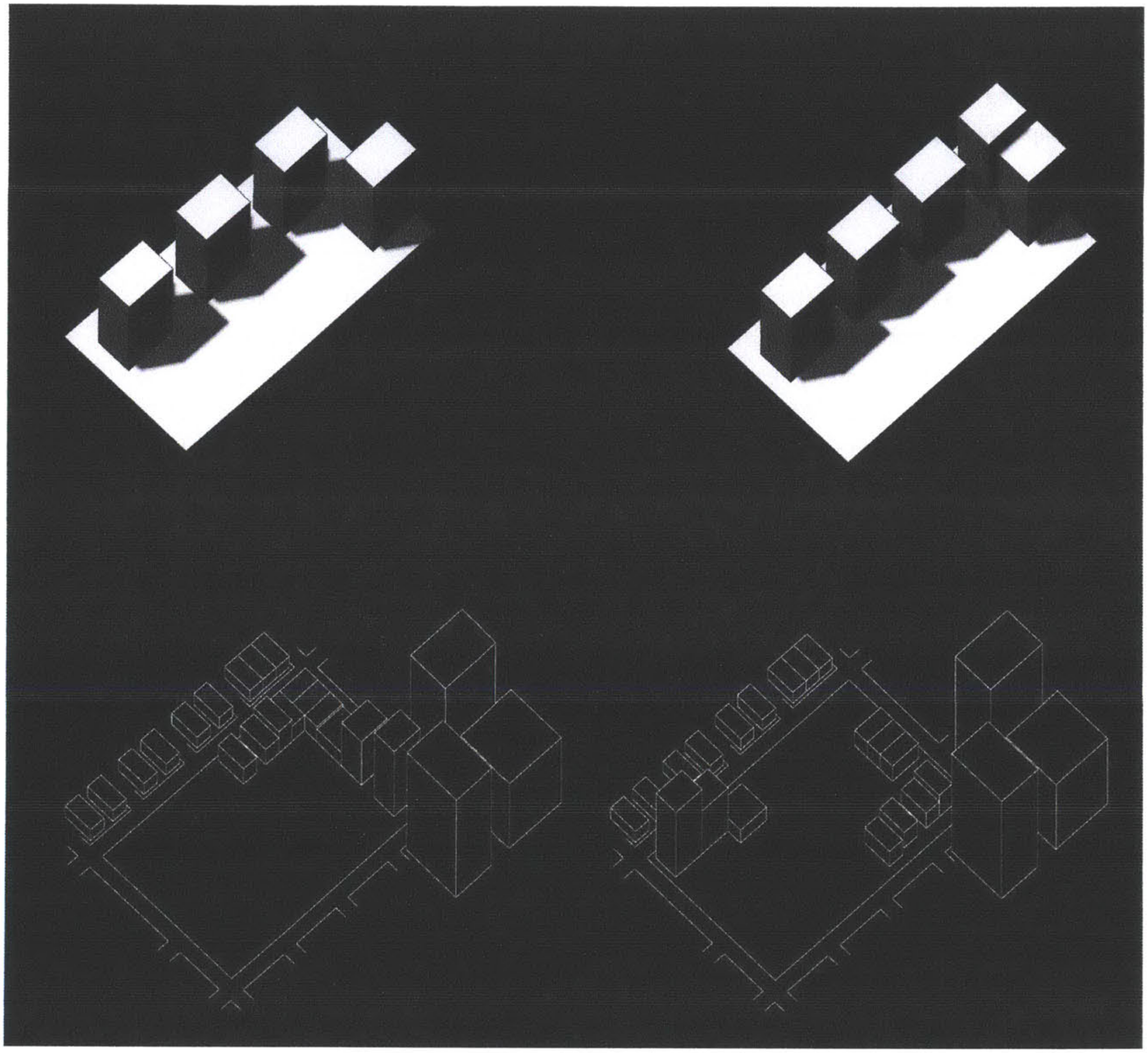
Components are objective. They are elements that exist within a city, such as buildings, building facades, parcel dimensions, sun exposure, building shadows, open spaces, parks, waterfronts, etc. The list is almost endless. It is up to the designer how many components he/she wants to consider during the design process. Generally, more components require more complex relationships and operations. However, it doesn't mean designers need to include as many components as possible during the design process. A good designer knows which components are important for the project and which are irrelevant.



4i.1. Some of the components taken into consideration in this thesis: (from left) sunlight, building mass, large open space, building scales and parcel sizes

Relationships, at least at this point, are subjective. One component may have multiple relationships with other components based on the operation that contains it. Relationships define how each component affects others within an operation. It is up to the designer to define these relationships based on what kind of design scheme he/she wants to create.

For example, as shown in figure 4i.2, the top two diagrams show two components, in this case building mass and building shadows, with two different relationships. The left diagram shows a relationship where the base of each building cannot be covered by any building shadows, resulting in a design scheme where the building masses are spaced further apart from each other, exposing each of their street levels to receive



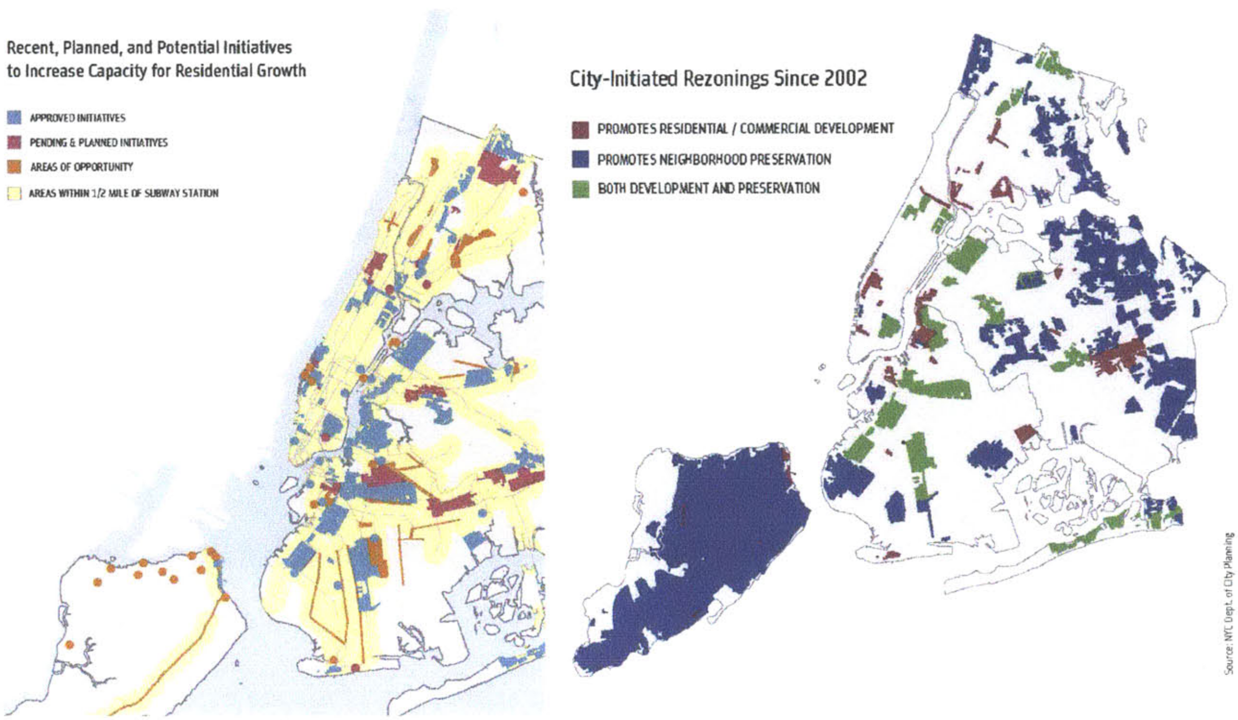
4i.2. Different relationships defined by different designers based on different design agenda

direct sunlight exposure. The right diagram shows a different relationship of the same two components, where building shadows are allowed to cover only the base of other buildings, resulting in a scheme where direct sun exposure cannot reach the ground spaces of each building.

Another example of this is shown by the bottom two diagrams of figure 4i.2. In this case, the two components being considered are surrounding (existing) building sizes and new building sizes along with their placements. The diagram on the left shows a relationship where the designer decides to place new buildings of similar sizes with their immediate surrounding context, creating a similar condition with what already exists on site. The diagram on the right shows a relationship where the designer decides to do the exact opposite, placing large new buildings around existing smaller buildings and small new buildings around existing larger buildings. Depending on what kind of city the designer wishes to design, different relationships will result in different urban design schemes.

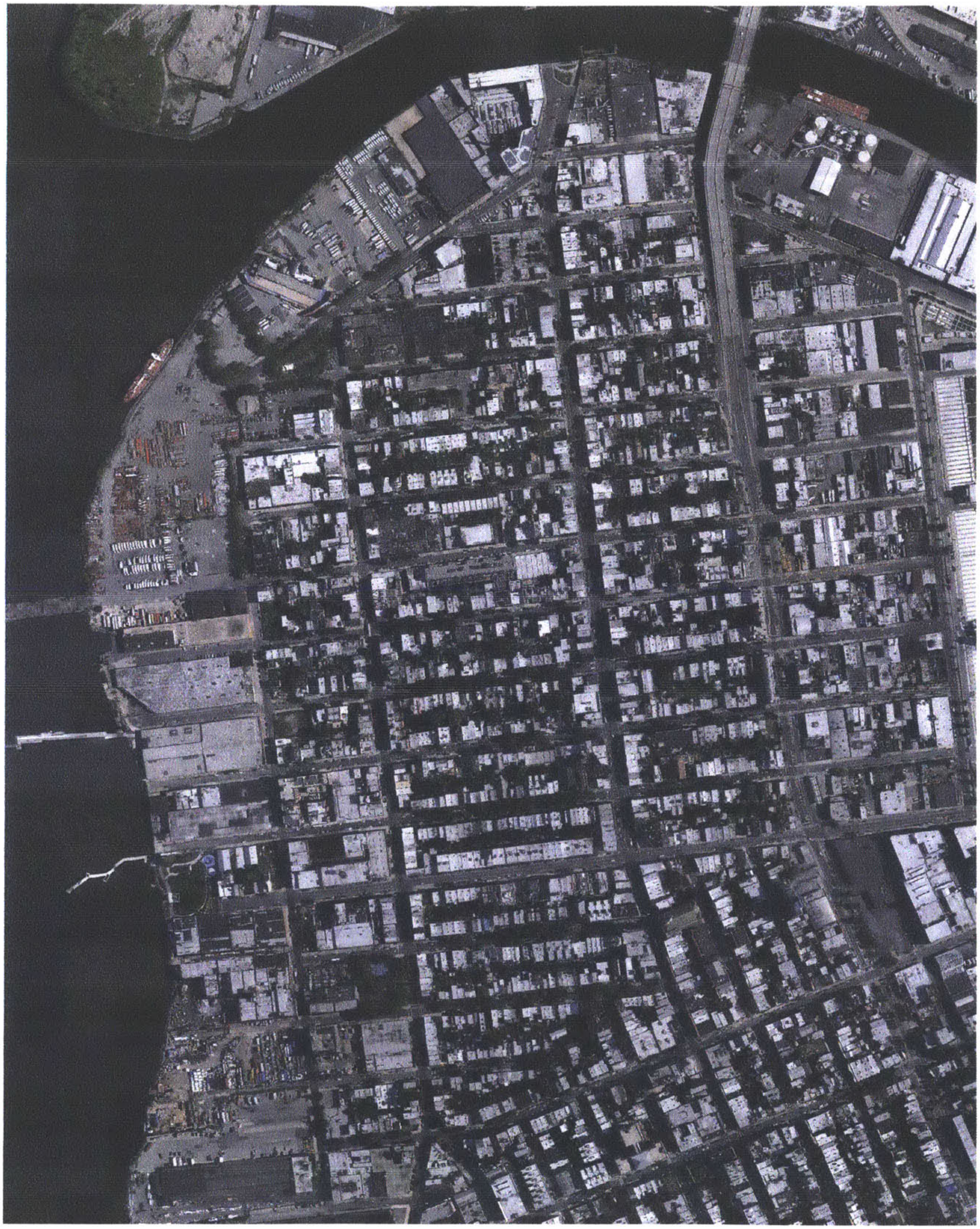
ii. Site selection

In order to test the proposed urban design methodology, I have chosen a site in Greenpoint, Brooklyn. The site was simply selected based on Mayor Bloomberg's PlaNYC 2030, a long-term planning agenda to anticipate "a growing population, aging infrastructure, a changing climate, and an evolving economy" (PlaNYC, 3). It designates various areas of New York City for various future developments. Based on this plan, parts of Greenpoint are planned for increased residential capacity in the form of new neighborhoods centered around residential and commercial developments.



4ii.1. PlaNYC 2030 potential initiatives and zoning maps (PlaNYC, 22-23)

PlaNYC provides concrete program agenda for the site which allows the thesis to focus on experiments without having to worry too much about site programming and analysis. The site selection is not critical to the successes and failures of the project, but selected area in Greenpoint provides a variety of urban scenarios that include a waterfront, a relatively regular urban fabric, large industrial and post-industrial buildings, low-rise residences, and commercial activities.



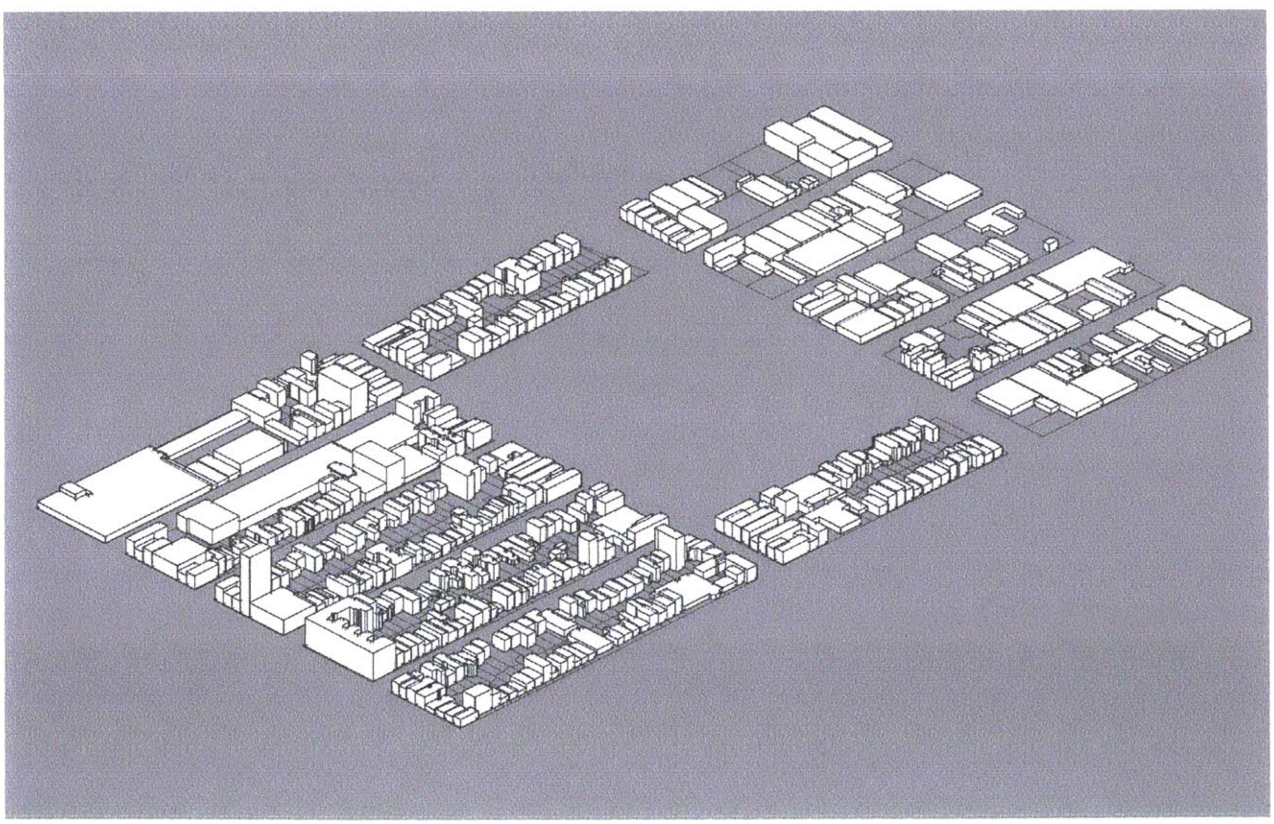
4ii.2. Site: Greenpoint and its waterfront

iii. Operations

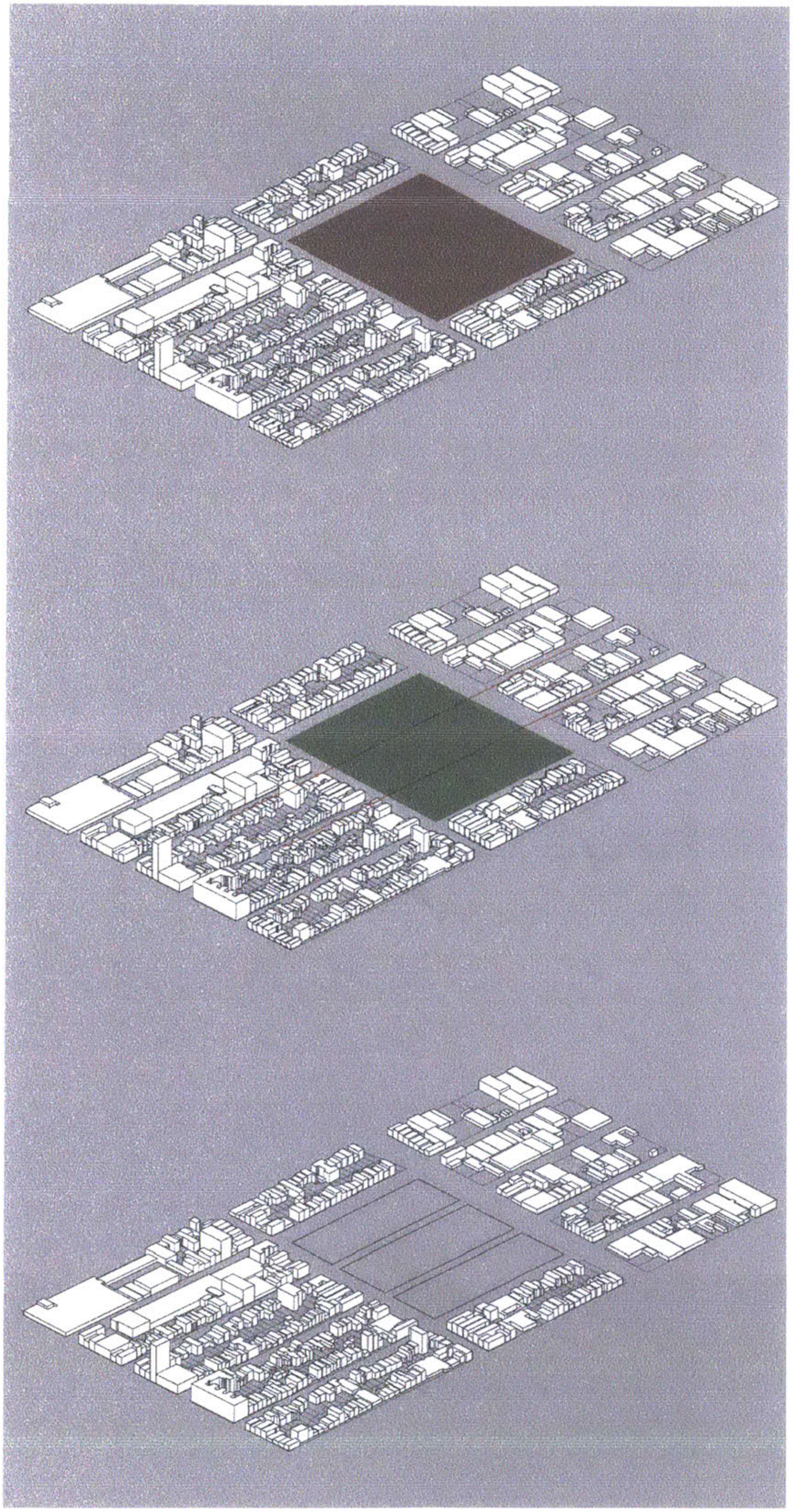
Each design scheme produced in this thesis is a result of a series of *operations* that are constantly tweaked and developed as more experiments are conducted in order to find out proper relationships between components and, more importantly, how tweaking relationships explicitly affects the urban form. Each operation contain multiple components and specific relationships between them.

There are a few operations I created during this thesis, each of which plays a specific role in the creation of an urban design scheme. Each of them was tested on a generic rectangular site shown in figure 4iii.1.

The first operation is called *RoadNetwork* (figure 4iii.2). It deals with the formation of the urban fabric. It is a way to create circulation system and deal with an oversized site by splitting it up. It works by connecting existing roads that end at opposing edges of the site. In this operation, a site is identified. In this case, it is recognized as one oversized block indicated by the red color (figure 4iii.2 top). The threshod for tolerable block size is determined by the designer. Depending on the number, this initial size may be either appropriate or oversized. If it is oversized, we proceed with the RoadNetwork operation.



4iii.1. Generic site to test various operations



4iii.2. RoadNetwork operation

After recognizing the site to be oversized, it identifies existing roads that lead to and end at the site's edges. It then connects the ends of these roads that are located at the opposing side of the site (figure 4iii.2 middle). This can be tricky if the site's shape is irregular as it becomes ambiguous as to which sides are opposite of which.

Now that the site is split, the color indicator turns green, indicating the resulting split blocks are now within the tolerable defined size and they are no longer oversized. Finally, new city blocks are created, generating a new urban fabric.

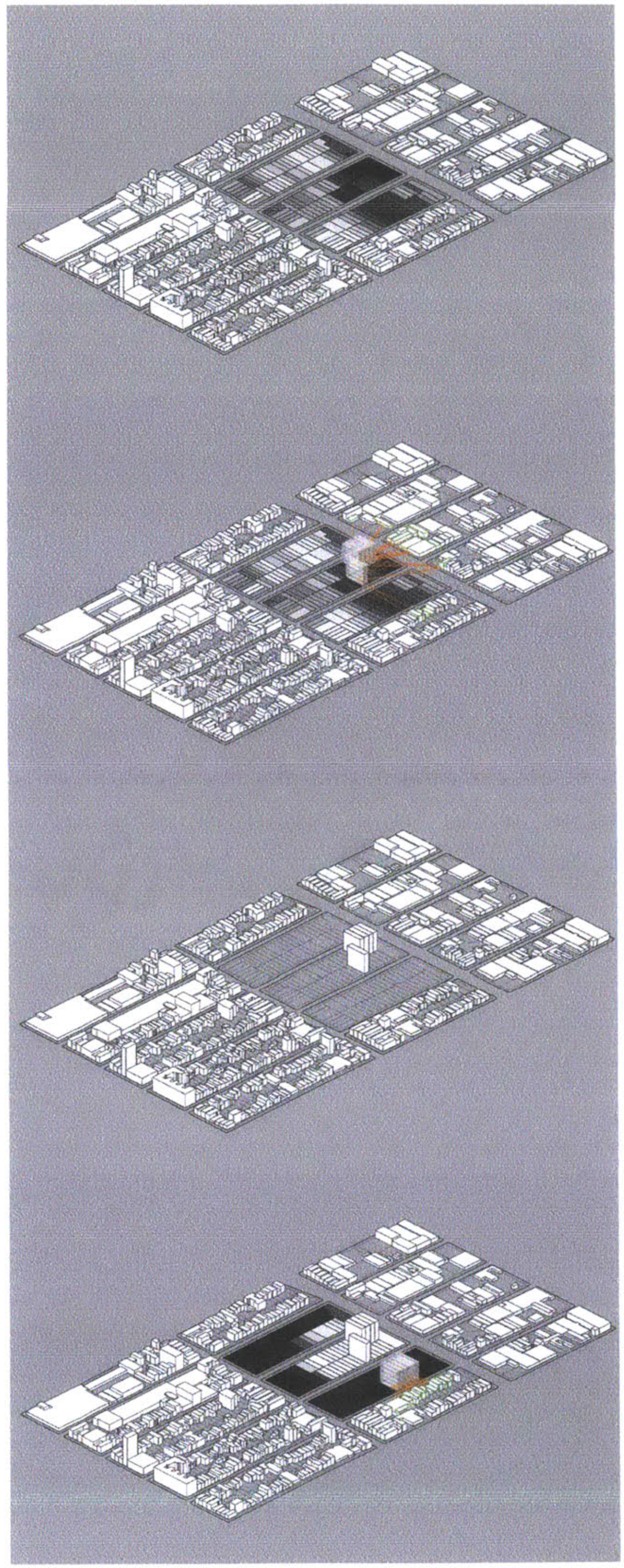
The second operation is called *BuildingHeights*. It deals with the sizes of new to-be-developed buildings as well as suggesting a build order based on surrounding context's density. The "recursive" part of the proposed methodology is demonstrated clearly here.

The operation is divided into two sub-operations.

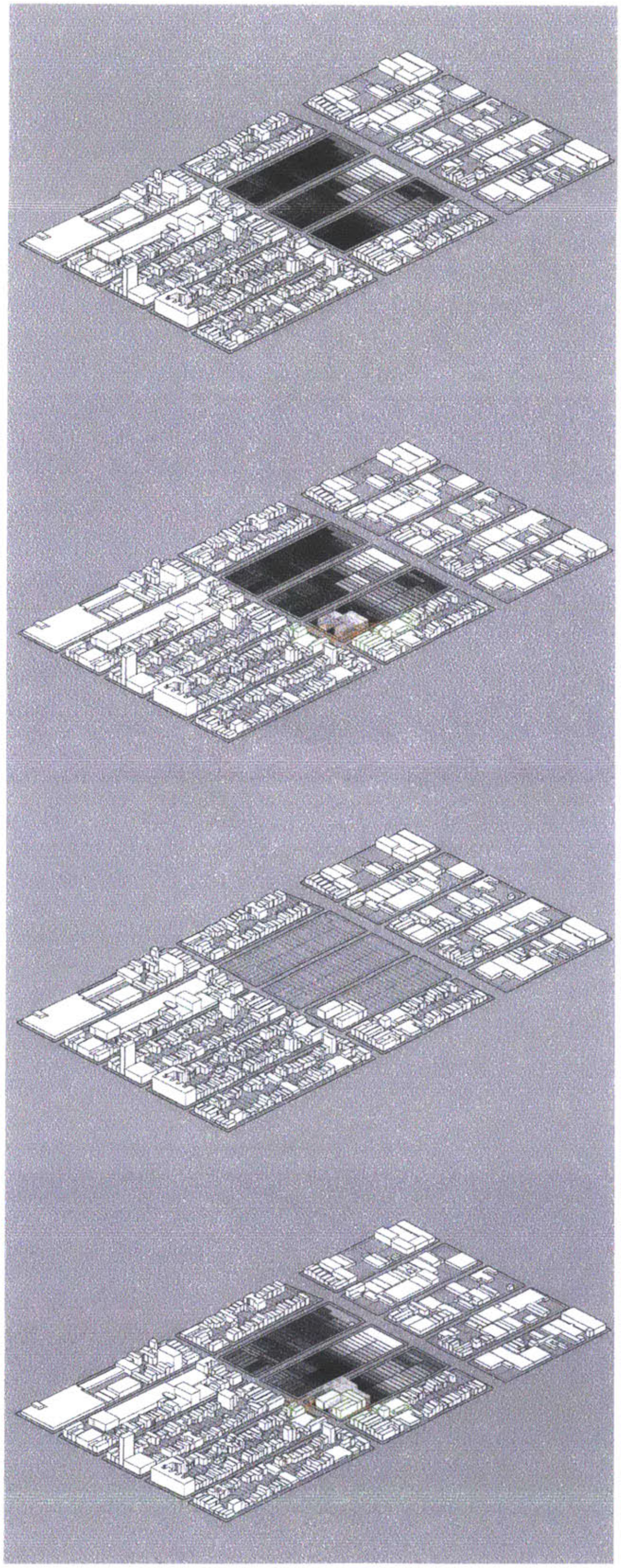
The first is called *CatalystSequence* (figure 4iii.3). This operation makes sense when used for developing large buildings that can be a catalyst of urban activity. It works by taking the least dense area around the site and suggests that it should be developed first during the design process. The grayscale field (figure 4iii.3 top) shows the surrounding density value of each parcel in the site. In this case, the darkest parcels have the lowest surrounding density value. The designer decides how many buildings he/she wants to place on each sequence. Ideally, one building at a time would produce the most accurate result as it will affect the density field the least in one sequence. In this case, I decided to place five buildings per sequence.

Because the method is recursive, once the first design sequence is done, we must re-evaluate the entire site again based on what we just did. The bottom image of figure 4iii.3 shows a different field of surrounding density, which takes into account our own design moves, affecting all of the sequences ahead.

The second sub-operation is called *GrowthSequence* (figure 4iii.4). It is the exact reverse of CatalystSequence. This operation makes sense when used for extending an existing urban



4iii.3. BuildingHeights operation (CatalystSequence)



4iii.4. BuildingHeights operation (GrowthSequence)

environment with smaller buildings. The idea is to build where there are a lot of urban activities already since smaller buildings do not have the same capacity to house a lot of people and generate urban life on their own.

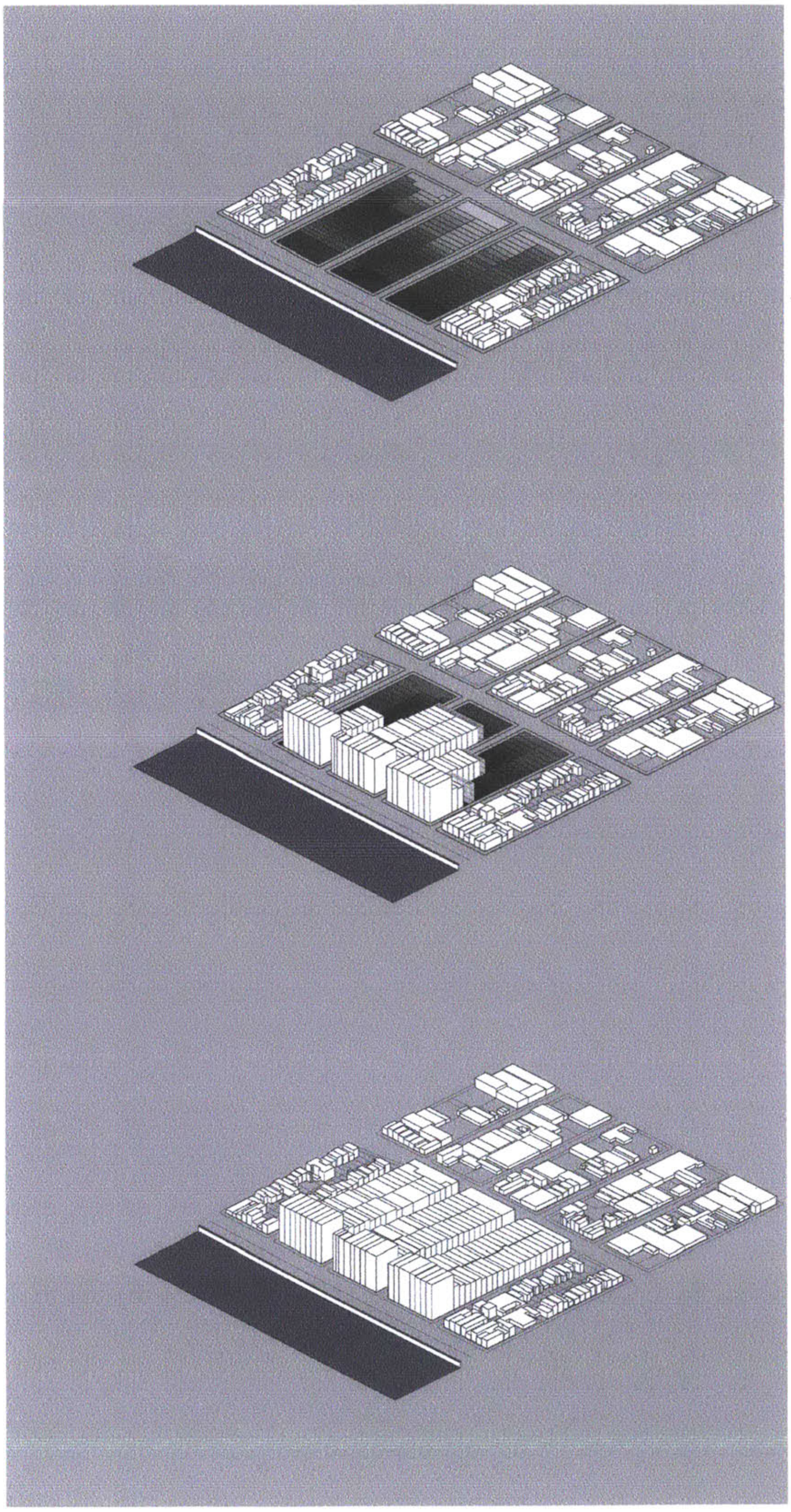
The third operation is called *OpenSpace*. It deals with how a large open space, such as a waterfront or a large park, affects the design sequence as well as the size of the buildings. This operation works together with BuildingHeights if a large open space is present at the site. In the example shown here (figure 4iii.5), we assume an active and successful waterfront public amenity, strong enough that it makes sense to design along the water earlier in the design process. It affects building's size based on how far the building is to the nearest edge of the water.

The diagram on the top shows a field of density, similar to those in *BuildingHeights* operation that suggests the design sequence. This field, however, is affected by the waterfront edge significantly, placing greater priority on the parcels along the water regardless of them being away from existing buildings. The designer must define the level of success of the waterfront. Depending on how he/she defines it, the waterfront may not be strong enough to pull priority towards the parcels along the water. It may not affect the design sequence at all. It may place even greater priority on parcels away from the waterfront in the case where the waterfront is completely undesirable for development and public activities.

The fourth operation is called *SunShadow* (figure 4iii.6 and 4iii.7). It deals with large and tall buildings to ensure that the subsequent buildings in the design process receive ample daylight. The designer decides what time frame he/she wants to take into consideration in this operation. This decision can be influenced by the program of the site (morning sun for residential, afternoon/evening sun for parks and playgrounds, etc.).

It works by removing parcels that are covered by shadows of buildings in each sequence, ensuring that no buildings are placed there. The base sequence is generated by BuildingHeights operation.

Figure 4iii.6 shows the operation using the morning sun (9:00 AM)



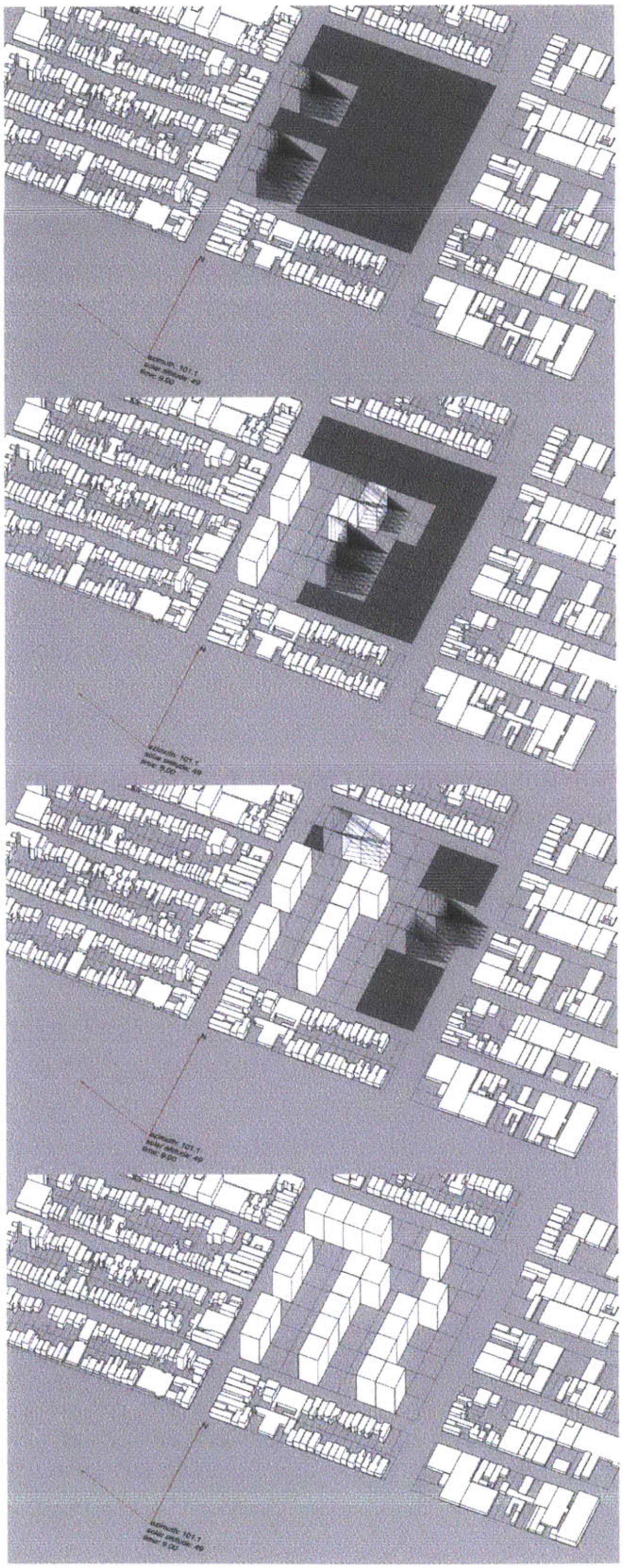
4iii.5. OpenSpace operation

as a component whereas 4iii.7 shows the operation using the noon sun (12:00 PM). In these examples, the relationships remain the same, but the components change. By using different components, we arrive at a different design scheme.

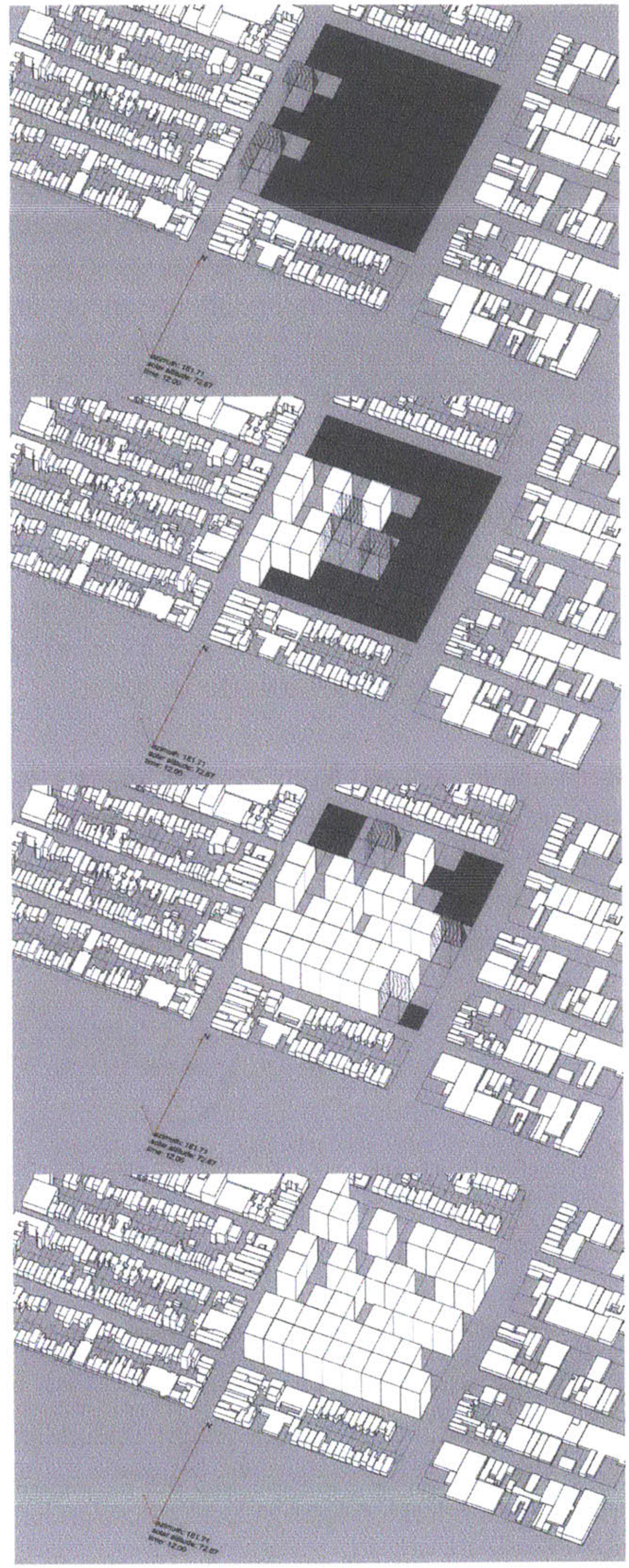
The version of the operation shown here has a major flaw. As shown by figure 4iii.7, because the operation only removes shaded parcels on each sequence, parcels that are not shaded remain even if developing them will cast shadows over previously developed buildings. This problem was fixed in later versions and operations.

The fifth operation is called *BuildingTowers* (figure 4iii.8). This operation stemmed from the previous operation, *SunShadow*. Just like it, the sequence here is also generated by BuildingHeights operation (surrounding density field). It is used to create a tower-based neighborhood complex. It works by taking parcels selected by BuildingHeights and creating a low-rise tower base (primary), whose height can either be determined by BuildingHeights or manually entered by the designer. It then takes the parcels adjacent to it, checks their density values, and creates extensions of the tower base (secondary) where the values are high enough. It also creates a tower on top of the primary tower base, whose height can also be determined by BuildingHeights or manually enterred by the designer.

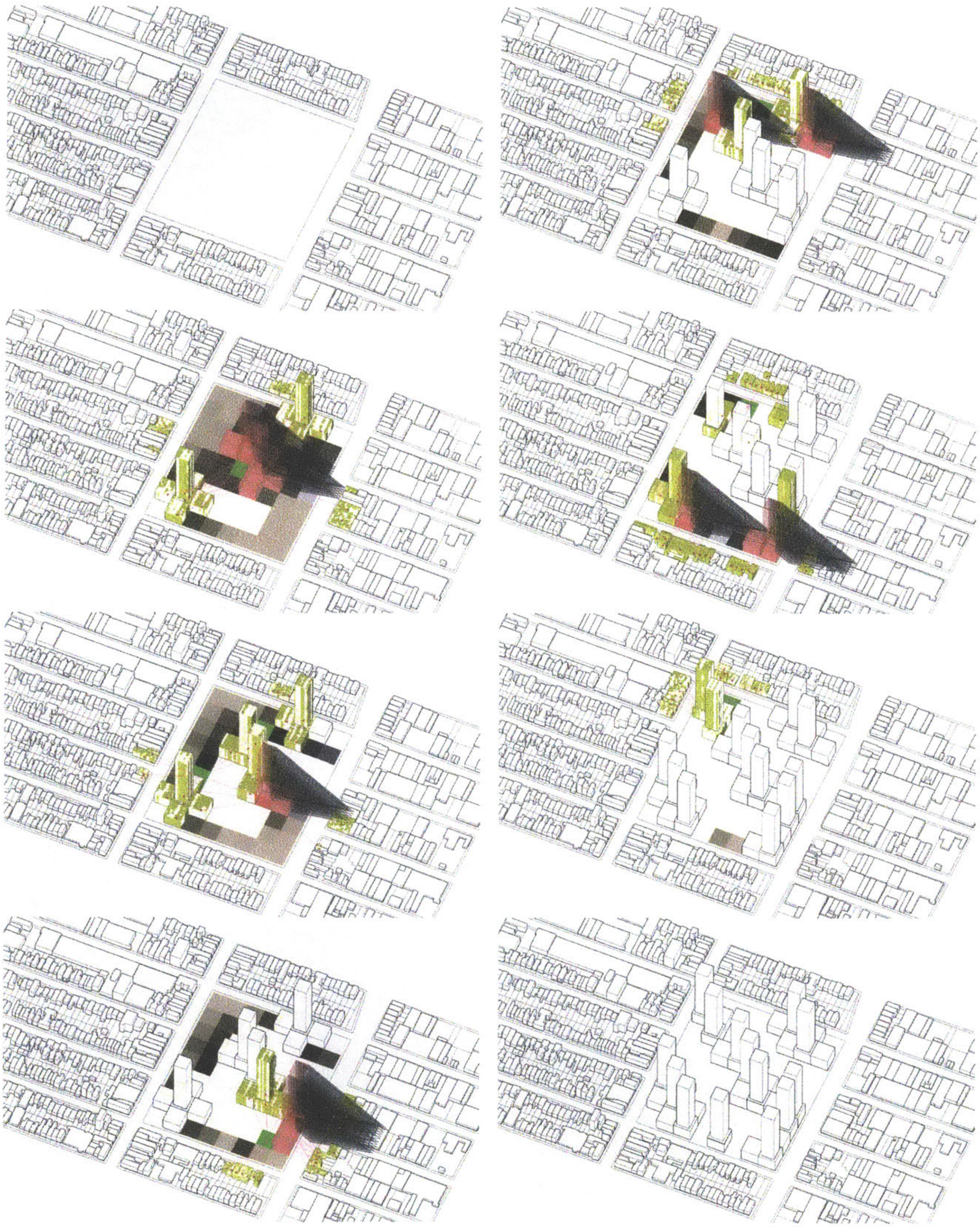
BuildingTowers includes a very important feature that SunShadow does not. Whenever a parcel is selected, it checks whether placing a tower there will cast shadow over those created in previous sequences. If it does not, the operation will place a tower base, check for tower base extensions, and place a tower. If, however, it casts shadows over previously created buildings, it will not do any of the former steps and eliminate the parcel from future considerations. These parcels are highlighted in green in figure 4iii.8.



4iii.6. SunShadow operation (9:00 AM)



4iii.7. SunShadow operation (12:00 PM)



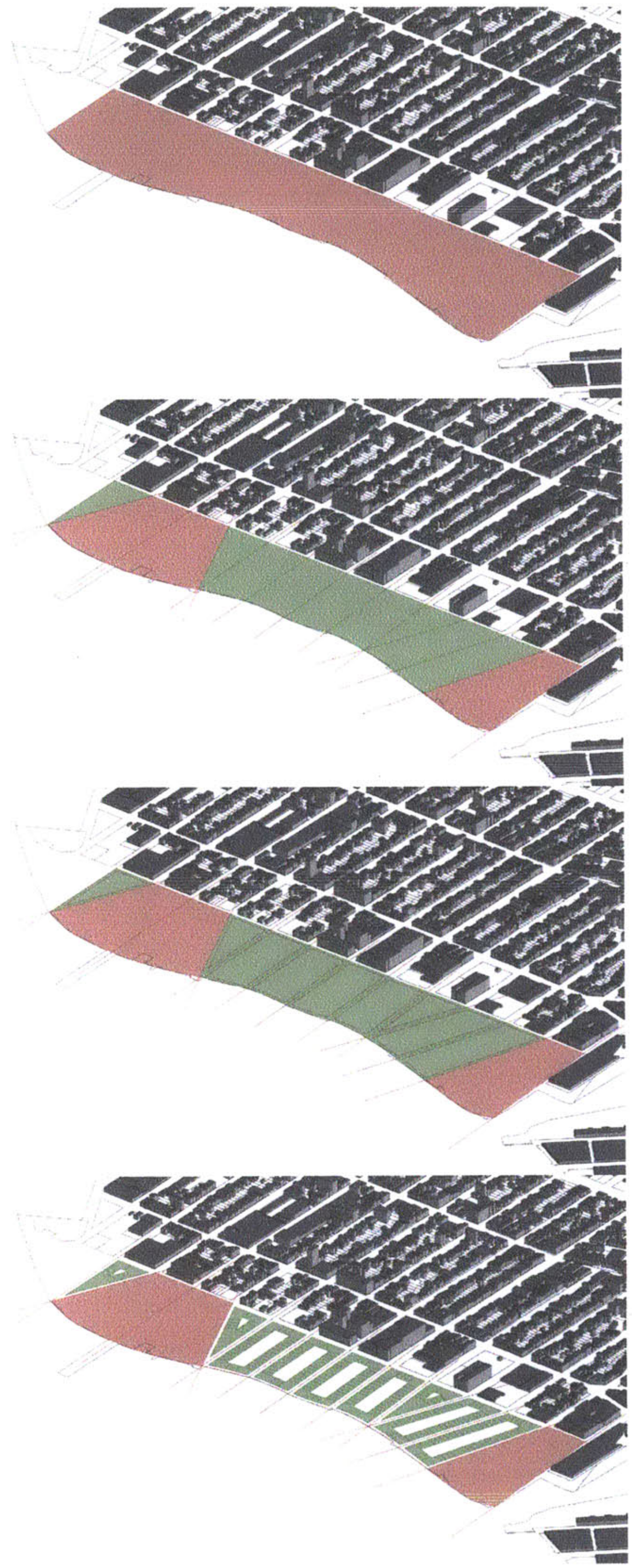
4iii.8. BuildingTowers operation

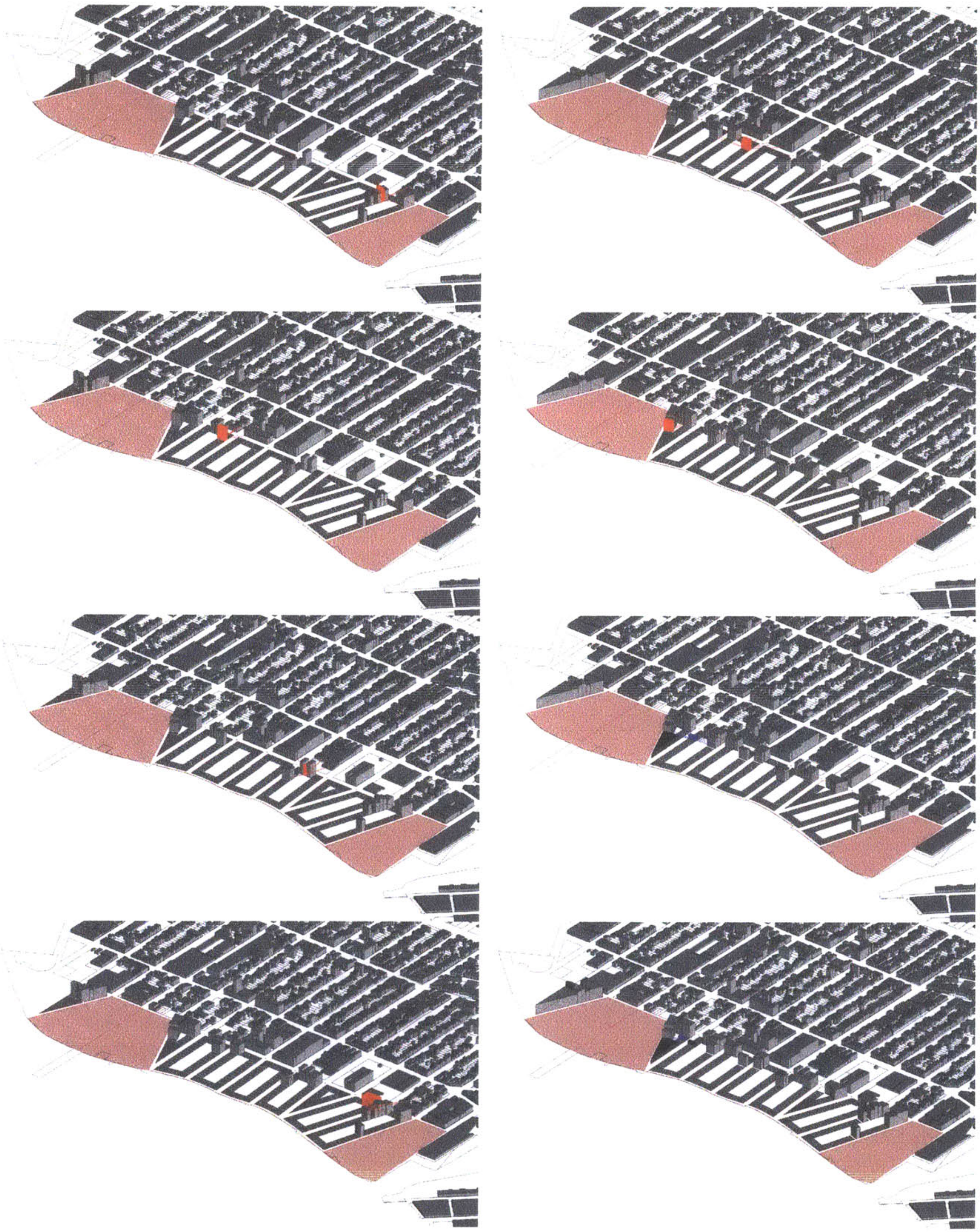
iv. Experiments

The ultimate goal of the experiments is to demonstrate that the proposed methodology can be adopted as a standard of urban design practice. Thus, the first experiments were only concerned with making an implementable urban plan. From this point on, each experiment will be referred as *Combined-X*, where X is a number that identifies the iterative version of the experiment (i.e. Combined-1, Combined-2, etc.). Each of the Combined experiments is conducted on the same exact site in order to reduce as much unnecessary variables as possible in the experiments.

It is important to keep in mind that the overall design agenda of each experiment is to create a new mixed-use neighborhood that consists primarily of residentials, which is derived from PlaNYC's planning agenda.

The images on the left (figure 4iv.1) show sequences of the first Combined experiment (Combined-1), which utilizes two operations: RoadNetwork and BuildingHeights. There are a few assumptions made when the experiments began. The first

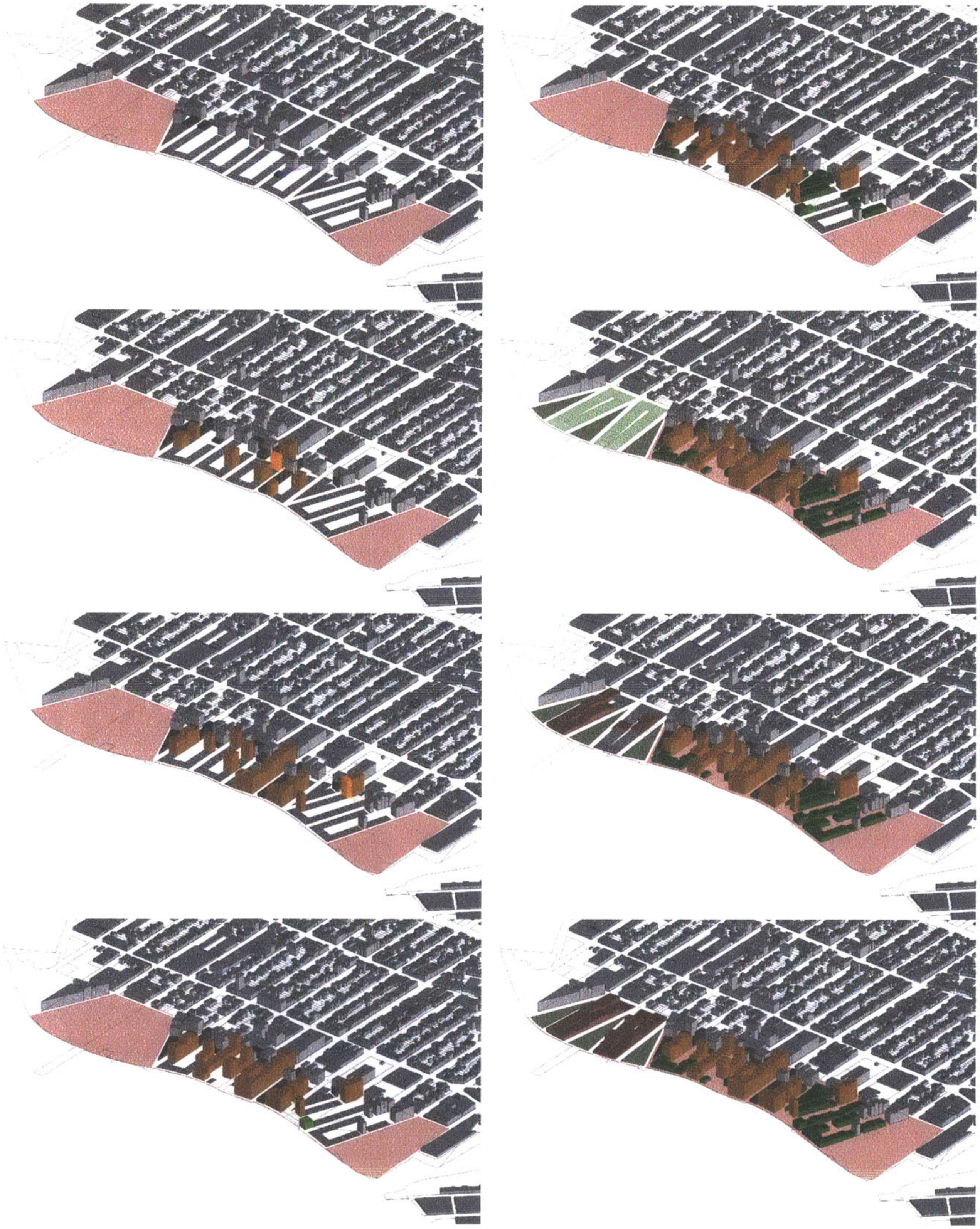




4iv.1. Combined-1 experiment sequences is that new blocks and parcels structure are similar with the ones that already exist around the site. The second is that new buildings have similar sizes and heights with those that already exist around the site. These assumptions are made as part of my own personal design agenda. The experiment could have been conducted with a different (but consistent throughout the various Combined versions) agenda and the overall goals would still remain.

Combined-1 showed a degree of success in generating an urban fabric with a network of roads. However, in addition to ignoring the waterfront, the experiment was way too slow because each sequence of the recursive process only calculates one parcel at a time.

Combined-2 (figure 4iv.2) is the most time consuming experiment in this entire thesis. There are 247 recursive sequences in this experiment because each sequence only calculates one parcel at a time. The purpose of this experiment was to simply see what kind of design scheme the methodology might produce with just two simple operations. During Combined-2, settings

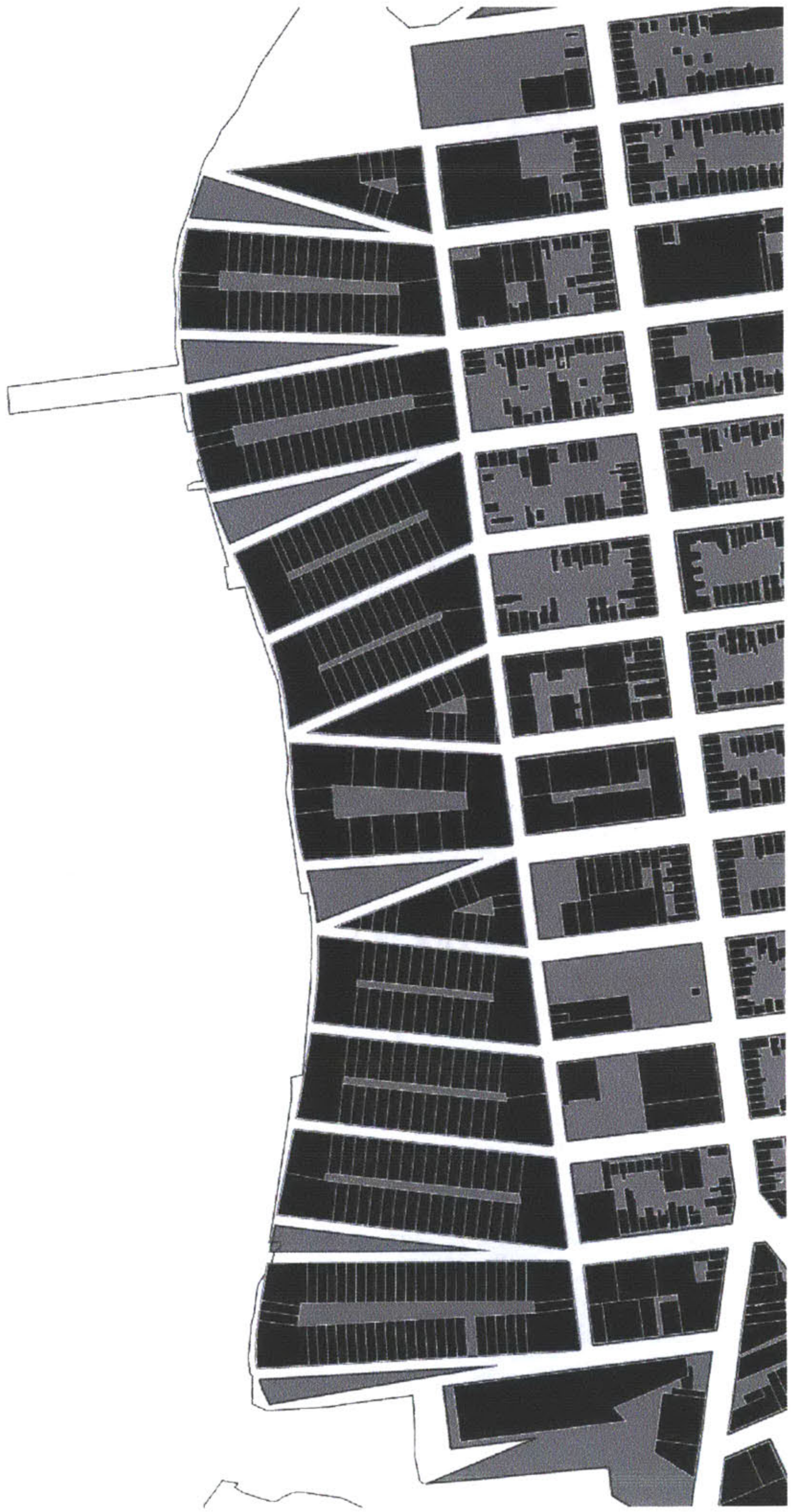


4iv.2. Combined-2 experiment sequences

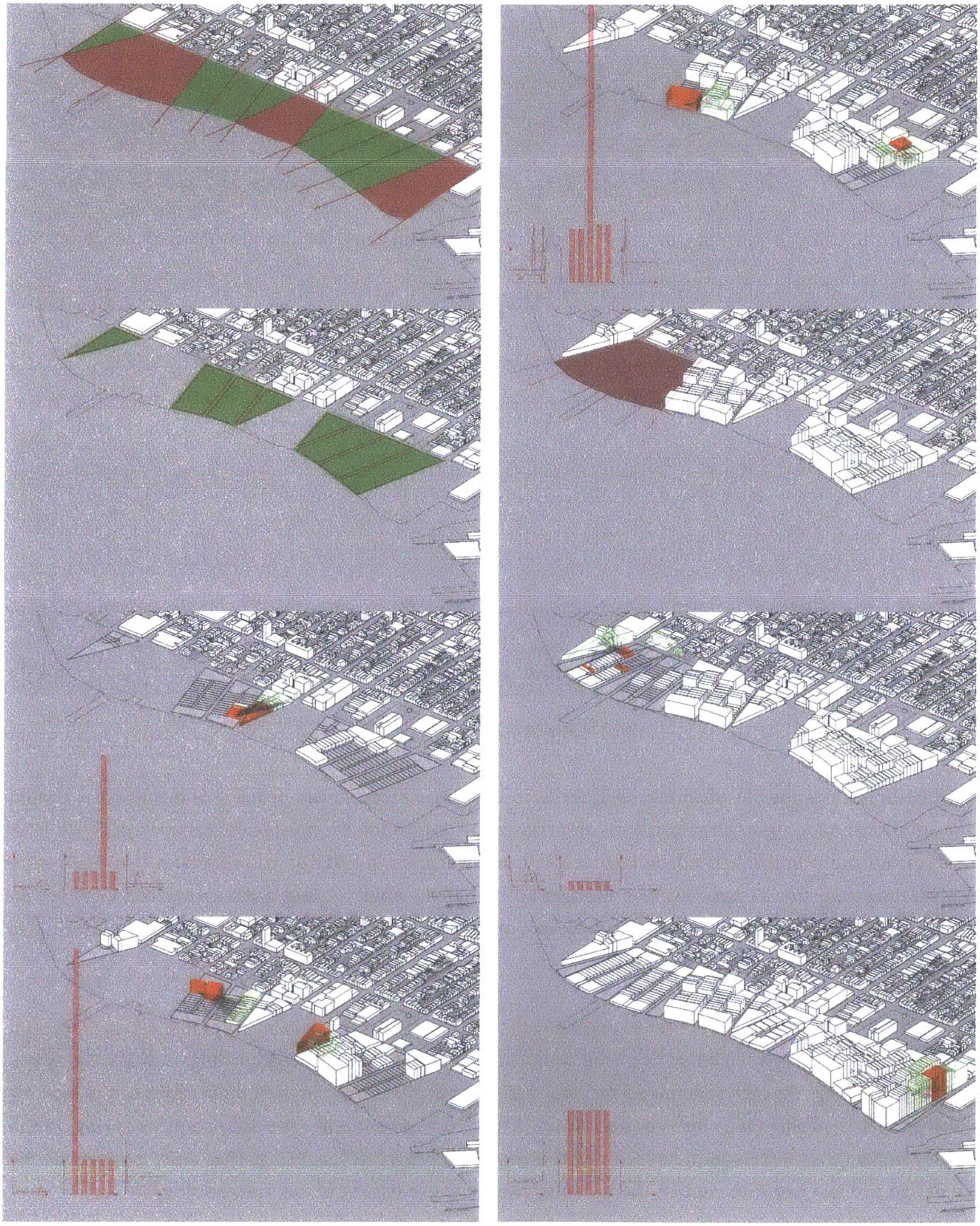
within each operation had to be tweaked every now and then in order to produce a feasible and implementable result. The experiment was inconsistent because the operations failed to produce even the simplest acceptable urban design.

Combined-3 (figure 4iv.3) is the first experiment that shows promise and acceptable urban plan. Unlike the previous two, Combined-3 calculates five buildings at a time in each sequence, speeding up the process of completing the entire plan. However, the operations involved in this version ended up creating many sharp triangular urban blocks that obstruct the view corridors from the city towards the water. (figure 4iv.6, bottom) This was the result of seeking the nearest path from the existing road ends towards the waterfront's edge at the expense of other types of the neighborhood's connections to the waterfront.

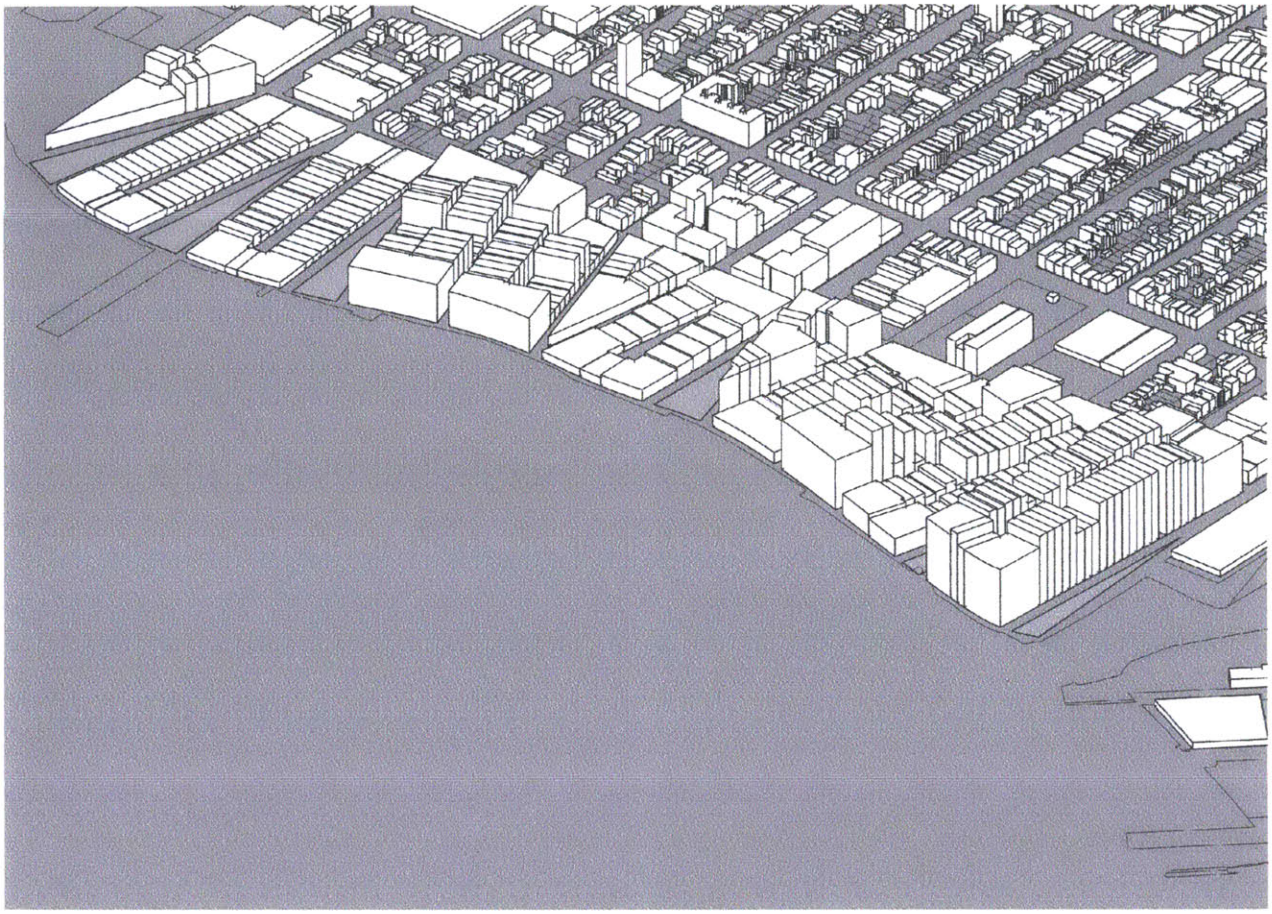
In addition, this version introduces a set of bars and graphs that show three information constantly changing at each sequence: surrounding buildings volume, new buildings volume, and new buildings GFA. This feature was originally introduced



4iv.3. Combined-3 final urban plan



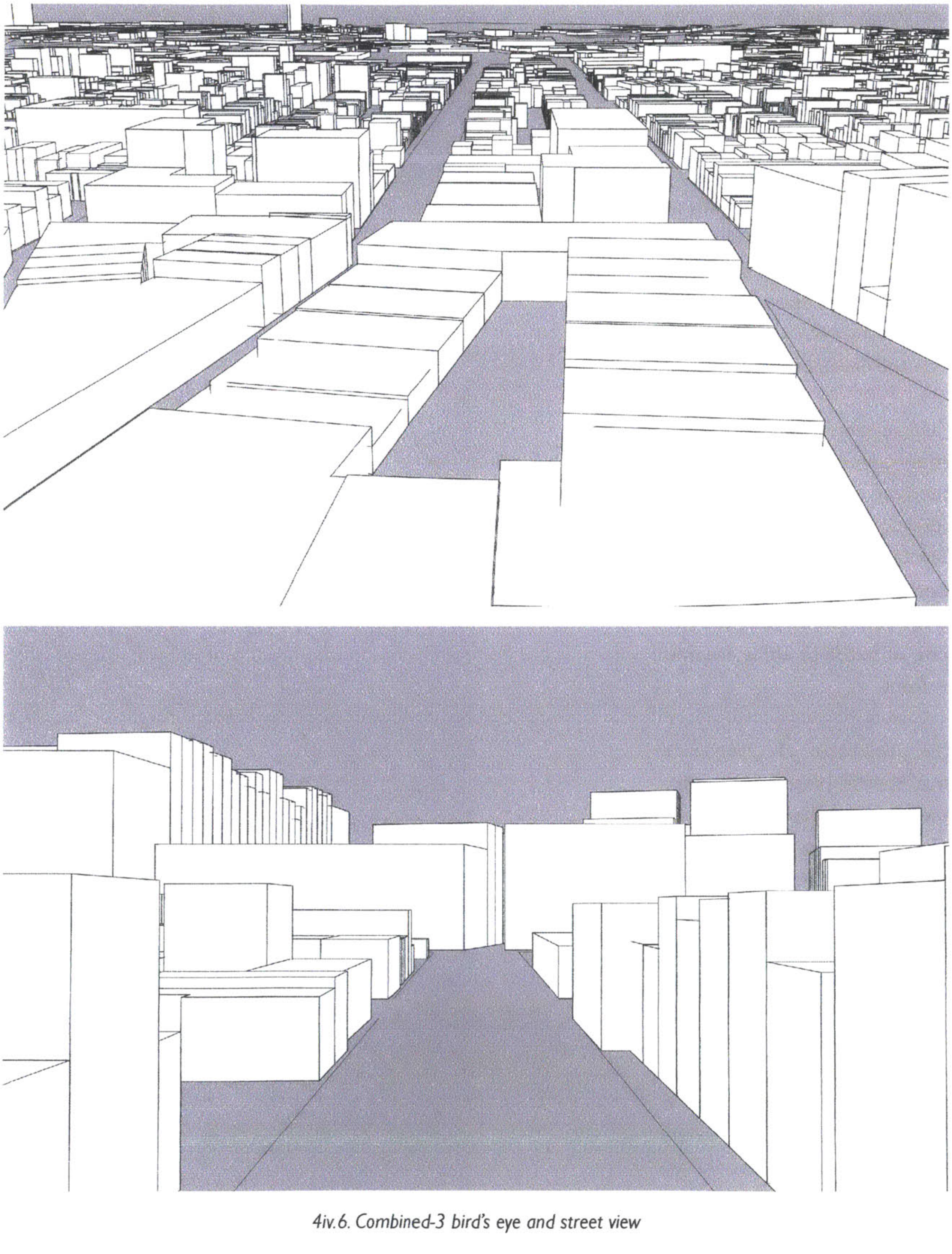
4iv.4. Combined-3 experiment sequences



4iv.5. Combined-3 final axonometric

with the urban designer in mind. If a designer is to use this method in the process of designing, it should take advantage of computer's calculations and constantly update the designer so he can always check how much of the site context he's taking into account in his analysis in addition to the amount of real estate he's creating with the design. This was thought to be helpful when a client gives a required GFA for an urban scheme. Believed to be somewhat irrelevant and distracting from the true purpose of the thesis, this feature was removed in the later versions.

Combined-4 (figure 4iv.7) is the first experiment that successfully results in an acceptable urban plan. Each sequence calculates eight buildings at a time. In the images on the right, the red buildings indicate the newly calculated buildings on each sequence. The lines radiating outwards from each of them point to the existing buildings that are being taken into consideration. In all of the experiments, the early sequences rely on the existing buildings as information sources. As the sequence progresses, buildings that were created during the design process begin to replace them due to the recursive nature of the methodology.

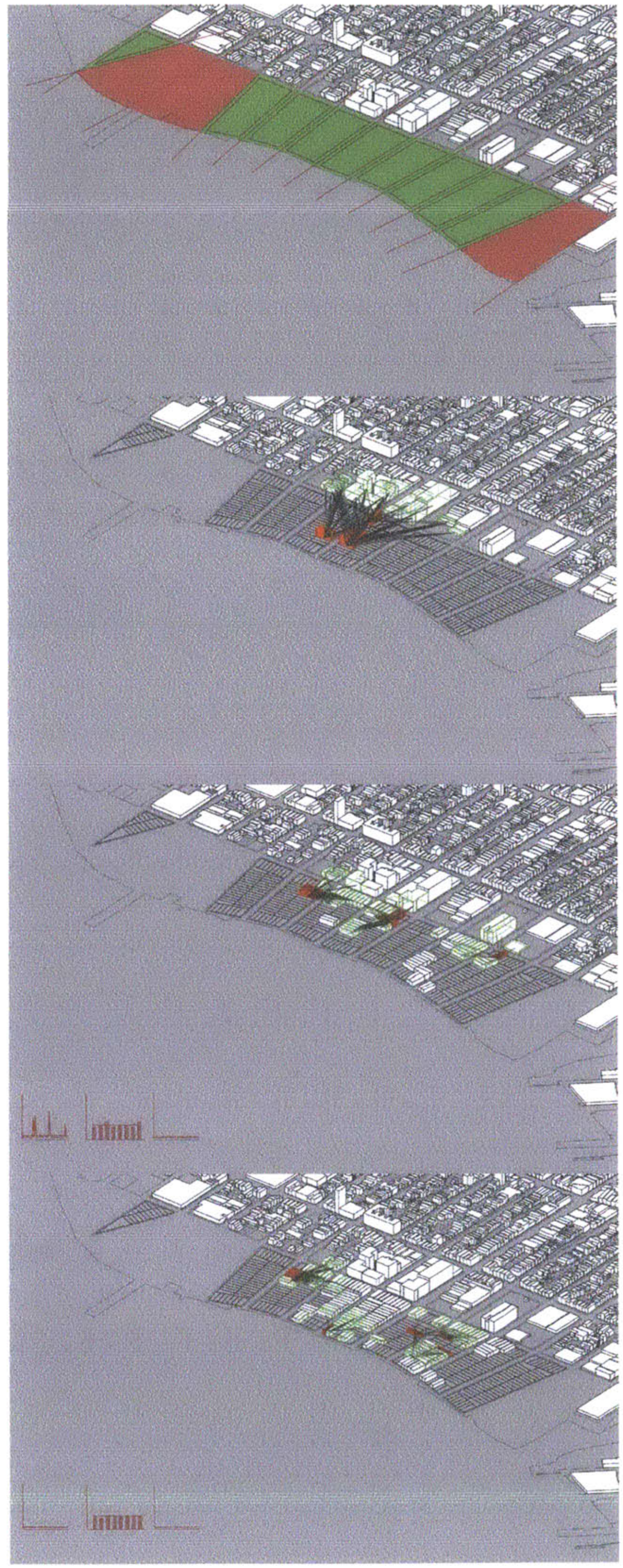


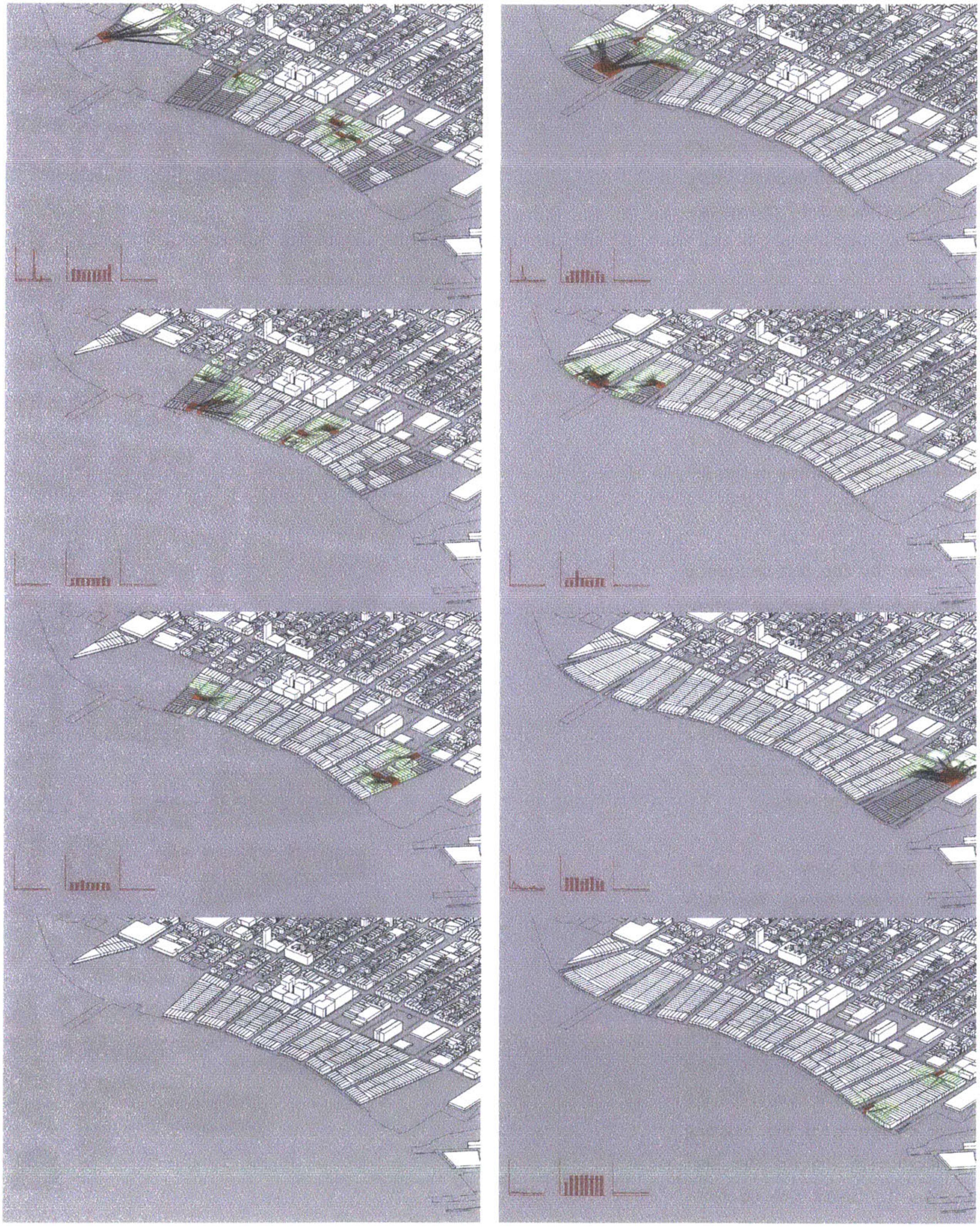
4iv.6. Combined-3 bird's eye and street view

Combined-4 results in an urban scheme that is simply an extension of the existing urban fabric, both in plan and building sizes. It preserves view corridors of the neighborhood behind the site by extending streets as straightly as possible while still creating the nearest waterfront edge. However, it still disregards the value of the waterfront and how it affects the development along it.

Multiple experiments stemmed from Combined-4, with each iteration improving and adding operations to the previous one. Combined-4-1 (figure 4iv.8) saw the introduction of the OpenSpace operation, affecting the volume of buildings along the waterfront.

The application of OpenSpace in a specific site such as this one required the operation to be tweaked from the generic context it was created in. In this case, each parcel's distance to the nearest waterfront edge is checked. If the distance is over a certain number (defined by the designer), the parcel should not be affected by the OpenSpace operation. This is to prevent a diminishing effect of the waterfront and sets a threshold instead for how many parcels





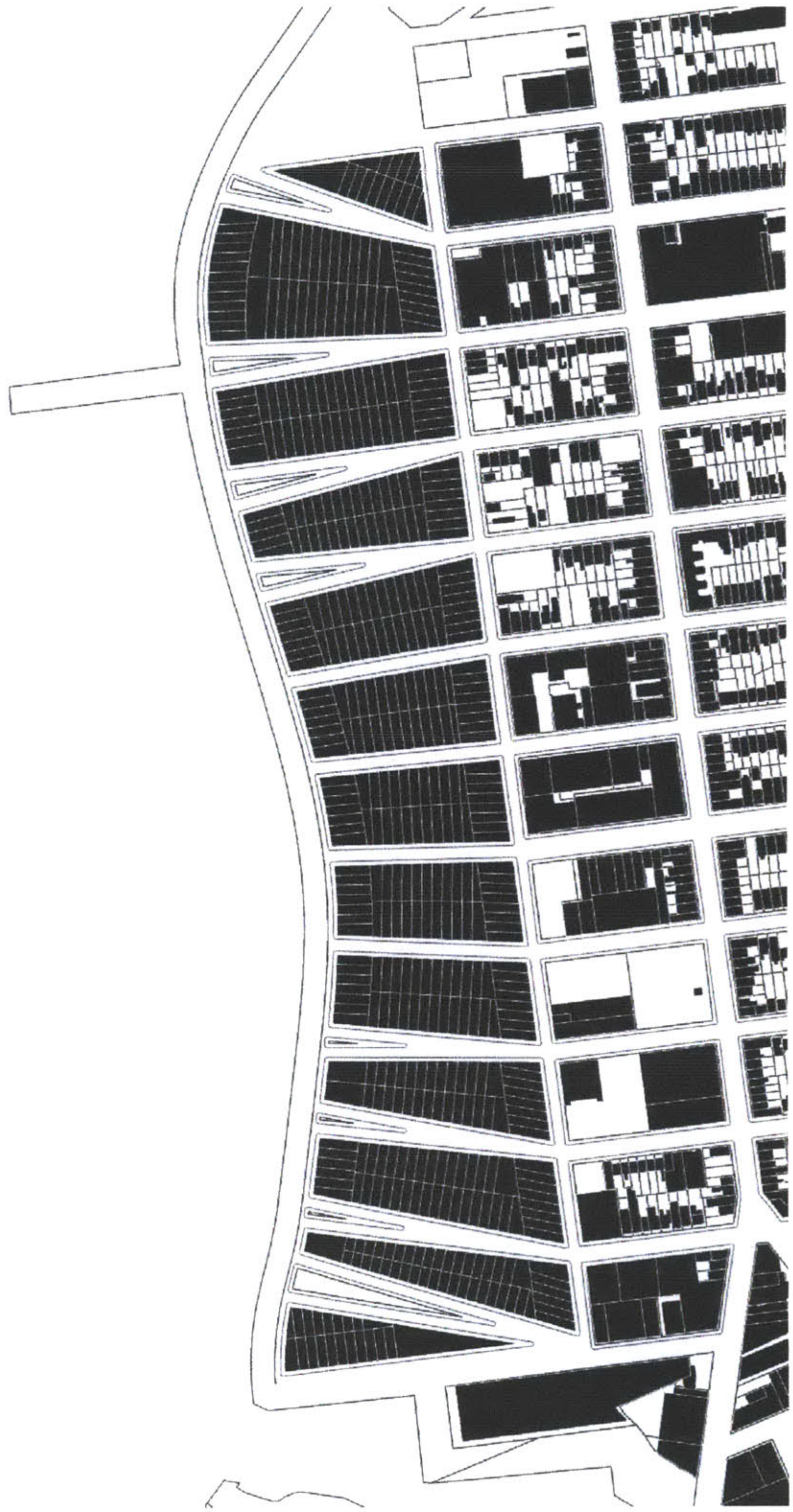
4iv.7. Combined-4 experiment sequences

should be affected by the waterfront. This is based on the idea that a parcel that is two blocks away from the waterfront and another one that is ten blocks away can be considered as being equally unaffected by the waterfront.

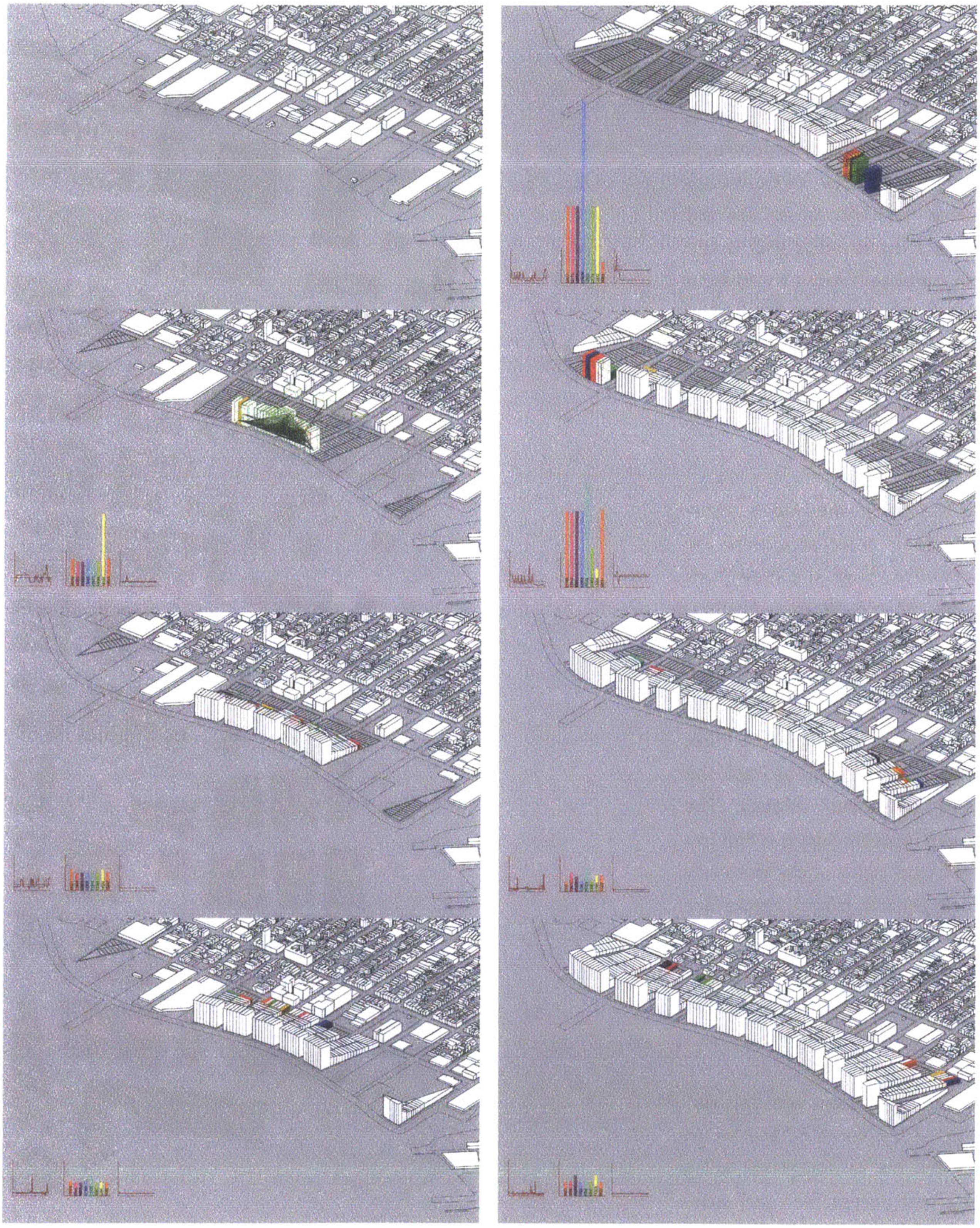
In addition to the introduction of OpenSpace, the graph feature also saw an improvement. The "new buildings GFA" chart is color coded to show which newly created building in the sequence has which new GFA.

As shown by the last sequence in figure 4iv.9, the parcels immediately in front of the watefront result in taller buildings. The issue here is that this resulted in a rather large continuous wall-like surface created by the facades of each of these highrises.

Combined-4-2 saw the introduction of two things: SunShadow operation and a new version of parceling that created two different parcel structures. So far, all of the experiments have only been using a generic New York City parcel that mimics the parcel structure of the existing neighborhood around the site. In order to break the continuous highrise facades wall along



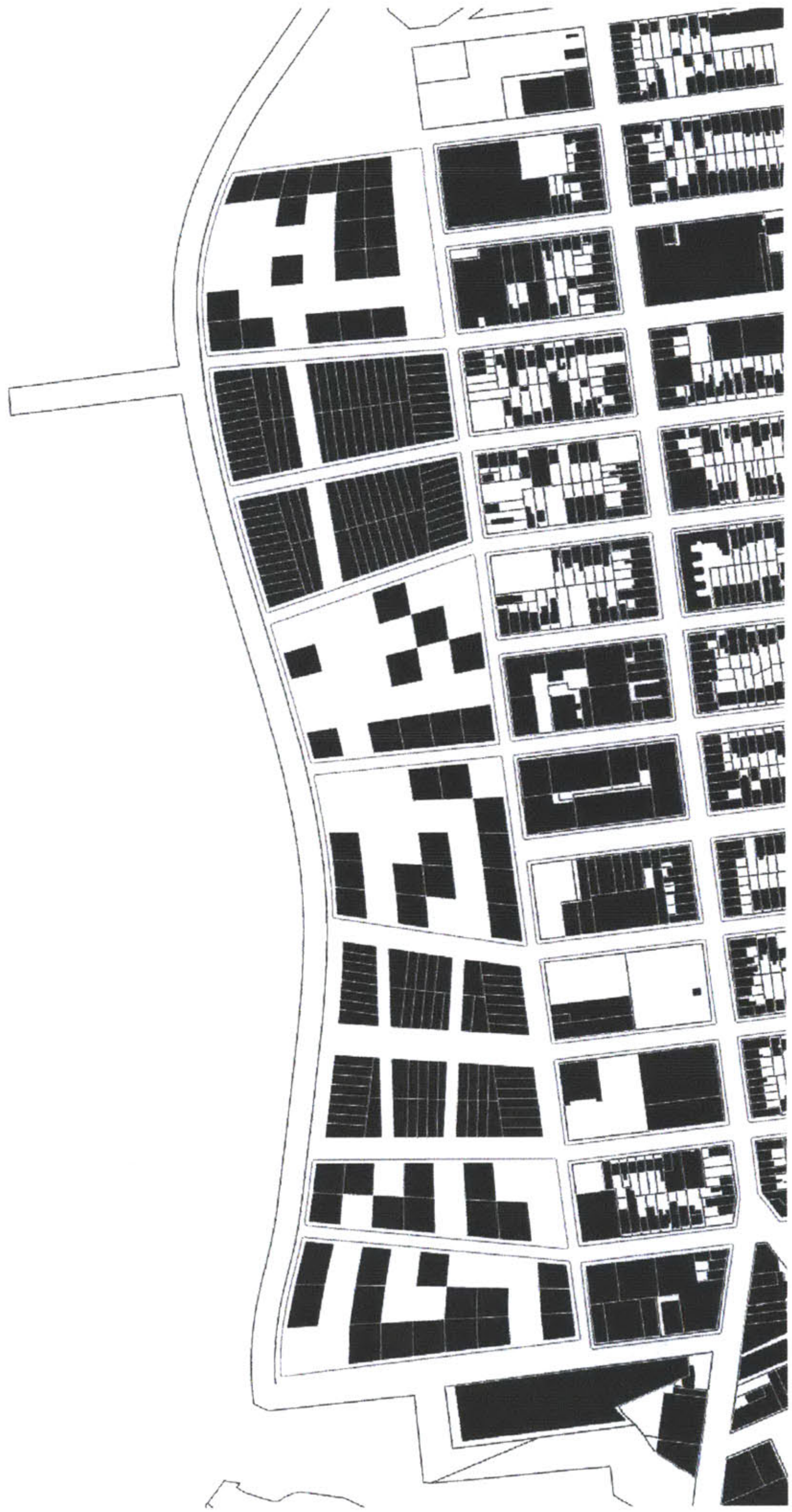
4iv.8. Combined-4-1 final urban plan



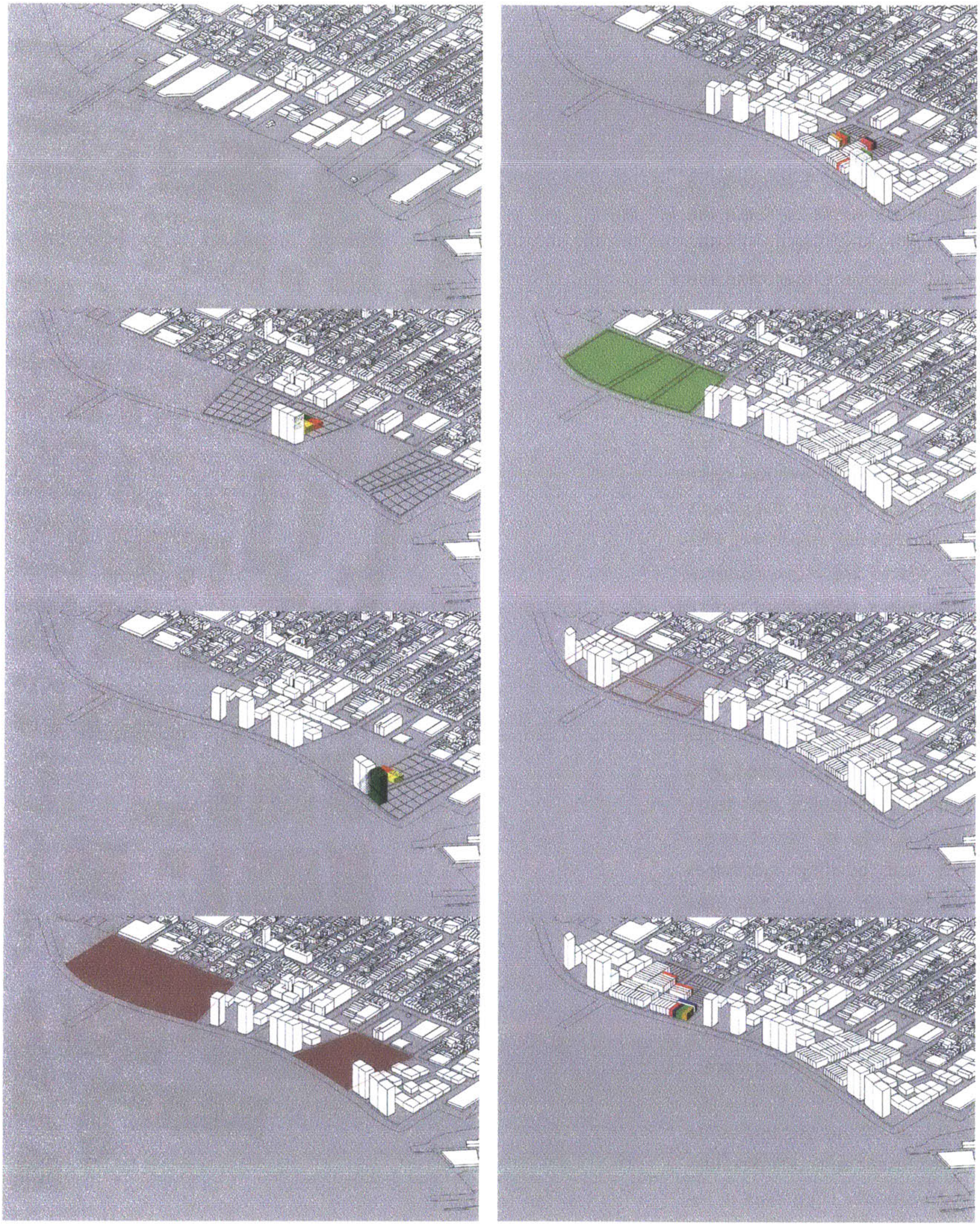
4iv.9. Combined-4-1 experiment sequences the waterfront, Combined-4-2 specifies a different parcel structure for different building typologies. In this case, the generic New York parcel structure is designated for low-rise developments (less than seven stories) while a hypothetical grid is laid out on larger blocks to create a highrise apartment complex. The large blocks perform as apartment complexes with a few towers and a series of open spaces in the middle.

As the design method is recursive, some internal streets are created through the New York generic parcel blocks, connecting open spaces in the various large apartment blocks (figure 4iv.10). In figure 4iv.11, the first three images show the first blocks to be developed are the large apartment blocks. The fourth (bottom left) and fifth images (top right) show the New York generic parcel blocks are split with through streets running in them, connecting the large apartment blocks created in the previous sequences.

The main problem with this version is that some of apartment towers are so staggered, failing to create acceptable open spaces in the large apartment blocks.



4iv.10. Combined-4-2 final urban plan



4iv.11. Combined-4-2 experiment sequences

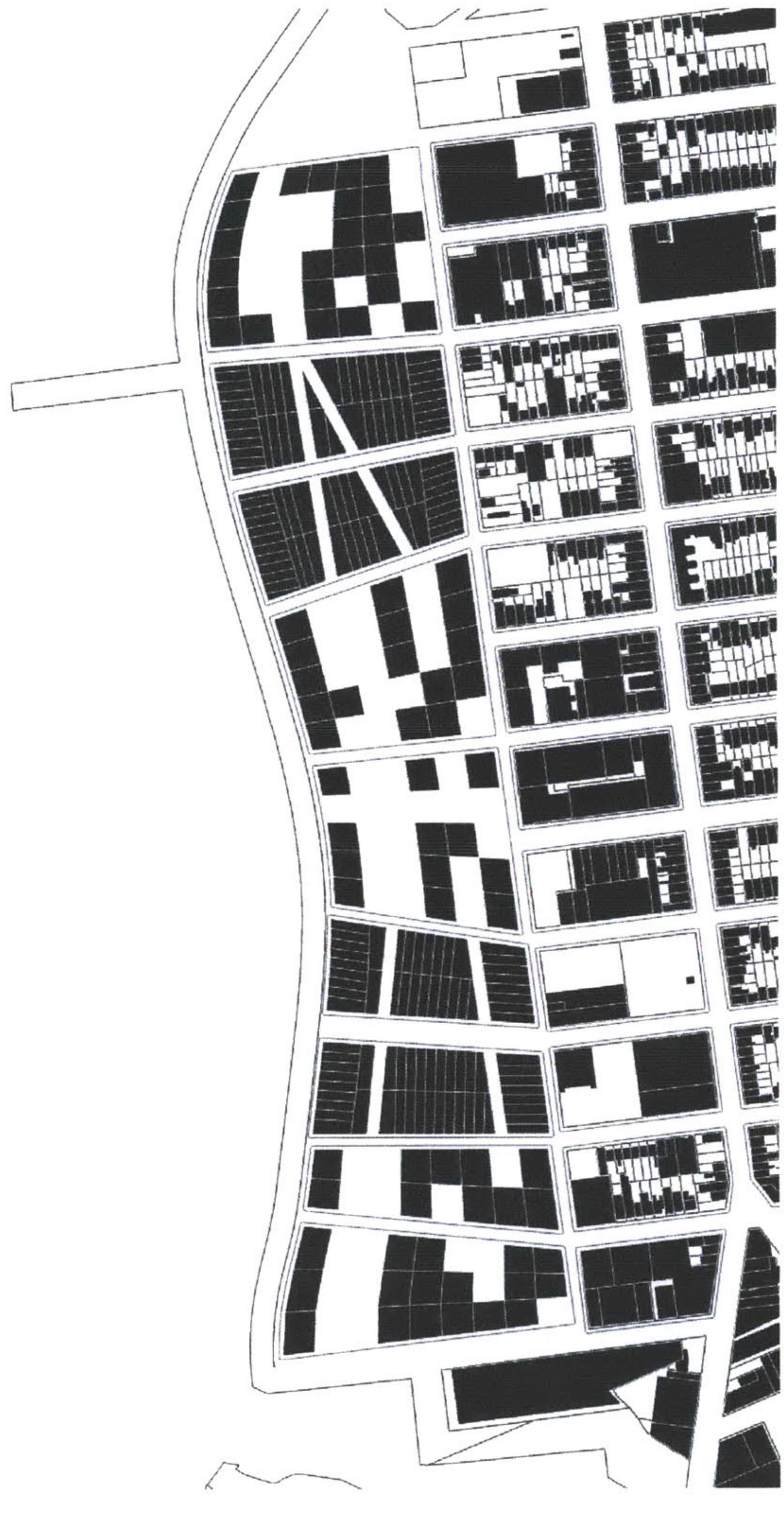
This is believed to be caused by the sun angle setting in Sun-Shadow operation used in this experiment.

Thus, Combined-4-2a tests a different sun angle to see if the resulting overall urban scheme would improve. Other than the sun angle, everything else remains the same with the settings of Combined-4-2.

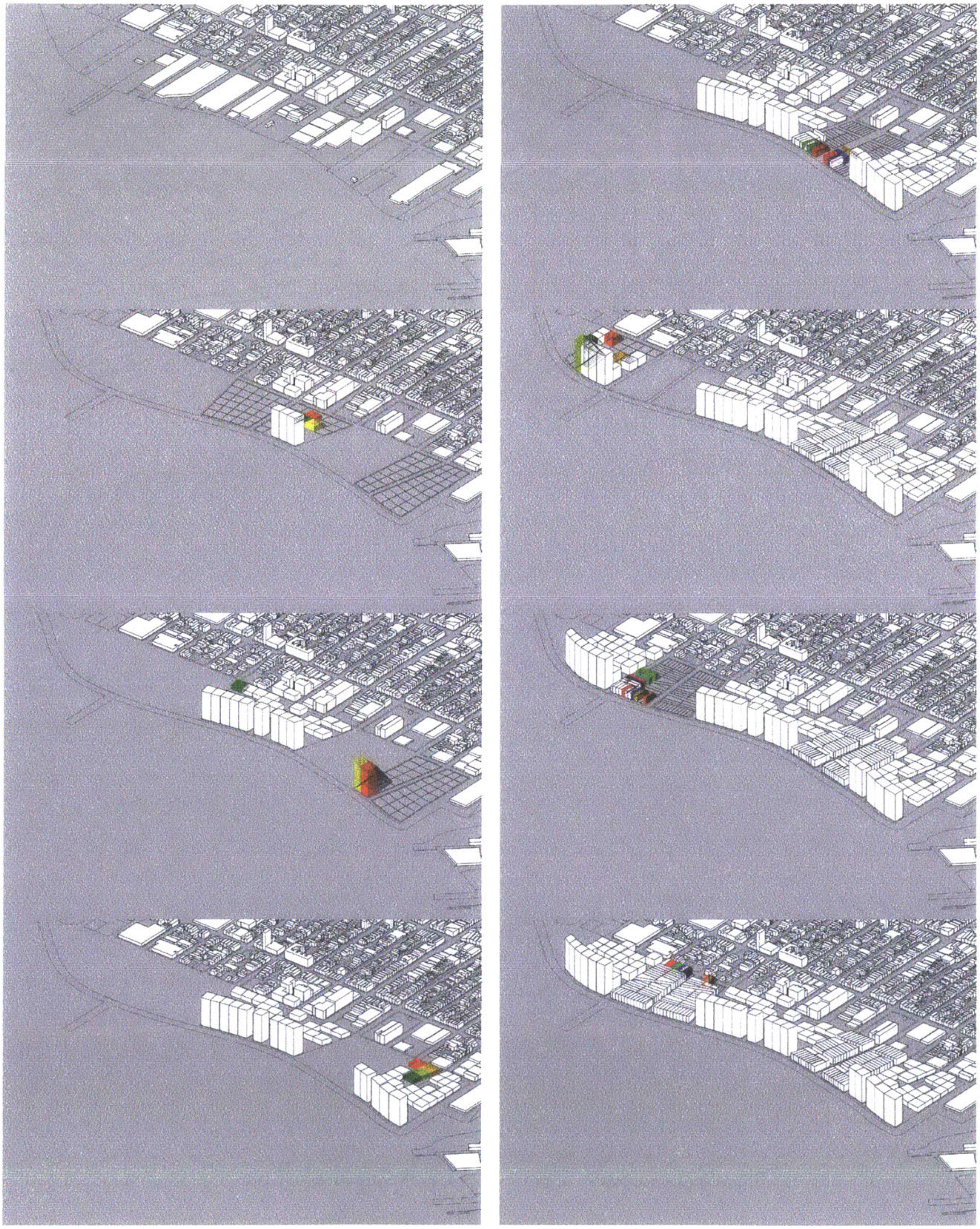
The result is very similar to that of Combined-4-2, but the open spaces and tower placements are significantly improved. The open spaces are more continuous and less fragmented (figure 4iv.12 vs 4iv. 10).

Combined-4-2a resulted in an acceptable urban plan with a set of open spaces connected by a set of streets (public and semi-public), a mix of parcel structures and building typologies with highrise towers near the waterfront, and streets that connect the existing neighborhood directly towards the waterfront that simultaneously preserve visual connection over the water.

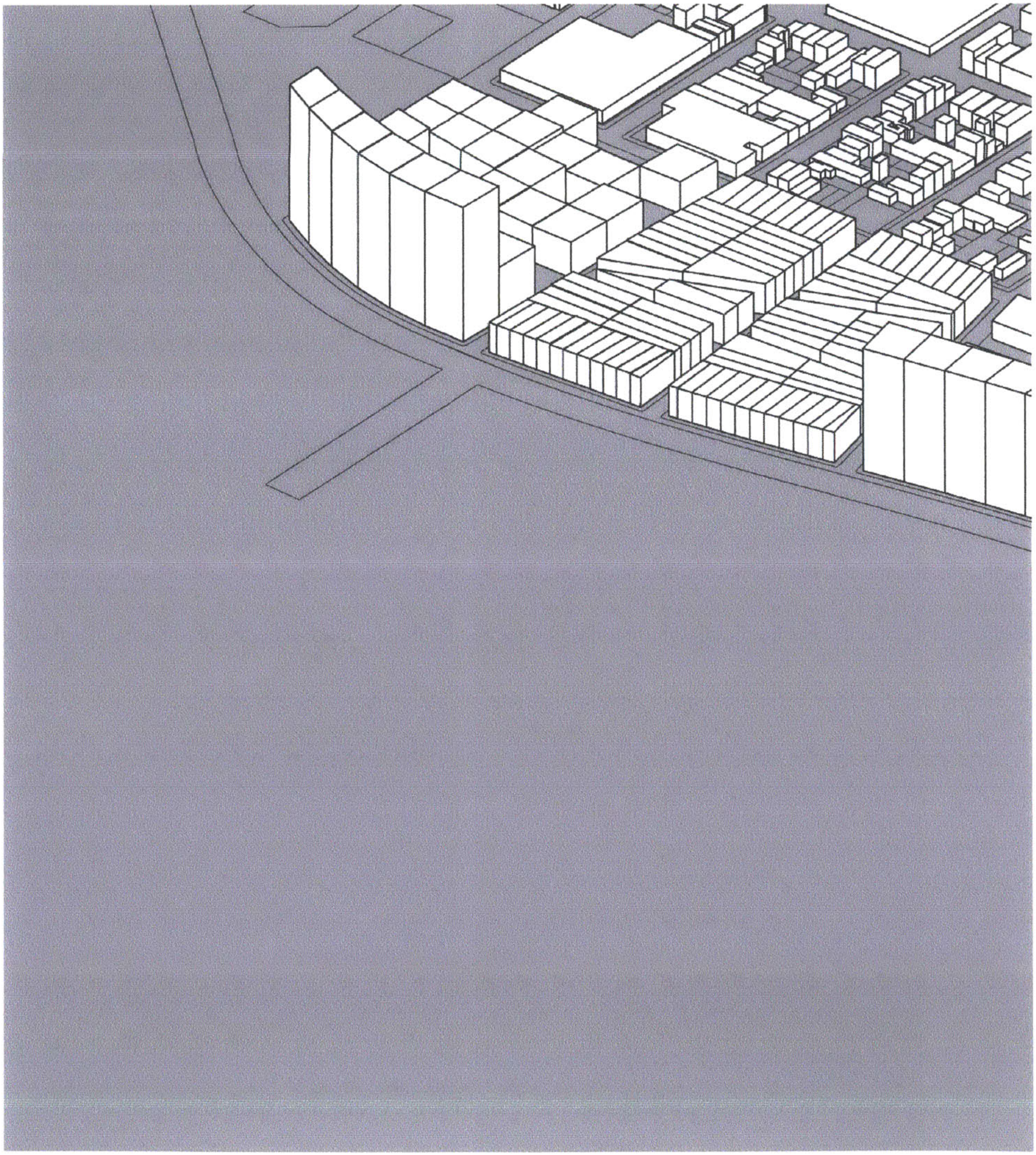
So far, all of the sequences do not represent an actual development sequence happening in reality. The sequence is a way

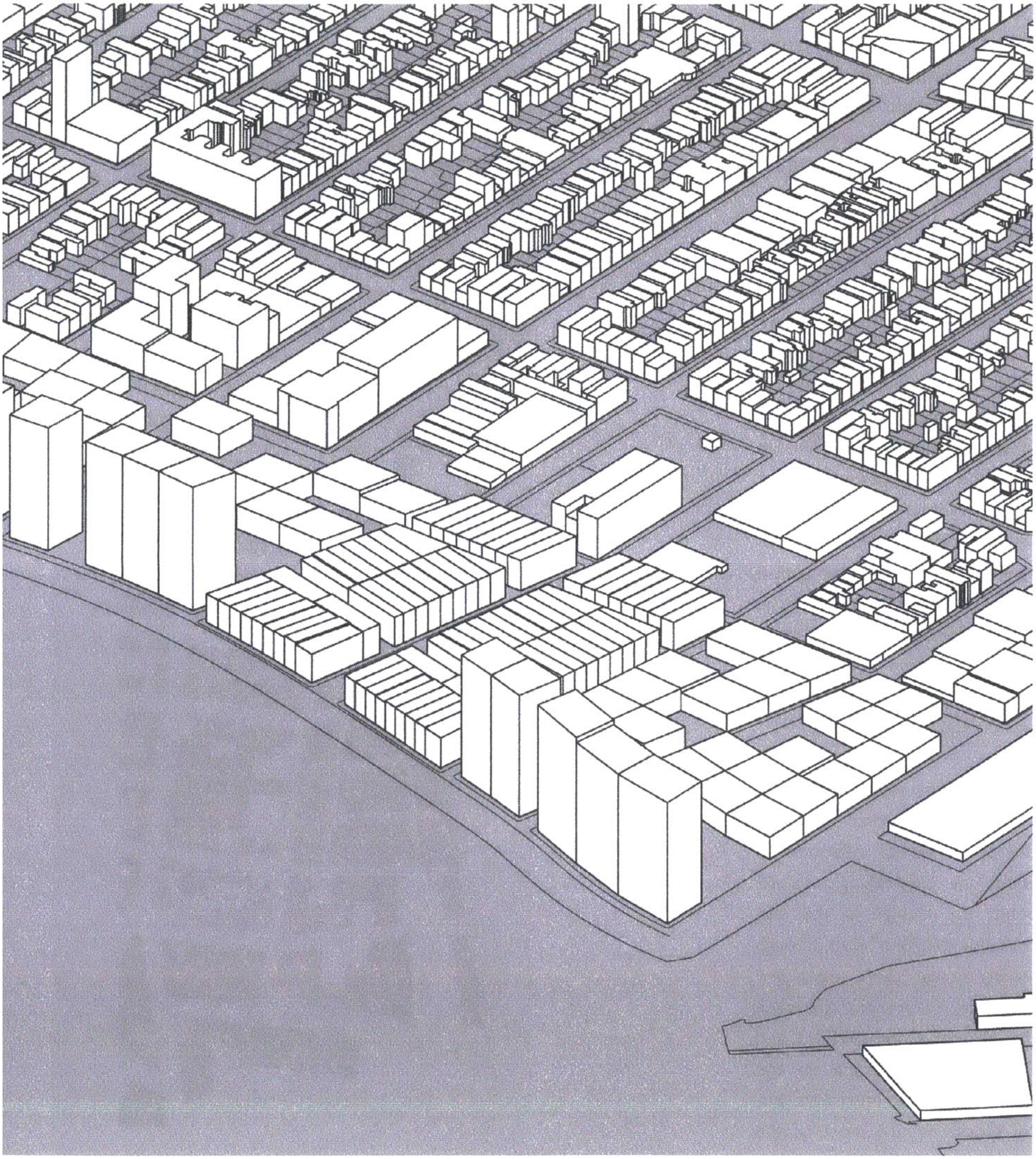


4iv.12. Combined-4-2a final urban plan



4iv.13. Combined-4-2a experiment sequences



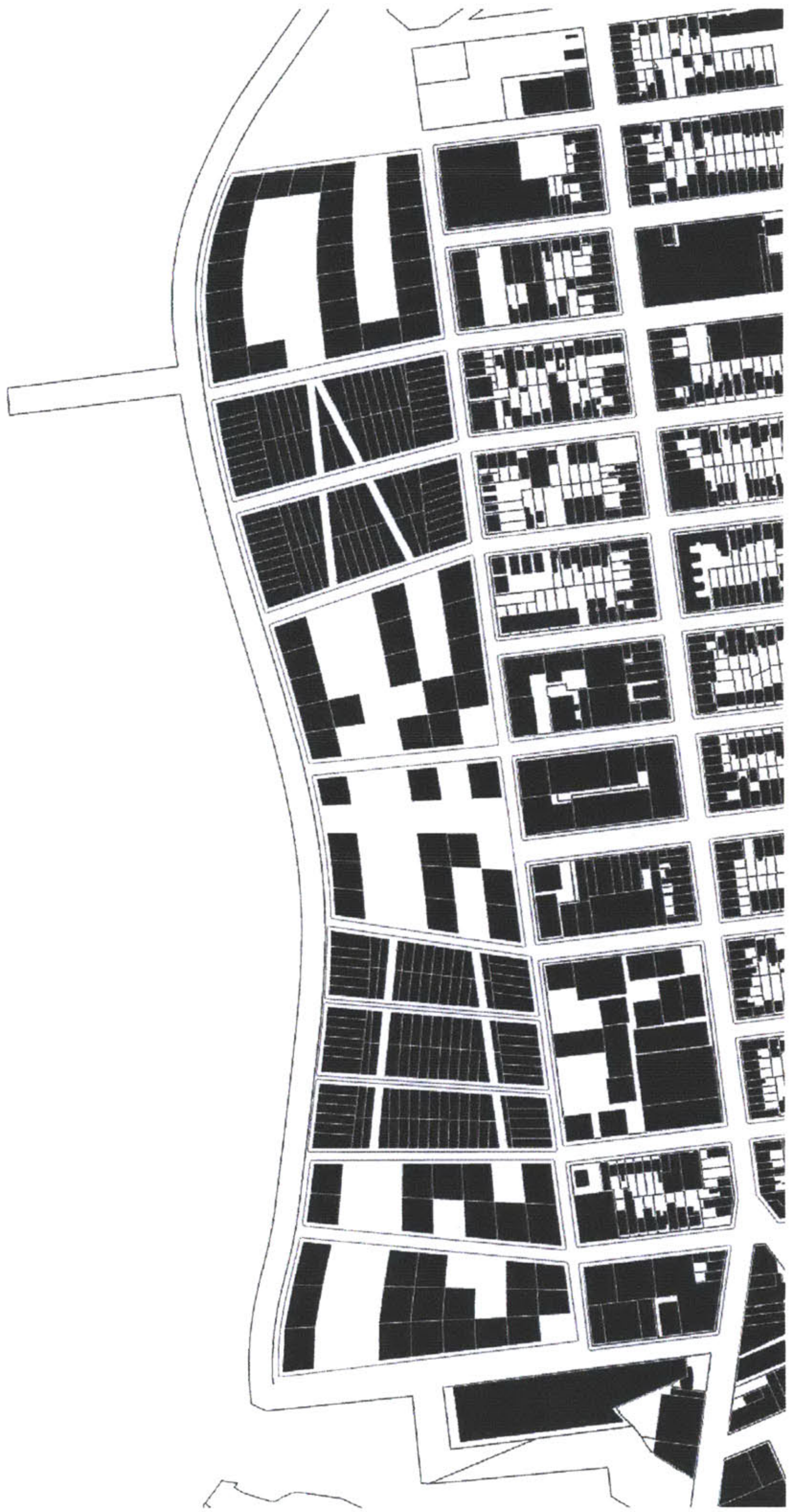


4iv.14. Combined-4-2a final axonometric

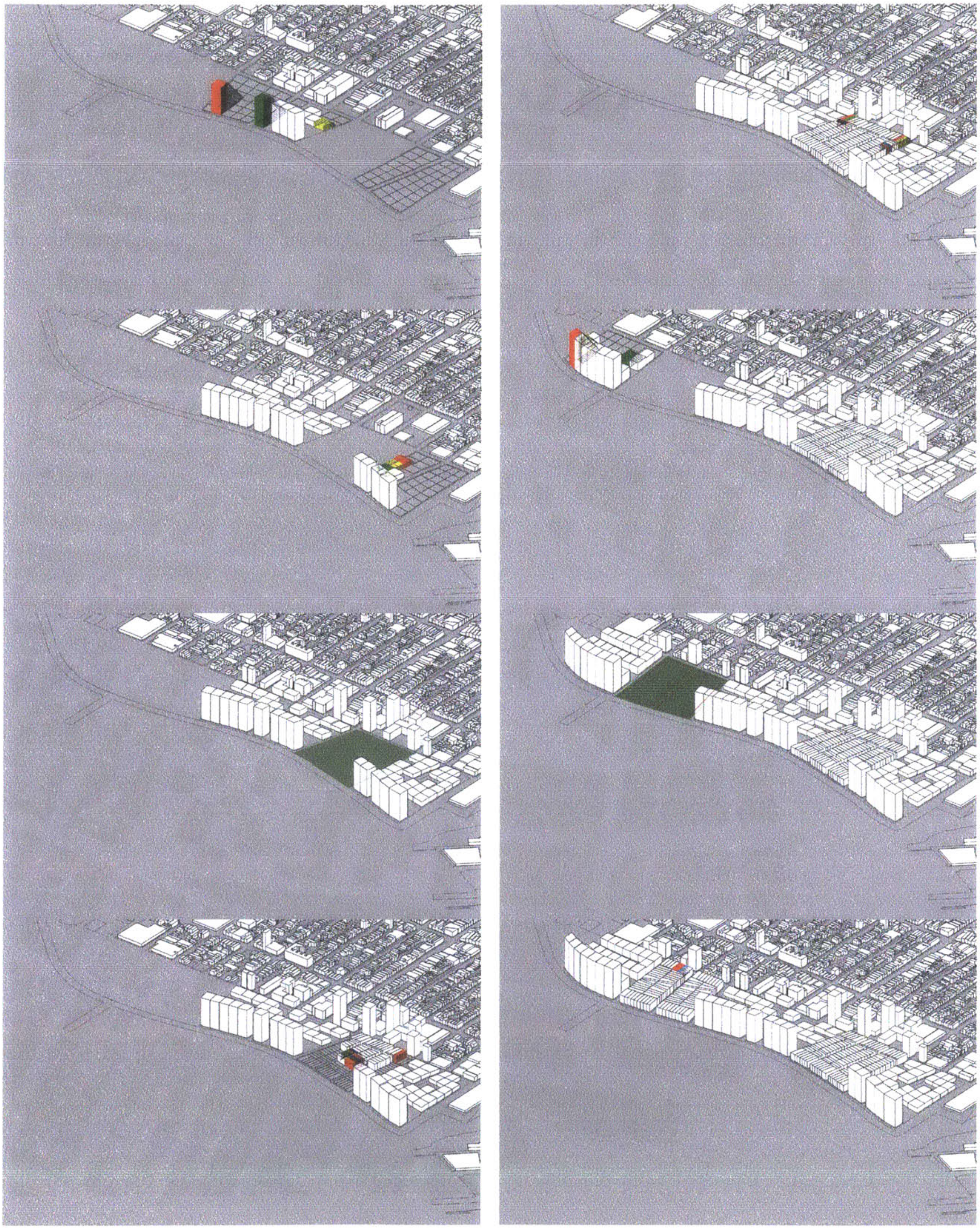
for designers to approach urban design. It represents the design process proposed in this thesis. By thinking about it sequentially and recursively, we are not attached with the absolute form of the final urban plan.

Through Combined-4-3, I imagine a scenario where 4-2a design scheme is being implemented and developed. Over the course of the development, the neighborhood around the site changes and develops as well. By the time the early phases of our site's development reaches a certain point (figure 4iv.16, images 2-3), the rest of the plan is now less appropriate since the surrounding neighborhood is no longer the same neighborhood as the one when Combined-4-2a was created.

Thus, Combined-4-3 shows an alternative plan that maintains the same set of relationships about the city, taking into account the change in the surrounding neighborhood. Though mostly similar, there are a few noticable differences between the plan of Combined-4-3 and Combined-4-2a, mainly in the southern generic New York parcel blocks, where most of the neighborhood changes occured.

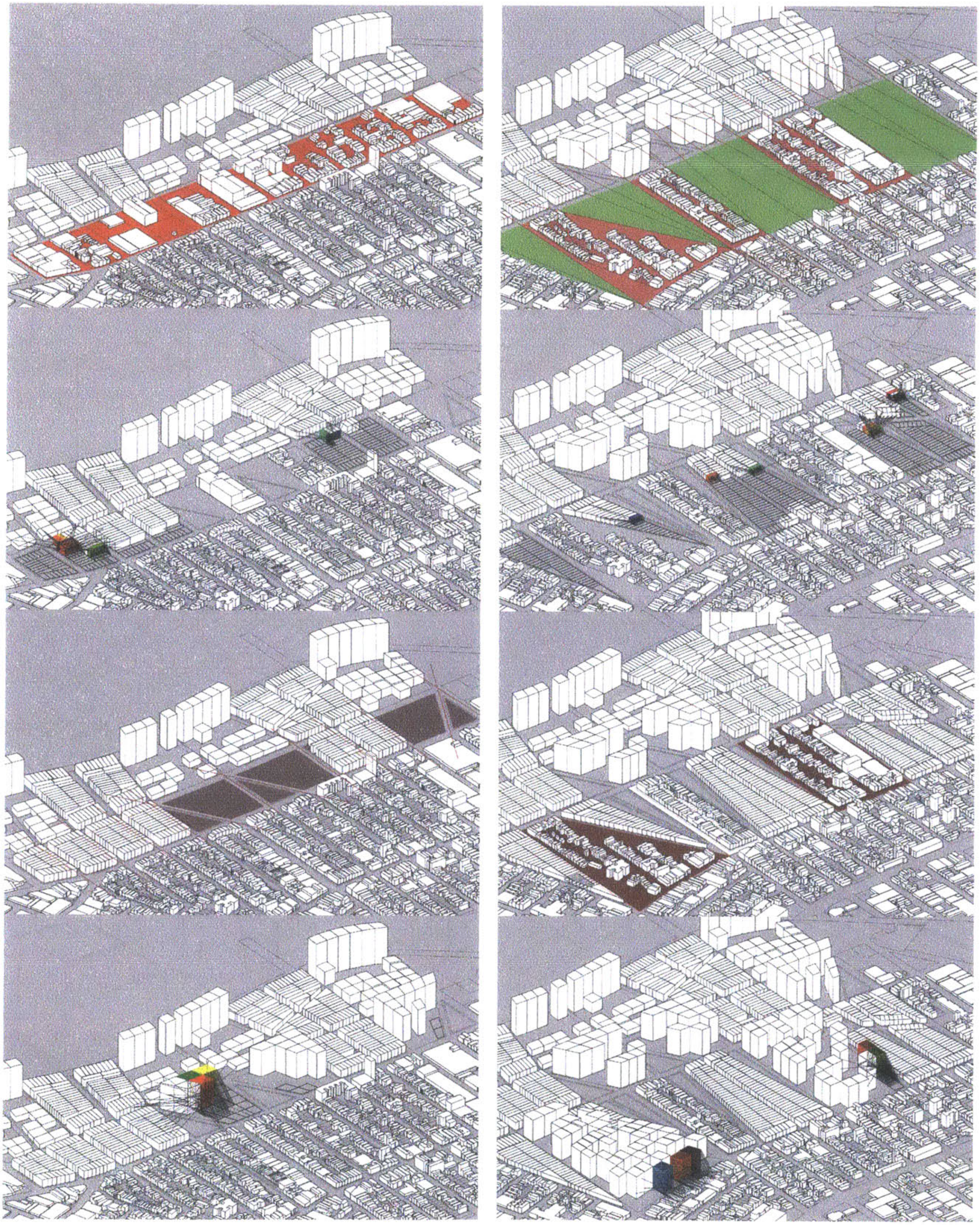


4iv.15. Combined-4-3 final urban plan

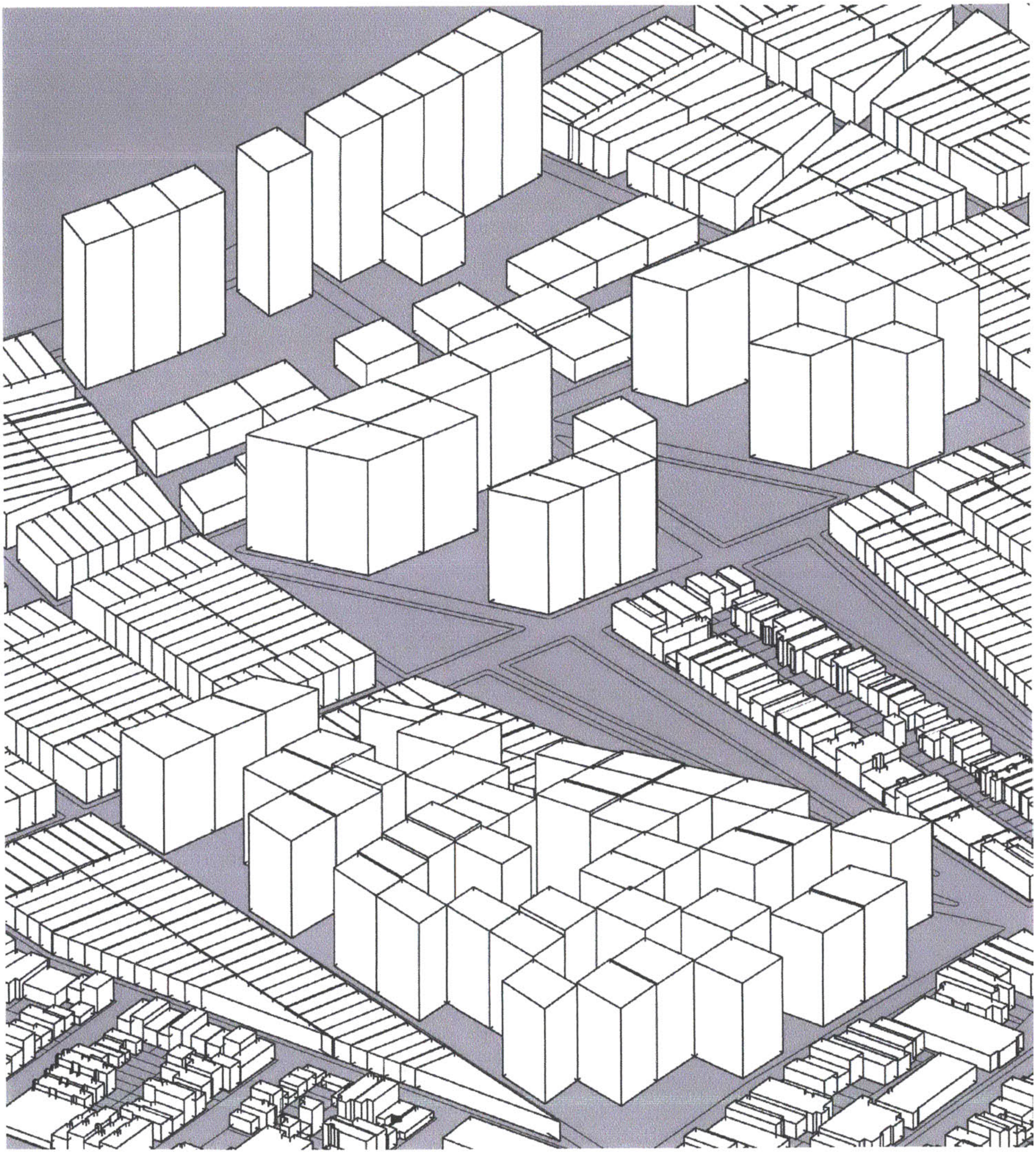


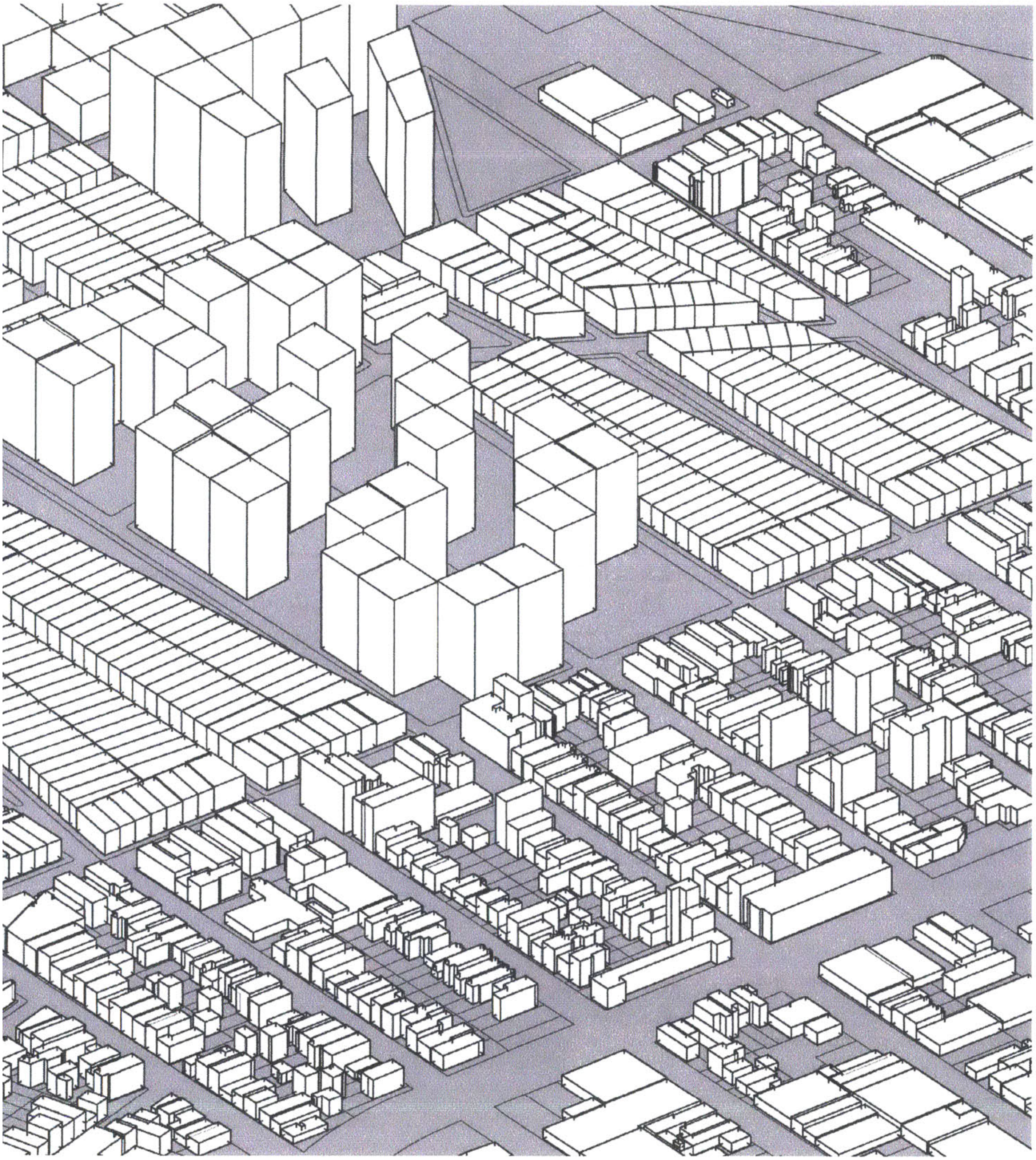
4iv.16. Combined-4-3 experiment sequences

4iv.17. Combined-5 final urban plan



4iv.18. Combined-5 experiment sequences



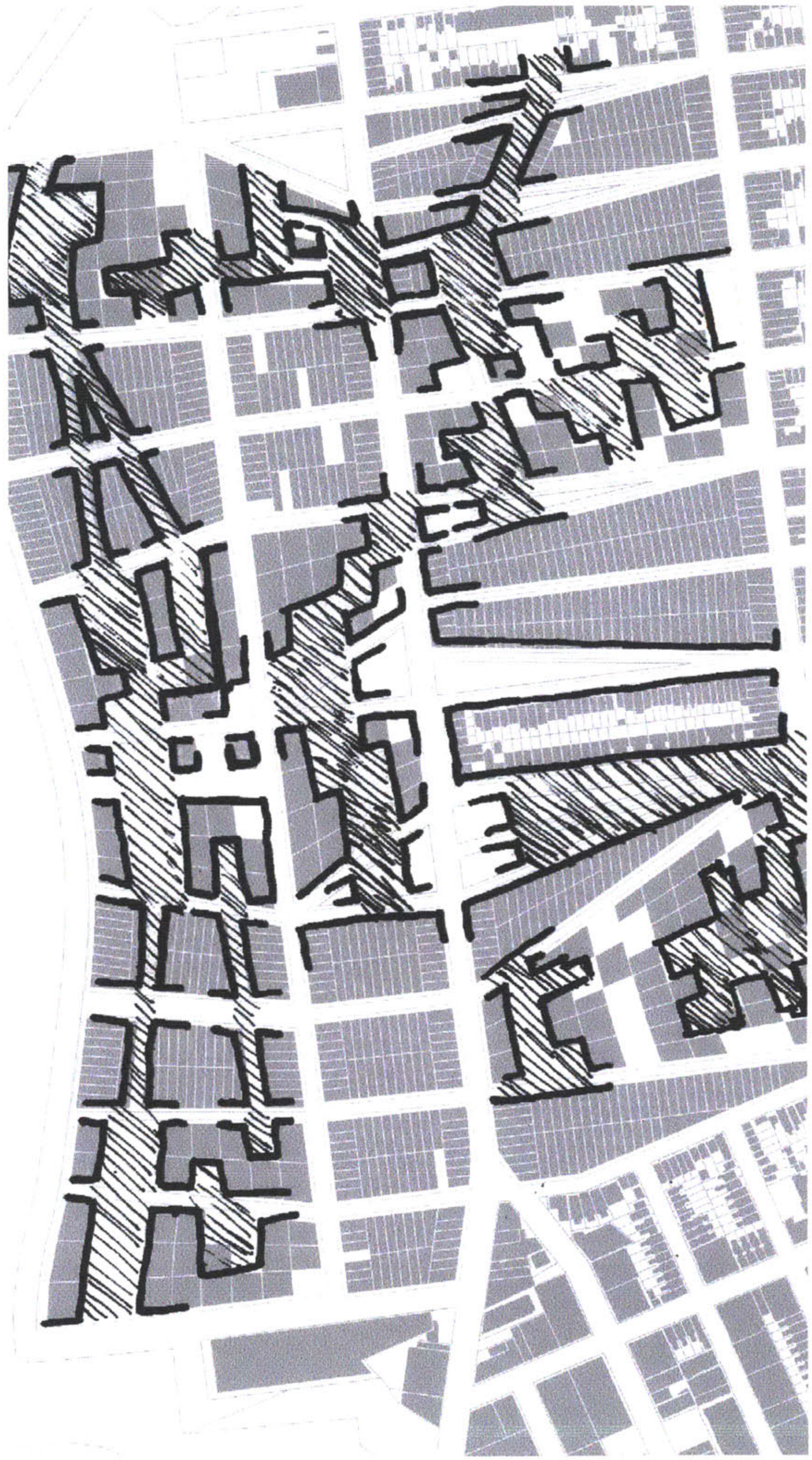


4iv.19. Combined-5 final axonometric

At this point, the methodology has been proven to be feasible in generating an acceptable and somewhat complex urban plan. If we evalute the results of 4-2, 4-2a, and 4-3, we cannot describe them as one single idea the way architects often describe their urban design schemes. These schemes are derived from a set of components and relationships that remained consistent throughout the design process, performing recursively by calculating changing variables in each sequence.

I proceeded to extend 4-2a inland, away from the waterfront, simply to see what I would get. In doing so through Combined-5, I discovered more weaknesses of the previous operations and experiments. The final urban plan (figure 4iv.17) shows a very checkerboard-like urban pattern, creating bad scenarios for highrise buildings and inaccessible open spaces. In addition, the highrises are too close to each other (figure 4iv.19), meaning the SunShadow operation was inadequate in creating proper apartment tower complexes when used in a larger scale than the previous experiments.

At this point, I re-evaluated my

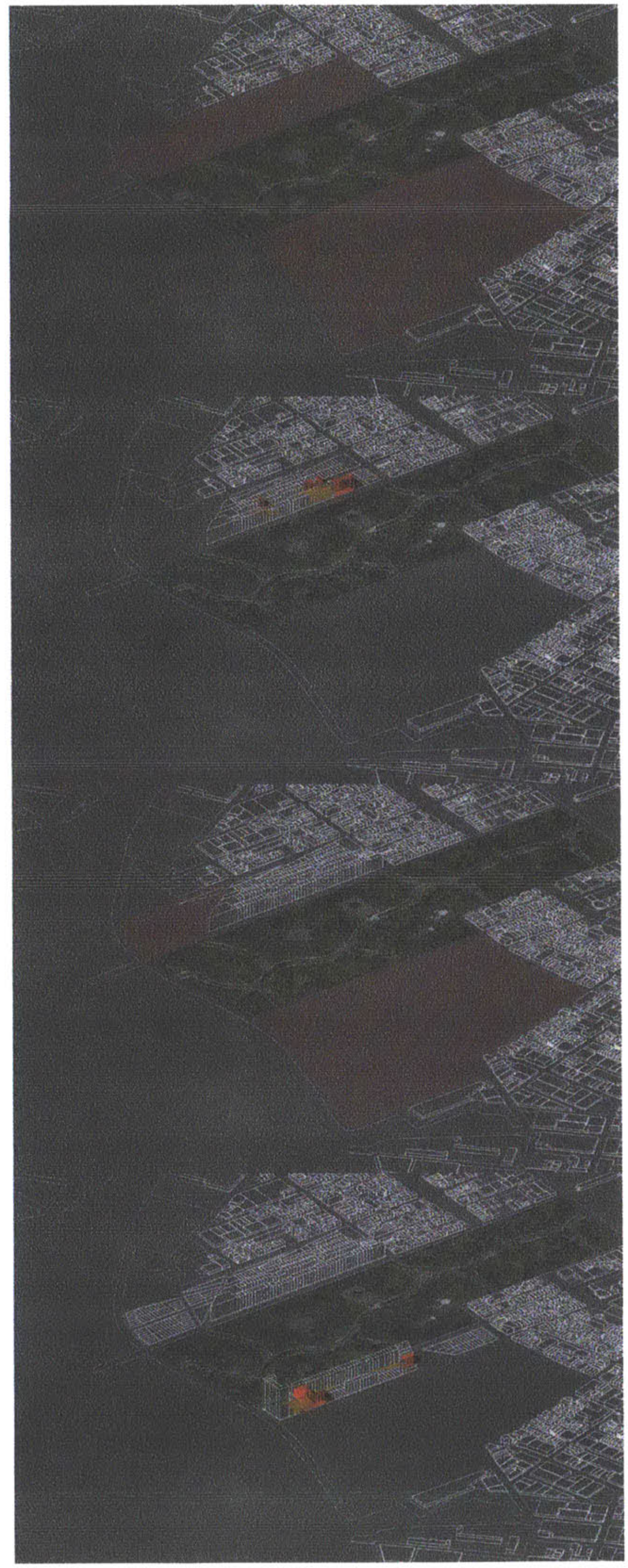


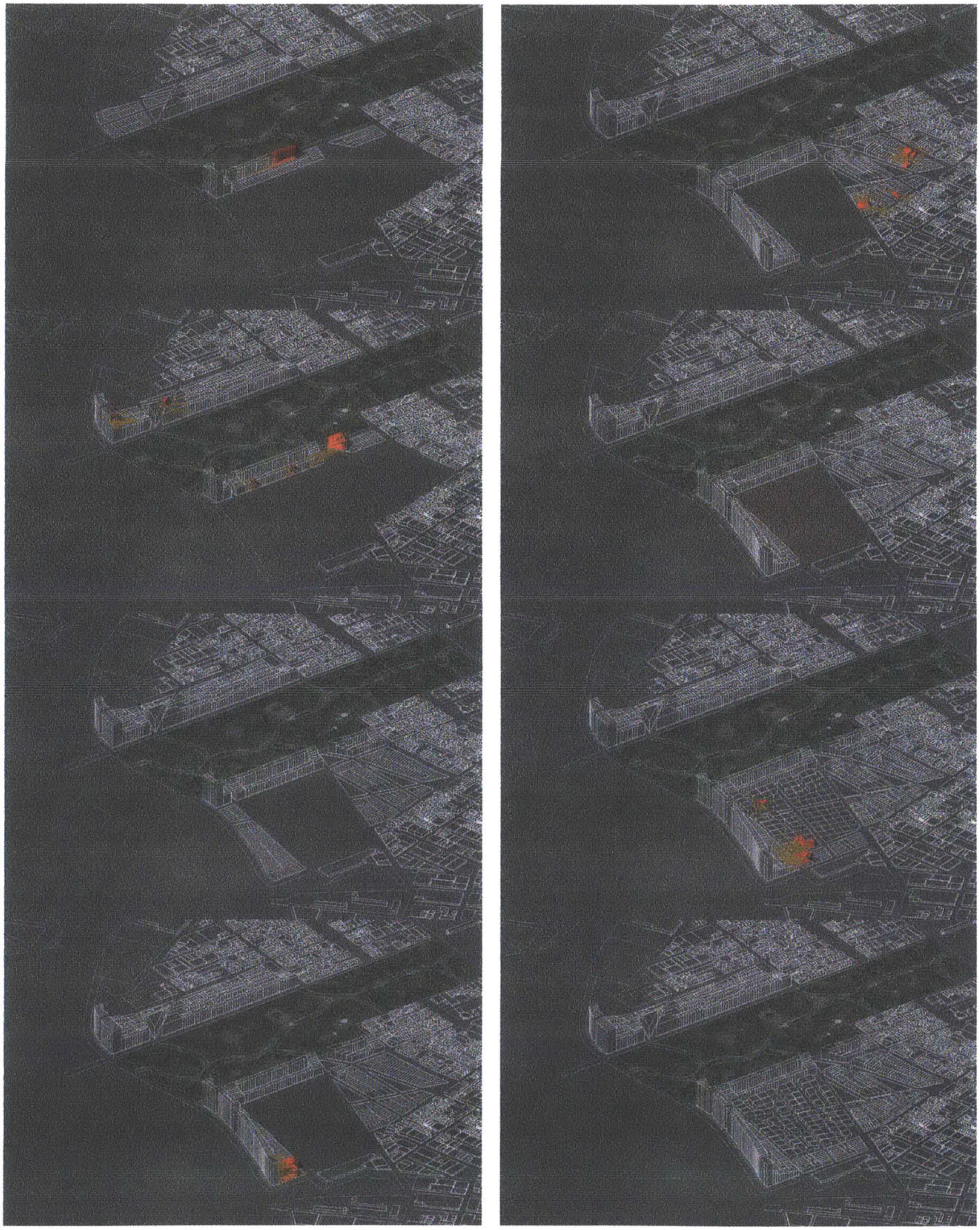
4iv.20. Open spaces from the fixed plan of Combined-5

4iv.21. Fixed urban plan from Combined-5 entire experiment process. The computational and parametric aspect of my thesis was never intended to produce a system that can create a flawless urban scheme where every nook and cranny of the scheme is solved. Rather, it was meant to assist designers in the process of urban design. Accepting this, I took the result of Combined-5 and quickly fixed the errors in the plan in order to create a working urban plan (figure 4iv.21 vs. 4iv.17). If we evaluate the thesis this way, then the experiments can be considered successful in achieving their goal.

However, one curiosity arose. With this method of urban design, is it possible to come up with a design scheme that includes a large object in it (e.g. New York's Central Park)? Since the method is recursive and sequential, it seems that it is impossible.

In the next experiment (Combined-6), I tried exactly just that. I overlaid a piece of New York's Central Park on the site and designed recursively with the operations I've created to see what kind of issues and design I would encounter. I imagined an urban design project that has a

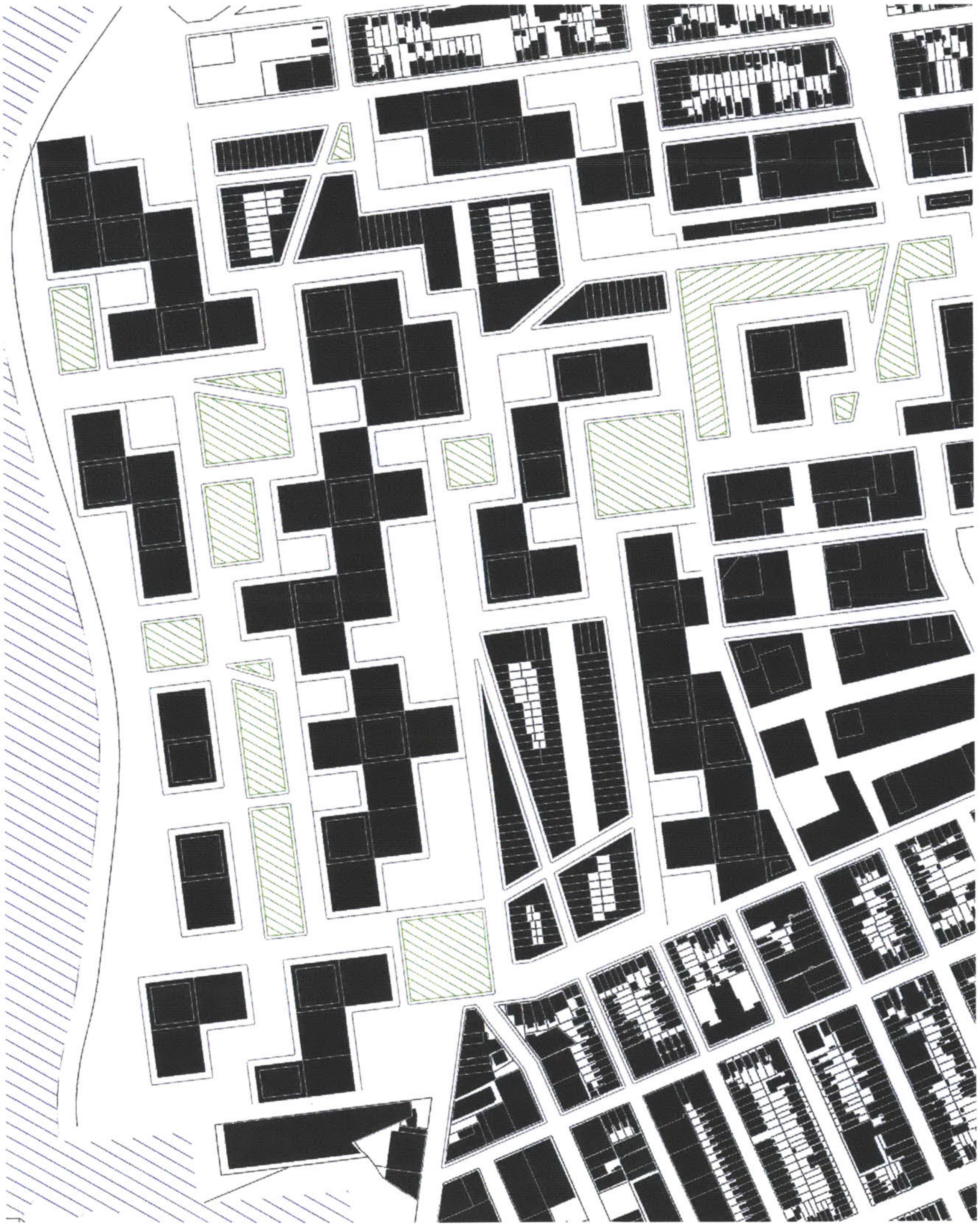




4iv.22. Combined-6 experiment sequences

4iv.23. Combined-6 final urban plan

4iv.24. Fixed urban plan from Combined-6



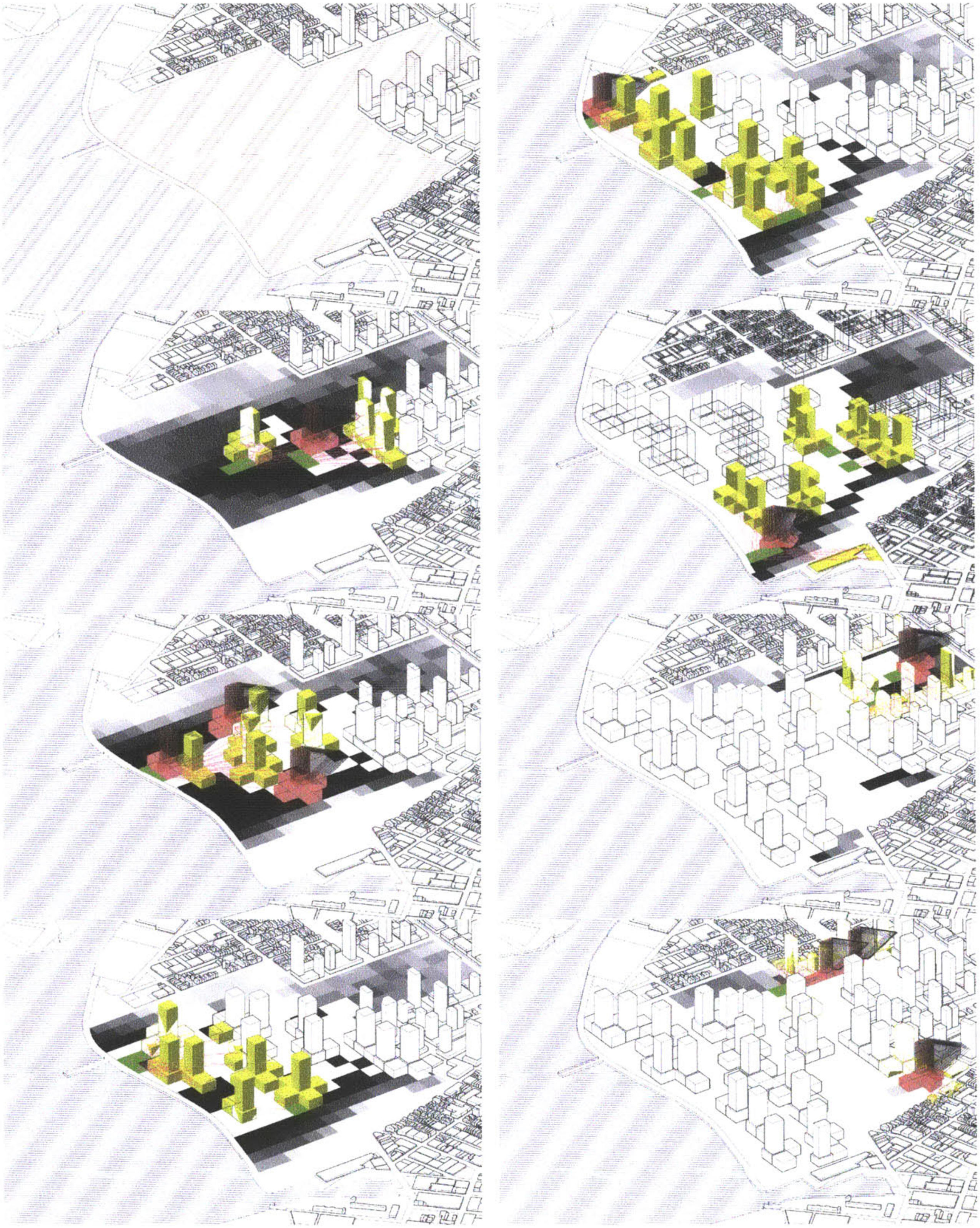
4iv.25. Combined-7 final urban plan

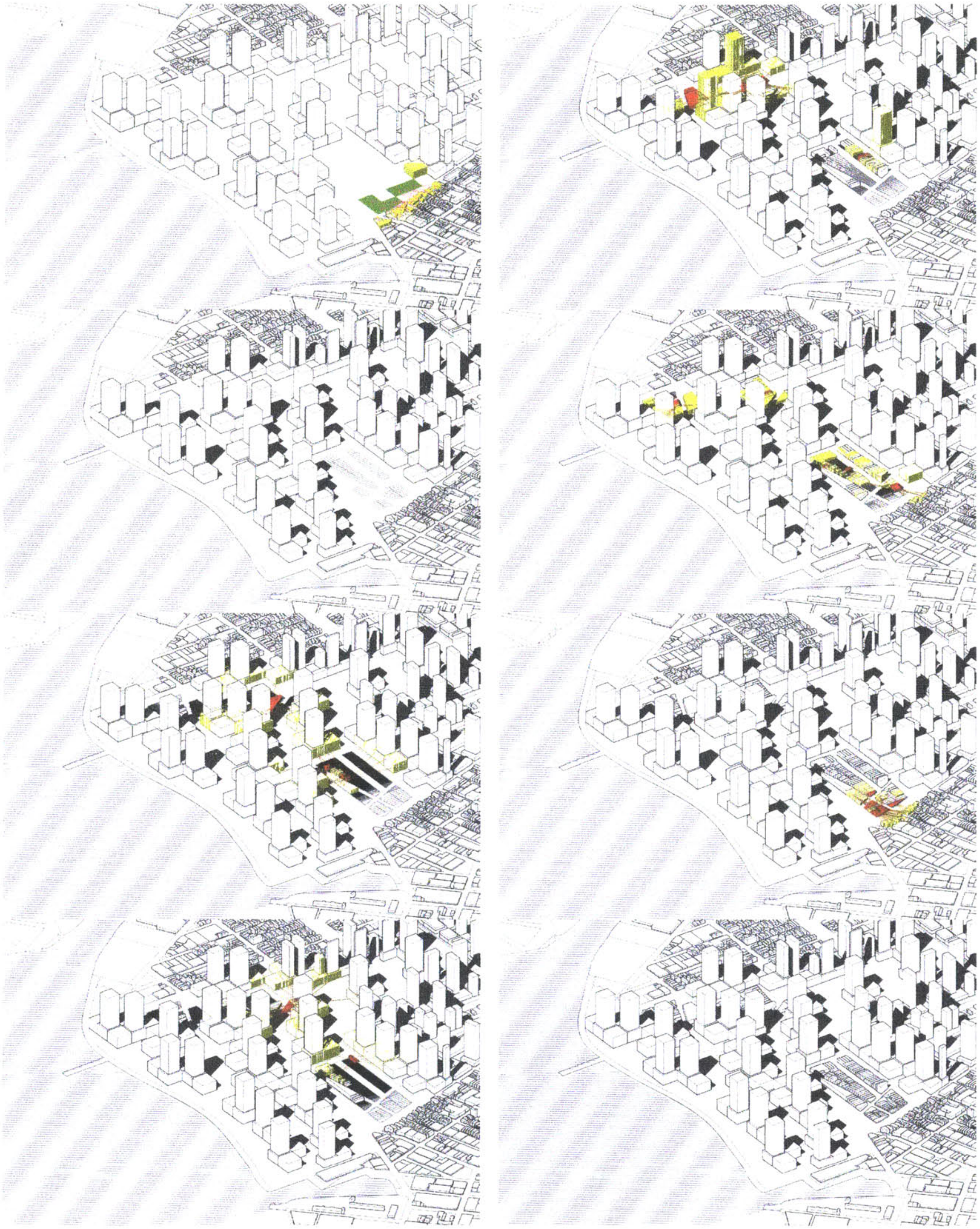
large park as one of the client's or city's requirements

Unfortunately, the large object in this case was placed in the beginning of the design process. This meant Combined-6 is the same with the previous experiments, except that it has a large open space in the middle (OpenSpace operation now works along the park's edge in addition to the waterfront edge). This experiment did not try to use a recursive and incremental design method to create a large park. At this point, it is uncertain whether that is possible or not.

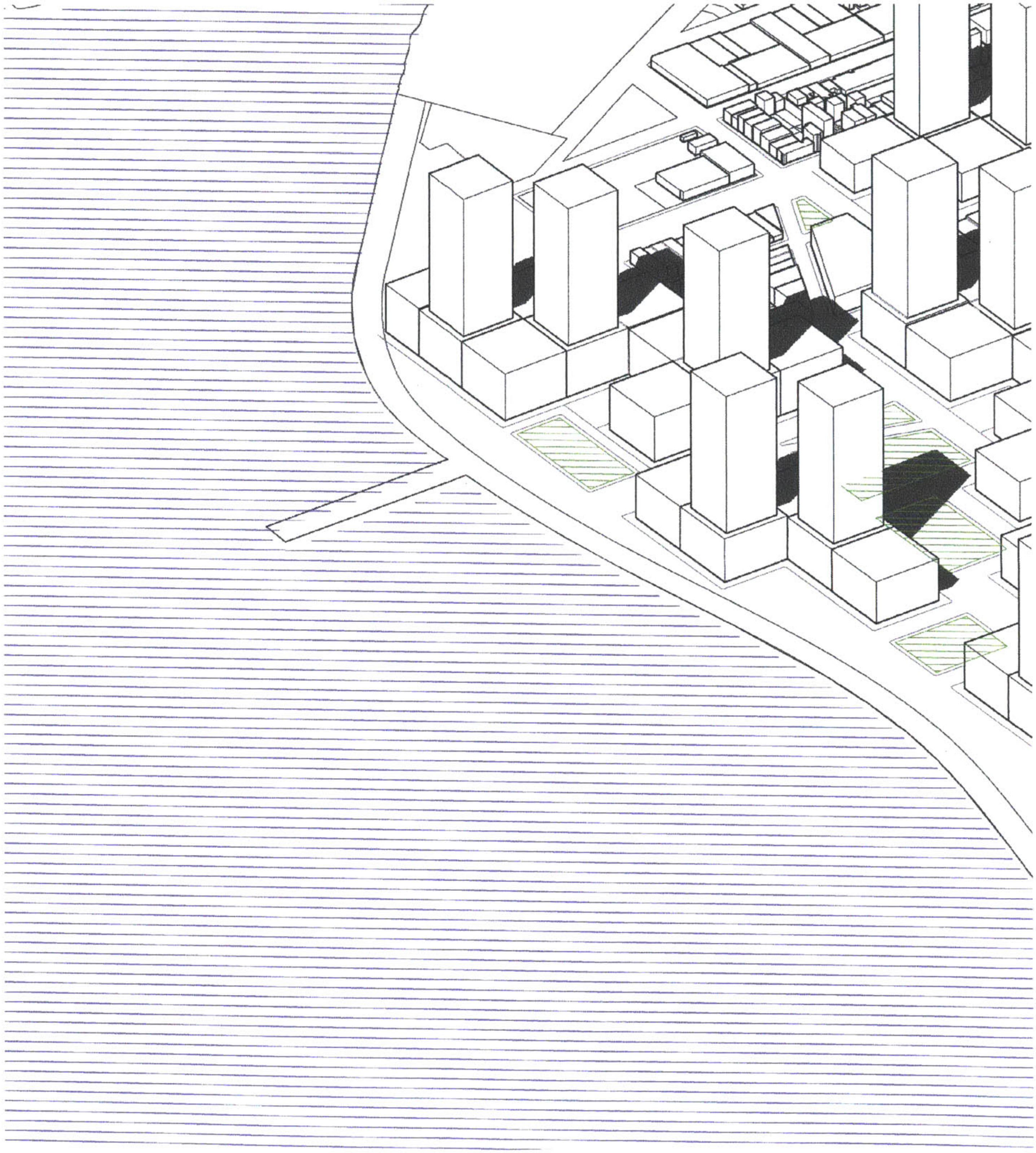
Regardless, the result of Combined-6 is satisfactory. The urban scheme contains streets that connect the existing neighborhood and the newly designed neighborhood to the park's paths and waterfront edge, high-rises along the waterfront and park edges, mixed parcel structures with multiple building typologies, and multiple networks of open spaces connected to each other as well as to the waterfront and park by public and semi-public streets.

We can imagine a much more elaborate park design that has much more complex edges with

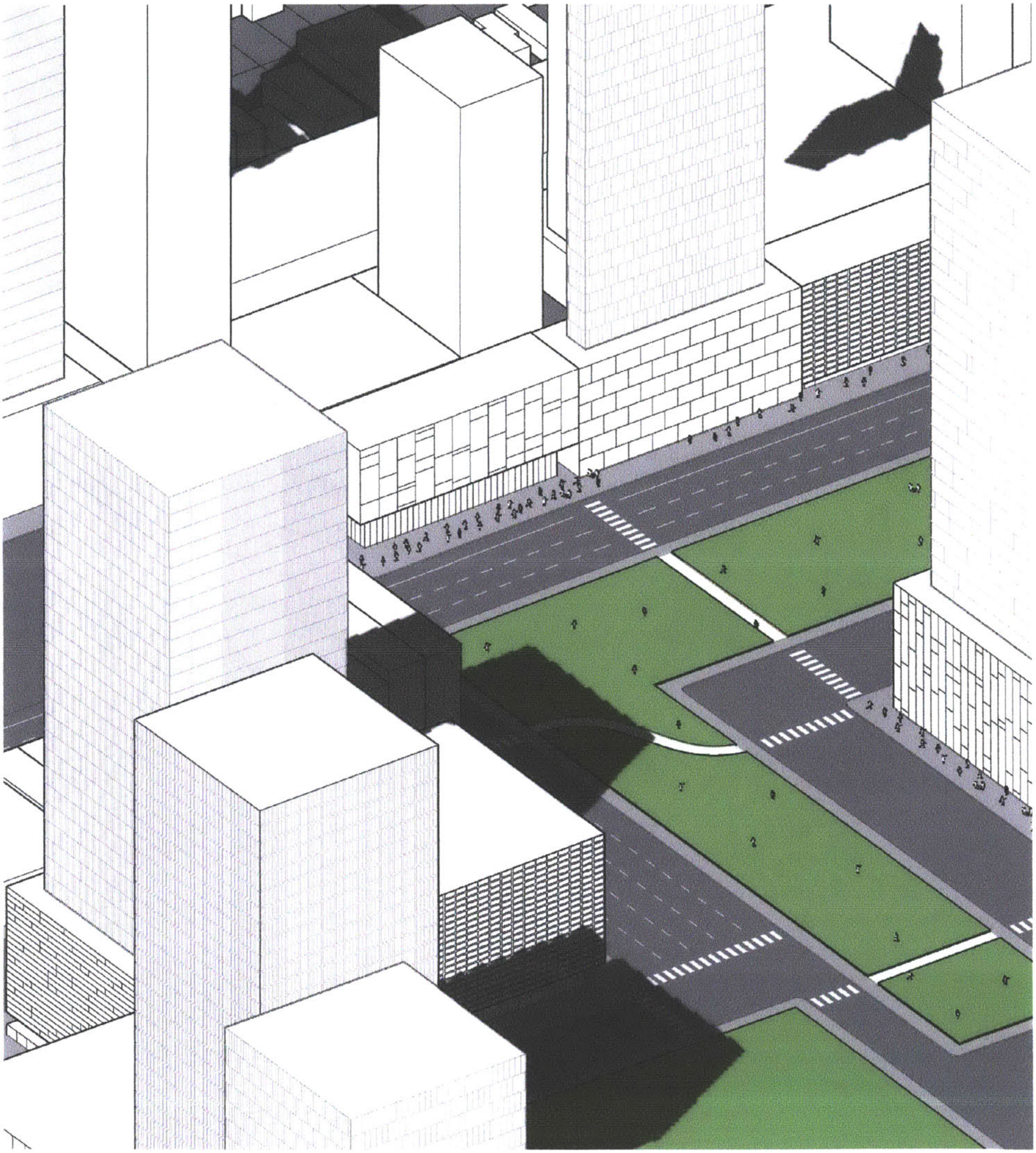


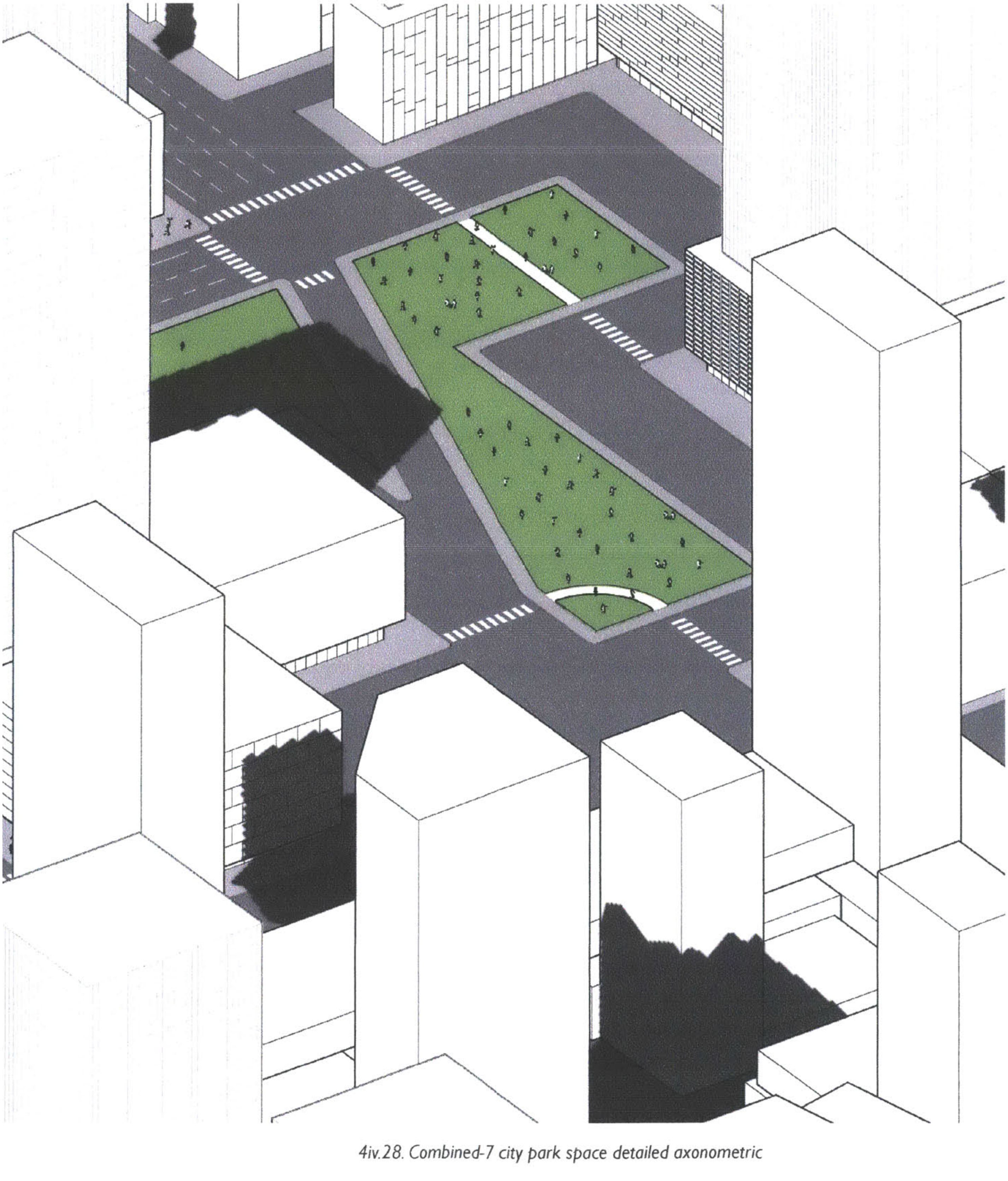


4iv.26. Combined-7 experiment sequences

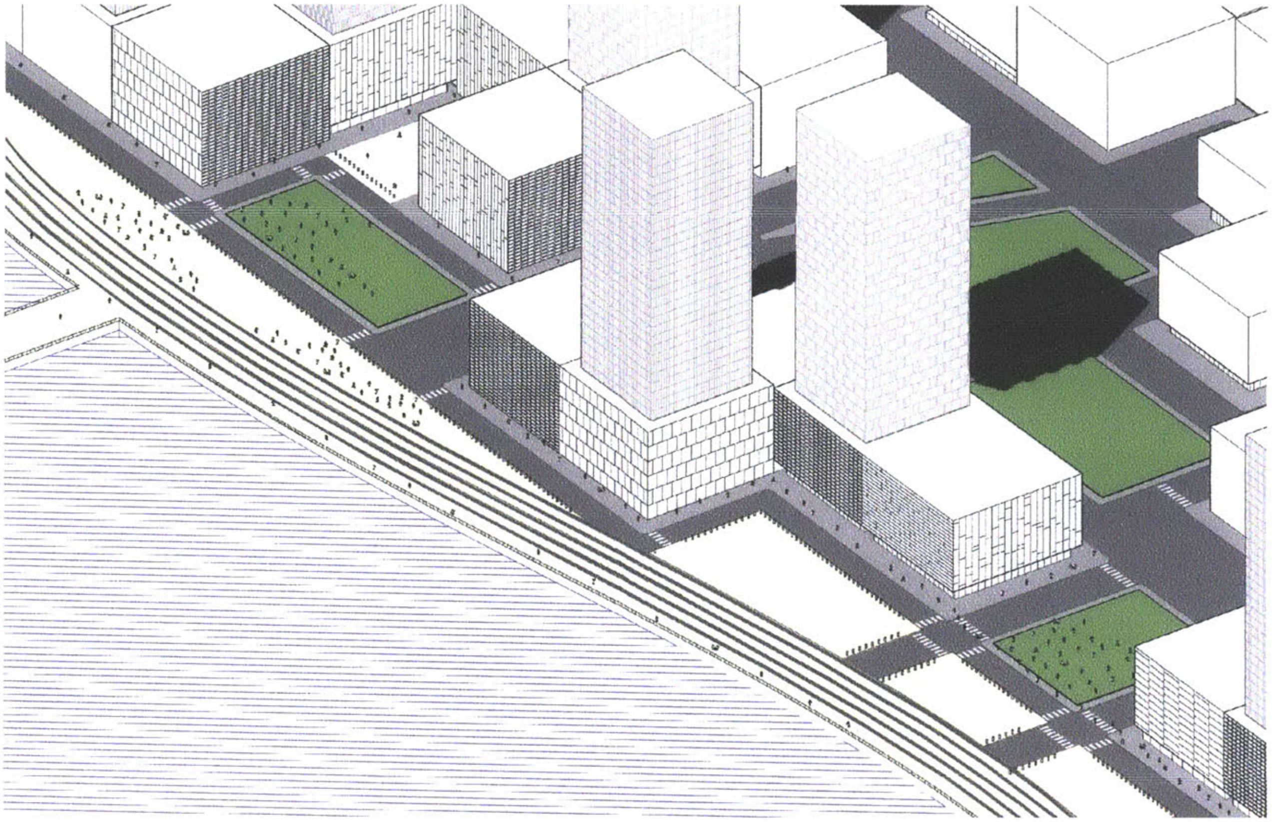


4iv.27. Combined-7 final axonometric





4iv.28. Combined-7 city park space detailed axonometric

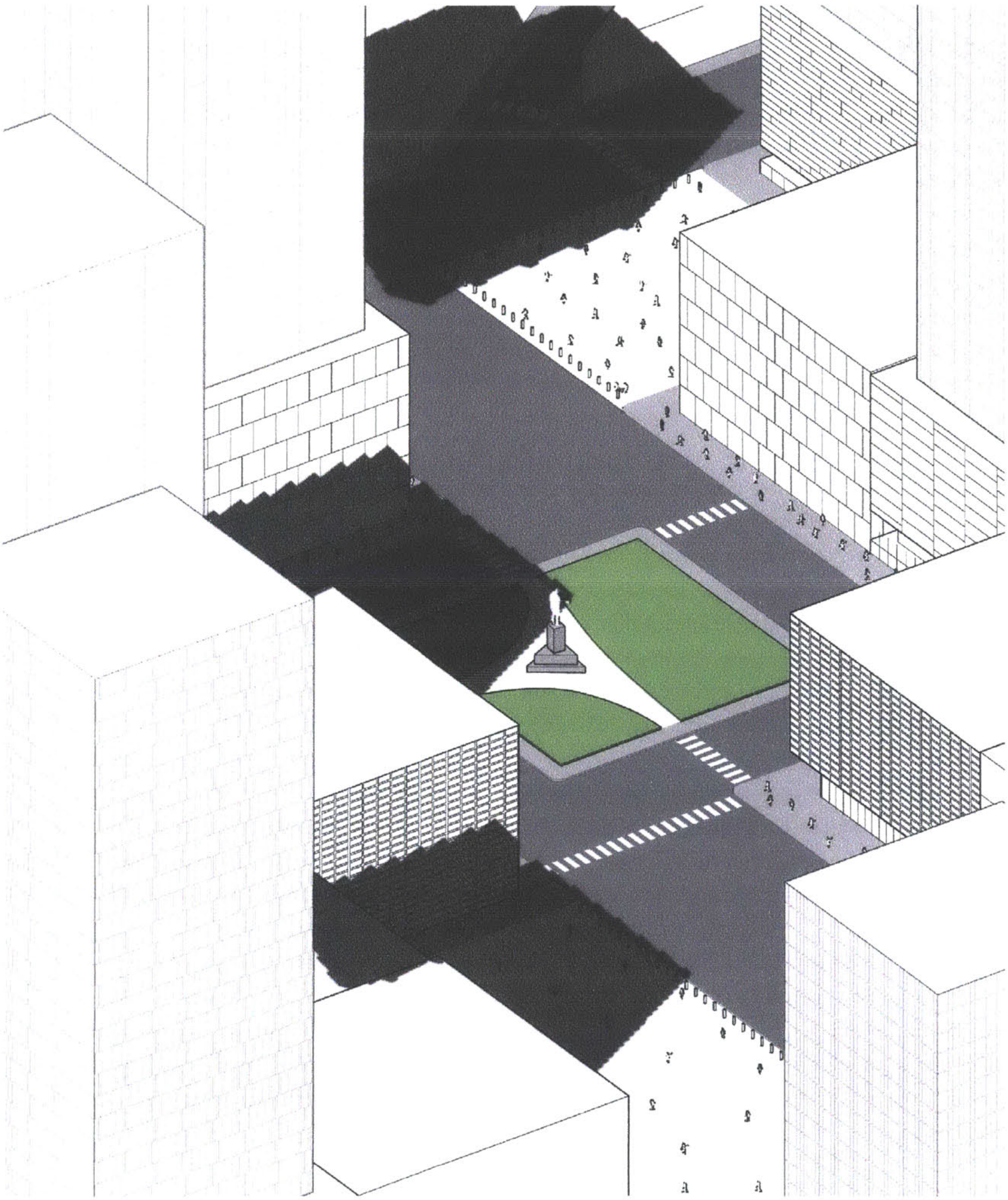


4iv.29. Combined-7 waterfront promenade detailed axonometric

multiple park entrances. This would not diminish the effectiveness of the design methodology since it relies on components and relationships, not form. Regardless of how complex the shape may be, a park will still have the same components that were used in Combined-6: edges and entrances (vehicular and pedestrian),

We can even insert a less conventional public amenity such as the Highline (New York) and the design methodology would still work just fine. The Highline has edges and a series of entrances spread along the park. We may treat the edges differently than the way we treat the edges of a conventional park, but that is the beauty of the design method. The *components* remain the same but the *relationships* are up to designers to decide.

So far, all of the experiments have been more or less about creating a new neighborhood that resembles its context in terms of blocks and parcels structure while creating new public spaces; a mixture of high, medium, and low density developments; and a mixture of potential building typologies based on footprint area, building heights, and location. So far, the experiments have stayed very close to PlaNYC's agenda, assuming the city wants to expand existing neighborhoods without disrupting too much of the current city structure.



4iv.30. Combined-7 small public square detailed axonometric

I decided to experiment with a completely different scenario in Combined-7. In this case, I imagine a large developer that owns the entire site, has strong political and economic leverages, and therefore has more control over what gets developed on the site. The client wants to create a new neighborhood identity with a series of highrise apartment towers, offices, large retail complexes at the street level, a variety of parks, and a strong waterfront identity. The client has a vision that this neighborhood is to become a new urban center in the area with high population and strong public life through busy streets and a high level of commercial activities.

With that in mind, Combined-7 saw the introduction of BuildingTowers operation, which is a more sophisticated way of creating highrise building complexes than what I have been using so far. Combined-7 results in an urban scheme with streets that continue and connect surrounding existing streets into various spaces within the site; a variety of open spaces that consist of parks of various sizes, locations, and contexts as well as building plazas located in front of some of the large tower complexes; a small mixture of parcel structures and building typologies; and a public waterfront recreational space.

The resulting urban plan is more complex than any of the previous one. Since I was not concerned with strict continuation of existing streets in this scheme, I overlaid a rectangular grid (figure 4iv.26, image 2) on the site, simply cropped by the site boundary. After BuildingTowers is completed (no more parcels can be developed without having new towers cast or covered by shadows on/of those previously designed), there are many leftover undeveloped spaces that are too wide and large to become streets and public spaces. These leftover spaces are split into smaller blocks using RoadNetwork, the way the previous experiments were done, and became smaller parcels with smaller developments (4iv.26, image 10). This is a way to fill up the leftover spaces with a second type of urban fabric and development.

Unfortunately, the rectangular grid proved to be too rigid for this scheme. Even though each tower base complex has a unique configuration, all of the buildings individually have exactly the same size and shape. A quick look at the urban plan reveals the inherent arbitrary grid that was imposed onto the site. Perhaps an operation that creates a more appropriate grid should be devised as the base for running BuildingTowers.

Ultimately, each design scheme beginning in Combined-2 successfully created a variety of open and closed spaces that can be appropriated as public and private. These spaces are most resolved in Combined-7 (figures 4iv.28, 29, and 30). Figure 4ivi.28 shows a long park space. Figure 4iv.29 shows a series of parks and paved plazas along a promenade that steps down towards the waterfront edge. Figure 4iv.30 shows a small square at the center of a building cluster along with privately owned public spaces that are delineated by road blocks.

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5. CONCLUSIONS

The most important aspect of this thesis is not so much based on the degree of completion and precision of the components, operations, and experiments set up throughout the thesis. It is much more about getting us designers to focus on relationships and preventing us from attempting to materialize our own preoccupations through an urban form, which is often too simplistic, visual-based, and one-dimensional for urban design projects by providing an option that takes advantage of computational parametric tools. To reiterate, urban design, especially in larger scales, cannot afford to have subjective design ideas projected to it. Architecture is much more forgiving as it is small enough to become a vessel of an individual's interests and passion. By focusing on a city's components and their relationships, I think it is more possible to propose actual, not just seemingly, complex and multi-dimensional urban schemes through layering of rules and keeping track of what each of them does and how each of them affects the others. This thesis is the antithesis of the desire to create the next canonical urban scheme.

One of the weaknesses of this methodology is that it relies heavily on context information in the form of abstract or physical data. The richer the context, the more complex the design schemes can potentially become. If this is to be used in a town planning project where a city or a large developer is seeking to establish a satellite city away from the city center in the middle of a vast agricultural land, the methodology will suffer as there is not as much information. In such scenarios, we will have to work with information derived from the forces of nature such as topography, sun exposure, or wind direction in the absence of density, road networks, public transit, existing open spaces, etc.

As it stands, the components, operations, and experiments I have set up in this thesis are simplistic and primitive. For the purpose of this thesis, it has been my intention to keep them simple, controlled, and contained in order to really understand what each component or relationship does, focusing on the design outcomes. I realize by imbuing this work with words such as computation, digital, and parametric, many complex urban information and analyses come to mind, including topics such as thermal comfort, air quality, mass transit connectivity, carbon footprint, noise, health, crime rate, and pollution. At this point, I am uncertain of how, and if, any of these information should affect the process of urban design. I believe if my method is developed further with more components and operations layered into the system, the outcome will become that much more complex and sophisticated, creating responsible and well-informed design schemes that otherwise would have been very difficult to achieve through the mind of individual designers.

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