ABSTRACT

Title of Thesis: Shifting Gears: Exploring Parametric Design to Renovate an Urban Waterfront

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A powerful tool currently being used by architects and planners, parametric design has yet to be embraced by landscape architects. Through research and design, this thesis seeks to answer two questions: what is parametric design and how can it benefit the field of landscape architecture? Looking at historical and present-day sources, the evolution of computer aided design has been drawn out leading to the emergence of parametric design. An explanation and analysis of parametric tools, including a series of case studies, has been conducted to show how these tools are presently being utilized by designers. Utilizing parametric methods and tools, a design proposal was created to renovate a waterfront site in Baltimore, MD that focused on highlighting the city history and promoting health for the local residents and inner harbor.

SHIFTING GEARS:
EXPLORING PARAMETRIC DESIGN TO RENOVATE AN URBAN WATERFRONT

By

Paul Edward Jester

Thesis submitted to the Faculty of the Graduate School of the
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“Our own epoch is determining, day by day, its own style.

Our eyes, unhappily, are unable yet to discern it.”

-Le Corbusier

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1.0 Introduction

Over the past twenty-five years, computers have become extremely prevalent in the architecture and design fields. Originally used as a way to draft more quickly, technology advancements have allowed computers to be an integral design tool to architects. The emergence of parametric design tools, allowing designers to quickly explore many ideas within a given set of parameters, has gained much popularity in recent years. These tools have even spawned a theory called *parametricism*, which has been described as the first epochal shift in design since modernism.

Parametric design software is gaining popularity amongst architecture and planning firms but it has not been utilized by many landscape architects. A few larger firms such as Fletcher Studio and West 8, have utilized parametric software on their projects and truly show how parametric design could be beneficial to landscape architecture field. These projects have been inspiring and have shown the range of landscape architects abilities in design, function, and sustainability.

This thesis is an investigation of parametric design and the benefits it offers to the field of landscape architecture, including a design proposal using the tools and methods of parametrics to aid in the redevelopment of an urban waterfront in Baltimore, MD. The proposed design conforms to the city's objectives for waterfront open space while utilizing parametric tools to aid in form generation and functional design layout.

The introduction of these new digital design tools has given architects and landscape architects a new way to approach design, utilizing quantifiable data to reinforce design decisions regarding form and sizing of their designs. Parametric design can significantly improve the field of landscape architecture by providing new tools of design investigation, form generation, and environmental design efforts.

2.0 The Evolution of Digital Tools

While today computers play a dominant role in almost all aspects of a landscape architects practice, it was not always this way. Before the digital revolution, architects and designers had only their triangles, pencils, and theories to design with.[1] While theory and sketching are still important to the design process it is clear that the field has made an irrevocable shift to the computational world. Computers have moved beyond digital drafting and now aid us in our design decisions. To grasp the significance of how designers are currently using computers, it is important to understand the history of computer aided drafting.

2.1 History of Computer Aided Drafting

Since computers were created, they have been intertwined with the profession of architects and engineers. It is important to understand how computers have been utilized in the past and how those interactions have evolved.

Beginning in the 1960's with the technology boom following World War II, it was apparent that architecture, and all design, would be affected by the era of electronics. Industrial design had already begun utilizing digital design tools to help create and refine aerospace and vehicle design. It was only a matter of time before the same digital tools were used to shape inhabited structures.[2]

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[1] Stefanescu, Dimitrie Andrei. 2012. *Tools of the Digital Fetish: Computation and User.* June 12. http://improved.ro/blog/?p=1337.

[2] American Institute of Architects, California Council. 2012. *Parametric Design: A Brief History.* June 25. http://www.aiacc.org/2012/06/25/parametric-design-a-brief-history/.

The first digital tool used by architects was developed in the 1963 by Ivan Sutherland. Sutherland created a computer program called Sketchpad during the course of his PhD thesis at the Massachusetts Institute of Technology.[3] Also known as the “Robot Draftsman”, Sketchpad allowed designers to digitally draft by hand. While it did not offer any new design tools, it did have some benefits over hand drafting. Sketchpad allowed the user to quickly make changes without having to redo an entire drawing. It also had the capability of exact measurements and precise curves in the design process. This was beneficial for designers to quickly see and adjust measurements or angles without worrying about hand-drawn error or ruining a drawing. Sketchpad pioneered the way for human-computer interaction in the architecture field and is considered the ancestor of modern computer aided drafting programs. Following the release of Sketchpad, many other computer aided drafting systems emerged in the 1960’s. All of these systems improved on the initial human interface and drafting abilities of the designer.

Figure 1: Demonstration of Sketchpad software on a TX-2 Console at MIT in 1963

[3] Sutherland, Ivan Edward. 1963. "Sketchpad: A man-machine graphical communication system." University of Cambridge, September.

In 1970, digital design research shifted focus and began concentrating on producing digital 3D.[4] These models were forms generated by text based code and script entered by the user. A drawback of this input process was that the models could not be quickly manipulated. One major milestone of these 3D investigations was the invention of NURBS (non-uniform rational basis spline), created by Ken Versprille for his PhD thesis. NURBS was a new way of programming a line within the computer software. It was less intensive on the computer hardware and more intuitive for the designers to draw. NURBS formed the basis of modern 3D curve and surface modeling.[5] While these studies and investigations revealed a lot about the capabilities of computers, the average user and designer could not utilize the tools due to cost and the difficulty of learning the software.

In 1982 a revolutionary program, AutoCAD, was released and still dominates the market today as the primary digital drafting tool. The developers of AutoCAD set out to deliver a program with 80% of the functionality of other programs, but for 20% of the cost.[6] AutoCAD set a new standard for digital design software. After its success, competing companies began to offer increasingly advanced digital drafting tools at more affordable prices. The continued advancement of computers and technology also aided in design

[4] Cohn, David. 2010. *Evolution of Computer-Aided Design.* December 1. Accessed January 2014. http://www.deskeng.com/articles/aaazer.htm.
[5] Ibid.
[6] Ibid.

software to become more accessible.[7] While this software and affordability was a groundbreaking idea, the software stayed in the 2D realm for the average user.

The next step forward was to create a CAD program based on 3D geometry. The release of Pro/ENGINEER in 1987 made this a reality and provided a new tool to engineers and architects.[8] One drawback when the software was first released was how computer intensive it was. At first the software could only run on UNIX operating systems because PC's at the time were not powerful enough, thus limiting how many people were using it. As PC's became more powerful, its popularity and use increased in the engineering field. Pro/ENGINEER allowed for solid modeling, assembly, drafting, sub-divisional NURBS, surface modeling, and design parameters to be implemented. Pro/ENGINEER was the first software to implement design parameters. This new tool allowed users to set defined parameters which the project had to abide by.[9] Pro/ENGINEER served as a foundation for many of today's 3D modeling and parametric design software currently used by designers.

As computers and technology advanced, architects began experimenting with 3D modeling and parametric design to shape their structures. By the early 1990's, computer advancement allowed designers to tectonically manipulate standard Euclidian shapes (cubes, cylinders, spheres, pyramids) due to increased user interface. And by the 21st century, computers had developed

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[7] Ibid.
[8] Mitol, Diana. 2013. *The Evolution of CAD Drafting.* June 06. Accessed January 2014. http://info.cadcam.org/blog/bid/148578/The-Evolution-of-CAD-Drafting.
[9] PTC Inc. n.d. *Product & Service Advantage.* Accessed January 2014. http://www.ptc.com/company/history-and-acquisitions.htm.

enough to allow designers to manipulate and generate non-Euclidean shapes.[10] This allowed for the modeling and experimentation of all forms and materials. Parametrics aided these studies by allowing the designer to set known limits, such as structural limitations of a material, and having the computer assist them by staying within the defined parameters.

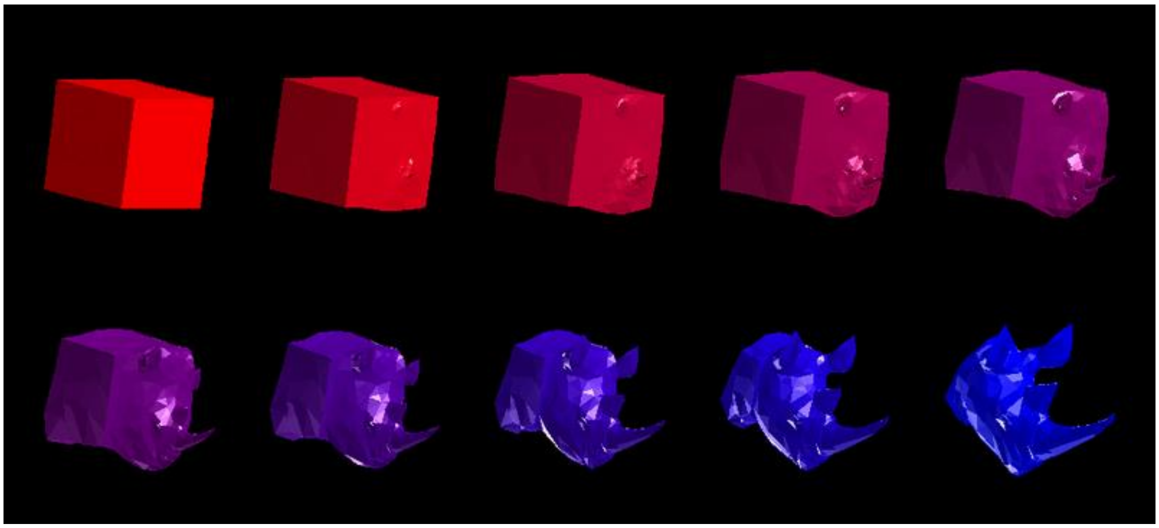

Figure 2: A simulation showing the computer's ability to take a Euclidean cube and morph into an irregular shape (webee.technian.ac.il)

With every advancement in computers, the design software has become more complex and powerful but with an easier interface and a lower cost, allowing all designers to experiment with the new software. Parametric tools are the latest advancement in digital aided design to become available to all users. It is becoming a well utilized tool in many types of design such as art, architecture, and jewelry. The computer has evolved past the role of a simple drafting tool and now actively shapes and informs both the design and designer.

[10] Kolarevic, Branko. 2003. *Architecture in the Digital Age: Design and Manufacturing.* New York: Spon Press.

2.2 The Computer as a Tool

In 1965, Christopher Alexander, an architect and mathematician, wrote an article for *Landscape Magazine* discussing the role of computers and architectural design. Alexander stated the computer is a tool that we can use to help solve problems that we cannot solve ourselves. At that time, the architectural and environmental design field had yet to encounter a problem with such complexity that it actually required the use of the computer to aid in design.[11]

Alexander's concern with the introduction of computer drafting software was that designers would use it unnecessarily. He believed that designers would make their desire to use the computer their primary goal, and their desire to understand form and function second.[12] The computer can aid designers in exploring a wide range of options that the designer would not or may not have the time to explore on their own. These explorations are only valuable if the differences between the alternatives is significant. If the changes are not significant, the explorations would have been a waste of time. Alexander argues that designers cannot apply the computer to design, but must wait until they have to use the computer to solve the design.[13]

As architectural theory and practice expands and we begin to understand more complex forms, we will have to utilize the help of the computer to create these forms.[14] As the computer works its way into the design world, we must

[11] Alexander, Christopher. 1965. "The Question of Computers in Design." *Landscape*. Spring, 6
[12] Ibid. 7
[13] Ibid. 8
[14] Ibid. 8

remember that the principals of design are much more important than using a computer.

While Alexander's articles were written at a time when computers were first being introduced to architectural design, many of his concerns still hold true today. Even with all the advancements in computers and digital design, it is still just a tool, a supplement to our design knowledge and theories. The computer can be used to help designers explore new shapes and how to build them, but the designer themselves must still understand the contextual impacts and experiential effects the structure or landscape will have on visitors. Landscape architects and others in design fields that utilize computers must understand that the computer does not replace our design fundamentals. It only helps us to explore them in a new way.

2.3 Computers and Concept

Many recently successful projects utilize the computer and technology to aid in the design process. While the projects have been successful, a number of architects and landscape architects have their doubts about using the computer to aid in design. The argument is that firms are just highlighting technological advancement without any greater meaning or design understanding, a concern similar to that of Christopher Alexander in 1965.

Nikolaos-Ion Terzoglou, a lecturer at the National Technical University of Athens, wrote "Architecture has concentrated on technological means and instrumental procedures that, in certain cases, manage empty forms without conceptual concept."[15] Terzoglou is saying that architects are too focused on using the most recent computer program or sustainable feature, disregarding the meaning behind their design. He believes architecture no longer conveys a poetic meaning or highlights the culture and history of a place. He believes there is a lack of spiritual purpose. Indeed, many of today's projects do not 'arouse us' as architecture should, but just highlight the most recent technological advancement or sustainable feature. Technology and sustainability are important aspects of today's design world, but should not be the focus or concept of a design.

Technology, from computer software to digital fabrication, has enabled designers to create that which could not be created by hand. We have begun to encounter complex problems that actually require the aid of the computer to construct and fully understand. Nonetheless, the poetic or conceptual statement may still be missing from what is generated. It is the job of the designer to help highlight what makes the given site of the project special. This is the role the designer should play: highlighting a certain cultural aspect of the site while utilizing the computer to create a beautiful, sustainable form.

As understanding of the software continues to expand, designers will be able to more efficiently utilize the software to enhance our concepts. Combining concepts with parametric tools will only improve the final product by providing more reasons for design decisions. Currently, designers are getting lost in the form-making power of parametric design and are not utilizing it to its full potential,

[15] Hendrix, John Shannon. 2013. *The Contradiction Between Form and Function in Architecture*. Milton Park: Routledge.

the exploration of design concepts and enhancing user health or design performance within these new parametric forms.[16]

[16] Rybczynski, Witold. 2013. *Lost Amid the Algorithms.* June. Accessed January 2014. http://www.architectmagazine.com/design/parametric-design-lost-amid-the-algorithms.aspx?dfpzone=general.

3.0 Emergence of Parametric Design

One powerful tool in the digital age is parametric modeling, stemming from the parametric thought process, in which all aspects of a design are interrelated on some level. With parametric software, design components become linked and will automatically influence each other when manipulated. This software has led to a new design theory, *parametricism*, where the design parameters are directly influenced by the surrounding site context. To fully understand parametricism, we must understand the thoughts and processes that led up to its inception.

3.1 Parameters and Design

While today the term *parametric* is generally related to the computational world, it has existed much longer and has always influenced great architecture and design.[17] Advancements in technology have made parametric modeling more powerful, but the thought process behind the software has existed for centuries.[18] For example, to properly design a classic Greek or Roman column, the sculptor would follow specific set of mathematical rules (or parameters) were to make sure it was correct.

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[17] Anderson, Johnathon, Ming Tang, Maria Vera, and Shai Yeshayahu. "Parametric Thinking [Not Modeling] as a Generator." *Ming3D*. N.p., n.d. Web. 26 Aug. 2013.

[18] Jones, Stuart Mackenzie. 2008. "Visualizing Landscape Systems with Parametric Modeling." Athens: Williams College

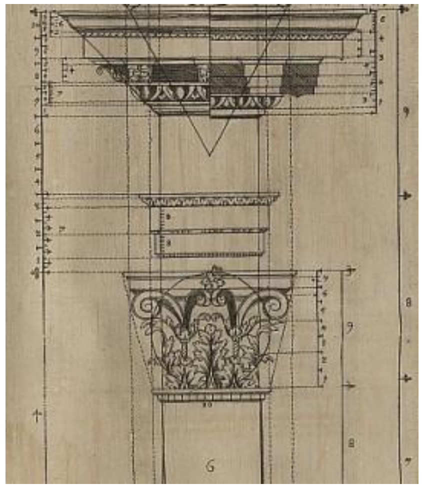

Figure 3: Proportions of classic Corinthian column (www.house-design-coffee.com)

Great architecture has always been informed my multivalent parameters ranging from culture and society, site constraints, and recently, environmental concerns.[19] Architects have always had to consider these options and followed their own intuition and design theory, their personal design parameters, in order to help them propose a feasible design. The development and introduction of technology to the design field has provided us a new way to envision and interact with these parameters.

3.2 Parametric Tools

Computer technology has advanced to provide a broad range of parametric tools to designers. These tools are a new method for architects to define design constraints in order to visualize opportunities. By linking the parameters to a visual output, designers can quickly see and experiment through a range of design variables and input. At the most basic sense, parametric tools

[19] Moussavi, Farshid. 2011. *Parametric Software is No Substitute for Parametric Thinking.* September 21. http://www.architectural-review.com/viewpoints-farshid-moussavi-on-the-need-for-parametric-thinking/8620000.article.

involve tying real world values or theories to a visual output in such a way that allows manipulation real world variables to affect and change the output.[20]

These tools are fundamentally different from typical digital design tools. Unlike traditional design software, which essentially mimics the hand drafting process, these new digital tools are focused on the relationships and parameters between design elements. Traditional design has rules and parameters, but they are rooted in the intuition and experience of the designer. The final design has been created by rules but they can only be interpreted from the final forms generated. With parametrics, the design rules are explicitly described, and the form emerges directly from the parameters and relationships decided on.

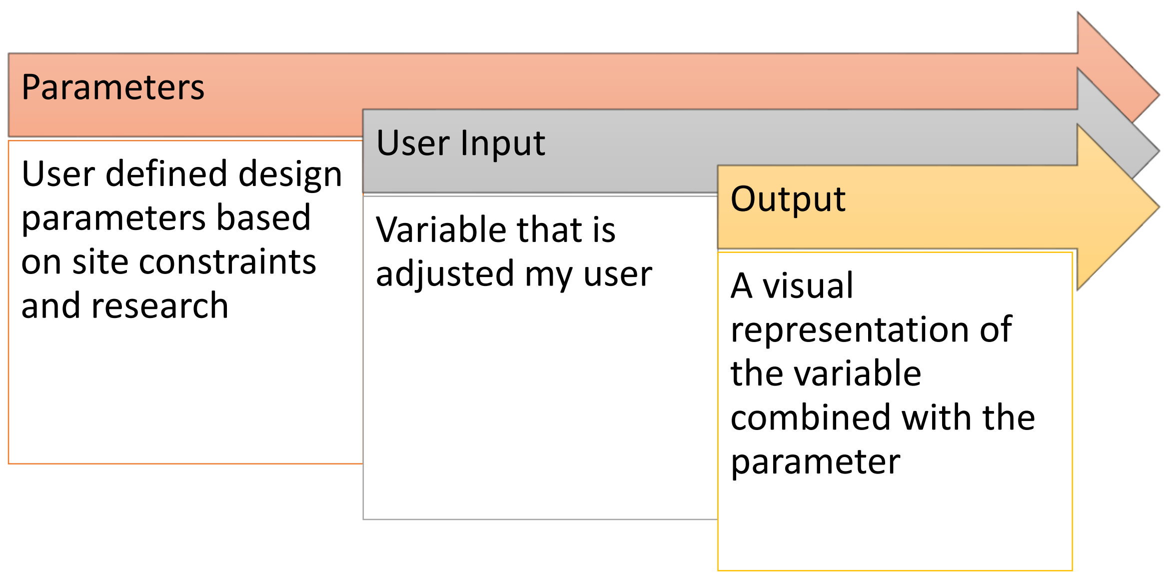

Figure 4: Graph showing the parametric thought process (Graphic by Paul Jester)

[20] Herlitz, Jeff. "No Scripting Required." *Landscape Architecture Magazine* May 2012: 64-70. Web. 11 Dec. 2012.

An example of a parametric tool would be Microsoft's spreadsheet program Excel. The user inputs a series of mathematical formulas with variables that can be modified. Based on the equations and input data set up, Excel can use the pre-scripted data connections to provide an answer. And as the input data changes, Excel provides an immediate change to the output.[21] It is driven by mathematics and the formula the user inputs and is commonly used for maintaining financial records or creating cost estimates. Excel is focused as a mathematical program and has limited visual output, but other parametric tools have focused on visual or theoretical exploration.

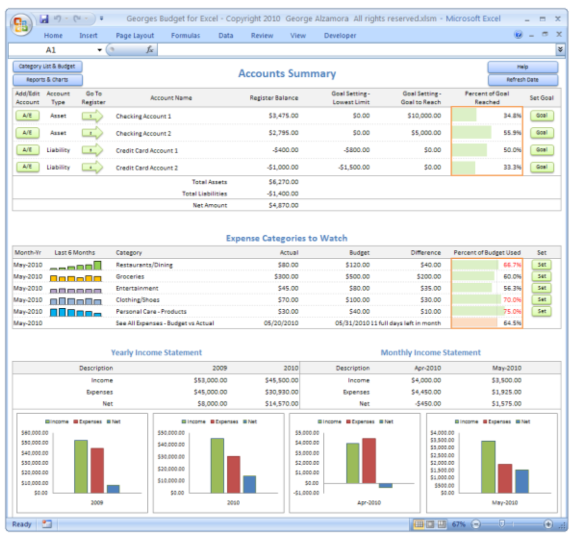

Figure 5: Figure 4: An example of a Microsoft Excel spreadsheet and how programmed formulas assist in budgeting and finances (www.georgesbudget.com)

One parametric tool that helps to visualize theory is Adobe's free online tool 'Kuler'. Kuler is driven by color theory which has particular rules, such as complementary colors, shades of the input, or compound colors, which aim to define desirable color schemes and palettes. In this parametric tool, the user

[21] Jones, 2008

inputs a base color, and then by the theory parameters selected, the software produces the color scheme as an output. The theory parameter remains fixed, while the user input changes and therefore changes the output. This same process of user input combined with design parameters to vary the output can be used in landscape architecture.

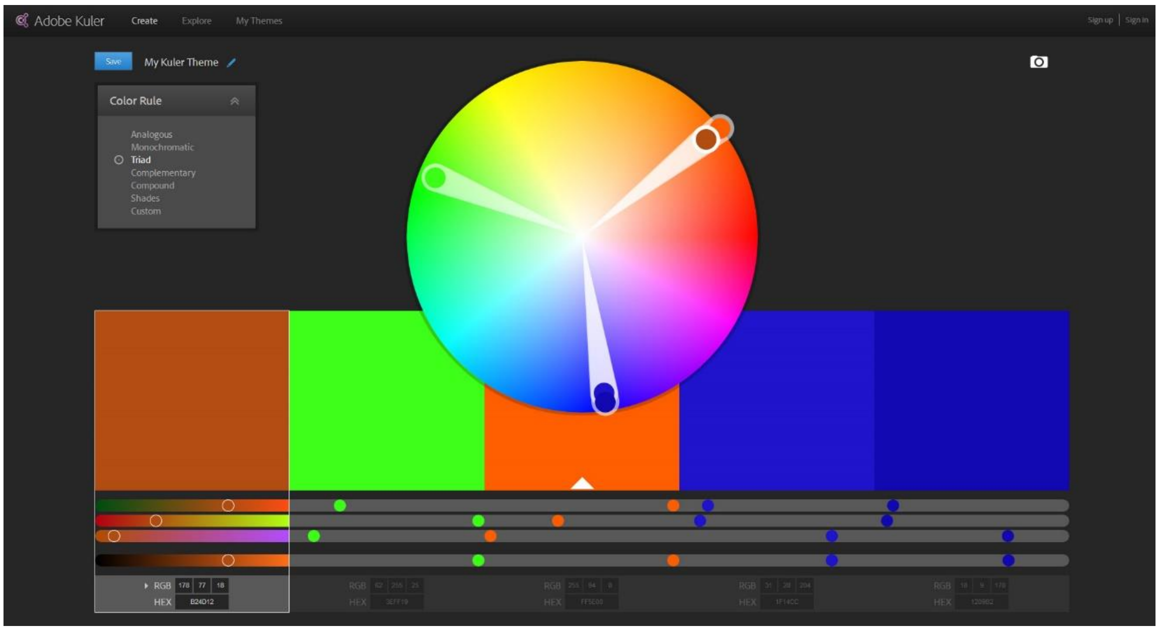

Figure 6: Adobes Kuler tool creating a triad color scheme based on an input color (Image by Paul Jester)

A rudimentary example of how parametric tools can be used by landscape architects can be found in the relationship between a sidewalk and a road.[22] A sidewalk will need to be placed at a predetermined distance from the road, due to code or zoning. As a parameter, the designer can input that the sidewalk always needs to be located 3’ (or however far the requirement is) from the road and parallel to the road. From that point on, whenever adjustments are

[22] Jones, 2008

made to the road the sidewalk will automatically adjust without the designer needing to go back to manually adjust it.[23] The sidewalk only exists as a visual output of the parameter that was programmed. The advantage of this interaction is that it allows the computer to visualize the new scenario whenever a change is made, as opposed to creating the relationship by hand every time a road is drawn. Thus the designer will be able to visualize and experiment with many alternative design options throughout their process. These same formulas or parameters that the designer decides on can impact other aspects of a design such as the sizing and configuration of spaces across a site.

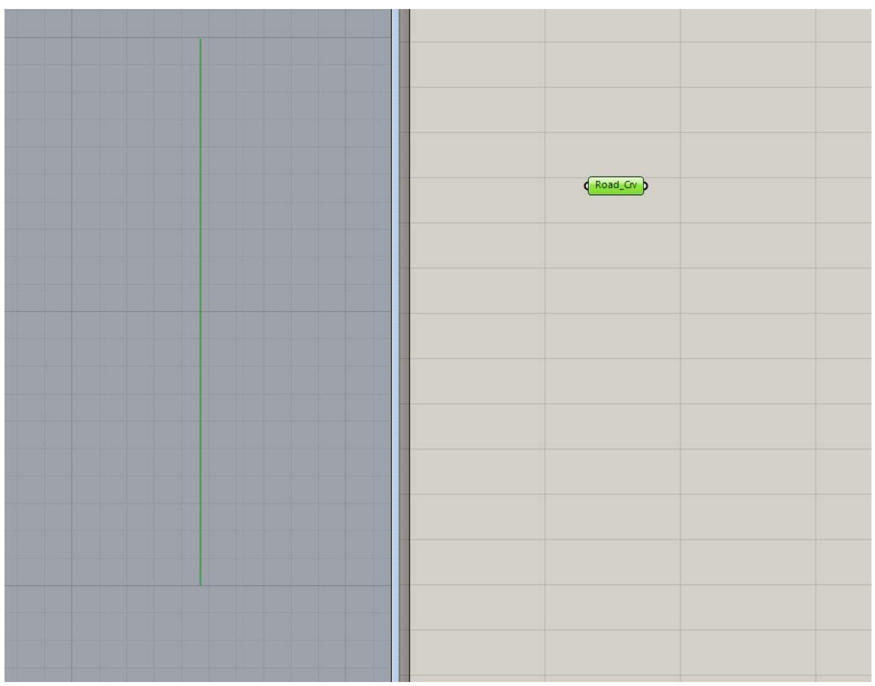

Figure 7: Identified by the green line, the edge of a road is drawn into the computer and identified by parametric tool (Graphic by Paul Jester)

[23] Herlitz, 2012

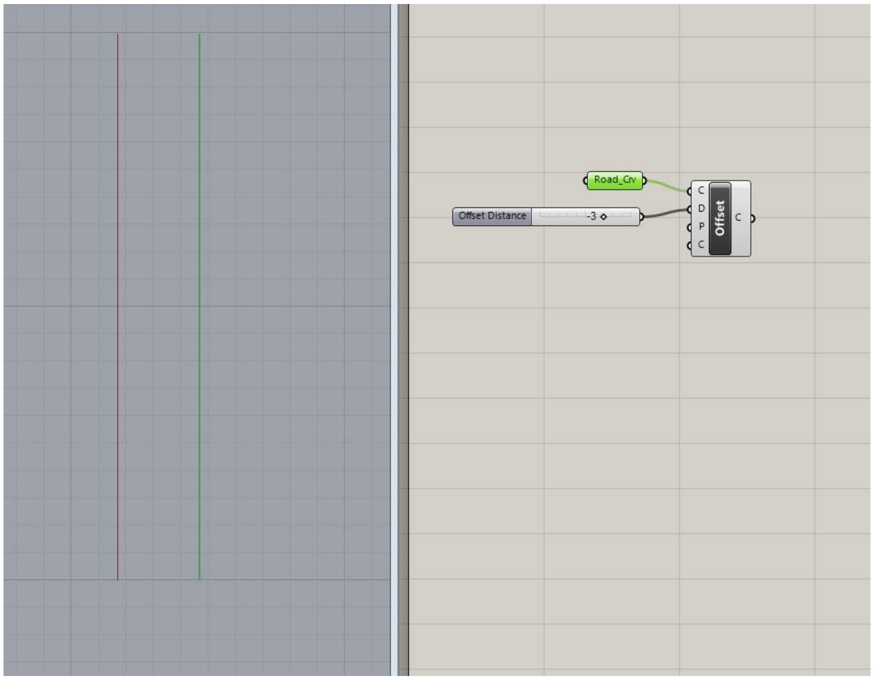

Figure 8: Identified by the red line, a sidewalk projection is created based on the scripting of the parametric tool (Graphic by Paul Jester)

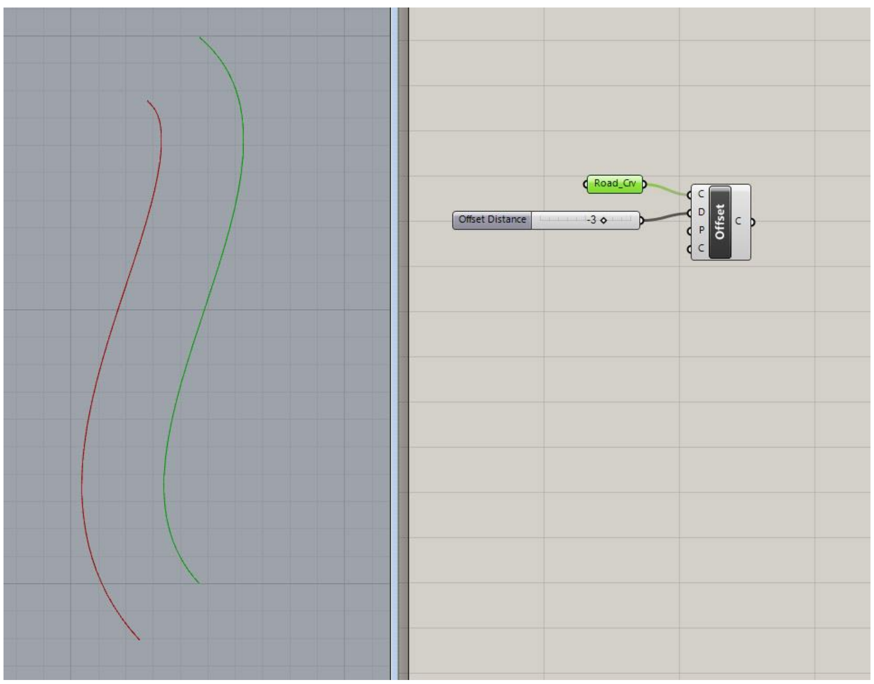

Figure 9: As the edge of the road is manipulated, the sidewalk is as well because the parameters defined by the designer (Graphic by Paul Jester)

3.3 Benefits of Parametrics

Parametric tools offer significant advantages over traditional drafting techniques. The main advantage is the ability to quickly adjust variables and visualize how it changes the design. The user can run a series of trials through which they analyze the various design proposals, choosing the best features of each one. By being able to quickly visualize many possible design solutions, the designer will be able to provide the ideal solution based on the sites context and needs. This visualization and manipulation of data has been showcased in storm water management studies by using topographic and rainwater data.

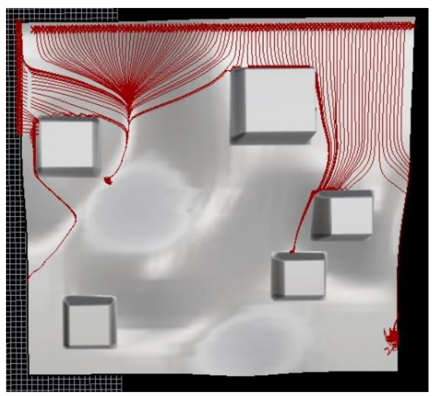

Figure 10: Storm water runoff simulation (www.grasshopper3d.com)

The benefit of seeing storm water interaction on an existing site, or a proposed design, is how intuitive it becomes for the designer to understand. Using the numbers, parametrics could allow landscape architects to visualize and design storm water systems with form simulations instead of numbers.[24]

Another benefit of parametric tools is the capability to help physically construct the digital model. With the organic shapes being produced by

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[24] Herlitz, 2012

parametric design, a number of analysis tools are being developed to aid in the construction or digital fabrication of design. These tools will utilize known structural limitations of building materials and allow architects to understand how to build their new designs.[25] For example, the well-known landscape architecture firm NOX utilized parametric construction software to aid in their 'Eye Bridge' proposal.

Figure 11: Eye Bridge by NOX (www.nox-art-architecture.com)

This competition award winning proposal is a unique pedestrian bridge. Each piece of the bridge differs and has to be custom made based on the digital model.[26] Using parametric software, NOX was able to create developable construction documents based on known structural limitations of the bridge material. This ability for extreme differentiation in a project used to be an

[25] Jones, 2008

[26] Amoroso, Nadia. 2012. *Digital Landscape Architecture Now.* New York: Thames & Hudson Inc.

obstacle, but with new parametric tools and fabrication technologies, it has become a cost efficient and artistic way of design.

Parametric tools are early in development and are continuously developing new features. Many tools are currently based on form generation and experimentation, but recent developments have been utilizing the tools for analysis of site conditions. As the tools develop, evolve, and are learned by the profession, they will be able to assist designers in many ways and will evolve and produce results, good and bad, based on the users input.

3.4 Disadvantages of Parametrics

As with all developing technologies, there are always a few drawbacks. The major drawback is the learning curve associated with parametric tools. These tools are fundamentally different from previous digital design tools as they are not just a drafting device, but actually aid in the design process using defined parameters. They require users to approach design in a new way, and to be accepting of generated forms based on the input designer parameters.

The user must also learn how to use the software, inputting design parameters and adjusting variables. Different programs have different levels of accessibility and ease of learning. Newer software is switching to a visual scripting instead of the traditional text based programming. Visual scripting allows the user to intuitively understand the relationships that are programmed and how they affect the visual output. While many programs are becoming available to landscape architects, the ability to properly understand and use the software is the most important factor, and will vary between designers. As with most hands-on design and construction, even the most capable tool in unskilled hands is of little value, while a skilled expert can make the simplest tools very capable.[27]

3.5 Parametricism

An associate at Zaha Hadid Architects, Patrik Schumacher is a main proponent of parametric design. He has coined the term *parametricism* to represent new design and theories that are emerging from the new tools. Parametricism is the embodiment of parametric thinking and parametric software. It can be utilized at all scales and applications of design ranging from interior design to large scale urban planning.[28] Schumacher believes that it is the first epochal architectural style since modernism. He argues that it cannot only create a new aesthetic but change the way people live and interact with their surroundings.

Parametricism aims to combine all contextual design factors of a site, including quantifying social and cultural factors, to influence and generate various design proposals. By combining these factors, he believes that the computer explorations will help to arrive at the ideal project proposal. As with any style in the design world, it comes with a set of guiding principles. The following five principles seek to inject parametric thinking into the various levels of design:[29]

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[27] Jones, 2008

[28] Carpo, Mario. "A New Global Style." *The Digital Turn in Architecture 1992-2012*. Chichester: Wiley, 2013. 240-257. Print.

[29] Ibid.

1. **Parametric interarticulation of subsystems:** A scripted *association of design systems*. The change in any one of these systems creates a change in the other systems.

   The interarticulation of systems means that all elements of the design are linked together through parameters. As one element is manipulated, it will affect the ones it is connected to as well.

2. **Parametric accentuation:** Enhance the sense of integration by means of *accentuating differentiation*, creating a richer articulation and more orienting visual information.

   A key aesthetic ideal of parametricism is that elements within a structure or design are different. Most buildings designed by parametricism highlight this differentiation by creating smooth undulating shapes where each panel and segment of the structure is different, and must be individually fabricated.

3. **Parametric figuration:** A tectonic malleability of the design in which quantitative variations in the design field create *qualitative shifts in the visual appearance.*

   The tectonic malleability is achieved through the data that is input to the parametric scripting. As the input data changes, the output and structure is also influenced.

4. **Parametric responsiveness:** The connection between the existing design and the surrounding context allow for a *dynamic design that actively responds to changes* in the built environment.

The responsiveness is again related to the input data and the parametric scripting. The idea is that as the data evolves and changes with the surrounding environment, the building will also be able to physically adjust and adapt to provide an optimal structure for the current conditons.

5. **Parametric urbanism – deep relationality:** Using the previous guidelines to achieve deep relationality in the urban context where all 'swarms' of *buildings in the urban setting have some level of connection.*

   Parametric urbanism is similar to the interarticulation within a design, but it now applies to the entire urban fabric. The idea is that a series of buildings will have a connection, and as one structure is manipulated, others will be too.

Overall the premise of parametricism is that all architectural and urban elements must be parametrically malleable. Instead of configuring into rigid geometries like the previous architectural styles, Parametricism brings a level of flexibility into a play of responsive systems and contextual adaptations.[30]

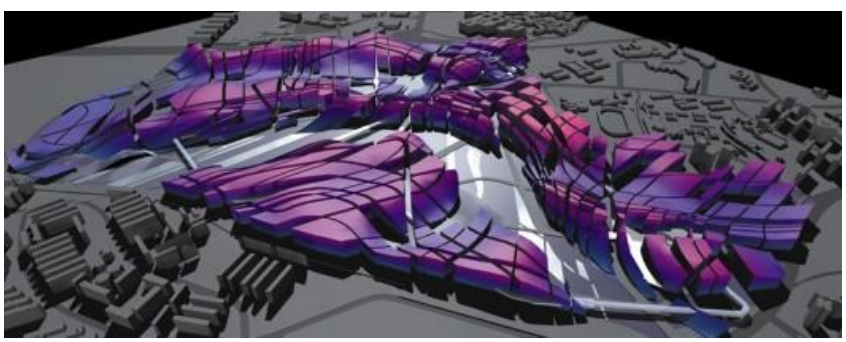

Figure 12: Visualization of city planning utilizing the five guidelines of Parametricism (www.patrikschumacher.com)

[30] Shankar, Vivek. n.d. "Architecture, Anticipated Needs and Future Innovations + Dynamic." *Vivek Shankar Design Partnership.* Accessed 2013. http://www.vsdp.in/wp-content/themes/twentyten/pdf/Anticipated%20Needs%20and%20Future%20Innovations.pdf.

Parametricism is a new design style utilizing the parametric thought process and recent innovations in digital software allowing for parametric manipulation of the design. It has the ability to design at all scales from furniture to architecture to regional planning. Parametricism is still in early development as a theory, but has the potential to not only change beliefs about design, but create a whole new guiding principle for landscape architects and designers which will impact and react to changes to create a better life for those who interact with the design.

The architect Le Corbusier once said that “the styles are a lie”.[31] He believes that we do not design in styles but in trends and beliefs of the time; styles are for history to decide upon. Following this belief, it is bold for Schumacher to define parametricism as a new style. It is important to recognize that parametric tools and parametricism as a style are two different things. Parametricism as a style is highly criticized in the architecture field. It is very new and not fully understood. Unfortunately parametric tools have become linked to the style. The tools must be rescued from the connection before they can be fully utilized.[32] The tools have the ability to program and visualize anything that the designer can think of, and should not be linked to a set of guidelines. Once the separation of tools from styles occurs, parametric tools will be able truly embraced and utilized by designers.

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[31] Corbusier, Le. 1960. *Towards a New Architecture.* New York: Praeger Publishers.
[32] Moussavi, Farshid. 2011. *Parametric Software is No Substitute for Parametric Thinking.* September 21. http://www.architectural-review.com/viewpoints-farshid-moussavi-on-the-need-for-parametric-thinking/8620000.article.

3.6 Parametric Software

A number of computer programs have begun implementing parametric tools. Many of these programs, such as Maya and CATIA, began as animation software. Designers would utilize the parametric tools to quickly manipulate their movie or video game characters. As the parametric tools developed, many architecture firms started exploring form design using the software. This thesis explores parametric design with the program Rhinoceros3D and the plug-in Grasshopper3D.

Rhinoceros3D

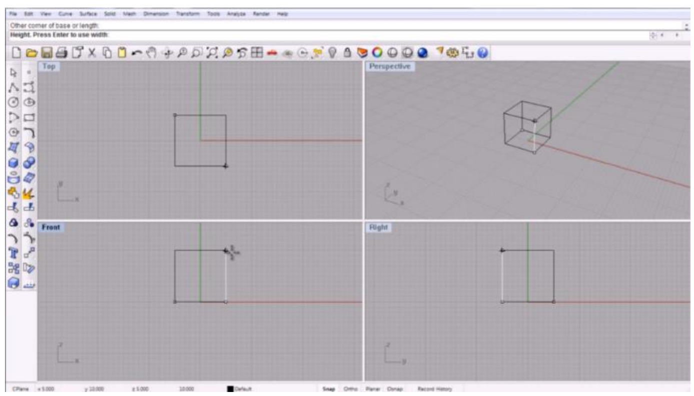

Figure 13: Rhino's standard user interface (www.cadjunkie.com)

Rhinoceros3D (Rhino) is a digital modeling software from the McNeel Company. Rhino is a non-uniform rational basis spline (NURBS) modeling software. NURBS modeling was first developed in the 1970's and 1980's. They are efficiently handled by the computer and allow for easy human interaction. Commonly used for industrial, marine, or jewelry design, Rhino has been utilized by architects in recent years. The increase in Rhinos popularity is due to its diverse applicability, low learning curve, and it's relatively low cost in comparison to other modeling software.

Grasshopper3D

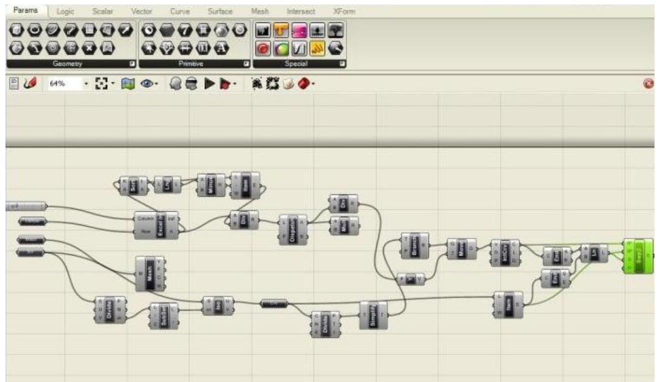

Figure 14: Grasshopper 3D user interface utilizing visual scripting icons (www.grasshopper3d.com)

Grasshopper3D (Grasshopper) is a plug-in for Rhino that is currently in beta development and offered as a free download. Grasshopper is a graphical algorithm editor that works directly with Rhino components. It allows people who do not know coding and scripting of software to access the script using a visual interface. By accessing the script users can quickly and easily manipulate the objects they are generating in Rhino. Grasshopper gives designers the ability to geometrically manipulate their Rhino models based on the designed parameters. Unlike text-based programming, Grasshopper scripting relies on visual icons for the user interface. The advantage to using icons is that the relationships and parameters can be more intuitively and visually understood. This is a benefit when trying to explain and justify design decisions to outside sources. The visual script allows for evidence based design decisions throughout your process.

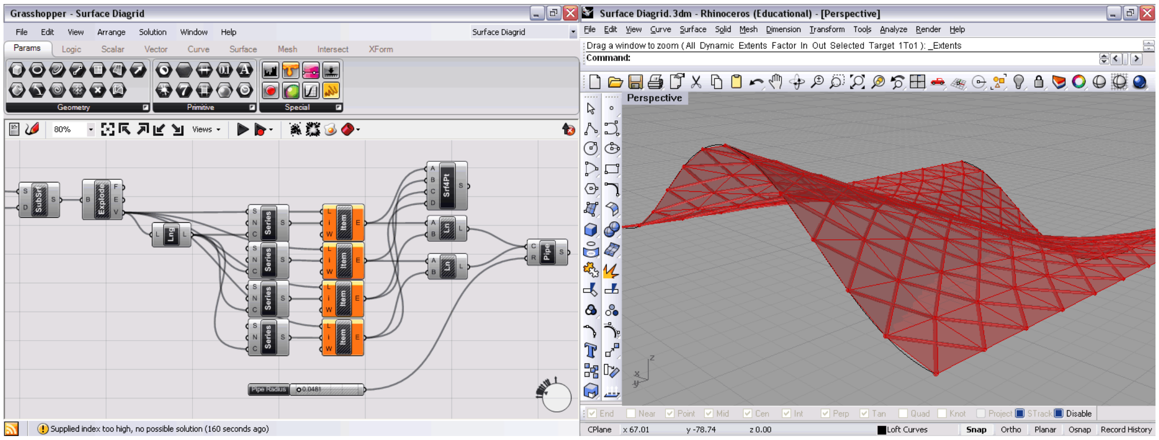

Figure 15: Grasshopper scripting with Rhino3D visualization (http://caad2.asro.kuleuven.be)

4.0 Philosophy of Parametric Design

Parametric thinking, and parametric software, stems from the philosophy of Gilles Deleuze, a French philosopher. From the 1960's until his death, Deleuze wrote influentially on the topics of philosophy, literature, film, fine art, and architecture.

Deleuze was born in Paris to conservative, middle class parents. He attended public school most of his life. He studied philosophy at Sorbonne, at the University of Paris from 1944-1948, where he was strongly influenced by his teachers and the readings of Descartes and Hegelian.[33] Deleuze published *Empiricism and Subjectivity* in 1953, the first of many publications he would produce.[34]

While teaching in Paris in 1969, Deleuze met Felix Guattari, a psychoanalyst and political militant. They worked together on several books; the most influential being *Capitalism and Schizophrenia*, *Anti-Oedipus*, and *A Thousand Plateaus*.[35] Deleuze and Guattari authored many texts, and their main goal within these texts was to create new concepts or new ways of perceiving life. The texts and concepts never truly have an ending, but are experimental and aim to invoke unconventional conversation. Deleuze has said that "If the thought occurs to me while I'm standing in a queue at a bus stop, then it's not a thought I'm going to share with the person standing next to me. I would go for a

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[33] European Graduate School. n.d. *Gilles Deleuze-Biography.* Accessed January 2014. http://www.egs.edu/library/gilles-deleuze/biography/.

[34] Stanford. 2008. *Gilles Deleuze.* May 23. http://plato.stanford.edu/entries/deleuze/.

[35] Ballantyne, Andrew. 2007. *Deleuze & Guattari for Architects.* Milton Park: Routledge.

commonplace remark about the sunrise. If a stranger turned to me and started talking about 'Spaceship Earth', then I would start to react."[36] They aimed to create conversation and spark new ideas about life with their ideas.

With the ideas being experimental, they always have the ability to bring up new ideas or reasoning that could bring about new possibilities in living.[37] This is why the ideas are so appealing to architects who want to promote life and experiment (whether it be with new materials, spatial arrangement, or software to aid in design). Andrew Ballyntyne, author of *Deleuze & Guattari for Architects,* believes that the writings of Deleuze and Guattari when read by an architect, who wants to embrace a new interpretation life has to offer, the ideas will immediately be pleasing. The following are three concepts that were highly influential in the field of architecture and specifically in the development of parametric design.

4.1 Multiplicity

Multiplicity is a belief that all people and objects are linked together and affect each other. According to Deleuze and Guattari, "There is no clearly defined threshold point in things that separates one from the other, just a cultural habit that makes us draw a line and put things in quite separates categories."[38] They believe that even though people have set these boundaries, people are not individuals, but a mass network of nodes that are interconnected through thought and action. Each person's thoughts and actions can directly or indirectly affect an infinite number of others.[39]

[36] Ballyntyne, 1
[37] Ibid.
[38] Ballyntyne, 84
[39] Stanford, 2008

The multiplicity and connections between objects can be directly seen in parametric design. In parametric design, certain objects can be linked together through computational algorithms. As one object is manipulated, it will also change the objects that are linked to it. For example, if a design calls for a series of circle to be connected by tangent lines, the designer can program this into the computer. And as the circles change size and position, the lines will always remain tangent.

4.2 Machine | Human Relationship

The Machine | Human relationship is a prominent thought process in parametric design. Deleuze and Guattari propose that machines have a life of their own, and they depend on us as much as we depend on them.

They compare this dependency to the evolution of the Thynnine wasp and the wasp-orchid. The wasp-orchid has evolved to closely resemble a female Thynnine wasp. When the male wasp tries to mate with the orchid, he instead picks up pollen, transferring it to the next flower that seduces him.[40] The wasp and orchid have become one system that depend on each other for survival.

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[40] Ballantyne, 23

Figure 16: A wasp shaped color pattern on the wasp-orchid (www.surfbirds.com)

Humans and machines have also become one system that depend on each other. Humans use computers to help think through complex problems, organize everyday life, or just relax. But the computer is just as dependent on us, for it would not survive or exist if humans did not tend to the machine, improve its design, or be willing to burrow underground to find the raw material to build the machines. Humans rely on computers, and computers rely on us. Through this connection a new identity and system is formed.[41]

Parametric tools has created a new relationship between the software and the designer, going beyond the physical dependence. It has given architects new tools that work within the computer, but for the designer. A designer's needs informs the tools (whether they be analysis or form generation) and then the tools inform the designer.[42] This bi-directional relationship of information is

[41] Ballantyne, 25
[42] Stefanescu, 2012

just like the relationship between man and machine or wasp and orchid; they depend on each other.

4.3 White Wall | Black Hole

The theory of White Wall | Black Hole is one that not only applies to landscape architects, but all designers. This theory explains how designers utilize concept to create their vision. Using a concept or metaphor is a common design process. It gives the project a deeper meaning and can help with design decisions. The design concept is not always easy to discern, but the white wall | black hole theory helps to explain its role in the design process.

The white wall represents a reflective screen, highlighting any information projected onto it (the final design). On the other hand, the black hole is the opposite. The black hole reflects nothing, but absorbs everything (the concept which drives decisions). The important thing to remember is that they are one system working together to reflect certain aspects and absorb others. Deleuze points out that within this system “there is something unknowable behind the white wall, a ‘subject’ or concept with thoughts and feelings, which, if they are to be inferred at all, can only be inferred from the signs that are inscribed on or projected on the white wall.”[43]

For a landscape architect or designer, the final product becomes the white wall while our concept becomes the black hole. People who visit the landscape will only see and experience the final design. But the concept for the design may only be inferred from what the designer chose to highlight in the design. The

[43] Ballantyne, 64

guiding principles and concepts in the design become the ‘unknowable subject’, or black hole, behind the finalized design (the white wall).

5.0 Parametrics in Practice

The following case studies look at how landscape architects and planners are currently utilizing parametric design software. From these projects, we can gain a better understanding of the current abilities and understanding of parametrics in the design process. We can also envision how landscape architects can further integrate these design ideas into their projects.

5.1 Kartal Pendik Master Plan

Designer: Zaha Hadid Architects

Location: Istanbul, Turkey

Date Designed/Planned: 2006

Client/Developer: Kartal Urban Regeneration Association

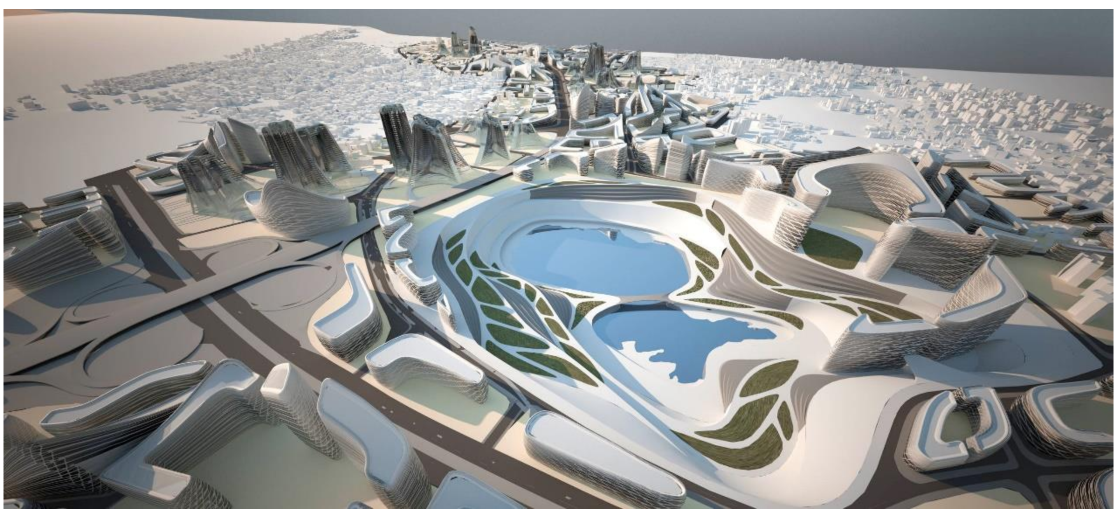

Figure 17: Proposed birds-eye view of the Kartal Pendik master plan (www.zaha-hadid.com)

Zaha Hadid Architects is an architecture and urban planning firm that has won a number of master planning competitions utilizing parametric design software.[44] One of their most well-known projects is the Kartal-Pendik Master

[44] Carpo, 251

plan, completed in 2006. This project was a design proposal for a 136 acre city subcentre on Istanbul's Asian side with the goal of reducing pressure on the city's historic core.[45] The new development would renovate an industrial area of Istanbul and become a link between Asia and Europe. The area was a blank slate and allowed Zaha Hadid Architects to utilize parametrics through their entire design process, aiding them in road layout and building strategy.

Figure 18: Rendering of proposed circulation pattern, created by Maya's parametric programming (www.zaha-hadid.com)

Recognizing that the transportation infrastructure was important to the successful renovation of the area, Zaha Hadid Architects focused on an innovative road layout as a springboard for their design. Recognizing the existing points of circulation, the planners used the program Maya to assist in their proposed road layout. Maya, originally used in computer animation, has a hair dynamic tool that parametrically bundled the incoming circulation into larger

[45] Carpo, 251

roads within the boundaries of Kartal Pendik.[46] The proposed road layouts are unconventional but created larger areas between for structures and public amenities.

With larger expanses of land between the roads, Zaha Hadid Architects were able to create environmentally innovative buildings. By calculating sun angles and winds, the buildings tectonically wrap the blocks and adjust height to allow for passive heating and cooling of the buildings. Since the structures surround the block, public open spaces were able to be created as interior courtyards, allowing the master plan to incorporate a large amount of green space. The designers experimented with various scripts that configure each block based on parcel size, proportion, and orientation.[47]

Figure 19: Proposed buildings overlaid with new road system (www.zaha-hadid.com)

[46] Schumacher, Patrik. 2009. “Parametricism: A new Global Style for Architecture and Urban Design.” *Architectural Design*, August.
[47] Carpo, 250

Zaha Hadid Architects were able to successfully use parametric ideas and software to design the Kartal Pendik Master plan. It is inspiring at how they combined environmental factors and the software. By combining environmental factors and computers, we are able to reach a new level of preciseness and accuracy within our sustainable designs. The software also allowed them to apply these techniques to a large area containing many structures simultaneously, a feat that would have been close to impossible without the technology.

These benefits are not without drawbacks though. The proposal for the Kartal Pendik Master Plan took approximately three years of research and design.[48] This is a long time, and the proposal is still only conceptual. A lot more work still needs to occur before construction of their proposal could begin. With parametrics being a new design practice, there is a lack of information to aid in the design which could have possibly slowed down the design. While Zaha Hadid Architects proposal includes many new and innovative design ideas, they also had to design the software to aid them. As parametric design keeps expanding, designers will begin to have a database of digital scripting that has been utilized by others, but at this time it does not exist.

[48] Carpo, 241

5.2 Whispering Garden

Designer: NOX

Location: Rotterdam, Netherlands

Date Designed/Planned: 2005

Client/Developer: CBK Rotterdam

Figure 20: Rendering of Whispering Garden project (www.nox-art-architecture.com)

Whispering Garden, a competition winning design, is an interactive public artwork. The project consists of an interactive structure along the River Meuse in Rotterdam. Based on the legends of sirens, who would lure passing ships onto the rocks. Whispering Garden utilized advanced wind studies, including direction, force, and duration. Sound artist Edwin van der Heide interpreted these studies to create computer-generated voices that actually sing within the structure based on the current wind dynamics. The steel and green glass structure, work together to create a new experience for visitors with each step they take.

Through the aid of software such as AutoCAD, 3D Studio Max, Rhinoceros, and Photoshop NOX is able to realize their design goals. NOX has been at the forefront of digital design in architecture and landscape architecture since the early 1990's. Their design philosophy is that architecture should be a reflection of people's feelings. For NOX, the use of digital design software allows them to utilize a 'method that augments human experience' and they believe that their designs are not capable without the computer. This is quite clear in the Whispering Gardens project. The incorporation of reactive sound elements and the form of their structure show their use of 'machines' that follow geometric systems with intertwined parts.

The Whispering Gardens project is strongly fueled by its design metaphor and could not have been achieved without the computer. By using the computer to analyze the existing wind conditions, NOX was able to make a unique form that highlights their design concept, connecting the senses of visitors while telling a story as well. A bi-directional relationship is created to design the final form. NOX was able to envision their design concept and how it should be embodied in the proposed structure. And by using parametric software, they were able to construct a form that would have been difficult to design by hand. This link between parametric tools and concept development was able to create a new exploratory form that is fueled by both aspects.

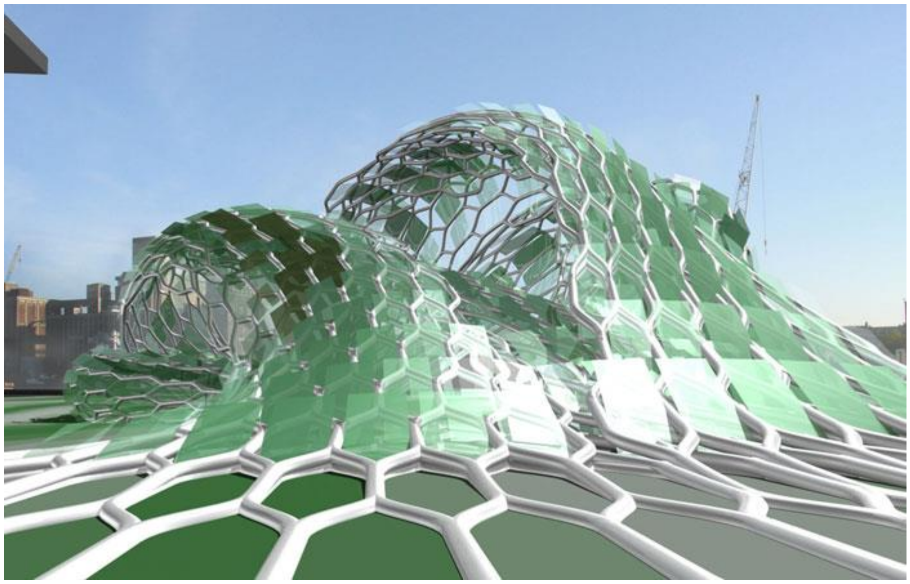

Figure 21: Main Entrance to Whispering Garden proposal (www.nox-art-architecture.com)

There are two main drawbacks on this project. One is the unique shape they chose for the on-site structure. While it is aesthetically pleasing, it does not seem to consider the full range of needs for people who may be visiting the site. The shape seems to be driven by the design concept and not the desires of people who come onto the site.

Another missed opportunity by NOX was the chance to play with the existing topography to enhance their concept. The designers decided to create an object, a sculptural piece in the landscape, which could be placed along any waterfront. If they had taken the next step and changed the topography to match the structure, the entire site could have become a unique experience.

5.3 City on Fire | City in Bloom

Designer: West 8

Location: Rotterdam, Netherlands

Date Designed/Planned: Spring 2007

Client/Developer: CBK Rotterdam

Figure 22: Nighttime view of West8's installation (www.west8.com)

City on Fire | City in Bloom was a temporary design installation that sought to memorialize the 1940 bombing of Rotterdam.[49] West 8's design was a wire-framed flower sculpture, comprised of 64,000 red and purple flowers, shaped to look like flames.[50] The flower sculpture was situated in the heart of Rotterdam and depicted the burning of the city during the bombing and the blossoming of the city after World War II.[51] It was a temporary installation that was on display for six-weeks, and literally bloomed while it was installed.[52]

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[49] Amoroso, 281
[50] West8. N.d *Brandende Stad – Bloeiende Stad*. Accessed September 2013. http://west8.com/projects/all/brandende_stad_bloeiende_stad/
[51] Ibid.
[52] Amoroso, 281

To achieve their design, West 8 utilized computer software such as 3D Studio Max, mixed with photo modification software such as Adobe Photoshop and Adobe Lightroom to highlight their design.[53] Using 3D Studio Max, West 8 was able to digitally construct the installation before the actual construction. The use of the computer software allowed the design team to fully conceptualize what they were going to build, by pushing and pulling various points in the grid to simulate the flame structure in the design. The software was also able to analyze the surface area of their sculpture, allowing them to know how many flowers to purchase to fully cover the structure

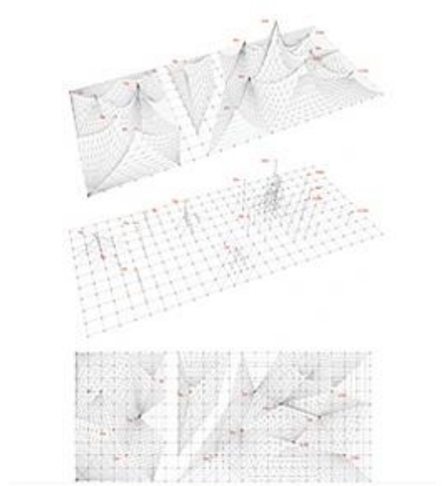

Figure 23: Surface analysis by West8 in design process (www.west8.com)

City on Fire | City in Bloom is another project where the computer helped the designers to fully highlight the design metaphor in the project. Linking their conceptual idea with the form generation power of parametrics, West 8 was able to make sure the sculpture they were creating truly represent their fire concept. By using the computer, they were also able to create the structural grid needed

[53] Ibid. 274

to support the flowers. This is a great example of how parametrics can affect all scales of design, from the overall design goal of the flames to the small scale of structure. Without the software, the designers would have spent much longer either calculating how to construct this project or would have had to build it on site which may have affected the final shape. By using the computer to aid in their design and construction process, West 8 was able to make sure their vision came to fruition.

5.4 Horseshoe Cove

Designer: Fletcher Studio *(in collaboration with Matsys)*

Location: Marin Headlands, California, USA

Date Designed/Planned: 2009

Figure 24: Birds eye rendering of Horseshoe Cove (www.fletcherstudio.com)

Horseshoe Cove, located in the Marin Headlands of California, has emerged as one of the most significant cultural, educational, and recreational areas along the San Francisco Bay. The project brief called for the redevelopment and restoration of the water's edge while protecting the existing area from rising sea levels.[54]

[54] Amoroso, 60

Fletcher Studio in collaboration with Matsys, created a design proposal that stitches together water and land creating a new hybrid edge condition.[55] This new edge condition, where land and water meet, acts as the central circulation across the site creating a meandering promenade that links important features across the site.[56] The interior spaces of the promenade contain the primary functions of the site whether it be fishing piers or a bermed earth amphitheater.

Figure 25: View of proposed berms throughout Horseshoe Cove (www.fletcherstudio.com)

Fletcher Studio and Matsys used Rhino software to test the complex geometries and forms they were proposing across the site. Through these experiments the designers were able to increase the overall edge conditions between water and land. This increase in edge allows the opportunity of more

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[55] Fletcher Studio. N.d. *Horseshoe Cove*. Accessed September 2013. http://fletcherstudio.com/projects/parks/horseshoe-cove/
[56] Ibid.

plant life and wildlife to occur.[57] The form trials also helped to design the meandering promenade that connects the site features to each other.

Horseshoe Cove is a beautiful site focused proposal that incorporates environmental concern and user experience into its design. Fletcher Studio has created a unique waterfront experience that allows for a full range of activities that doubles as a sustainable model for future projects. The incorporation of environmental concerns and user experience is one that all designers should strive for. But by using Rhino, Fletcher Studio was able to make sure that both of these things had a high priority within the design and feed off of each other. The sustainable features create pleasant spaces for visitors and the programming layout informed the sustainable practices.

[57] Amoroso, 60

6.0 Applying Parametric Design

This thesis proposes utilizing parametric thinking and tools to renovate a waterfront site in Baltimore MD. Combining parametric design, existing site constraints, and the planning goals of the city should create a new, unique waterfront space for the public to enjoy.

6.1 Site Selection & History

The Key Highway waterfront redevelopment is a large project that the city of Baltimore has been planning and developing since 2005. The Baltimore City Planning Commission worked with a group of neighborhood residents, property owners, and other stakeholders in conducting a two and a half year study of the Key Highway Waterfront to create a set of recommendations and guidelines on how to redevelop the space. The overall goal is to turn Key Highway into a premier waterfront boulevard with mixed-use development and new public open space along the waterfront.

This Key Highway project is a 70-acre site located along the South Baltimore Peninsula on the Northwest Branch of the Patapsco River in Baltimore City. The area is close to the row home neighborhoods of Federal Hill, Riverdale, and Locust Point. Key Highway also supports local maritime industry such as the Domino Sugar refinery.[58] Also included in the Key Highway area are cultural resources such as the Baltimore Museum of Industry and the Downtown Sailing Center.

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[58] City of Baltimore: Department of Planning. 2008. *Key Highway Waterfront Study.* Neighborhood Study, Baltimore: City of Baltimore.

Figure 26: Key Highway study area with the focus area in yellow. The Webster Street Open Space is highlighted in green. (Graphic by Paul Jester)

Within the boundaries of the Key Highway redevelopment is the Webster Street Open Space. This site is approximately 4 acres and has a waterfront promenade. This thesis proposes a renovation of the Webster Street Open space using parametric design. This space is ideal for an exploration of parametric design due to its lack of existing site constraints. It is a blank slate, similar to the Kartal Pendik Master Plan, where parametric design can be fully explored with consideration of surrounding contexts and adjacencies.

6.2 History of Key Highway

Figure 27: An aerial view of Baltimore's Inner Harbor during the 1950's. Key Highway and its industrial past can be seen on the left side of the photo. (www.kilduffs.com/harbor)

The history of Key Highway, and South Baltimore in general is directly tied to the shipping and industrial development along the waterfront. Originally a southern expansion from the existing city center, its geographical closeness to downtown and vast waterfront property made it a natural spill-over place for industries which could no longer find space to expand in the city center.[59] A major infrastructure that supported the expansion was the construction of the B&O railroad. The railroad combined with the new marine terminals led to Key Highways success as an industrial waterfront.[60] A few of the most notable companies of the Key Highway industry were the Columbia Iron Works (established 1879) and the Proctor and Gamble Plant (opened 1926, now the Domino Sugar Plant). The Domino Sugar plant has a large sign, which has

[59] City of Baltimore: Department of Planning. 2008. *Key Highway Waterfront Study.* Neighborhood Study, Baltimore: City of Baltimore.
[60] Ibid.

become an iconic symbol of Baltimore and representative of the industrial history of the city. Another company, the Bethlehem Steel Shipyard dominated most of the Key Highway Waterfront. With its proximity to the Chesapeake Bay, Bethlehem Steel quickly became a major shipyard for the region, boasting wet and dry docks and employing nearly 2,000 workers at its peak.[61]

Similar to other waterfront industry in Baltimore, the workers wanted to live close to their place of work. This created a series of neighborhoods, located inland, but behind the industry. The south Baltimore neighborhoods are composed of Federal Hill, Riverside, and Locust Point (including Ft. McHenry). The neighborhoods were primarily working-class people living close to their place of employment.

In the 1950's, the industrial movement of Baltimore and Key Highway became stagnant due to the deterioration of the railroads, the lack of city sponsored port authorities, worsening port facilities and industrial competition from other regions. While very few industries still exist along Key Highway, the industrial evolution of the area is still visible.

6.3 Key Highway Today

The Key Highway Waterfront contains parking lots, vacant lots, a restaurant, a bar, the Baltimore Museum of Industry, and one office building. The two remaining industries in the area are the General Ship Repair Company and the Domino Sugar Factory.

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[61] City of Baltimore: Department of Planning. 2008. *Key Highway Waterfront Study.* Neighborhood Study, Baltimore: City of Baltimore.

Figure 28: Aerial view of Key Highway today highlighting vacant lots and parking (Image courtesy of Baltimore Planning Commission)

In 1984, the Bethlehem Shipyard, located west of the current day Webster Street Open Space, was no longer considered a practical business in the area.[62] The owners of the shipyard auctioned the land to private developers who began developing the retired shipyards as a high-rise luxury residential community. Once built, this development caused numerous issues for the local residents. The high-rise structures not only block views to the water but also create an unwelcoming environment along the waterfront. While it is open to the public, the development is gated, appearing to be private land that outsiders should not enter. Most locals do not enter the boundaries of the development, disrupting the existing 7-mile waterfront promenade that wants to continue along Key Highway. One member of Baltimore's area study even described the new development as

[62] City of Baltimore: Department of Planning. 2008. *Key Highway Waterfront Study.* Neighborhood Study, Baltimore: City of Baltimore.

“fortress-like”, blocking the visual and physical access to the water for the inland residents.[63]

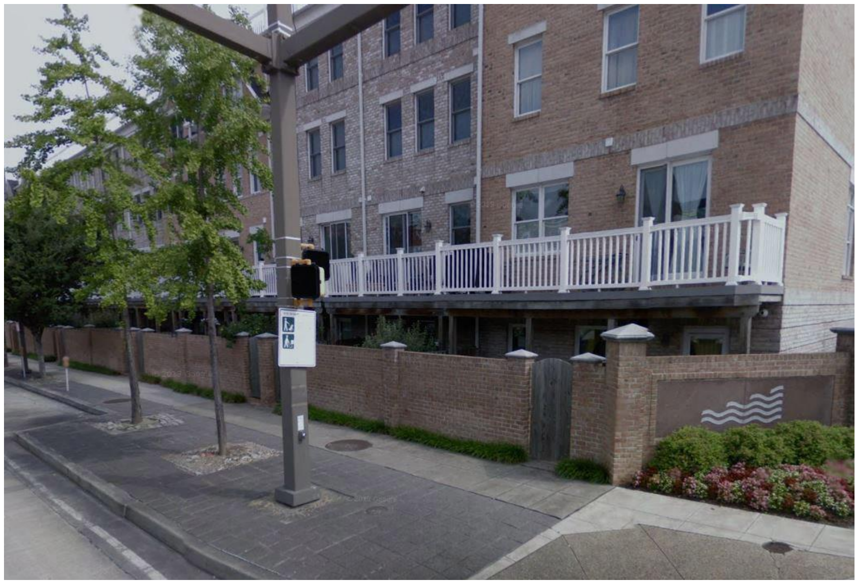

Figure 29: Street view of new development on key Highway (www.google.com)

Located to the east of the Webster Street Open Space is the Baltimore Museum of Industry (BMI). The goal of the BMI is to collect, preserve, and interpret the industrial heritage of Baltimore. They present this information through a series of educational exhibits and programs which explore the industrial stories and the people who created them.[64]

6.4 Baltimore’s Goals for Open Space Development

Development of the Key Highway waterfront, specifically the open space, is a top priority for the planning commission of Baltimore. By developing the open space the city would provide amenities such as a waterfront promenade, seating areas, and places for recreation. Once these are in place, it improves

[63] City of Baltimore: Department of Planning. 2008. *Key Highway Waterfront Study.* Neighborhood Study, Baltimore: City of Baltimore.
[64] Baltimore Museum of Industry. n.d. *About Us.* Accessed 2014. http://thebmi.org/page/about_us.

the chances of businesses to be successful in the area and further development to occur. To achieve successful open space, the city has two priorities in its development.

Waterfront views and access are critical to the creation of the public waterfront along Key Highway.[65] Views and access provide a physical link which connects the neighborhood with the waterfront. The city is proposing to extend the existing promenade from the high-rise development, which also wraps the waterfront north to downtown Baltimore, to the Baltimore Museum of Industry for pedestrian and bicycle access. The city is also proposing to protect two existing view corridors along Webster Street and Lawrence Street. These view corridors will link the inland residents with the water and lead directly to connections to the promenade.

Figure 30: Existing Webster Street view corridor (Photo by Paul jester)

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[65] City of Baltimore: Department of Planning. 2008. *Key Highway Waterfront Study.* Neighborhood Study, Baltimore: City of Baltimore, 24

As the waterfront views and access are developed, the next step is to create public open-space along the waterfront. The creation of public space along Key Highways waterfront would provide the local residents a place to relax and enjoy a number of passive and active activities such as picnicking, sunbathing, or volleyball.[66] The cost of providing open space is very expensive, especially since the ideal areas for it to be located are on private property where the city has a reduced amount of control. The planning commission's goal is to link the development of public open space to development credits, allowing developers to build taller buildings. The two prime areas for public open space are tied directly to the previously mentioned view corridors along Webster and Lawrence Street. This thesis proposes a design for the Webster Street Open Space utilizing parametric design techniques to create benefits to the local community.

[66] City of Baltimore: Department of Planning. 2008. *Key Highway Waterfront Study.* Neighborhood Study, Baltimore: City of Baltimore 30

6.5 Webster Street Open Space

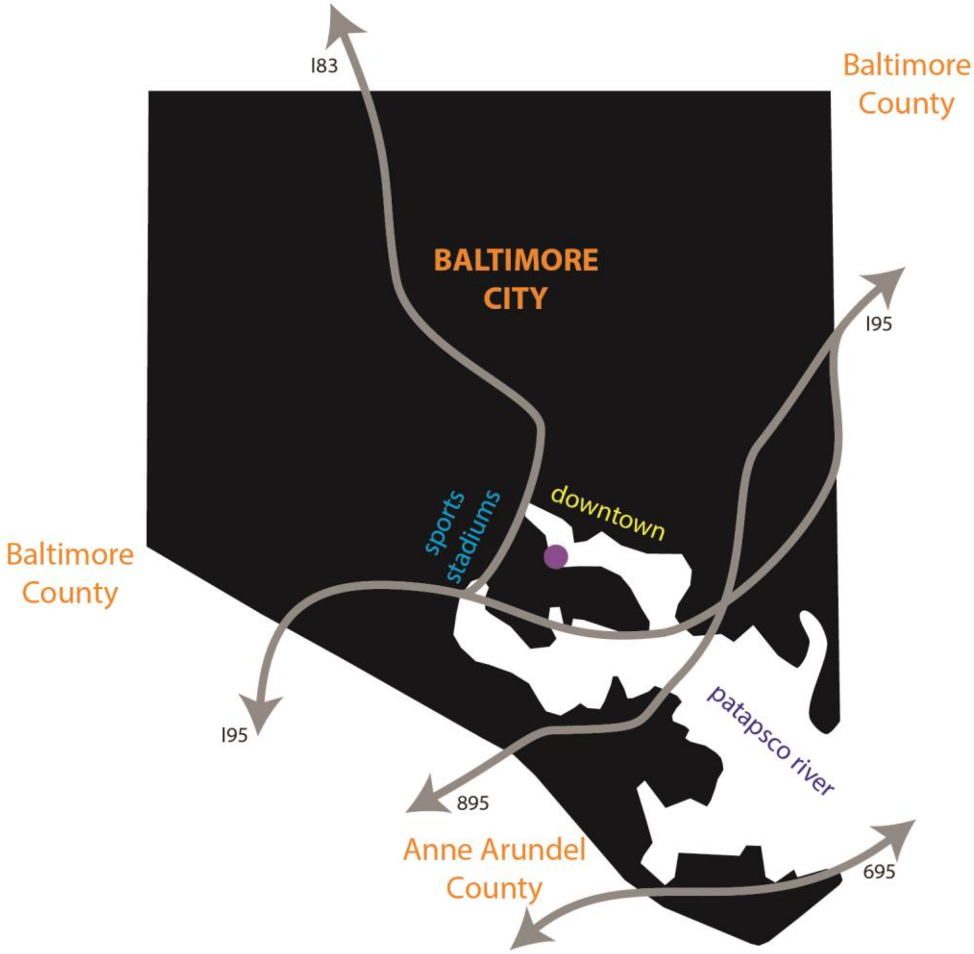


Figure 31: Identified by the purple dot, the Webster Street Open Space is located close to the heart of Baltimore (Graphic Created by Paul Jester)

The Webster Street Open Space is located in the Key Highway area in South Baltimore. The space is located along the waterfront at the intersection of Key Highway and Webster Street. The space was once a critical part of the Bethlehem Shipyard in storing materials and having access to the large ships that needed repair. Today, the space is a privately owned, vacant, deteriorating parking lot that is primarily used for storage. Even though it has direct waterfront access, the site is blocked off from public access with a chain link fence. The fence not only physically impedes residents from enjoying the waterfront, it also disrupts the view corridor along Webster Street.

Currently the city planners only plan to develop the vacant lot at the northern end of Webster Street. To the west of the site, there is a parking lot which would be connected to the space by the proposed waterfront promenade. The city is concerned with the number of parking lots along the waterfront and current plans show a number of parking garages being built inland from the water. Therefore, this thesis proposes to expand the open space design into the parking lot with a design of public waterfront space and a public promenade expanding from the existing high-rise community.

Figure 32: Highlighting proposed design area. The purple shows what the city plans to develop, the blue highlights the proposed expansion of open space (Graphic by Paul Jester)

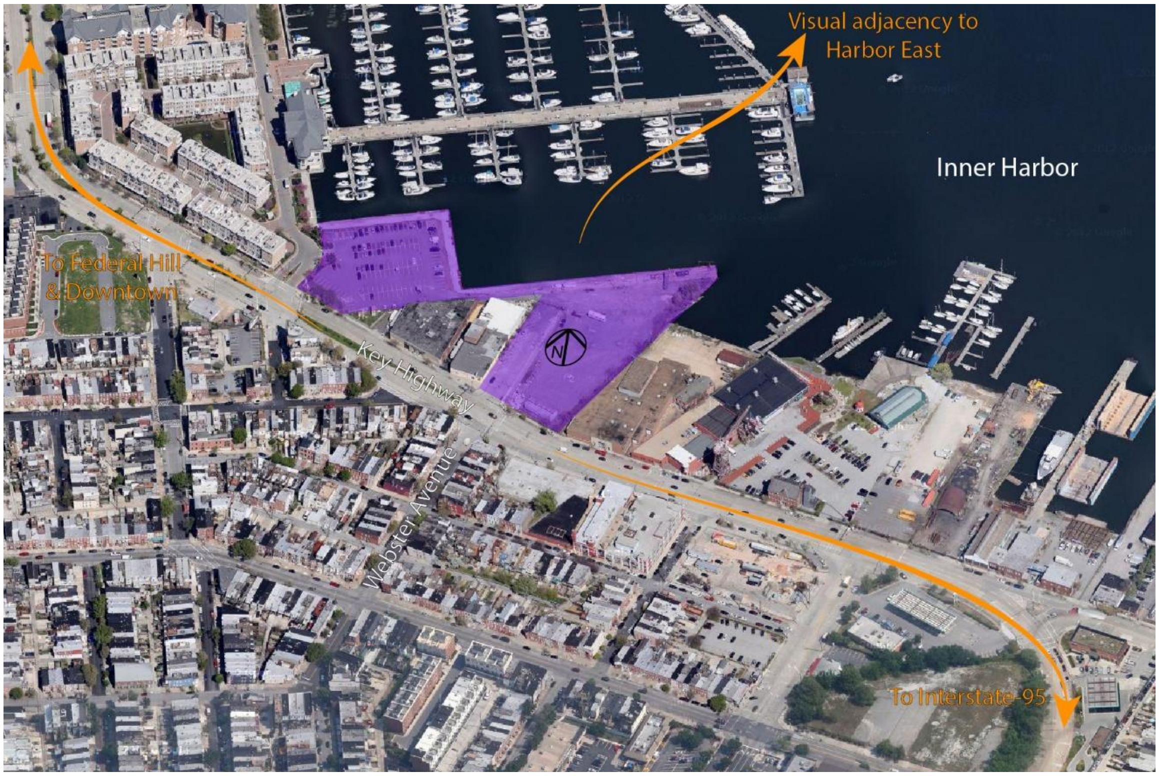
6.6 Site Inventory and Analysis

Site analysis of the Webster Street Open Space is a critical step in the design process. All of the design decisions were based on the careful analysis of the site's conditions in relation to the surrounding context. By understanding the site constraints, we begin to understand how to make our design goals a reality.

Figure 33: Webster Street Open Space site boundaries (Graphic created by Paul Jester)

Location

The Webster Street Open Space is located at the Intersection of Key Highway and Webster Street in the southern portion of Baltimore, MD. It sits along Baltimore's Inner Harbor and has direct waterfront access. From the site, there is a direct visual adjacency across to the harbor to the recently built Harbor East development. The waterfront is located along the Northern edge of the site and Key Highway runs along the Southern edge.



The site is approached primarily from the east and west along Key Highway and is extremely close to Interstate 95, a major highway that runs North and South of Baltimore. Even with this close proximity, the site is very quiet and the interstate cannot be heard while on it. The site also has a close proximity to downtown Baltimore, Fort McHenry, and the popular neighborhood of Federal Hill.

Zoning & Land Use

Overall, the Key Highway area including the Webster Street Open Space is currently zoned M-3 (an industrial zoning and residential category). The area has grown and adapted and is slowly becoming a mixed use area, including industry, residential, commercial, and institutional but the zoning regulations have not been updated with the area. The last time that the zoning code was updated was in 1971 and reflected the industrial waterfront of the time. [67] Despite the vast difference in land use from 1971 to today, the zoning of the area remains unchanged. It is believed that the M-3 zoning code is a main reason why the Key Highway area has lacked development or improvement.

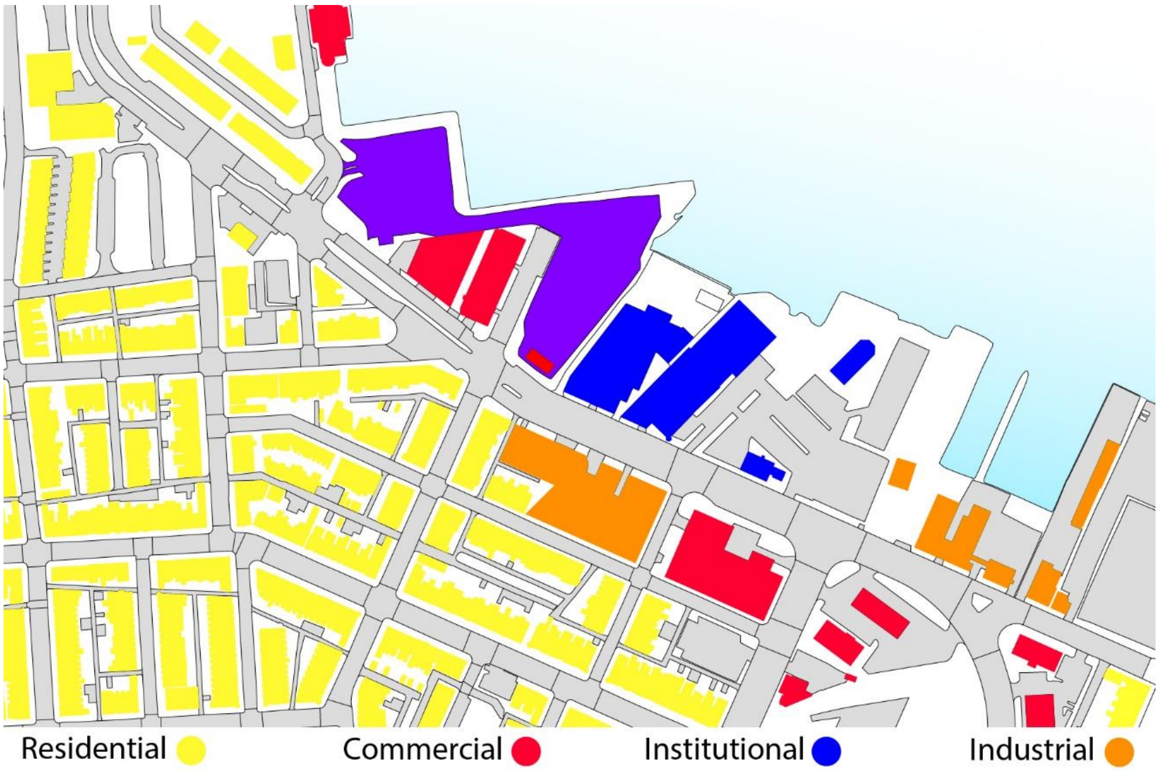


Figure 34: Existing land use surrounding site (Graphic by Paul Jester)

Today, while the industrial history of the site can still be seen the land use has drastically changed. The main land uses of Key Highway today are vacant lots, residential housing, and public institutions including the Baltimore Museum of Industry. While not official as of now, the Baltimore city planners have proposed to change the existing zoning to business and mixed-use development.

[67] City of Baltimore: Department of Planning. 2008. *Key Highway Waterfront Study.* Neighborhood Study, Baltimore: City of Baltimore, 17

This change in zoning will encourage development and businesses to move into the area and revitalize the neighborhood.

Climate

Located along the Mid-Atlantic Coastline, Baltimore is protected from harsh weather variations throughout the year. This is due to the protection of the Chesapeake Bay and Atlantic Ocean to the East and the Appalachian Mountains to the west. The average fall/winter temperature is 31.8 °F while the average spring/summer temperature is 77 °F. Freezing temperatures do not usually occur after April or before October permitting approximately 200 frost-free days a year. Precipitation in the area averages 41 inches per year. The rainfall is fairly even throughout the year, but the largest amounts accumulate during the thunderstorm and hurricane seasons in the late summer.[68]

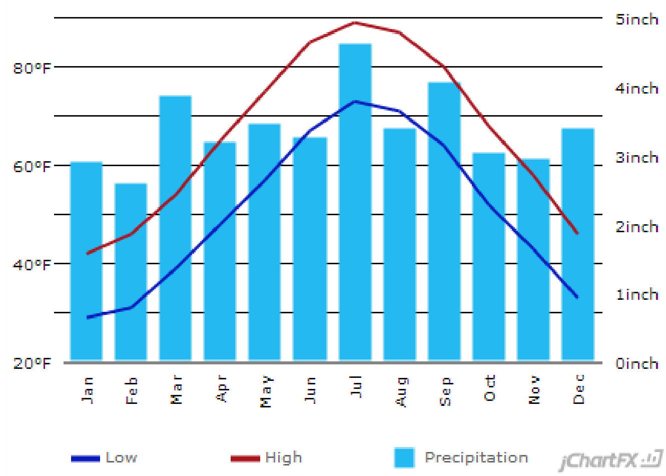


Figure 35: Chart showing the monthly averages for temperature and rainfall in Baltimore (www.usclimatedata.com)

[68] Advameg, Inc. n.d. *City-Data.* Accessed January 2014. *http*://www.city-data.com/us-cities/The-South/Baltimore-Geography-and-Climate.html

The winds in Baltimore are primarily from the south during the summer months and from northwest during the winter months. Throughout the year, the wind averages between 7-8 miles per hour.[69] The southern winds would be beneficial during the summer. Unfortunately those winds are blocked by the neighborhood and businesses along Key Highway. The winter winds will come across the site with minimal obstruction and should be screened to keep the site comfortable during the winter.

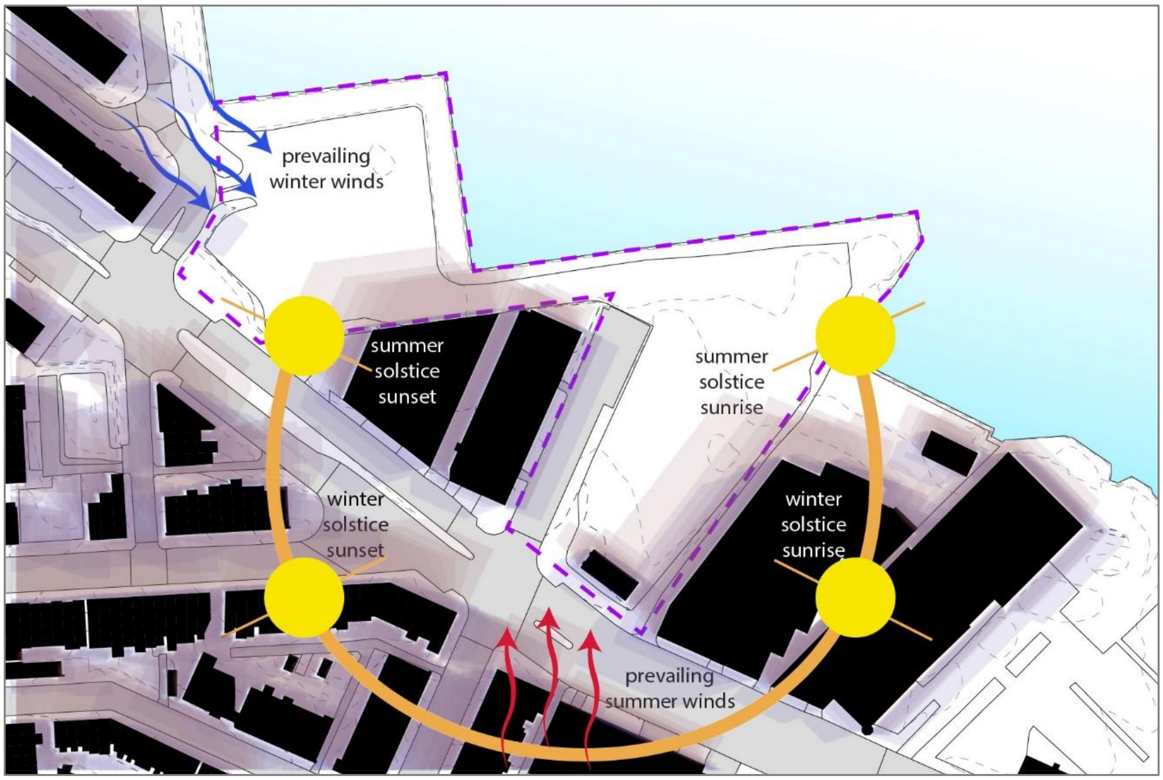


Figure 36: Prevailing winds and dominant sun positions with cast shadows throughout the year (Graphic created by Paul Jester)

The site is primarily open on the south side creating a beneficial solar orientation. This orientation allows plantings across the majority of the site. A consideration for the site is adding in vegetation or structures where people can

[69] http://www.windfinder.com/windstats/windstatistic_baltimore_inner_harbor.htm

escape the heat during the summer months, especially with the absence of wind. A consideration with the sun orientation is the shadows cast by the surrounding structures. By understanding the shadows better placement of plants and hardscaping can be achieved.

Soils

Figure 37: The on-site soils are poor due to the high percentage of impervious groundcover (Photo by Paul Jester)

According to the United States Department of Agriculture (USDA) soil survey, the entire Webster Street Open Space is designated as 44UC. 44UC is urban land with a 0 to 15 percent slope and cannot be used as farmland or for gardening. The site soils fall into hydrologic group ‘D’, and is the lowest rating soils can receive. Soils in this category have high runoff potential and water movement through the soil is restricted.[70] The site soils fall into group ‘D’ largely because of the surface covering. The entire site is paved with asphalt creating

[70] USDA: Natural Resources Conservation Service. n.d. *Web Soil Survey.* Accessed 2013.

the high runoff volume and poor sub-grade movement of water. The state of Maryland has a goal for all redeveloped properties that the new design must reduce existing imperviousness by 50%.[71] A goal of the proposed design for the Webster Street Open Space is to meet the goal of 50% through the introduction of green spaces and pervious materials. Since a reduction of impervious materials is a quantitative number based on site calculations, it can become a design parameter.

Topography

Topographically, the Webster Street Open Space is relatively flat with no physical features to work around. From the waterfront to Key Highway there is only a 10' elevation difference with an average slope of 2.5%. The flat conditions are ideal for pedestrian access and allow for a wide range of design solutions.

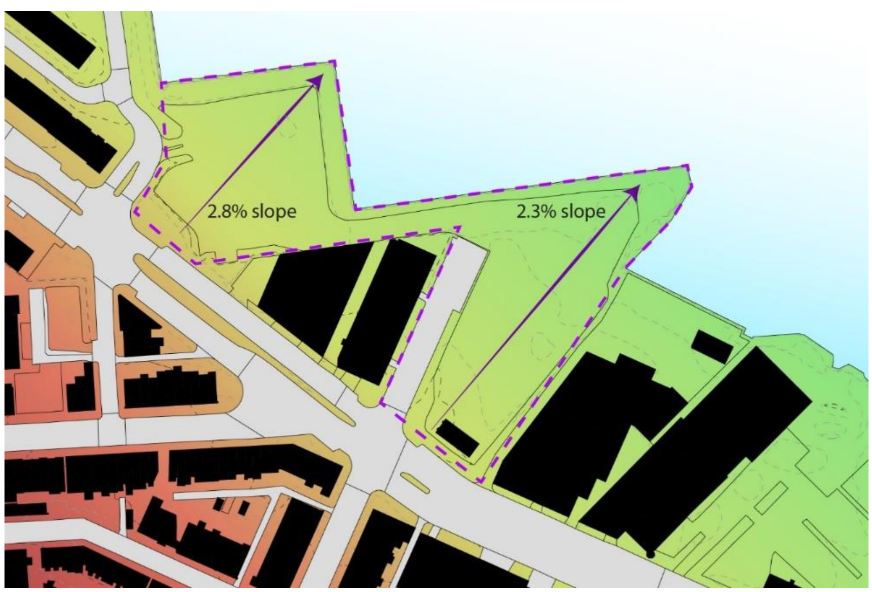


Figure 38: Topography across site with red being the highest points and green being the lowest (Graphic created by Paul Jester)

71 http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/SWM%202005.pdf

Hydrology

The watershed for the Webster Street Open Space is almost identical to the site boundaries. The city drains intercept most of the off-site water, but a small amount from the nearby buildings and property run onto the site and should be captured.

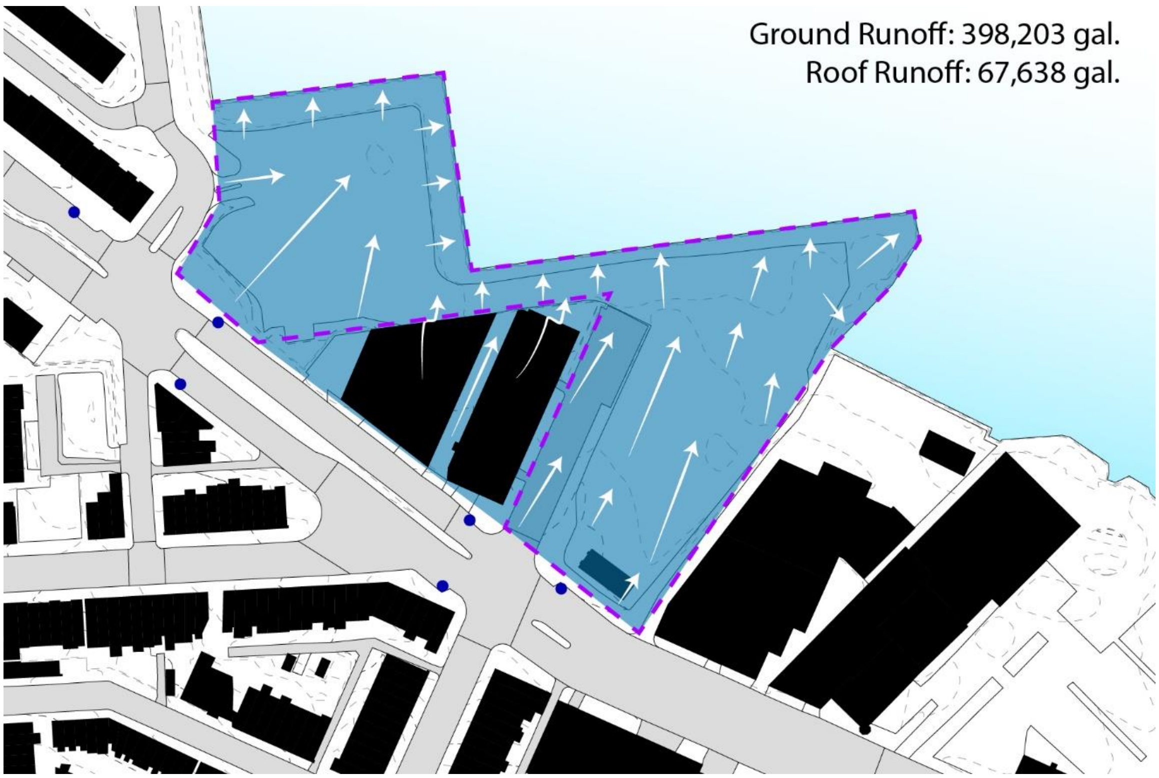


Figure 39: The site watershed, highlighted in blue, and existing flow patterns across site. The blue dots represent the city drains which intercept most of the off-site water. (Graphic by Paul Jester)

Due to the impervious nature of the site, all of the water from the site flows directly into the river. With an average rainfall of 41 inches per year, the Webster Street open space has an annual runoff of 465,841 gallons that enter the Inner Harbor untreated. The design should incorporate a way to capture and treat the majority of the water. The state of Maryland has a goal for all redeveloped properties that the new design provide water quality treatment for at least 20% of the sites rainfall.[72] For the Webster Street Open Space, this sets a design goal to capture and treat a minimum of 93,136 gallons of water. Since the runoff mitigation practices are quantitative numbers, they can become a set of design parameters that begin to shape and form areas of the site.

Vegetation

Figure 40: Street trees along Key Highway (Photo by Paul Jester)

As previously mentioned in the soils analysis, the site is completely paved over. The only vegetation on site is grass and weeds that have grown through the cracks in the surface material. The lack of existing vegetation creates an opportunity to introduce a new, native plant palette to South Baltimore. A few plants to consider are Red Maples, Honey locusts, Fountain grass, and Astilbe.

[72] Maryland Department of the Environment. 2000. "Facts About Maryland's Stormwater Management Program." *The Department of the Environment.* Accessed February 2014. http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/SWM%202005.pdf.

According to the USDA, the city's position along the Mid-Atlantic allow for plants that fall into the 7A or 7B hardiness zone will be able to survive the weather and climate changes typical in Baltimore. The location of the city in the state also allows for a unique combination of plantings from the Piedmont and Coastal Plain physiographic regions.

Going outside the site, there begins to be some vegetation in the form of street trees along Key Highway. The trees lining the highway are a mixture of Ginkgo trees and Maple Trees.

Local Population

The Baltimore Neighborhood Indicators Alliance (BNIA), is an organization that provides census and demographic information for the numerous neighborhoods of Baltimore. The BNIA groups the Webster Street Open Space into the Federal Hill Neighborhood which is located west of Key Highway. The population of the neighborhood is a little under 13,000 residents with a 50/50 split of male to female. It is predominantly a Caucasian area with an average age of 25-64. The area is fairly safe and healthy with minimal crime or health issues reported.

The neighborhood of Federal Hill is a popular place for young professionals who work in Baltimore. One concern is the stress that an urban life and commute can create for residents. The density and demands of urban living can impose psychological demands that people need to recover from. The proposed design for the site should introduce a connection to nature that can provide mental restoration for the residents.

6.7 Design Goals

After conducting a thorough site analysis, three site specific goals were formed to aid in the design of the Webster Street Open Space. By combining the following design goals, site analysis, the city's goals and parametrics a thorough, holistic design proposal can be generated that meets all of the sites' needs.

Highlight History

The industrial history of Key Highway is representative of the city's waterfront history. Originally a southern expansion of the city center, the shipping and material industries were supported by the B&O railroad. The Webster Street Open space should highlight the history and successes of Key Highway.

A symbol commonly associated with industry is a gear. Similar to a pulley system, gears are a system of rotating machine parts that are used to produce a mechanical advantage while transmitting power or a change in motion. Gears are strictly man-made and there is nothing in nature quite like it. Poetically, gears have a range of symbolism associations including precision, cooperation, mathematics, being part of a whole, and procession. Webster Street Open Space can begin to embody these concepts and symbols.

As a system of gears works together for mechanical advantage, the site design will be a system of spaces and elements that work to achieve the following goals of visitor health and harbor health. And as with shifting gears in a car, the driver must start in first gear and progress to fifth gear, the Webster

Street Open Space will be a small example of new ideas and processes that can occur on the Baltimore Waterfront.

An industrial concept can be highlighted in the Webster Street Open Space by using specific materials and how the different spaces on site are formed. The design concept of gears will be used to form different areas on site by embracing the metaphor of gears, pulleys, and serpentine belts. Materials that will highlight the industrial history of Baltimore include steel, wood, concrete, gravel, railroad materials, and shipping materials. With the sites proximity to the Baltimore Museum of Industry, new opportunities would be created to blend with and expand on their mission as well by creating new outdoor locations for historical displays or lectures.

Healthy Residents

It is expected that by the year 2025 half of the anticipated global population will be living in cities.[73] With this percentage of people living in an urban environment, urban open spaces will become increasingly important for residents quality of life.

A number of studies have shown how stressful urban life can be. The constant stimuli of a city can be mentally exhausting, mentally and physically draining residents whether it be the noise, rough commute, or a number of other factors.[74] Studies have shown that these affects can be minimized when having access to nature or green space in the urban environment. Green spaces

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[73] Woolley, Helen. 2003 *Urban Open Spaces*. London: Spoon Press.
[74] University of Washington. 2013. *Green Cities: Good Health.* November. Accessed February 2014. *http*://depts.washington.edu/hhwb/Thm_Mental.html

provide necessary places and opportunities for physical activity, improving cognitive function, learning, and memory.[75] Open space also has positive effects on mental health by providing a restorative environment, reducing mental fatigue and leading to improved work performance and satisfaction.[76]

To ensure the mental and physical restoration of the local residents, the Webster Street Open Space must include a broad array of activities for visitors. The three main focuses of the open space design will be children's activities, passive recreation, and active recreation.[77] Children's play is an important activity in open space and varies from the traditional adult activities of football or Frisbee. Areas for children's activities aid in childhood development, and should be a place of imagination where the children can play and create games or activities of their own.

Passive recreation is important for the mental restoration of residents. It can include activities such as watching wildlife, reading, resting, or meeting with friends. By providing a series of spaces, solitary and social, that allow users to relax and decompress the design allows a mental rest that is much needed in urban life.

Active recreation includes a range of activities including walking, cycling, soccer, and football enjoyed by the large percentage of the population. The ability of an open space to provide such a wide range of activities, either through

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[75] Ibid.
[76] Ibid.
[77] Woolley, 2003

incorporating multi-purpose fields or creating a waterfront promenade, adds to the health and social fabric of the region or is therefore very important.[78]

Healthy Harbor

As waterfront development continues in Baltimore, the water quality of the harbor deteriorates. The city and separate private companies, such as the Waterfront Partnership and The Campbell Foundation, have developed and begun to implement a plan to clean the harbors water. The goal of these agencies is to have Baltimore's Inner Harbor fishable and swimmable by the year 2020.[79] This is an ambitious goal given the current state of the harbor water.

Healthy Harbor, an initiative of the Waterfront Partnership, has defined and researched six problem areas to focus on regarding water quality. These categories are bacteria, nutrients, dissolved oxygen, water clarity, chlorophyll (amount of algae in the water), and trash.[80] These indicators for the Harbor were produced by EcoCheck, a partnership between NOAA and the University of Maryland Center for Environmental Science. The assessment that they conducted helps everyone to understand factors that impact the waters health, which allows designers to better target solutions and provide guidance for future monitoring. Their cleanup efforts have been effective thus far, and new development should not hinder the progress.

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[78] Woolley, 2003

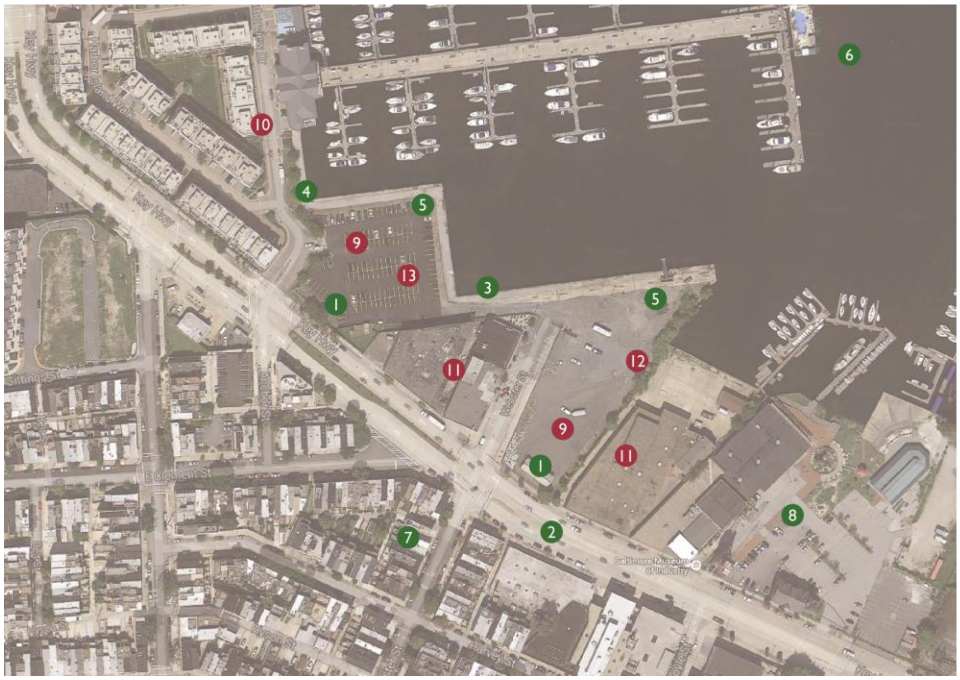
[79] Waterfront Partnership. 2014. *Waterfront Partnership of Baltimore.* Accessed August 2013. http://waterfrontpartnership.org/.

[80] Waterfront Partnership. 2014. *Healthy Harbor.* Accessed August 2013. http://healthyharborbaltimore.org/.

While the Webster Street Open space is too small to clean the whole Inner Harbor on its own, it can serve as a model of proper storm water management. Setting an example of proper techniques and minimization of pollutants into the harbor for other redevelopment along the waterfront. The main tactics used in the Webster Street Open space to promote a healthy harbor will be the introduction of vegetative material, rain gardens, bio-retention, green roofs, pervious paving, and the reduction of existing impervious materials.

6.8 Opportunities and Constraints

By combining the site analysis, personal design goals, and city design goals an inventory of the opportunities and constraints of the site can be developed to prioritize the various objectives.



OPPORTUNITIES	CONSTRAINTS
1. Flat Topography	
2. New Development Along Key Highway	9. No Existing Vegetation
3. Waterfront Site	10. Privately Owned Development
4. Connection to Existing Promenade	11. Existing Structures
5. Storm water Treatment	12. Minimal Privacy From Structures
6. Views Across Harbor	13. Poor soil Quality
7. Nearby Residential	
8. Connection to Museum of Industry	

Many design opportunities presented themselves through the site analysis. The Key Highway development is a major opportunity for the site as it will bring in new businesses. Developing the Webster Street Open Space is a vital step in this process as it will improve the surrounding outdoor space around the new businesses. On-site opportunities include a flat topography and the existing Baltimore promenade. The existing topography allows a full range of activities and programming to be incorporated across the site. The site design can also tie into the existing 6-mile harbor promenade, creating a pedestrian safe, waterfront experience to nearby attractions such as Federal Hill and the Baltimore Museum of Industry. The Baltimore Museum of Industry is in close proximity to the Webster Street Open Space and could potentially utilize the area for outdoor events they sponsor. Being on the waterfront also creates an opportunity to interact with the water; a unique opportunity that is not available in all parks.

The existing site does have a few constraints to be considered when making design decisions. The two major constraints are the existing structures and the poor soil quality. The entire site has poor urban soils, making it a tough place for vegetation to grow. Also, the existing structures create a site separation. Two distinct areas are formed and must be unified in the design proposal.

6.9 Webster Street Design Proposal

The Webster Street Open Space is currently a blank slate, with minimal on-site obstructions and a rich historical context. With a thorough analysis of the site, parametric tools and thinking can be utilized in the design proposal to highlight the sites history and create a design that enhances health of the visitors and the Baltimore Harbor.

Design Concept

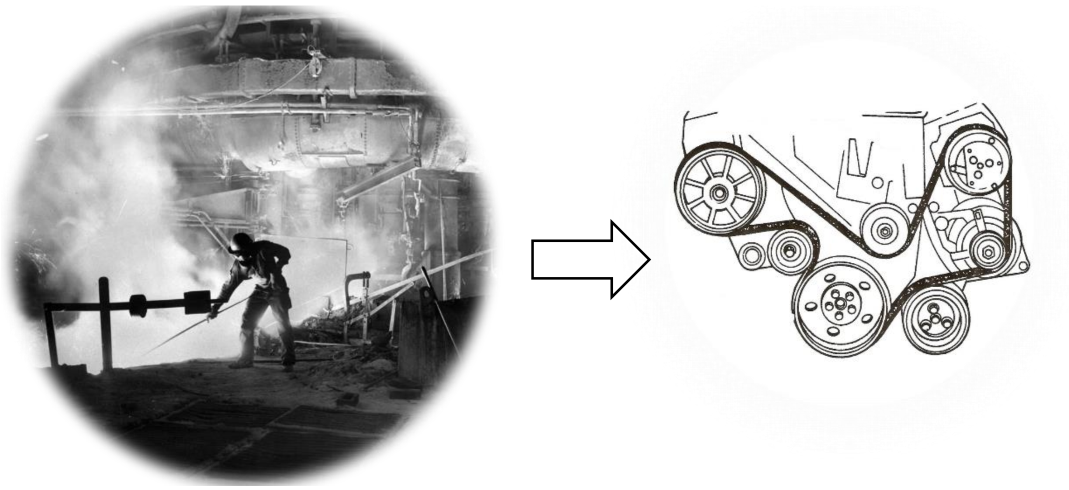


Figure 41: Graphic showing how the industrial history of Key Highway became a concept (Images from www.darkroom.baltimoresun.com & www.turbododge.com)

The industrial history of Key Highway and the Webster Street Open Space will be highlighted in the design and materials used on site. Parametric tools were not utilized to create this concept, but they will be used to help envision the proposed form, highlighting the metaphor behind the design. Since the entire Key Highway area was originally an industrial expansion from the city center, the design of the Webster Street Open Space should highlight this industrial history. A symbol commonly associated with history is the gear. As series of gears works together for a mechanical advantage, the site design will be a series of spaces that work together to achieve a healthy harbor and healthy residents. The spaces and connectivity will be created following the form of the serpentine belt. A serpentine belt is a commonly used belt and pulley system seen in many of today's machines. The shape and setup of a serpentine belt will create a design that links programming in the Webster Street Open Space as well as provide a visual continuity, unifying the entire site.

Concept Development

Once a concept had been decided upon, a series of design sketches, driven by the industrial concept, were created. An analysis of these sketches aided in learning more about what does and does not work within the Webster Street Open Space. As previously mentioned, parametric thinking does not require advanced computer software. Just like the Greek sculptors, design ideas were generated which follow a specific set of rules. A series of sketches was created to envision the variety of space making that could occur on site. All of these sketches followed a set of rules, defined by the designer which were used to enhance the design concept. The parameters were that all programming must be defined by a 'gear', and that all gears must be linked by a continuous 'belt'.

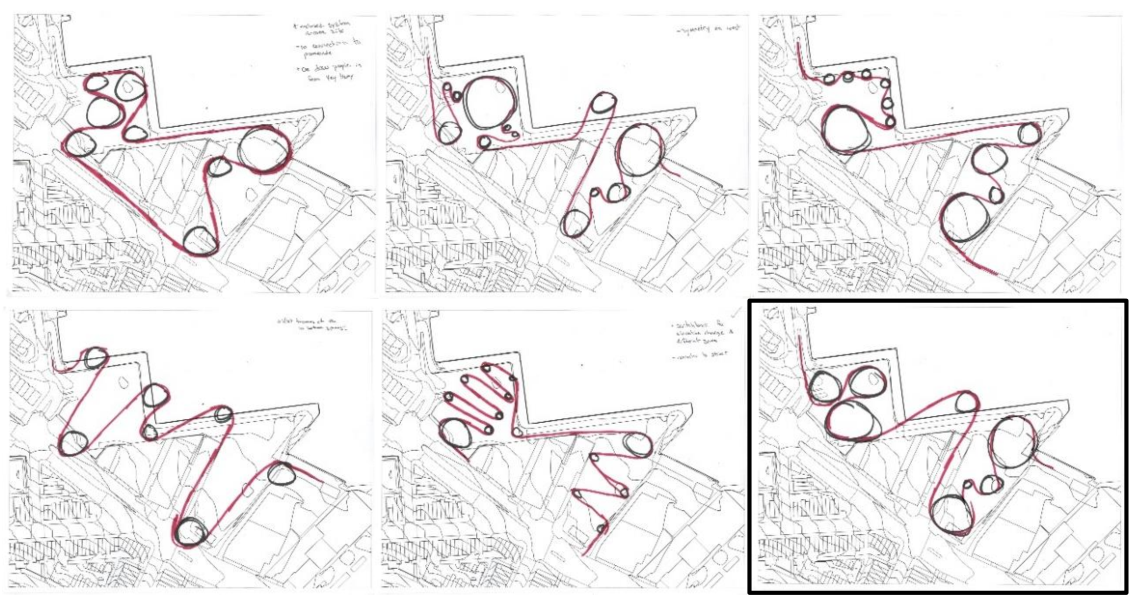
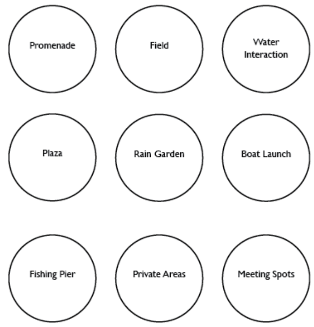


Figure 42: A sample of sketches created to experiment with basic form, the final form decided on is outlined in black (Images by Paul Jester)

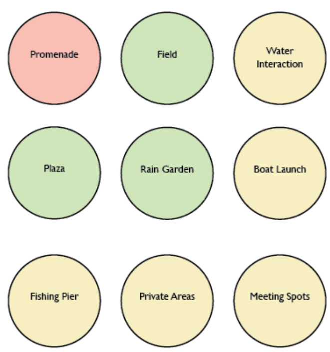
By creating a number of sketches, an analysis of each one was conducted to determine the pros and cons. By analyzing these sketches, a thorough understanding of design ideas that work and don't work on site was achieved. A number of lessons from this exercise were learned including that the site must be part of the entire harbor, not an internal system. By linking and expanding the site design into the existing Harbor Promenade, an inviting atmosphere is created and can bring non-local residents to the area. Another lesson learned is that not all programming must be spatially defined within a gear. This system of gears creates a series of leftover space that can be perfectly filled by non-defined programming such as private reading areas. They do not require spatial sizing but are flexible and can fit where needed.

Design Development

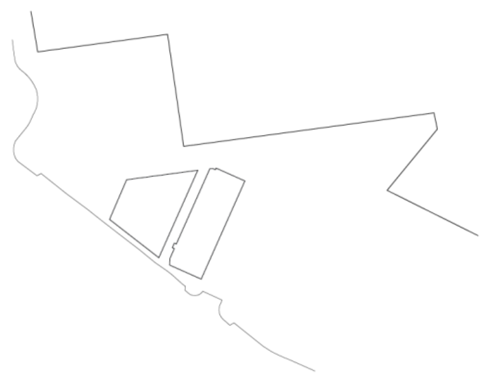
The following diagrams illustrate how the design for the Webster Street Open Space evolved from a basic concept sketch to a complete design.



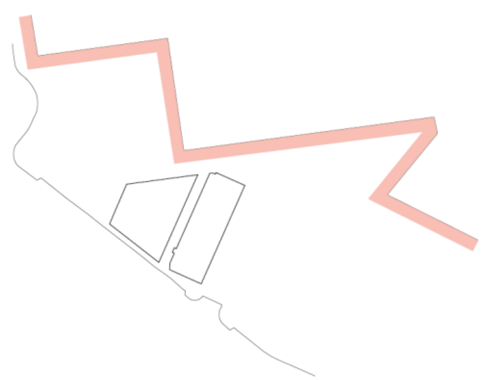
The first step in developing the design was to identify programming for the site. The programming includes spaces such as athletic fields, a waterfront promenade and rain gardens. All of the programming aims to achieve the design goals of a healthy harbor and healthy residents.



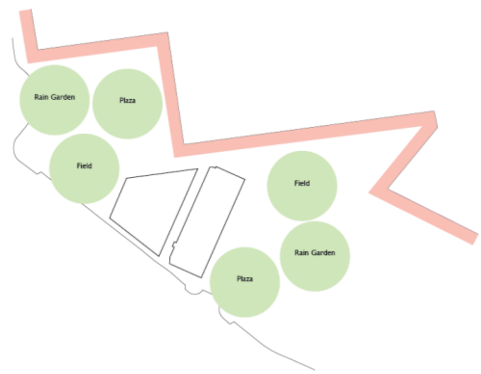
After deciding on the sites programming, each topic was categorized based on spatial requirements. The red circle, indicating the waterfront promenade, is a city defined program that must be met through the design proposal. The green circles, atheltic fields, plazas, and raingardens, have recommended spatial requirements but are variable based on site constrains and contextual needs of the design. Parametric scripting will be utilized to make sure they are sized appropriately based on the local demographics and site constraints. The yellow circles include fishing piers, water interaction, places to read and many other activities. These programs do not have defined spatial requirements and can adjust to fit into the leftover space of the design.



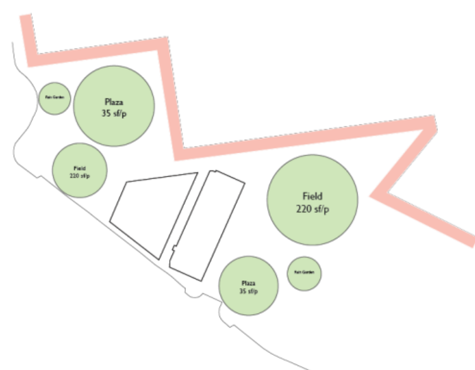
All of the programming must fit within the Webster Street Open Space boundaries. This site is waterfront property and will complete Baltimores waterfront promenade, ending at the Baltimore Museum of Industry.



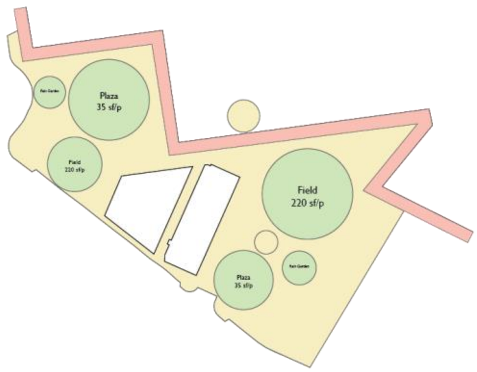
The waterfront promenade, a 30' brick walkway, is a city defined program and must be incorporated into the site design. It was the first programming to be envisioned on site, allowing the remaining program to be designed and work properly with it.



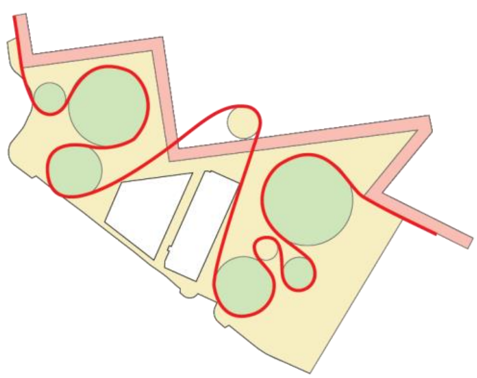
The next step was to place the spatially defined programming. The fields raingardens, and plazas were placed based on a series of bubble diagrams to create ideal adjacencies with each other and the surrounding context.



These programmed areas all have recommended spatial requirements. Using parametric tools, these spaces were properly sized based on the local demographics and site context. The parametric tools also made sure to keep the ideal adjacencies as the spaces were manipulated. These spaces also form the base of the designs industrial concept, representing a series of gears

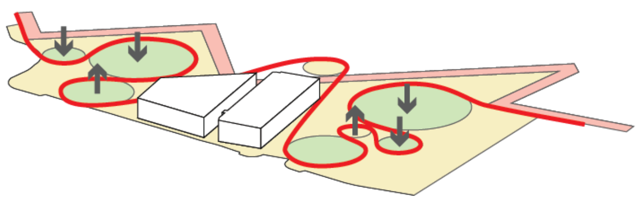


Once the city and spatially defined programming was decided upon, the remaining programming fills in the leftover space. Certain areas such as the fishing pier and a small hill could be identified within this space, creating more gears.

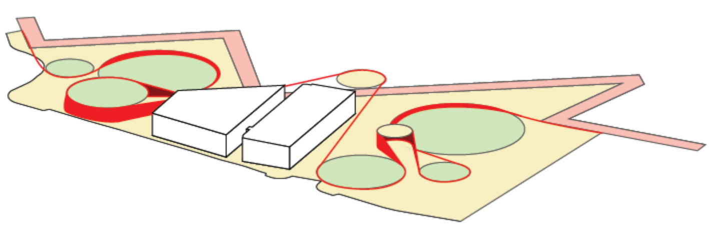


After all of the defined programming was in place a belt was incorporated, linking the gears and creating a series of distinctive spaces between gears.

These spaces would become the remaining program such as private sitting and reading areas. The belt ties into the existing promenade, encouraging people to explore beyond the site boundaries. It also creates a unifying element between the two distinct sides of the site, allowing a holistic design proposal. This wall was also parametrically developed, creating a unique site element and linking the various spaces as they were manipulated.



By pushing and pulling the gears, topography is created across the existingly flat site.The topography adds to the variety of spaces created and creates a uniquewaterfront experience not available elsewhere in Baltimore.



Through this design process a unqiue waterfront experience was created along Baltimores Inner Harbor. The design highlights the industrial history of Key Highway while incorporating a variety of activities and spaces that enhance the health of the Inner Harbor and the nearby residents.

Parametric Development

The parametric development of this design was a vital step, and shows how landscape architects can begin to use the tools to optimize their designs. For the Webster Street Open Space, parametric tools were used to optimize program sizing based on a person's spatial requirements. The parametric scripting created was able to match the concept sketch decided on, but includes adjustable variables to manipulate program sizing and location. The software also allowed for a constant visual analysis and linking of the spaces.

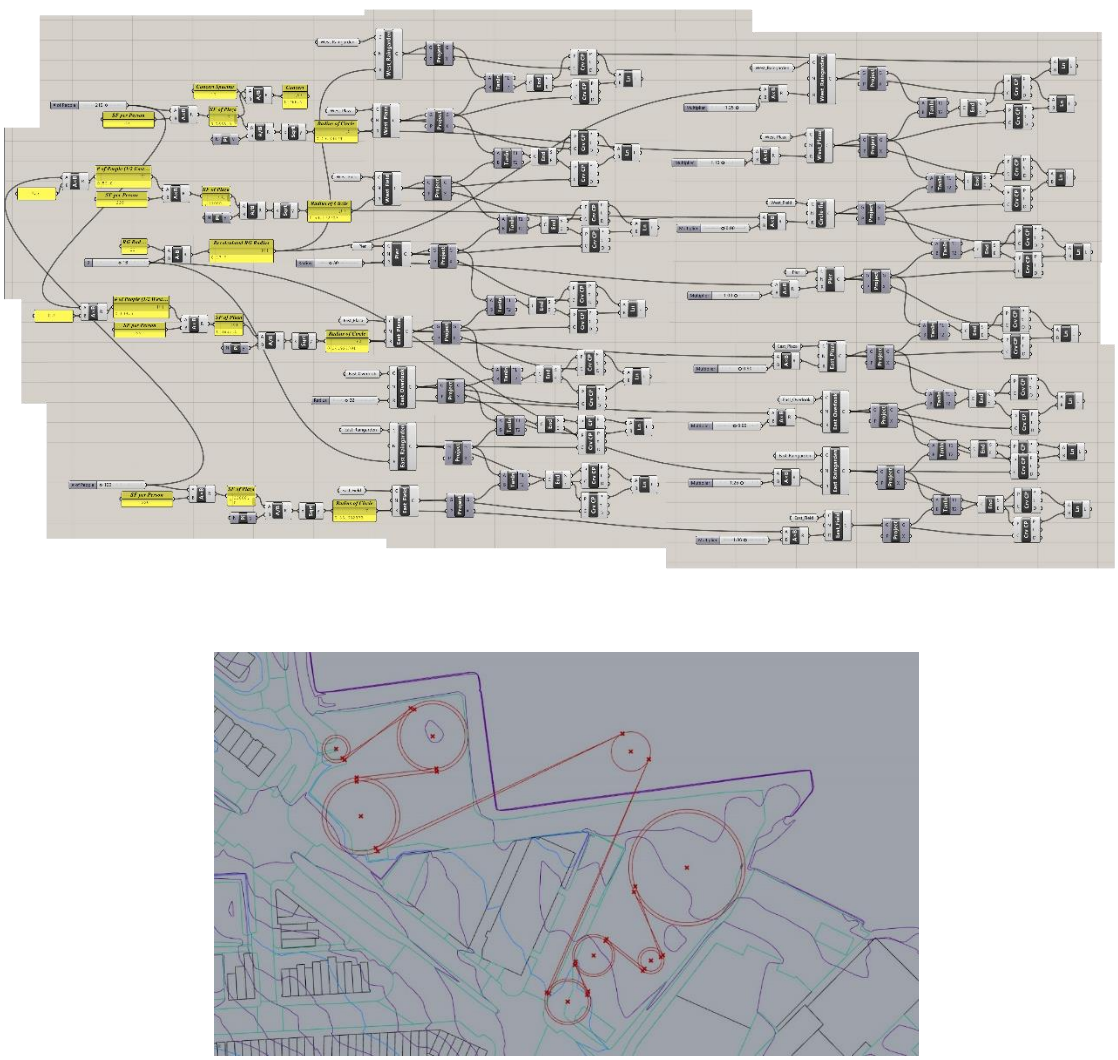


Figure 43: The parametric scripting and the model formed (Images by Paul Jester)

Each circle or gear is connected to a point in model space, and will move as the point moves. The various programming was positioned based on a series of bubble diagrams. Once positioning and adjacencies were decided on a sizing parameter was included to explore the amount of people that can fit on the site based on the local demographics and site constraints.   Example of how parametric tools were used to visualize program sizing is for the design of the plazas and multi-purpose fields.

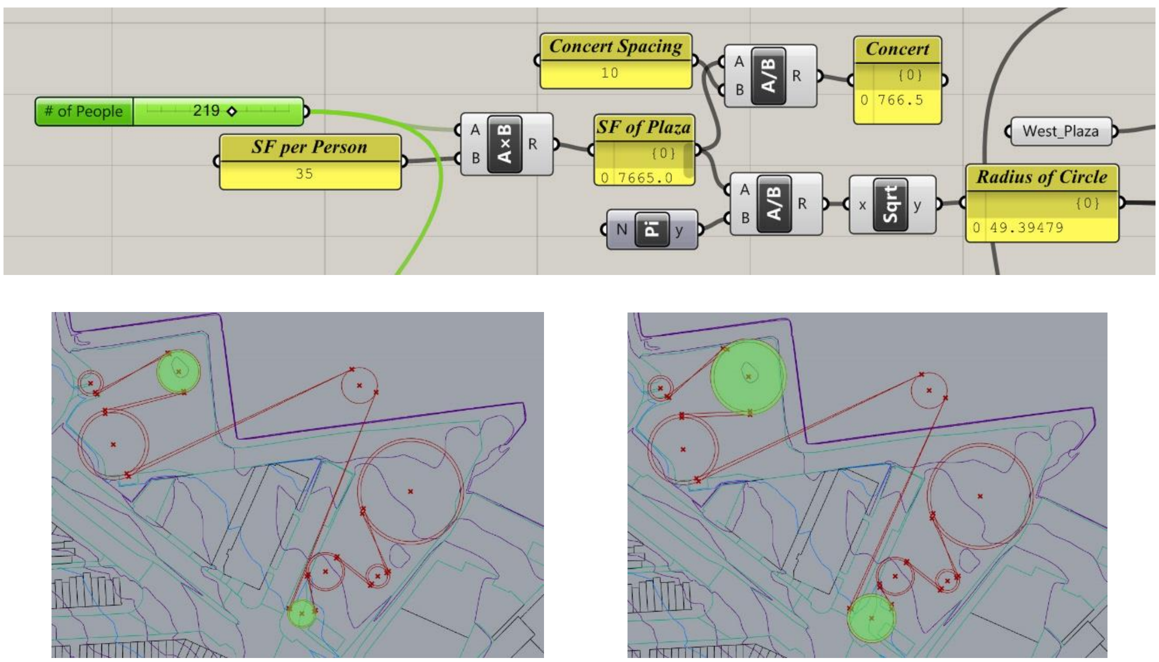


Figure 44: Highlight of the plaza scripting, showing the visual range of 100-300 people on-site (Images by Paul Jester)

According to landscape architecture standards, a person needs approximately 35 square feet to comfortably move throughout a plaza. These calculations can be programmed into the software. And as the number of people for the plaza adjusts the model provides instant visual feedback allowing for quick analysis. This process permits optimal decisions to be made based on the data provided from the local demographics and amenities that currently surround the site. A side script, using a spatial need of 10 square feet per person, was also developed to show how many people could fit onto the plaza during a concert. In the above example, the plaza which can will comfortably hold 219 people during average use, has a maximum occupancy of 766 people during a concert.

The same spatial programming was done to calculate the size of the fields, except the square footage per person changes to 220. The software allows the designer to visualize a larger range of numbers than one might perform on their own. A similar process was taken for the on-site rain gardens.

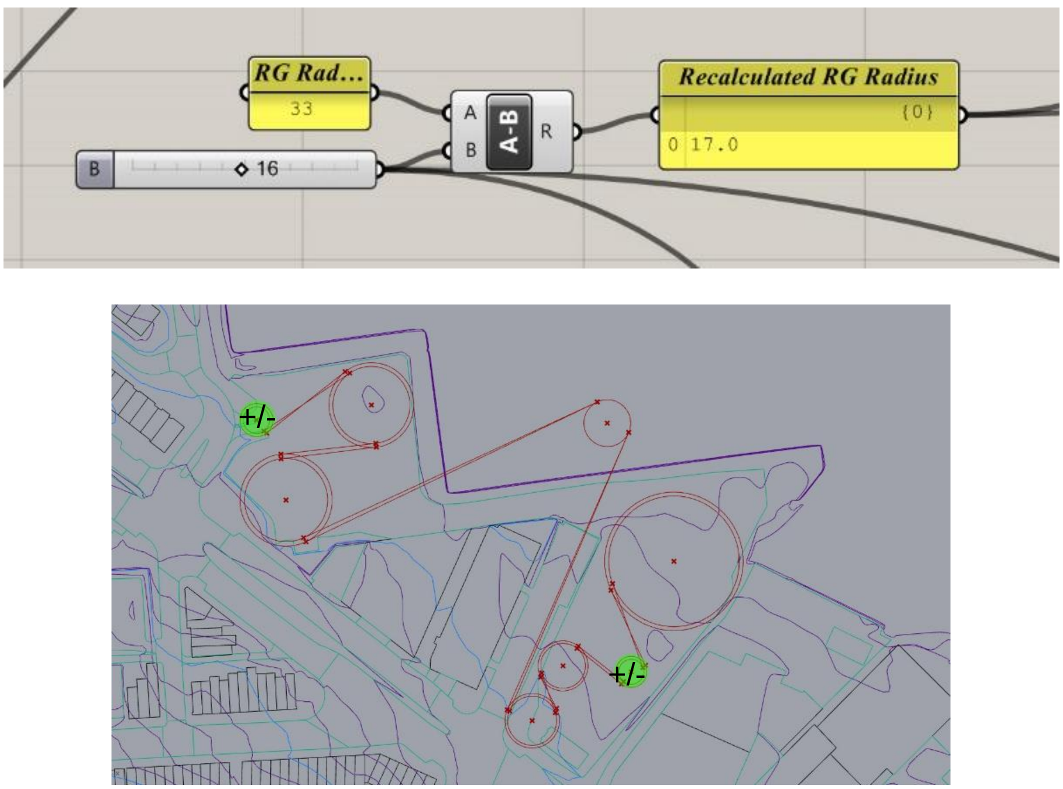


Figure 45: Scripting of rain gardens and spatial relationship (Images by Paul Jester)

The design proposal calls for a series of rain gardens to help with storm water mitigation. The rain garden mitigation sizing was calculated based on runoff from the site. By having a total number, the software allows designers to manipulate multiple rain gardens while maintaining the proper area for mitigation. Beyond sizing of spaces the software allows the designer to generate forms in three dimensions.

'Belt' Construction

The uniting element of the Webster Street Open Space is the belt which connects the gears. Coming from the design concept of the serpentine belt, the connecting element is a highly customized wall that weaves throughout the site, connecting and defining the various spaces. The wall construction would consist of a cantilevered concrete retaining wall with railroad ties mounted horizontally across it. The mounted rails will highlight the industrial history as well as serve as a visual element to pull people through the site. The software allows for 3D visualization of the wall throughout the site, allowing the designer to understand height and spatial implications of various areas. For the Webster Street Open Space, the design takes the human dimension into account when forming the wall. The wall will adjust height to create topography as well as site amenities such as seating or visual screening.

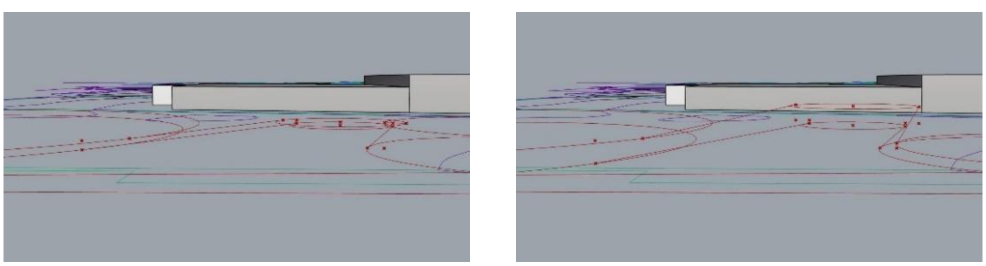


Figure 46: Wireframe perspectives showing visual output as wall changes height (Graphics by Paul Jester)

By constructing the wall digitally, the software can also aid in the fabrication and physical construction of the wall. By having an understanding of the construction techniques, the designer is able to script and visualize the entire wall system. Once the wall is built digitally, the software can break it down into developable pieces that could be actually built. Without the aid of the computer, the curvature and variances of the wall would be impossible to calculate. By using parametric tools, visualization and experimentation of the wall was possible to decide on the ideal solution for the Webster Street Open Space.

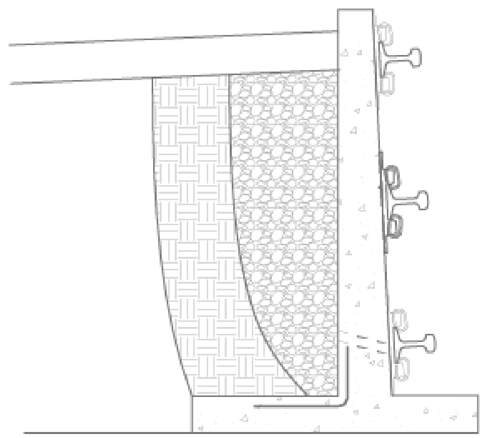


Figure 47: Typical construction detail of wall; concrete cantilevered wall with steel rails mounted horizontally (Image by Paul Jester)

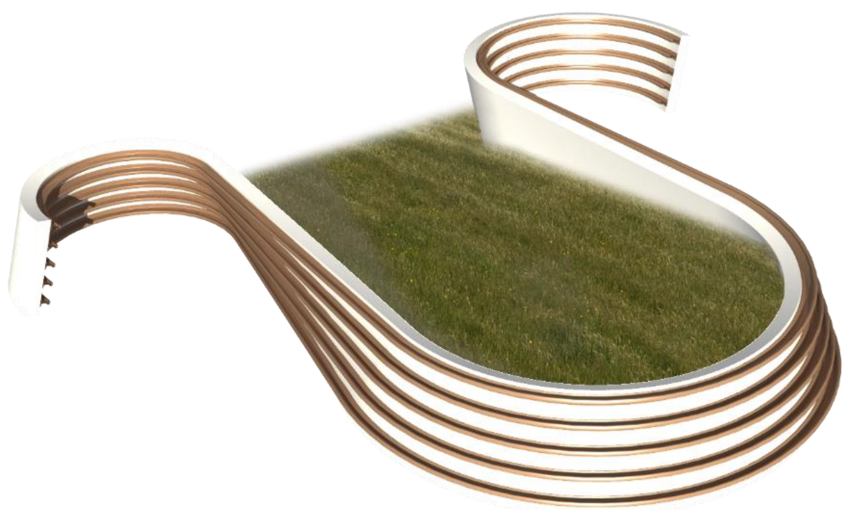


Figure 48: 3D rendering of wall appearance (Image by Paul Jester)

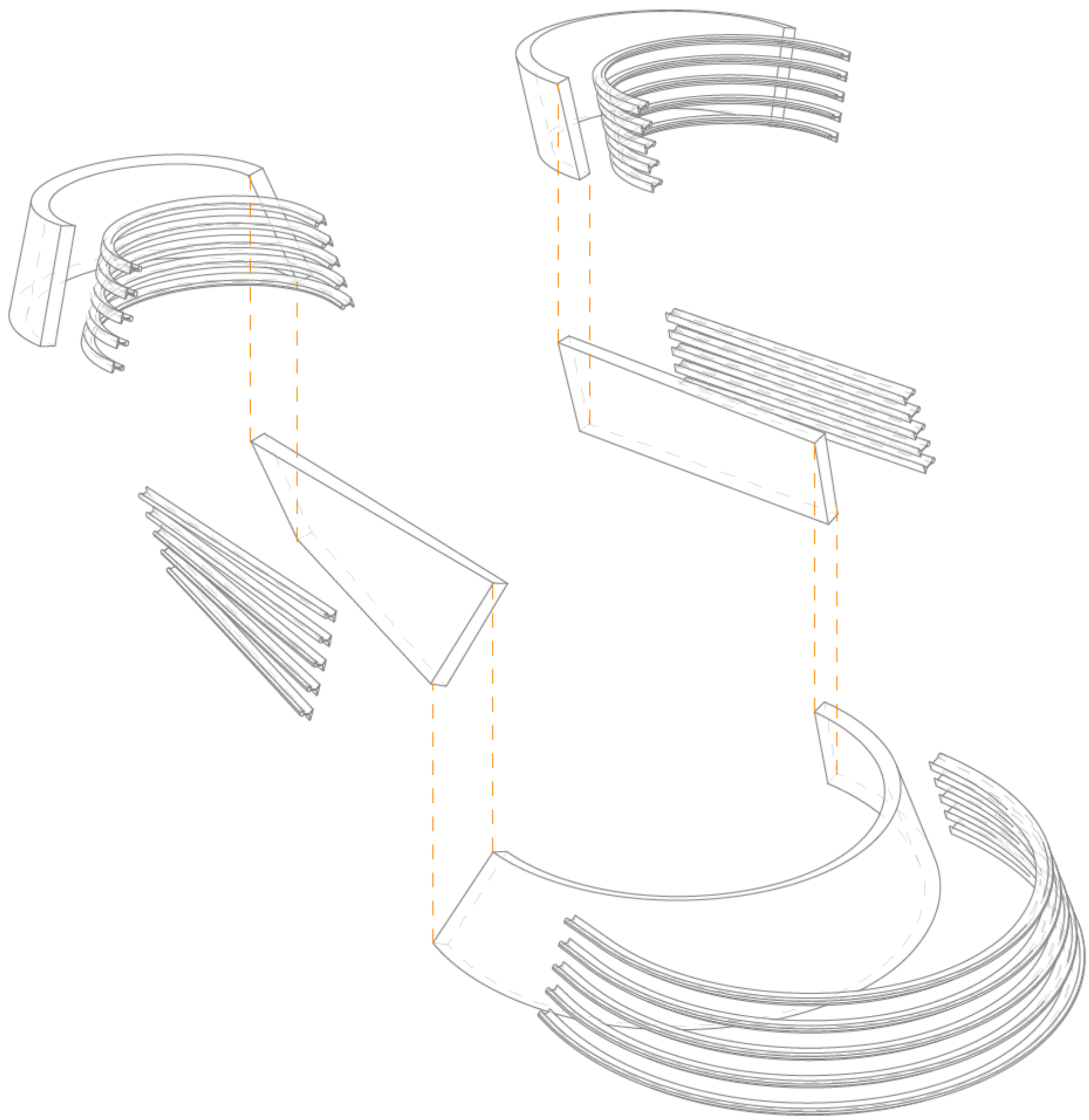


Figure 49: Using the computer, a developable model can be designed to physically construct the wall (Image by Paul Jester)

Master Plan

By using the parametric tools in the design process, a plan for the Webster Street Open Space was fully developed. The site proposal highlights the industrial history of Key Highway while incorporating a variety of activities and spaces that enhance the health of the Inner Harbor and the nearby residents.

Figure 50: Proposed master plan of redeveloped Webster Street Open Space
(Image by Paul Jester)

The plan includes a variety of spaces that allow for a full range of activities to enhance the health of the harbor and local residents. The site design includes social and private activities such as soccer or reading. The range of activities creates an environment that allows for mental and physical restoration of the local residents. The design also incorporates sustainable features that aid in promoting a healthy harbor. By incorporating vegetation and permeable paving, a 53% reduction in impervious surface was achieved. This surpasses the Maryland state goal and also allows for a 44% reduction in storm water runoff. The following perspectives highlight a few key areas of the Webster Street Open Space design proposal.

Figure 51: View of West Rain Garden (Image by Paul Jester)

Entering the site from the west, a visitor may choose to follow the waterfront promenade or enjoy the rain garden, slightly offset from the promenade. The rain garden is formed by the industrial belt and is an ideal location for mental restoration. The rain gardens were sized utilizing parametric software, with the leftover space creating a private sitting area. In the rain garden, one may sit peacefully by themselves reading or looking out over the water. A small group could also potentially meet in this location, but the small size and minimal seating discourages large groups from disturbing the space.

Figure 52: View of Picnic Terraces (Image by Paul Jester)

Continuing along the promenade, a visitor to the site will come across the picnic terraces. Using the wall, the picnic terraces were created to provide a place of active recreation and rest. At the top of the slope, a large multi-purpose field can be used for many activities including soccer and ultimate Frisbee. The field was sized using parametric tools, allowing 220 square feet per person. Based on local demographics and other local amenities, the field was sized for an estimated 90 people. This would allow small and large groups to share the field. Since the field is elevated, the leftover space becomes a series of terraces that are planted with large shade trees to allow a place of rest from their games or a comfortable family picnic. Next to the terraces, a wooden stairway creates a pass through to Key Highway, allowing entry from and exit to the street and Riverdale neighborhood. These stairs also lead to an elevated seating area along the renovated commercial structures alongside the site.

Figure 53: Section from Key Highway to Promenade (Image by Paul Jester)

Figure 54: View from East Field, looking towards Inner Harbor during fireworks display (Image by Paul Jester)

The design proposal aims to not only create daytime activities, but also provide a safe place at night. One evening activity that visitors would be able to enjoy on-site is the various fireworks shows put on by Baltimore City throughout the year. The East Field would create an ideal viewing area to look across the harbor and enjoy the display. During the day the field could be utilized for athletic events or neighborhood farmers markets.

Figure 55: Section through East Field and Tidal Gardens (Image by Paul Jester)

One unique attraction of the Webster Street design proposal is a place where visitors can interact with the water. A tidal garden is created on the east side. The tidal garden will serve as a visual cue of the current tidal state of the harbor water. At low tide, an extra platform will be usable to visitors that would be underwater at high tide. The extra platform allows a safe place for people to interact with the water while also becoming an educational piece about tidal change.

Figure 56: Entry view from Webster Street (Image by Paul Jester)

The entrance from Webster Street, is a primary place for people to meet and explore the site. A public place, a large amount of seating, designed from railroad ties, is provided to accommodate crowds. The wall encourages people to explore the site due to its curved shape and guiding rails along it. The wall can lead people to more public or more private spaces as they require.

The Webster Street Open Space design proposal creates a variety of year- round spaces for mental and physical restoration while highlighting the industrial history of Key Highway. The concept development and on-site form generation was designed by using parametric thinking and tools. The digital explorations and visual analysis allowed for a level of design optimization that otherwise could not have been achieved.

7.0 Parametrics and Landscape Architecture

Landscape architecture has only begun to embrace how parametric tools can aid in the design process. Firms have begun to use the software to explore form, concept development, and spatial adjacencies. These explorations have been a great introduction for the field, but landscape architecture includes many more elements that could become parameters for a design proposal. Within a single design, landscape architects have to consider many elements including landform, circulation (pedestrians, vehicles, and bikes), planting selections, outdoor accessibility, hydrology, irrigation, and much more.

The one element that truly separates landscape architects from other design professions is the use of vegetation. Using plant material to architecturally design a space to enhance aesthetics and function, landscape architects must have a broad knowledge of different types and functions of plants. By understanding plant parameters, a designer can make the best decisions for the space they are creating.

7.1 Plant Parameters

Plant material has been researched for many years, creating a large database that practicing landscape architects can refer to when choosing plants. Plant selection requires the consideration of many factors to achieve the proper aesthetic and functional properties of a space. Some of the factors include plant size, color, and bloom time, how many leaves are dropped throughout the year, necessary soil, conditions, how much sun or shade is needed, and many more.

All of these considerations have been studied and catalogued into various books and online databases

Parametric tools give us the ability to incorporate this plant database into the design process based on existing or proposed site conditions. By programming the parameters of vegetation into the software, plant selection and visualization may be accomplished. The first step in parameterizing plants is to create a master plant list including the various parameters that the designer wants to use as deciding factors.

Botanical Name	Common Name	Height	Width	Spacing	Bloom	Sun/Shade
Shade Trees						
Acer rubrum 'Red Sunset'	Red Sunset' Red Maple	40'-50'	30'-40'	18'	March, Red	Full Sun-Part Shade
Gleditsia triacanthos 'Shademaster'	Shademaster' Honey Locust	60'-80'	60'-80'	35'	May, Yellow	Full Sun
Ornamental Trees						
Magnolia stellata	Star Magnolia	15'-20'	10'-15'	13'	March, White	Full Sun-Part Shade
Shrubs						
Viburnum dentatum	Arrowwood Viburnum	6'-10'	6'-10'	8'	June, White	Full Sun-Part Shade
Perennials						
Astilbe x arendsii 'Amethyst'	Astilbe	18"-36"	18"-24"	20"	June, Purple	Part Shade-Full Shade
Hosta 'Blue Angel'	Hosta	24"-36"	36"-48"	36"	August, Lavender	Part Shade-Full Shade
Rudbeckia fulgida goldsturm	Black Eye Susan	24"-36"	24"-30"	24"	June-October, Yellow	Full Sun

Figure 57: A sample plant schedule for urban design, including aspects to consider in plant selection

The above chart shows a sample list of plants that could be successfully planted in the Webster Street Open Space, highlighting important design aspects of each plant. After creating a master plant list, designers must turn this data into quantities. Computers, and therefore parametric tools, cannot understand words, but work with a series of numbers and values that are algorithmic. A main consideration when quantifying the plant data is that the importance of the design factor, in this case the plant design and relationships, is not lost. When quantifying data so a computer can interpret the information, the designer must make sure to not distort the data.[81] Not all data or design aspects can be easily quantified, which may lead to misinterpreting the data and poor proposals. Fortunately, plants have in-depth data and careful consideration of the quantifications and proper scripting will be able to produce usable results for designers.

Sun/Shade Scale				
1 Full Shade	2 Part Shade	3 Equal Sun/Shade	4 Part Sun	5 Full Sun

Bloom Month											
1 Jan.	2 Feb.	3 Mar.	4 April	5 May	6 June	7 July	8 Aug.	9 Sept.	10 Oct.	11 Nov.	12 Dec.

Bloom Color			
1 Red	2 Yellow	3 White	4 Purple

Figure 58: Charts showing how to quantify qualitative data

Some design factors are simpler to quantify than others. Parameters such as plant size and spacing are easier to quantify because they are already a numerical quantity. Other factors such as water intake or leaf drop are harder to quantify. The above charts show how qualitative data such as bloom color, bloom

[81] Alexander, 6

month, and the amount of sun a plant needs can become quantitative data that the computer can properly interpret. A designer would have to create a numerical range, such as a 1-10 scale, to quantify these aspects. A selected tree which intakes a small quantity of water would be a ‘1’ while a tree that uptakes a large quantity would be rated a ‘10’. Another example where a range of numbers would be used to determine relationships would be the amount of sun or shade that a plant needs. This could be quantified with scale ranging from 1-5. A plant that needs full sun could be ranked as a ‘5’, while a plant that survives with equal sun and shade could be ranked as a ‘3’. By giving a quantity to these factors, the computer understands the plant property and can begin to make relationships between the selected plants. When this is done for all plant parameters that are being considered, the computer can properly compute them to correctly visualize and aid in the selection of plant material. When first experimenting with parametric design, a landscape architect may only be able to parameterize a few plants. As a designer continues to explore and quantify various plant information, a large database will be created that can be investigated with the parametric tools.

Botanical Name	Common Name	Height	Width	Spacing	Bloom	Sun/Shade
Shade Trees						
Acer rubrum 'Red Sunset'	Red Sunset' Red Maple	40'-50'	30'-40'	18'	3.1	4
Gleditsia triacanthos 'Shademaster'	Shademaster' Honey Locust	60'-80'	60'-80'	35'	3.2	5
Ornamental Trees						
Magnolia stellata	Star Magnolia	15'-20'	10'-15'	13'	3.3	4
Shrubs						
Viburnum dentatum	Arrowwood Viburnum	6'-10'	6'-10'	8'	6.3	3
Perennials						
Astilbe x arendsii 'Amethyst'	Astilbe	1.5'-2'	1.5'-2'	1.75'	6.4	2
Hosta 'Blue Angel'	Hosta	2'-3'	3'-4'	3'	8.4	2
Rudbeckia fulgida goldsturm	Black Eye Susan	2'-3'	2'-2.5'	2'	8.2	5

Figure 59: Updated plant schedule to show all quantified data

The above chart shows how a full plant list can be quantified, allowing the computer to understand the data. For each plant, the height, width, and spacing can remain as a numerical value. But with these categories it is important to make sure that they all have the same units. In this example, all of the units were converted to be in feet. The other categories of plant bloom and color & the amount of sun a plant needs have been quantified into unitless values. These numbers relate to specific visual aspects and must be properly scripted to produce proper suggestions.

Once the data has been quantified into values for the computer to interpret, the data can be linked to parametric software such as Grasshopper. After the data is linked to the tools, further programming can be created for the tool to aid in plant selection and design that consider other design factors. This extra scripting can range from proper interpretation of the provided data or combining it with other data such as soils, sun patterns, or GIS. With the combination of the data, parametric tools and software will be able to not only represent plant material but also aid in plant selection. By linking the parametric script to modeling software, such as Rhino3D, a full understanding of the plant and space created can be visualized.

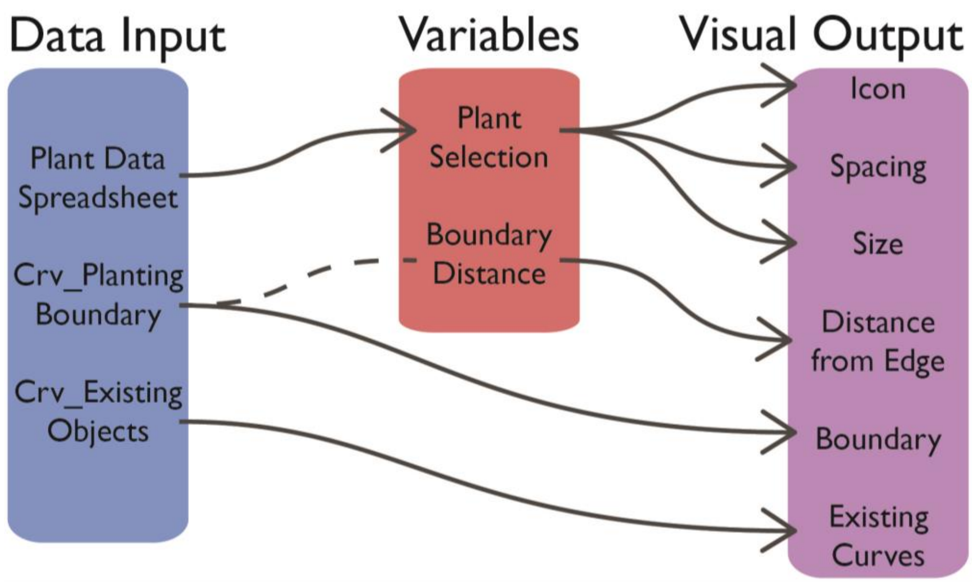


Figure 60: Diagram showing proposed scripting for plant parameters (Graphic by Paul Jester)

The above graphic shows a proposed way to script plant parameters into the parametric software. Parametric tools work with three overall variables; the input data, the adjustable variables, and the visual output. The input data for scripting plant parameters includes the plant data, the boundary of planting, and any existing objects that are within the boundary. The boundary and existing objects should already be identified, and the user can program the software to not place plants within a certain distance, which can be adjusted as needed, of these objects. The plant data will be interpreted from a provided spreadsheet including the necessary data. By choosing a specific plant from the list, the visual output (icons, spacing, and size) will be generated into the model space.

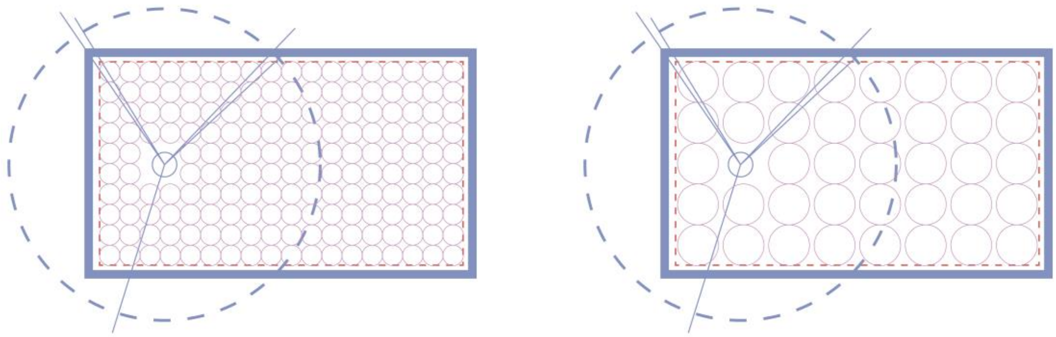


Figure 61: Possible visual output of plant scripting based on various plant selections (Graphic by Paul Jester)

Seen above are two visual outputs based on the proposed parametric scripting. Both of these utilize the same planting boundary, existing objects, and distance from the boundary but the plant selection changes. The left output shows a plant selection that is 1' sizing and 1' spacing. The right output displays a plant selection that is 2' sizing and spacing. By defining the planting boundary, the designer can quickly explore a number of plant selections and visually see how many plants will be needed to fill the space. Multiple planting boundaries could be defined within a large boundary allowing the designer to select and explore the relationship between plants.

7.2 Plant Visualization

Once the planting script has been linked to modeling software, the landscape architect can fully begin to understand the 3 dimensional impact of the plant selection and make decisions to fulfill the design goals. Creating perspectives to comprehend the proposed planting plan allows designers to make the correct decisions for the site and can also be a great selling point of the design. One drawback that designers encounter is properly representing the vegetation, whether it be plant size and spacing or proper color and fullness based on the season. This happens because plants have different bloom times or fall colors, and it is unrealistic to display all of the best qualities of the selected vegetation in one image Combining the parametric abilities for planting design with rendering capabilities of the computer, a proper representation based on seasonal and vegetation factors can easily be created.

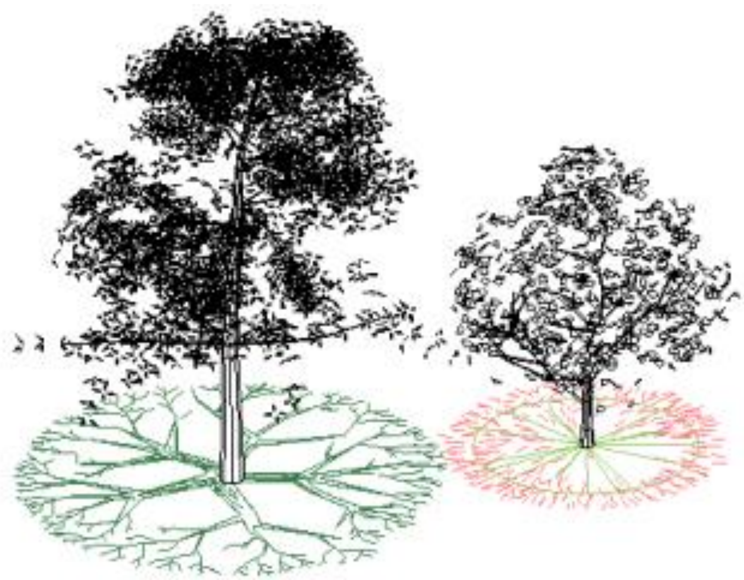


Figure 62: Image showing the association between a 2D icon and 3D representation (Image provided by www.landsdesign.com)

Once a planting plan has been decided on from the parametric scripting, a rendering software, such as Flamingo or LandsDesign, can utilize 2 dimensional plant icons for 3 dimensional visualization. In this way, the rendering software is another parametric tool that landscape architects can explore. By utilizing rendering plug-ins, plant data will be automatically associated with a specific planting icons and can be rendered to represent different species of vegetation and then manipulated to properly represent the time of year for realistic visual perspectives.

Figure 63: Rendering programs have the ability to visualize plants throughout the seasons (Image provided by www.landsdesign.com)

Proper visualization of plant material is a great tool for landscape architects so they know how the space will look throughout the year. By being able render the plantings throughout the seasons, they will be able to optimize their plant selection to achieve the proper aesthetic look throughout the year. For example, in the fall a section of shrubs may drop more leaves than the designer expected, creating an empty spot within the planting design. By being able to visualize the vegetation, they would be aware of this concern before installation of the design allowing them to either change the plant selection or add in additional complimentary vegetation. Combining designers' intuition and parametric tools for plant selection and visualization is an innovative step towards integrating landscape architecture and computational design.

7.3 Benefits to Landscape Architecture

Using parametric modeling to aid in plant design and visualization has many benefits for landscape architects. The ability to explore plant design and selection within a given set of parameters would greatly aid designers. The software can aid the designer is creating plant counts and proper planting design based on the defined parameters. The software also provides a tool that would rapidly create a large collection of plants, including visual representation. The parametric tools not only allow this visualization of one plant, but of any defined plant, allowing the designer to explore a much greater number and variety of plants. Once the proper scripting and coding has been laid out, the software may even suggest plants that had not yet been considered.

As is common with new tools, there are limitations of the software. The main concern with the introduction of parametric tools is the amount of time needed to learn and properly script the data. Much of the data is available, but quantifying it into values the computer can understand can be very time consuming. And even more time consuming can be the proper scripting to understand the values. Creating the scripting for the proper plant relationships to be interpreted by a parametric tool is extremely challenging. The challenge is thinking like a computer.[82] It can be difficult for a human to decide on which the best form of data is and how the relationships are formed in the computer software. As the parametric tools and thinking are taught more during the education of landscape architects, the programming and tools will become easier

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[82] Jones, 117

to use and more beneficial to the field. Right now the initial time requirement is considerable, but as the tools continue to develop the benefits offered to landscape architects will become invaluable.

Parametric modeling for planting design and visualization is a new idea and can only aid the designer's knowledge and intuition. The scripting is not perfect, but parametric plant data begins to show that many physical aspects and design theories can be parameterized to aid landscape architects in the full range of factors they must consider while designing.

8.0 Conclusions

Parametric tools and methods offer landscape architects new ways to synthesize data to aid in their design process and decisions. There are a broad range of parametric tools ranging from simple to complex which aid designers.

The most promising benefit of parametric tools and landscape architecture is the ability to combine the landscape architect's intuition with researched data. By being able to merge these, new forms and ideas can be generated that may not have been thought of or considered before. Unfortunately, very few landscape architecture firms have been able to explore parametric tools due to the learning time associated with the software. Firms must be profitable and cannot achieve this by using their time to learn all of the newest tools available.

To fully utilize the tools, parametric thinking and software must be taught in school. The software is not easy to learn and thinking parametrically is quite different from a traditional landscape architecture education. As the thought process and tools are taught more during education, the ability to use parametric tools will become more common. Very few landscape architecture schools are currently exploring the possibilities of parametric design, leading to it being a foreign idea in the educational and professional world of landscape architects.

Parametric tools also need more design data to truly aid landscape architects. Many aspects of design such as zoning, spatial requirements, and plant research already have a large sets of data that can be quantified and interpreted by the computer. These areas where values are well defined are a good starting point, but more information on how to quantify social or cultural factors with a design are needed. As more data is programmed and landscape architects become more familiar with parametric tools, the possibilities of design will only be limited by the imagination.

The advancement and power of computers have given landscape architects a new tool which should be embraced and utilized in design. Parametric modeling will never replace a designer's intuition and experience, but the software will become a tool, much like a drafting triangle or scale, that can aid landscape architects in design decisions regarding many topics including form, planting design, environmental design, and visualization of their landscape.

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