ABSTRACT

Title of Thesis:	ENHANCING QUALITY OF LIFE ON URBAN RESIDENTIAL STREETS BY CREATING PLACES FOR PEOPLE AND TREES
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Lower income urban rowhouse neighborhoods are often treeless with only narrow sidewalks separating the front door from the street. This thesis explores the opportunity to capitalize on the predicted shift from private automobile ownership to fleets of autonomous vehicles and the subsequent significant drop in parking demand. Space previously designated as parking lanes can be converted into continuous tree planting strips and social spaces along inner-city

residential streets. In this thesis, I propose three streetscape models utilizing the space no longer needed for parking: 1) the James Street Private Model that designs a 10' wide continuous tree planting strip, allowing trees, gardens and patios to be installed along the foot of the rowhouse steps; 2) the James Street Public Model that creates the same tree strip design but positions it between the sidewalk and the street; and 3) the Shared Street Model, set along a narrower alley street, that forms a meandering road shared with pedestrians, public spaces and trees. These streetscape improvements directly address the quality of life of the residents by enhancing their safety and security, physical surroundings, social relations and health.

ENHANCING QUALITY OF LIFE ON URBAN RESIDENTIAL STREETS BY CREATING PLACES FOR PEOPLE AND TREES

by

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Figure 1.1 Rowhomes

Chapter 1: Introduction

The evolution of this master's thesis began as I walked along the city streets lined by small two-story rowhomes on very narrow sidewalks and saw bustling people, babies pushed in strollers and kids riding scooters in the street. I thought about what it would be like to live on such a street. What would be my criteria to choose to live there?

First, I would need trees. Increasing the urban canopy is the goal of urban foresters worldwide. While undertaking the literature review for this paper, I learned that urban canopy is unevenly distributed, with more trees found in urban areas with higher incomes and more plantable space. Many major cities have undertaken major tree inventory and tree planting initiatives over the last twenty years (Lu et al. 2011) (Young 2011) and studies of tree survival have led to best planting practices. The problem remains, however, that in the very concrete dense urban environment, small tree openings in the sidewalk are the only option for planting street trees. Yes, some extraordinary trees grow to maturity in this setting, but a stunted, shorter life span is more common. (Roman and Scatena 2011) This dilemma is not new to our times. In 1870 Frederick Law Olmsted wrote,

Figure 1.2 Big tree in a small space

> "Thousands and tens of thousands [of trees] are planted every year in a manner and under conditions as nearly certain as possible either to kill them outright, or to so lessen their vitality as to prevent their natural and beautiful development, and to cause premature decrepitude…..The strips of ground reserved for the trees, six, twelve, twenty feet wide, would cost nothing for the paving or flagging." (Olmsted and Beveridge 2015, 475)

Next, my ideal street would need to have some space between the steps and the street. A space to stop, take a breath, say hello to a neighbor, rest your bags, put out a lawn chair, or even a little table would be valuable. In *Cities for People,* Gehl (2010) proposed that "soft edges" in urban life are very important. An edge is defined as the place where the city meets the building. The edge is where life in the buildings interacts with the life in the city. It is a zone where inside activity can move to a common space. This edge is the primary place for sitting and standing in the city.

Finally, my ideal street would need to feel like there is some social connection among the neighbors. This component of the street cannot be prescribed or guaranteed, but it is more likely to exist if the neighborhood has a shared history, common traditions, active community organizations and central social centers like a school or a playground. (Brower 2011, 273) Some shared endeavors and experiences could help create social bonds.

The "transportation revolution" provides the opportunity

As this thesis continued to evolve it was clear that this ideal street was not possible in the existing sections of the city where the roadways and parking lanes dominate the streetscape. The space needed for trees and "soft edges" does not currently exist. But a major opportunity for change is on our doorstep. Many scholars and experts in urban planning are predicting a "revolution in urban transportation" within the next thirty years. (Spinoulas and Davidson 2016) This change from individual ownership of automobiles to shared fleets of autonomous vehicles is predicted to reduce parking demand in the city by up to 90%. (Zhang and Guhathakurta 2017)

City streets have miles and miles of parking lanes. Los Angeles has 14% of its incorporated land designated as parking. New York City has between 3.4 - 4.4 million on-street parking spots. (Weinberger 2012) Over sixty companies are working to perfect the technology for driverless cars. Abundant research and complex modeling indicate that this new mode of transportation will provide greater safety, efficiency, lower cost, reduced carbon emissions, and be powered by renewable energy. (Levin and Boyles 2015) (Krueger, Rashidi, and Rose 2016) (Fagnant and Kockelman 2015) These academic studies examining this urban transportation revolution of autonomous vehicles (AVs) predict that the public will elect to trade individually owned cars for communicating, autonomous, shared and electric vehicles over the next 30-40 years. Many industries will be affected by this revolution. An example is the elimination of motor vehicle accidents that will make acquisition of organs for transplantation more difficult. (Clements and Kockelman 2017) When the individual ownership of cars is replaced by shared AVs, some models predict parking demand could be reduced by up to 90%. (Zhang et al. 2015)

Urban planners are considering the rules and incentives that must be in place to prevent AVs from driving without passengers (Zero Occupancy Vehicles) and to encourage citizens to continue to use public transit. Without planning, street congestion could be significantly increased as AVs populate our city streets.

If parking demand is meaningfully reduced, I believe that large parking garages and surface parking will be developed into parks, mixed use and residential buildings. The parking lanes along commercial and principal arterial roads and boulevards will be very valuable when converted into public transit lanes, bicycle right-of-way, and commercial sidewalk space. (Sipe 2017) It is in the residential setting that I propose the question:

> Can an urban resident’s quality of life be enhanced by redesigning residential streets to narrow vehicular traffic lanes and transform parking lanes into spaces for trees and places for people to linger and socialize?

Making cities more livable is the motivation

The Population Division of the United Nations Department of Economic and Social Affairs reports that North America is one of the most urbanized areas in the world, with 82% of the population living in urban areas. Their predictions suggest that urban population will increase to 68% around the world by 2050. ("UN DESA | United Nations Department of Economic and Social Affairs" 2018) If cities are to be home to so many people, then it is imperative that urban planners and designers endeavor to create an environment focused on quality of life.

Guiding the design by recognizing factors that can enhance quality of life

This paper will emphasize three aspects of residential street redesign: making adequate room to plant trees; creating social spaces and "soft edges" for the residents; and providing amenities to encourage using the outdoor spaces. It is my assumption that each of these design interventions will add to the quality of life of the residents on the street.

Design to increase tree canopy

Mature urban trees have measurable and significant benefits for city-dwellers as well as providing a habitat to support biodiversity. Cities often have an inequitable distribution of urban forest, limiting the cooling, water retaining, pollutant absorbing, and carbon sparing and sequestering benefits of the canopy as well as the aesthetic appeal in lower-income neighborhoods. Public investment is necessary to increase canopy cover in the less affluent areas of the city.

Design to create social spaces around residences that offer a transition zone between private and public space

By repurposing of parking lanes, these streetscape designs can add the buffer space that is missing in dense, older neighborhoods. The residents whose front doors open directly onto the sidewalk with a very small stoop and a few stairs could benefit from the reassignment of the parking lanes into places for people to linger and socialize. The spaces between buildings has been the subject of much observational research and has shown that people will visit and linger if the opportunity is offered. (Gehl 2010), (Brower 1973)

Design to provide amenities that encourage social interactions

Amenities to be included in the proposed street redesign include:

1. Trees underplanted with native groundcovers
2. Garden spaces for shrubs, perennials and wildflowers
3. Patio spaces for chairs, tables and potted plants
4. Places for picnic tables, grills and benches
5. Basketball hoops
6. Waterplay stations

Quality of life is determined in large part by our surroundings. This thesis proposes that a redesign of a residential streetscape that adds trees, greenspaces and places to socialize will enhance the quality of life of the residents on that street.

The thesis is organized as follows:

Chapter 1: Introduction

Chapter 2: Literature review in four sections

Chapter 3: Goals

Chapter 4: Streetscape design

Chapter 5: Three design models for Pigtown

Chapter 6: Maintenance plan

Chapter 7: Metrics, discussion and lessons learned

Chapter 2: Literature review

This literature review is divided into four sections. The first is an assessment of the state of research and speculations about autonomous vehicles and the opportunity to redesign city streets in the future of decreased parking demand. The second section examines the literature for an understanding of the primary goal of this project: the concept of designing for ‘Quality of Life”. The third section reviews the urban forest benefits, inequities, citizen preferences and optimum planting guidelines. The last section reviews the literature to learn about designing for personal space and places for social interactions as well as the practical specifications of urban street design. The primary sources of content for the literature review are published, peer reviewed, research studies in respected journals. Seminal books and design standard publications are included as well as contemporary online sites.

Adoption of Autonomous Vehicles will lead to decreased parking demand

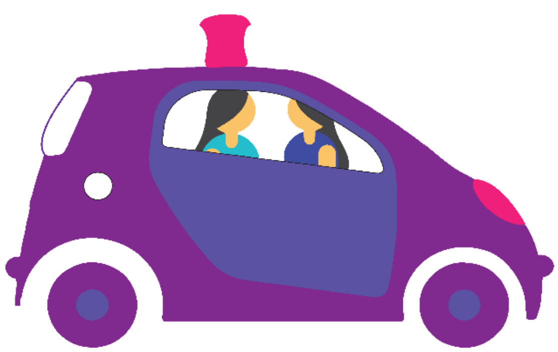


Figure 2.1 Shared autonomous vehicle

The purpose of this section of the literature review is to investigate the latest academic models designed to predict the timing and quantity of the profound impacts fleets of driverless electric cars will have on urban transportation and parking demand within the next few decades.

Cars spend 95% of their time parked. Bloggers are posting headlines like “An estimated 2 million people in Los Angeles could give up their cars to use shared autonomous vehicles spaces if SAVs become the easier and less expensive choice”. (Peters 2017)

Fagnant and Kockelman (2015) reviewed the existing literature and analyzed the predicted benefits, challenges, and impacts of AVs. Working with a cascade of assumptions supported by work done by researchers in this field, these authors attempt to predict safety, congestion, costs, impact on individual transportation decisions, and parking at 10%, 50%, and 90% penetration of AVs into the market. They go on to review the lives and money saved by the increased safety of AVs, how traffic congestion is reduced with smoother driving patterns (while acknowledging that this technology could increase demand), and how many parking spaces could be eliminated if the model of shared ownership was embraced. The authors also review the barriers to adoption of AVs, governmental oversight that is needed and concerns about cyber security in such a cloud-based transportation system.

Efforts to predict the savings in parking demand in the future of shared autonomous vehicle are the focus of two recently published articles. Zhang and Guhathakurta (2017) developed a simulation model to examine impacts of shared autonomous vehicles (SAV). The SAV system is a “centralized taxi service without drivers that will be more affordable and environmentally friendly to operate” (p. 80). Variables considered by the model included fleet size, parking costs, and miles predicted for the AV to drive without a passenger to find a parking spot. The results showed that 4.5% reduction in parking land can be expected after 5% penetration of SAVs into the market as well as each SAV can “emancipate more than 20 parking spaces in the city”. (p. 89) Some concern was expressed by the authors over the prediction that parking lots would be relocated to lower income neighborhoods as parking becomes more expensive. This would lead to the inequitable distribution of undesirable facilities in some areas.

The second report simulated a model in Atlanta that concluded that 90% less parking demand would be created by a SAV system. (Zhang et al. 2015) Results of the simulations showed that one SAV will replace 14 privately owned vehicles, more if the willingness to share rides is higher. The model indicates that for a client base of 10,000 people 700 AVs will be needed to keep the average waiting time to 2 minutes. The authors conclude that the decreased parking demand created by SAV system can free up a tremendous amount of space that can be used for green, open and "human oriented" use.

Predicting the years to move to 100% AV uptake was the subject of an award-winning article presented at the 2016 Australian Institute of Traffic Planning and Management Incorporated Conference.(Spinoulas and Davidson 2016) The research described by these authors focused on the building of a model to determine the likely rates of uptake for AVs and to predict what year we can expect 100% AV. This new model also was the first to consider the impact of single-occupant and multi-occupant shared AVs on overall car ownership and parking requirements. The model used in this study predicts that the fleet of cars will be all AV by 2046.

The conclusions of this section of the literature review are that adoption of autonomous vehicles is expected within 30 years and that parking demand will be significantly decreased. For more information on this subject see Appendix 2.1

Enhancing quality of life is the goal of the design

In the chapter "Streets Shape People" (Global Designing Cities Initiative 2015, 12), the authors write:

> "Urban streets provide the platform for everyday experiences and must, therefore, be designed to support human health and well-being for all people."

Assessing an individual's personal quality of life or well-being, and then designing to improve it, is a complex task. Can all the facets of a person's life be measured on a satisfaction scale? What are the key components to assess?

To help answer these questions, three published documents are included in this literature review because of their depth, thoroughness and relevance. The first is "Ecosystems and Human Well-Being" written by scientists from 100 nations at the request of the United Nations. (Millennium Ecosystem Assessment, United Nations 2005) This project's publication is intended to provide information to global decision-makers on the links between altered ecosystems and subsequent human well-being as well as to broaden the understanding, and evaluate policy, for sustaining ecosystems in harmony with human well-being. Included in this paper is a reference to work done by Narayan (Millennium Ecosystem Assessment, United Nations 2004, 74) who studied poor people from many countries by gathering and analyzing their ideas about what makes a good or bad life. Seven aspects of life were repeatedly heard:

- Safety and security
- Economic opportunity
- Physical space of living
- Health and mental health
- Social interactions

- Municipal services
- Freedom, choice and control

The second publication included is from the United Kingdom Office for National Statistics, “Measuring National Well-Being – What matters most to Personal Well-being?”(Office for National Statistics, United Kingdom 2013) The self-assessment Annual Population Survey data from 2011/2012 was analyzed to identify what factors were related to the personal well-being scores and found that:

- Poor self-reported health was strongly correlated with lower life satisfaction, “feeling of worthwhile” and “happiness yesterday” coefficients.
- Holding other factors equal, unemployment had a strong negative association with personal wellbeing.
- Higher education was correlated with higher anxiety.

A third reference to help identify the components most important in a person’s choice of where to live is from *Livable Streets*. (Appleyard 1981, 50) Researchers asked residents of a neighborhood what street factors were important when they chose where to live. People said the following factors were very important:

- 86% Safe from crime
- 86% Clean and unlittered, attractive and kept up
- 79% Near public transportation
- 75% Avoiding air pollution
- 71% Near greenery
- 70% Peace and quiet, safe from traffic
- 69% Backyard, privacy, social, good for children

Understanding the prime components that define a person's quality of life will inform the streetscape models to be presented in this paper. The built environment that adds to safety, the physical space of living, health, social relationships and choice will be the goals of this streetscape design work.

The urban forest has inequities, citizen preferences, benefits of trees and optimum planting guidelines

Inequities

The purpose of this section of the literature review is to learn how the uneven distribution of urban canopy relates to neighborhood income levels, density, home ownership, level of education and built form.

Multiple studies show a positive statistical correlation between areas with higher median income and the canopy cover. Landry (Landry and Chakraborty 2009) conducted a study to discover if the distribution of trees in Tampa, FL was statistically associated with race and ethnicity, income, and home ownership. The study measured street trees planted in the right-of-way (ROW). Census data from 2000 was used to measure the socioeconomic and racial/ethnic composition of the residential areas included in the study. The parcel-specific tree canopy cover was evaluated using imagery.

The data analysis showed that the tree cover on residential ROW increases significantly with median household income and the proportion of owner-occupied housing. This supports the inequity hypothesis that trees on ROWs are more common in areas with higher economic status. The authors conclude that public investment in planting street trees should be "nondiscriminatory."

Examining more than income levels to explain urban forest distribution inequity, Pham et al. (2012) studied the street tree cover (STC) in Montreal and compared it to both sociodemographic factors as well as "urban form." Urban form is different from density in that it addresses the space available for planting directly; density is one factor. Phan's investigations have confirmed that street tree cover is higher in expensive areas having residential streets and that low-income areas have more buildings that are negatively associated with STC.

The conclusions gathered from these publications are that the amount of canopy coverage is correlated with income, home ownership, and level of education in the urban setting. The availability of appropriate planting spots diminishes in the highly built, concrete inner city. Residents of lower income neighborhoods require municipal intervention to increase the canopy in the ROW. Adding to the urban forest will have benefits to the residents but not all urban dwellers value trees.

For more information on this topic see Appendix 2.2

Citizen preferences

Only one half of surveyed residents in two east Baltimore neighborhoods had positive responses to the prospect of new street trees on their street.(Battaglia et al. 2014) Both areas included in this study had had declining populations from 1970-2010 and have a population of about 90% African American. The available planting spaces were calculated in each neighborhood using GIS databases, aerial imagery, and tree pit data. If the neighborhoods were to maximize tree planting, they could each achieve around 16% canopy cover, three times the existing. In Baltimore, homeowners must sign a waiver agreeing to water young trees and take basic maintenance steps. This contrasts with NYC where trees are planted by the city in publicly owned sidewalks without permission.

Twenty-six interviews were conducted to elicit opinions about new street trees. The positive responses mentioned shade, aesthetic appeal and providing oxygen. Negative perceptions included bird droppings, insects, allergies to tree pollen and damage by roots. Two additional negative comments are worth mentioning that involve inadequate city services. One person wanted to know why the city would plant new trees when they never came and removed the dead ones, and another person would rather have the trash picked up than new trees.

Tree Benefits

The benefits of having trees close to where one lives has been studied and documented. (Mullaney, Lucke, and Trueman 2015),(Leff 2016),(Hirons and Sjöman 2019),(Urban 2008)

- Energy costs and greenhouse gas (GHG) emissions are reduced when trees provide cooling shade and block the wind
- Interception and absorption of stormwater improves overall water quality by slowing stormwater velocity, infiltrating and cleaning the water that is infiltrated into the soil and cooling the water before it enters the streams
- Tree roots help prevent soil erosion

- Soil quality is improved by adding biological activity, root turnover and root channels to the planting spaces
- Air quality is upgraded by intercepting particulate pollutants and some chemicals
- The cooling effects of transpiration helps reduce the inner city heat island
- Wildlife and biodiversity are supported, especially insects, bees, birds and butterflies
- A beautiful environment that is enhanced by trees that supports happiness, relaxation, and better concentration
- Socializing is encouraged in shady spots (Kweon, Sullivan, and Wiley 1998)
- Crime is lower in areas with more trees (Troy, Morgan Grove, and O'Neil-Dunne 2012)

The full value of the listed tree benefits is positively and directly correlated with the area of the tree's canopy. This canopy area is determined by the species and the age of the tree. The cost, in GHG emissions, of growing, transporting, planting watering and caring for a tree placed in an urban environment is such that a tree must live at least 30 years before it has positive carbon sequestration to add to the benefit list.(Petri et al. 2016) It is this fact that drives the quest for knowledge about the optimum urban tree planting environment.

Optimum planting guidelines

The classic advice is to pick the right tree for the right place. In the urban environment, there is no right place for trees because of the debris, compaction and toxicities of existing urban soil. The shade and cooling effects, particulate pollution collection and water absorption benefits of trees are related to the size of the canopy and are not fully appreciated until the tree reaches its mature size. To create a better space for trees, sidewalk suspension systems with specified and structural soils have been used successfully to allow tree survival in tight and impervious urban tree openings.

The research and advice explored in this part of the literature review is focused on an **alternative approach** available to cities who begin to redesign their streets, narrowing the driving lanes and removing parking lanes. The opportunity to remove asphalt and concrete and replace these surfaces with generously proportioned planting strips of uncompacted, biologically active soil will allow a more mature urban forest to thrive.

The US Forest Service and Davey Tree created *The Sustainable Urban Forest* guide (Leff 2016) to help municipalities assess their urban forest and plans to add to the canopy cover. The following definitions are included and are valuable to understand these issues:

"**Urban Forests** are systems of trees, other vegetation and water within any urban areas. They can be understood as dynamic green infrastructure that provides cities and municipalities with environmental, economic and social benefits." (from the 2011 Report of Vibrant Cities and Urban Forests)

Urban ecosystems include the built environment as well as the urban forest, the stormwater, the biotic habitat as well as the humans.

"Tree canopy cover is the surface area of land covered by the combined leaves, branches, and trunks of standing trees in an area when viewed from above." Some canopy measurement is done from land surveys.

Optimal tree canopy cover percentage varies by location of the city. Arid Western states are aiming for 20% whereas the Mid-Atlantic states have goals of 40-60%. For example, in 2007, Baltimore estimated its canopy cover to be 20% and has a goal of 40% by 2036.

"Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, sex, national origin or income with respect to the development, implementation and enforcement of environmental laws, regulations and policy."

In a paper published almost 100 years ago, Mattocks (1924) gives advice remarkably similar to what we know today as best planting practices. The author suggests that residential areas are the best place to plant street trees, at least 20 feet from the building and not with the same kind of tree on all streets because "the aesthetic appeal is dulled by the sameness [and] an epidemic of the insect pest to which that particular tree is liable could blight the whole of the trees in the area." (p.256) This author suggests planting trees in grass strips that are at least 4.5 feet wide with a width of 10 feet if possible. "Very narrow grass strips are worse than useless." (p.257) Even in 1924, planners were warned that "the desire for immediate effect often tempts people to plant the most rapid growers, but this is a mere waste of time and money. Quick-growing trees have short lives and soft, easily broken wood." (p. 260)

These pages of advice are remarkably consistent with the paper by Mullaney, Lucke and Trueman (2015) in which they evaluate the recent literature on this topic. This review of 100 studies examines the research concerning the environmental, social, and economic benefits of street trees as well as the problems and costs of damage done by trees and tree roots. Perception of residents is included as well as methods to improve street tree health. The reader is reminded that root growth of street trees is limited by drought, waterlogging, hypoxia, soil compaction, salinity, and increased concentration of heavy metals. The conclusions of the review are that the volume of root penetrable soil is the most limiting factor to street tree health. Lawn strip planting is significantly better for tree longevity and growing trees under pervious surfaces leads to the best outcomes.

Articles evaluating the status of major city tree planting initiatives from around the country are included in this literature review. One article is Torres' (2011), master's thesis from Plant Science and Landscape Architecture at the University of Maryland in 2011. Ms. Torres worked with Casey Trees to evaluate the condition of a large representative sample of trees at 3 and 4 years after planting in Washington DC. The total number of trees that had been planted by Casey Trees at the time of this paper was 10,000 and 4058 were included in this evaluation.

Overall tree mortality was around 32% after the 4^{th} year review. A few independent variables were found to have a statistically significant association with survival rate. One variable was the nursery source (one nursery lost 61%) and another was the season planted with summer the worst. Trees planted in institutional settings did the best as well as trees planted in continuous lawn strips. Casey Trees now has its own tree farm and a strict planting season that does not include any summer months.

The best conditions for tree survival after a New York City (NYC) tree planting initiative was reported by Lu (2011). Overall survival was 74% after 9 years. Factors statistically associated with greater survival were the presence of seating and a garden near the tree as well as other stewardship signs. Tree openings in lawns instead of sidewalks were more likely to foster trees that survived, as well as the presence of a perimeter tree guard. NYC tree planting has a better survival that many other initiatives reported in the literature. The authors credit the NYC program of planting by experienced contractors supervised by trained foresters and the use of larger (2.5-3") caliper trees.

Figure 2.2 Evidence of tree planting stewardship in Takoma Park, MD

Subsequently, NYC has changed its policy to planting trees in only the widest medians and to install tree guards at the time of planting.

Rehabilitation of Urban Soil

Recent published articles have described a novel approach that has the potential for major changes in the practice of rehabilitating urban soil for use in planting. Soil compaction and available soil volume are the primary limiting factors in the health of growing tree roots.

Additional factors that limit growth are inadequate water and water-logged anaerobic subsoils. Plastic suspension components that are placed in the planting area, in and around the other infrastructure, and designed to bridge the pavement overhead and to prevent compaction can be used where over-root paving is necessary. (Urban, n.d.) Underdrains are used to drain planting beds to avoid too much water in the roots.

In 2010 Rachel Layman wrote her Master of Horticulture thesis on the "Rehabilitation of Severely Compacted Urban Soil to Improve Tree Establishment and Growth" (Layman 2010) A six year follow-up study was done that evaluated the growth, canopy, and overall health of 5 tree species after 6 years growing in test plots.(Layman et al. 2016) At each the test plots, 4 inches of topsoil was scraped off and then each site was mechanically compacted to simulate an urban planting scenario. Test plots were prepared for the planting in four variations:

1. typical practice – replace 4 inches of scraped topsoil
2. topsoil plus rototill to 6 inches
3. "profile rebuilding" – add compost (decomposed leaves) to subsoil to 24 inches and then replace topsoil and rototill to 6 inches. Subsoil is broken up and veins of compost are observed to 24 inches
4. Control plot -no prep - agricultural land that has not been disturbed

After 6 years the growth and canopy of the "profile rebuilt" soil equaled or surpassed the trees grown in the undisturbed soil. The conclusion is that incorporating compost into the deeper soil layers is important in urban settings. The discussion mentions that inserting compost below the soil surface may have benefits to open compacted soil to root penetration and water.

Researchers at Cornell have taken a similar approach to restoring the porosity of urban soil while adding organic matter.(Sax et al. 2017),(Bassuk, Nina 2019) The Scoop and Dump process of soil remediation consists of spreading 6 inches of compost on the surface of compacted soil, using a backhoe to scoop up the soil to 24 inches depth and then lift it to 3-6 feet and then drop it to the ground. The compost is seen in the fissures created by this process. Soil health includes retaining clumps, clods and peds as well as incorporating organic matter. This study was designed to investigate the impact of this remediation technique for the improvement of urban soils. The results showed that all the measures of soil health for plants (aggregate stability, available water holding capacity, total organic matter, potentially mineralizable nitrogen, active carbon, and reduction in bulk density) were statistically better in the Scoop and Dump soil.

In *Up by Roots*, James Urban specifies clear principals and methods for planting trees to allow them to grow to maturity. (Urban 2008) A summary of the principals follows:

1. Cluster trees in contiguous soil volume.
2. Make larger planting spaces with ground cover outside the root ball diameter. Soil under pavement is never as good as soil without pavement.
3. Preserve and reuse existing soil resources
4. Improve soil and drainage as well as add organic matter like yard compost.

5. Treat compaction
6. Respect the base of the tree – the root crown will eventually be twice the diameter of the trunk.
7. Mulch rings of 6 feet are the best under trees and plants are better than lawn. Never use a tree grate.
8. Irrigation systems usually cause trouble in urban areas
9. Assure adequate soil volume – 36” deep and 1000 cubic feet for an average tree.
10. Plant B&B trees of 3” caliper at least 30-35 feet apart.
11. Plan for diversity of species with less than 10% from any one species and less than 20% from any one genus.
12. Design a drainage system with a perforated pipe (holes at the bottom) that runs parallel to any obstruction between planting soil and subsoil. Include a drain line cleanout and inspection riser pipes at the uphill end and periodically along the pipe.

Figure 2.3 A beautiful tree grate but a very ugly outcome

This section of the literature review reveals an emerging list of best practices for survival of street trees as well as an understanding of the inequities and benefits of urban trees. These best practices include planting in at least 10-foot wide lawn strip when possible, not planting in the summer, ensuring a respected nursery source for the trees, having professionals plant trees with 2.5-3-inch calipers, installing a perimeter tree guard, securing enough volume of uncompacted soil by Scoop and

Dump, and planting under trees, avoiding the root ball, to create additional habitat for the urban ecosystem.

Design for people and their social interactions using global urban street design guidelines

This section of the literature review consists of articles and books written to share ideas and research about what characteristics of a street will encourage the most social interaction. The site design of this design thesis is informed by the knowledge gathered in this review.

Sidney Brower, Chief of Comprehensive Planning of the Department of Planning, City of Baltimore, planned an observational study to give the city some insight about where people were "hanging out" in 1971. (Brower 1973) He drove around a 95-block area of residential Baltimore to observe and count the people outdoors. The long streets were lined by 19th century 3 to 4 story rowhouses with 4-5 steps leading from the sidewalk directly to the front door. The areas were high density and the occupants were lower income, predominantly African-American families.

Forty-two percent of the people observed were walking, running, standing or on the job. These people were classified as *transients*. One percent were working on the house or automobiles. The remaining 57% were sitting, playing, talking or gardening. These were classified as *recreational activities.* Only 3% of those engaged in recreational activities were in parks or playgrounds compared to 54% in the streets, alleys and yards, sidewalks, steps, and porches. Steps were crowded with people; some having pulled chairs onto the sidewalk. A local park along the route was unused.

Brower's conclusion is that "home-based recreation space acts as an extension of the house. It should be adjacent to the house … Recreation should be recognized as a legitimate activity on the public sidewalk, and the sidewalk should be designed to increase its recreational potential and safety." (p.369)

A historical perspective is welcome in Spirn's *The Granite Garden.* (Spirn 1984) This book addresses many contemporary urban issues despite having been written 35 years ago. Her chapters on urban pressure on living things includes the problems of street tree survival (averaging only 10 years at that time) and the trees suffering from deicing salts, people on the roots, dog urine, and needing more space, air, and water. She reminds us of the peril of planting too many trees of the same specimen.

The author with the most influence over the tone of this project is Jan Gehl. In *Cities for People,* (Gehl 2010) he reminds us of the importance of designing at the human scale and for the field of vision of a person as they walk along a street. His observational studies show that people use streets in which they are "invited to both walk and stay." (p.73)

Gehl reminds us that our field of vision above the horizon is such that when walking along building facades, only the ground floor is appreciated. And just as importantly, the human scale of the streets makes a big difference (e.g. Venice vs. Dubai). Gehl reports a study showing that seven times more people stopped if there was an interesting façade to see instead of a windowless wall.

The residential "soft edge" is like a porch or a stoop in an older residential neighborhood that serves as a semi-private zone. People make good use of the transition space. A study in Melbourne showed that there was increased activity in streets that had townhouses with small outdoor terraces. Activities in or near the "semiprivate edge zone" accounted for 89% of life on the street. Another of Gehl's reports in Copenhagen showed that rowhouses with front yards had three times more activity than identical dwellings without front yards. One square meter adjacent to the home is used more than 10 square meters around the corner.

> "No single topic has greater impact on the life and attractiveness of city space than active, open and lively edges." (p. 88)

Urban designers from around the world have collaborated *on Global Street Design Guidelines.* (Global Designing Cities Initiative 2015) It consists of all the principals and guidelines cities should use as they improve their streets over time. Listed here are a few of the important ideas from this book:

1. Streets should be designed with human health in mind. There are 1.2 million traffic fatalities globally per year. Air pollution is thought to contribute to 3.7 million air quality related deaths annually.
2. Travel lanes are recommended to be 9-10 feet wide. Truck and transit routes need 11 feet lanes.
3. Trees should be 10 feet from an intersection

4. Street lighting should be at the pedestrian level at a height of 15-20 feet for narrow roads and sidewalks with 25-30 feet tall light poles for wider roads. The spacing is 2.5-3 times the height of the poles. Light Emitting Diodes (LED) have low energy demand and have a long life. The temperature of the light is important in the mood of the space. LEDs in 3000K are recommended for pedestrian paths and 5000K for vehicular.

The conclusion for this section of the literature review is that built components of the street and the adjacent properties encourage social lingering and interaction. The “soft edge” of the home, with its stoop or front porch, will be an essential characteristic in the site design for this project.

Chapter 3: Goals

The goal of this streetscape design project is to create a street that enhances the quality of life of those that live along that street. This goal is intertwined with a secondary goal of increasing the tree canopy in all the neighborhoods where greenspace is sparse and transitions between the home and the street are meager.

The components of quality of life (and personal well-being) of safety and security, physical spaces of living, social relationships and health can be influenced by designing a streetscape that provides more trees and greenspace, delivers a quieter and safer street and provides amenities to promote social interactions.

Opportunities to enhance quality of life using:

- Urban Trees
- Street Design
- Design Amenities

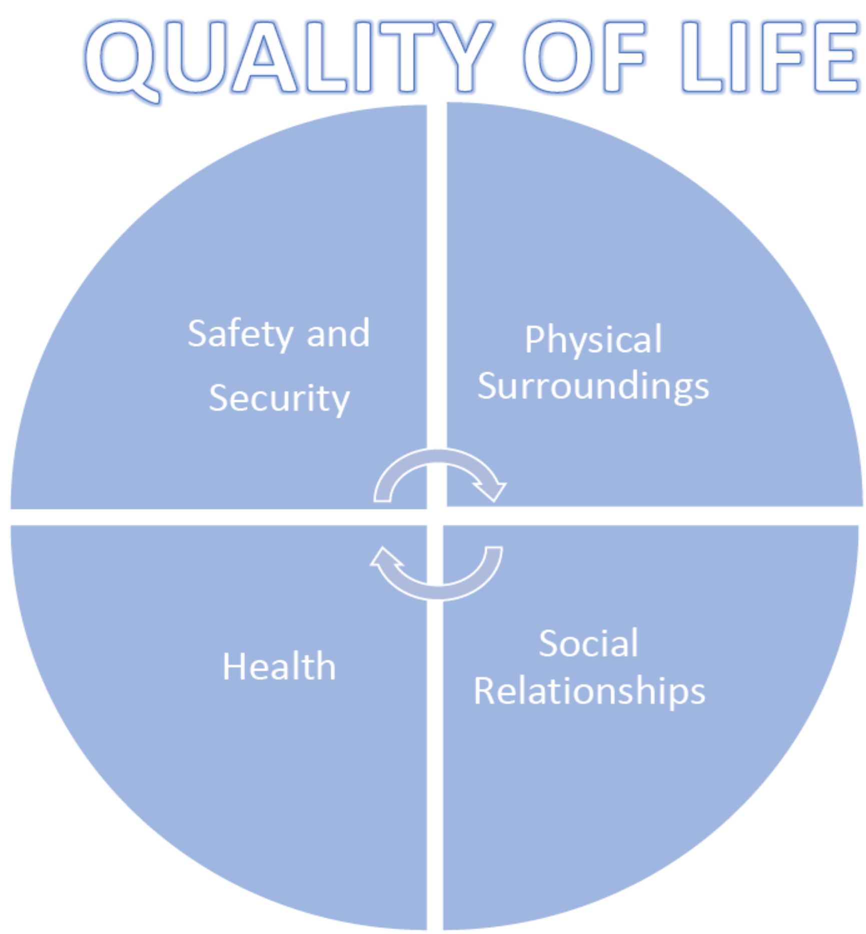


Figure 3.1 Components of Quality of Life

Safety and Security

- Urban Trees

Less crime with more trees
More ecosystem security with biodiversity

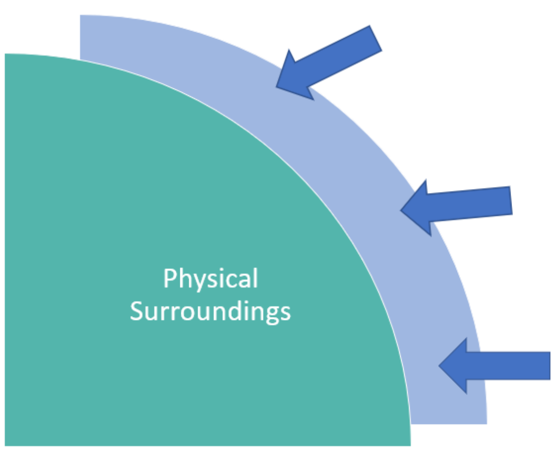
- Street Design

Narrow lanes to slow traffic
Create places for safe play
Warning signs about kids in the street
Wider sidewalks

- Design Amenities

Nicer street reduces vacancies and associated crime
More activity on the street provides more security

Physical Surroundings



- Urban Trees

Cooling shade lowers energy bills
Wind breaks
Cleaning and absorbing rainwater

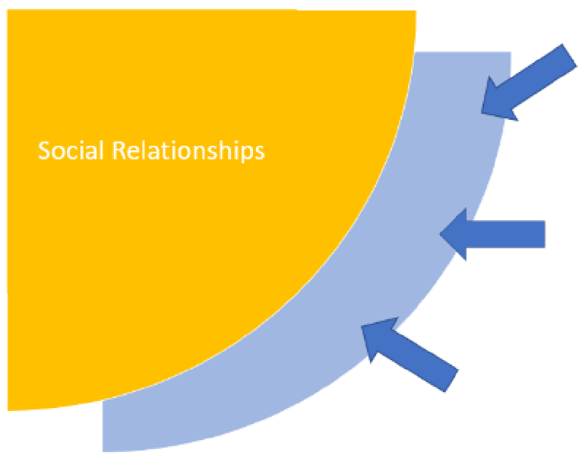
- Street Design

Moves vehicles further from the house
Allows urban gardens and habitats

- Design Amenities

Beautification of the street
Sitting, relaxing and recreation

Social Relationships



- Urban Trees

Shade for hanging out

Garden spaces to gather

- Street Design

Community involvement in design

Preserve historic house facades for neighborhood identity and pride

Stewardship of trees and gardens

- Design Amenities

Increase the space between private and public for opportunities to have social interactions

More room for sitting on stoops, stairs, chairs and benches

Unobstructed sidewalks for easy walking to shopping and gathering places

Health

- Urban Trees

Decreased heat island effect

Decrease particulate air pollution

Decrease stress and noise

Benefits of exposure to nature and biodiversity of nature

Cleaner and conservation of stormwater

- Street Design

Safer place to walk and bike

Outdoor exercise for kids of all ages

- Design Amenities

Exercise in yard work and maintenance

Vegetable garden

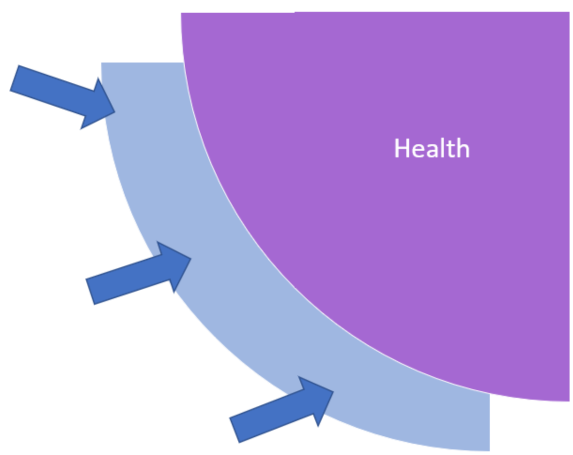


Figure 3.2 Goals of design

Figure 3.3 Enhanced Quality of Life

Chapter 4: Streetscape design

<u>Precedents</u>

Commonwealth Avenue Mall, Boston

Figure 4.1 Commonwealth Avenue Mall, Boston. Google Earth image

Many wide streets are shared with pedestrians. The Commonwealth Avenue Mall, in Boston, is 200 feet across from building to building in an historic Victorian neighborhood. The central 100 feet is separated from traffic and has a strolling path and majestic shade trees. This street was originally designed as a grand boulevard and has been successfully maintained as such, with two vehicular lanes and a parking lane on either side of the central greenway as well as generous sidewalks on the residential sides of the street. The width of this street and the opulence of the adjoining residences create a rare and wonderful scenario for sharing a road.

Converting traffic lanes into pedestrian plazas in New York City

NYC has been busy "rightsizing" streets and "placemaking" with the excess travel lanes. ("Broadway Boulevard: Transforming Manhattan's Most Famous Street" n.d.) Using guidelines to make intersections safer for pedestrians, slow traffic and provide more public space, the city has been working on many intersections along Broadway and elsewhere. These photo examples below, on 6th Ave and 14th street, the site of a remodeled Apple store. Google Earth historic maps show a fuzzy image in 2004 of this intersection painted with white stripes to direct traffic. In 2014, a temporary plaza with curbs, tables, chairs and a small food shack is visible. In 2018 construction was completed to create this permanent plaza. This step-wise, try-it-out approach has been used successfully to promote placemaking projects quickly and establish the benefits before undertaking extensive implementation.

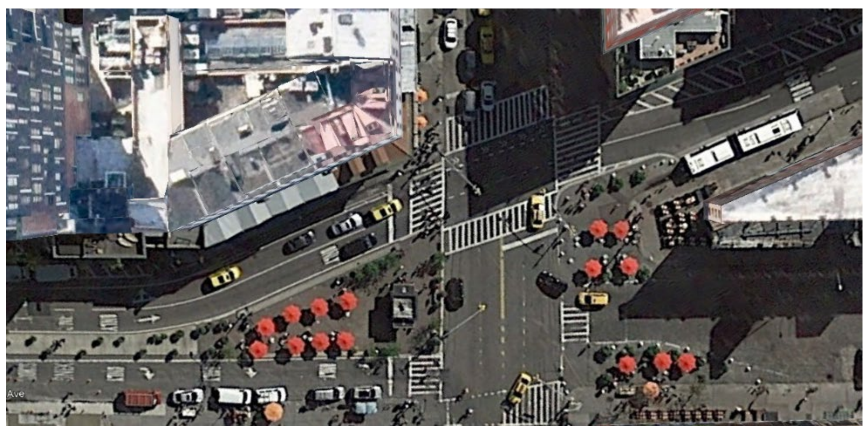


Figure 4.2 14th Street plaza in 2014 Google Earth image

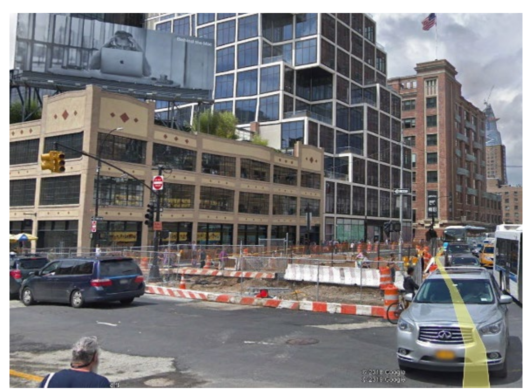


Figure 4.3 Plaza construction in 2018 Google Earth image

Figure 4.4 Completed 14th Street plaza

Figure 4.5 Inviting space at 14th Street and 6th Ave, NYC

Bell Street Park Shared Street, Seattle

Bell Street Park Shared Street in Seattle is the first shared street project undertaken by the city and was completed in 2014. ("Bell Street Park Shared Street, Seattle" 2016) The neighborhood of Belltown is a densely populated mixed residential and commercial area. The Belltown citizens played an active role in guiding the street's 4 block design. The design elevates the street into a level, continuous surface with a central one way 10' wide meandering common space for vehicles, bicycles, and pedestrians with an additional 4' of a darker paving surface on either side to allow wider and emergency vehicles. Recreational and ecological features are included: planters, planting strips and new trees, tables, chairs, public art, and LED streetlights. Maintenance agreements for responsibilities are divided between Department of Parks & Recreation to take care of street cleaning and upkeep of the landscape features while Department of Transportation maintains the streetlights and road. This was a $5.0 million project.

Figure 4.6 Bell Street Park Shared Street, Seattle Google Earth image

Of these three examples, the shared street is closest to the design concepts presented in this thesis. The gracious boulevard fostering trees and strolling, as well as the public plazas carved out of intersections are examples of aspirations to have trees and public amenities in the city. The models proposed in this paper aim to achieve these same goals but in a more needy, strictly residential environment.

Site selection criteria

The ideal site for this project is a rowhouse neighborhood without front porches or front yards, historically preserved, in a high tree-planting priority area and housing a disadvantaged population in a moderately stressed housing market.

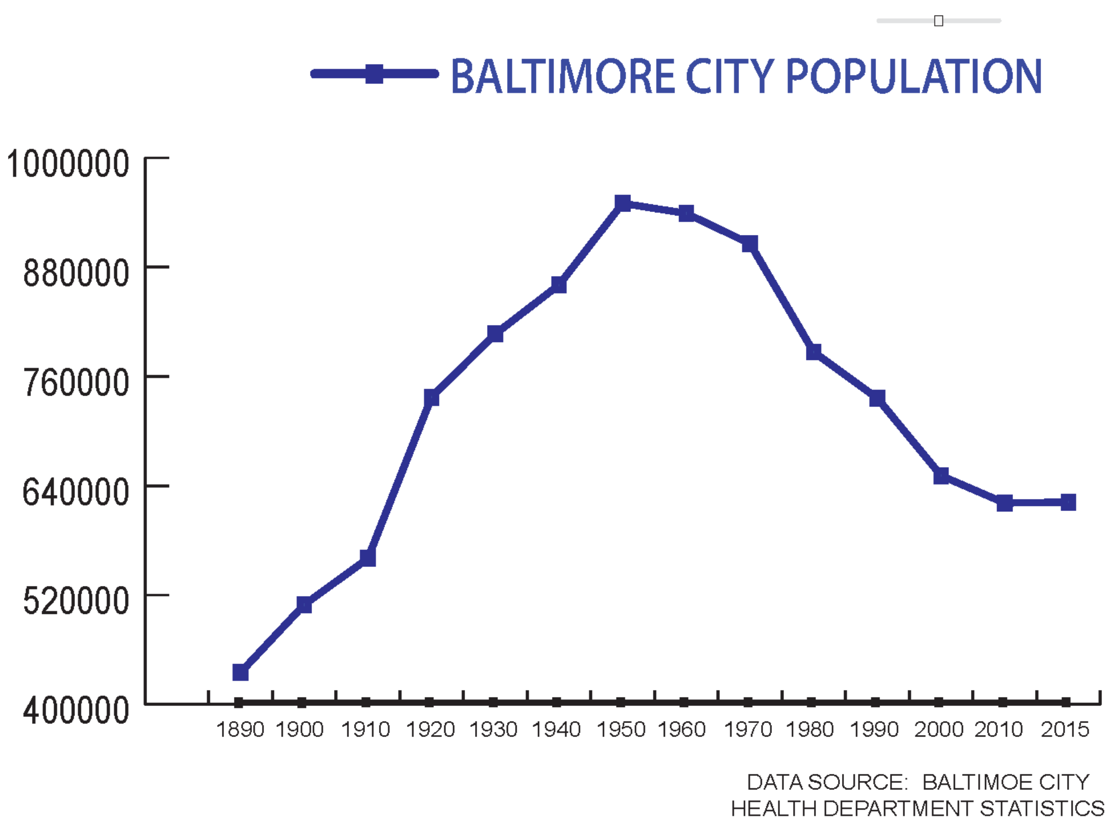


Figure 4.7 Baltimore City Population from Health Department Statistics

Baltimore City has an abundance of rowhouses. These homes were built during the period of 1850's through the early 1900's to house the immigrants and industrial workers who poured into the city. Baltimore was proud that it was able to expand and build seemingly endless blocks of rowhomes instead of having to house people in tenement buildings like New York City. After the transportation revolution of the automobile, those who could afford it moved out of the industrialized center of the city. Some of the homes in the city that were in poor condition and did not have any electricity or plumbing were demolished and replaced with housing projects in ambitious anti-poverty campaigns. By the 1970's and 1980's housing projects were themselves demolished and new modest rowhomes built as subsidized housing. Baltimore City's population peaked in 1955 at 966,000 residents. The current population is 622,150, having stabilized in 2010.

Baltimore City's Master Plan from July 2006 has a goal that includes "strengthening neighborhoods by adopting and implementing the Urban Forest Management Plan". ("Comprehensive Master Plan" 2016) The Baltimore UTC (Urban Tree Canopy) Prioritization Map uses weighted criteria to suggest the areas of the city most in need of tree canopy additions. A multifactor analysis was done in Baltimore to assess the highest priority areas for tree planting. (Grove, Grove, and Locke 2011) Criteria

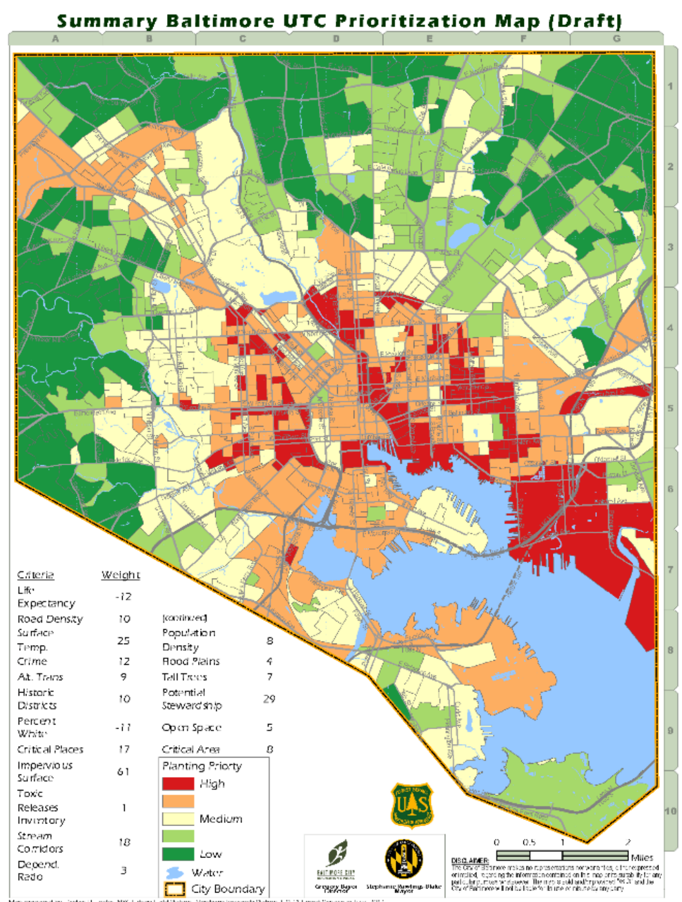
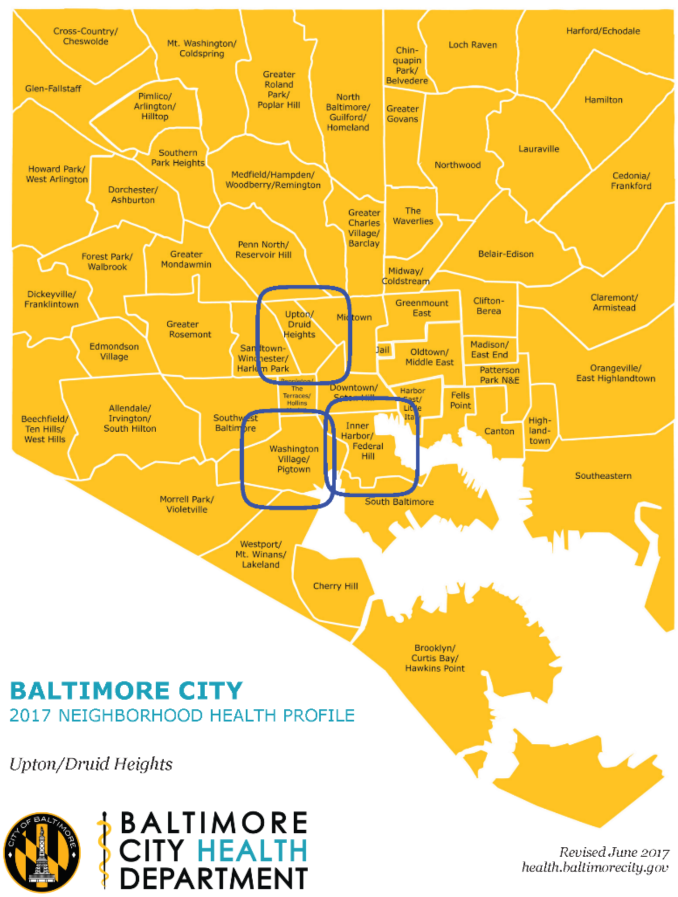


Figure 4.8 Tree Priority Planting Map Source: Baltimore City

included public health and safety, environmental justice, water quality, air quality, critical places and potential stewardship in addition to the lack of canopy.

The Master Plan also includes a goal of "protect and enhance the preservation of Baltimore's Historic Buildings and Neighborhoods" Rowhouses in registered historic places would most likely be protected from demolition during a revitalization effort. This design proposal will be limited to the streetscape so that the home facades and steps will remain.(Ryer and Pugh, n.d.)



Multifaceted demographic data is available from the Baltimore City Health Department in their Neighborhood Health Profiles.(Baltimore City Health Department 2017) Profound differences are revealed when neighborhoods are compared. The three neighborhoods' data shown in this graph illustrate how geographically close inner city neighborhoods have very different socioeconomic demographics.

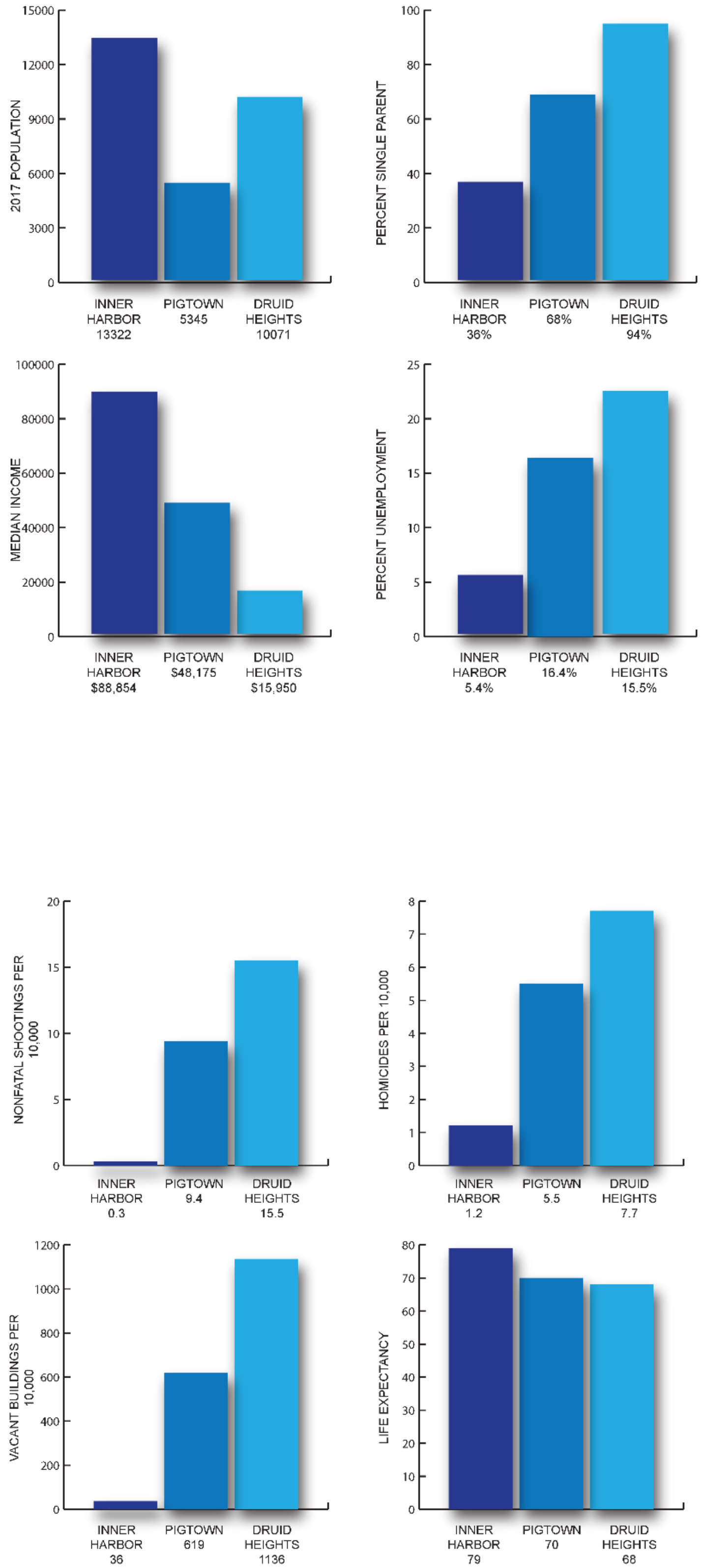


Figure 4.9 Demographic Data for 3 Baltimore Neighborhoods

Housing market analysis shows that some areas of the city are rebounding with increasing home prices and desirable locations. This map shows the city's 2014 Market Typology.

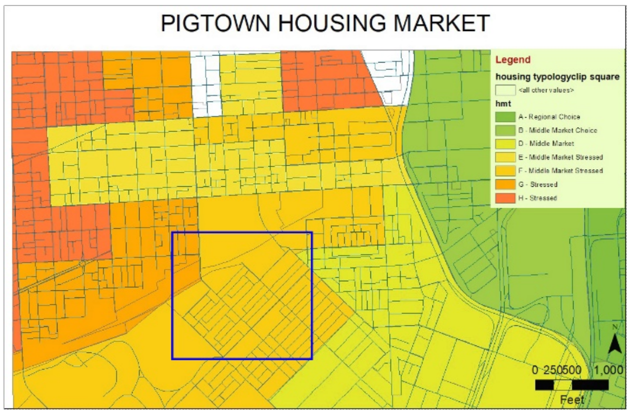


Figure 4.10 Source: Baltimore City Open GIS Data Focus on Pigtown Housing Typology

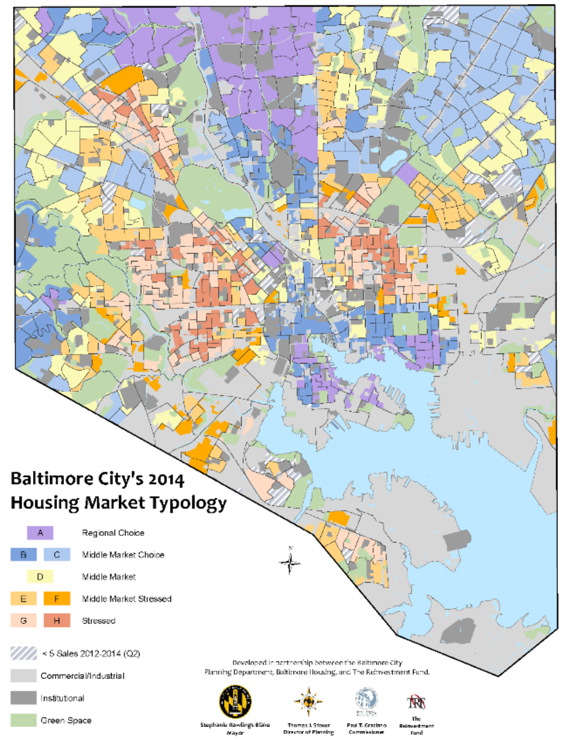


Figure 4.11 Baltimore City Planning Department, 2014

After reviewing the tree planting priority document, the demographics of some inner city neighborhoods and the existing housing market typology, Washington Village, more affectionately called by its original name of Pigtown and officially certified in the National Register of Historic Places in 2006, seems like an ideal location to anchor a set of street design models to be implemented in two or three decades.

Figure 4.12 Pigtown residents have rejected the attempt to rename the neighborhood Washington Village.

Figure 4.13 Typical Pigtown rowhome front marble steps

<u>*Site inventory*</u>

Architecture

The working class rowhouse is typically two stories with two or three bays of windows with two rooms front to back. The

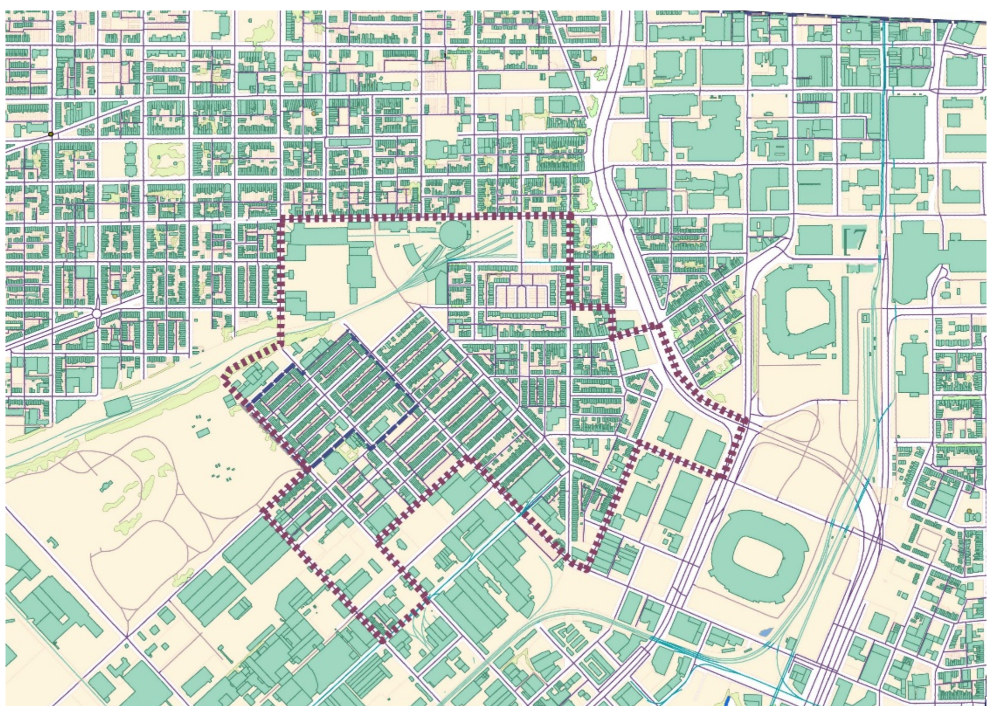


Figure 4.14 GIS map of Pigtown borders with Baltimore stadiums to the east and the B&O Railroad to the north and Carroll Park to the west

smallest are only one room deep. The front door leads from a small stoop down a few steps onto a narrow sidewalk and the street.

Developers started building in Pigtown south of the B & O Railroad in the early 1850's and increased the number of houses dramatically in the 1880's.(Hayward & Belfoure 1999) (Hayward 2008) In the post-civil war industrial expansion, developers would build three-story Italianate detailed rowhomes on the main and side streets with similar two story, smaller homes on the midblock alleys streets. This mixed-cost building created a wide range of home values within one block. The two-story smaller alley homes would look like the homes on main street, but because of their lower cost they often did not have toilet or bath facilities. The privy would be in the back yard. The citizens must have been thankful to the railroad magnate donor who built the Walters Bath House No. 2 on Washington Blvd. (p140) Storefronts were designed on the corner buildings first floor entrances.

German immigrants populated Pigtown in the post-war period and made good use of the nearby park at the old Carroll estate. By 1867, this very popular gathering place had day-long picnics, a shooting range, dances and bands. Breweries were common and a major employer. The name Pigtown came from the days when the B&O freight cars unloaded the pigs that would then be driven through the streets south to the slaughterhouses.

In 1939, the new Housing Authority had funds to embark on "slum clearing" for five areas in Baltimore City that overlaid the syphilis and TB hotspots (p248). Most of the demolished homes had cold water and electric service but no toilets or tubs and had been built in 1830-70. Poe Homes slum clearance project proceeded to build three-story boxy buildings with amenities, but displaced residents were unable to move in. The Poe House (residence of Edgar

Allen Poe) was spared and is preserved as a small rowhouse in stark contrast to the institutional looking apartments that stand there today. In 1995 new street-facing human-scale rowhome housing projects were built to replace failed public housing blocks. Pleasant View Gardens is an example of a collection of publicly funded rowhouses built to "restore qualities of community" (p187) The goal is to make the new public housing development feel like any other residential neighborhood of the city.

In the areas of the city designated as historical sites, restorations must preserve the stoop, continuity of wall surface between units, the heavy cornices, the vertical proportion of windows, and the repetitive rhythm of window spacing. (p188)

Figure 4.15 James Street houses, Google Earth image

Front porches and small front lawns were added to the rowhomes during the years 1905-1915 to compete with the homes built in the suburbs. The brick used to build the rowhouses began to be hard-fired and much more durable after 1900, preventing the need for painting or the application of formstone, a faux stone covering likened to vinyl siding for its tackiness and very popular until the mid-century. Placing formstone on new buildings in Baltimore is banned, but older historic homes have remained covered. It has been suggested that the removal of formstone is a sign of gentrification. Currently there are large swaths of Baltimore City with many abandoned buildings and empty post-demolition lots reflecting the population loss and the serious deterioration of the buildings.

Street typology and description

Washington Boulevard is Pigtown's main arterial commercial street. The remaining residential streets include two-way roads, alley roads and service alleys. Baltimore City had most of its downtown blocks built before those in Pigtown. This Atlas of Baltimore map shows how many buildings existed by 1914.

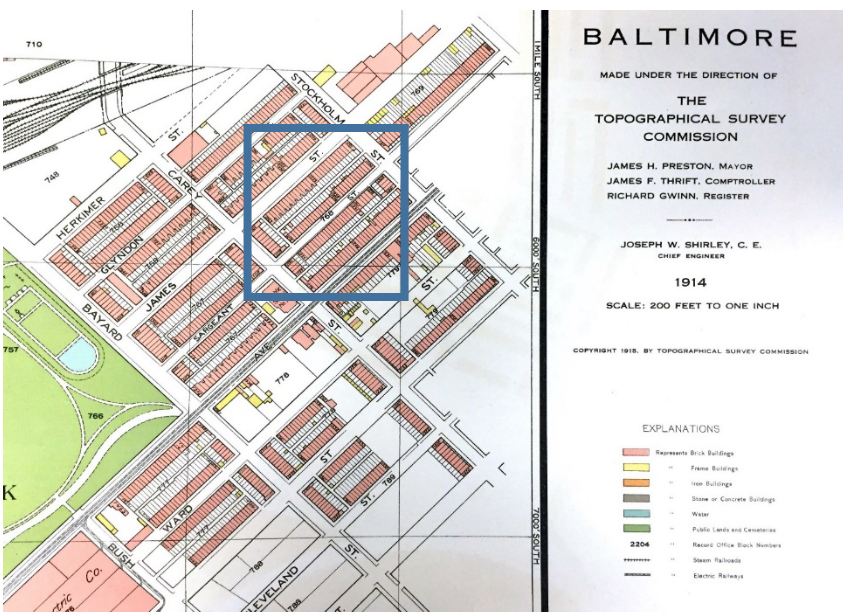


Figure 4.16 1914 Map of thesis site roads

The Pigtown streets chosen for the thesis design are representative of two residential street typologies. James Street has two-way traffic and is 64' across. Sargeant Street is a one-way alley street that is 40' across. Electrical poles and wires, as well as stormwater and wastewater drains are located in the service alleys that run midblock. The fresh water supply pipes are under the actual street.

The study block of James Street has a 10-foot sidewalk that includes 8' x4.5' openings for trees. Six out of 22 trees are either dead or appear in poor condition, but a few are up to 20 feet in height. The study block of Sargeant Street has 3-5-foot sidewalks and no trees. Cars are parked along all the curbs and a few houses have potted plants near the front stairs. Each side of the street has 3 streetlamps.

Observations of street life

I walked around the streets of Pigtown with an orange cooler on wheels, giving away free ice cream to anyone who would stop and talk (as well as those who just wanted a snack). My informal observations and conversations with the people I encountered in the neighborhood gave me a little window of insight into their lives. Everyone was very courteous. Three people sitting on a stoop (did they really live there?) and a person passing by responded to my question about what they would do with the space in front of their house if there were no cars to park. One gentleman said he would have a snow cone cart, another said a bench and picnic table for the kids, and another said, "something for the community". A visitor from another neighborhood wished for extra sidewalk for flowerpots and seating. I went around the streets looking for people using their front stoops as a social spot. I found one gentleman resting on his stoop and when asked about making use of the space he replied that he was only sitting there because he had locked himself out of the house. Another person said she wasn't allowed to smoke inside. The best use of the sidewalk between houses was discovered late in the afternoon (by then all the ice cream in the cooler was terribly melted). Two moms, a newborn, and three kids were sitting around a picnic table under an umbrella next to a grill cooking hotdogs. I was grateful they took most of the liquid treats off my hands.

My second visit to Pigtown to do more data collection gave me the opportunity to speak with a young man hired by the local business development group to keep the main commercial street litter free. He suggested more trash cans around the neighborhood streets. Another young man who grew up in Pigtown but then moved away remarked that he doesn't see the children playing in the streets like they did when he was young.

Finally, and with a cooler once again full of melted ice cream, I met a mom and three kids on scooters riding up and down the streets. The mother stated that it is her responsibility to sweep the sidewalk and pick up trash in front of her house. She likes her neighbors but is having trouble with her landlord (she said slumlord) because of problems with lead exposure and a broken refrigerator. I only mention the refrigerator because she, sadly, was unable to take the rest of the ice cream to save for later.

<u>*Site analysis*</u>

Opportunities

Abundant of ROW space will be available for redesign. By narrowing the travel lanes and repurposing the parking lanes, the prospects for generous tree planting strips and places for the residents' personal use are promising.

The neighborhood's status of historic significance may preserve this architecture. The population decline in Baltimore City over the second half of the 20th century created a housing excess and many vacant buildings in some parts of the city. There is an ongoing demolition plan to take down and eventually replace the derelict vacant buildings.

Constraints

Not everyone loves trees. Mature tree roots do interfere with sidewalks in traditional tree pits dug into sidewalks, so the residents' apprehension will need to be alleviated by understanding how a new approach to tree planting will allow trees and people to thrive together. Some residents are transient and may not be interested in any new street design. Maintenance of any new landscape must be delegated. The residents may think that strangers will make use of the areas added to the street front in front of their house and resent any added work or expense encountered because of the new landscape. Street changes in these models will need to work around the water supply pipe and its feeder pipes in the center of the roads.

Chapter 5: Three design models for Pigtown

Three design models will be described and illustrated, two for the wider James Street and one for Sargeant Street, the alley street. The following design principles hold for all three models:

- Citizen safety is priority
- Designed social spaces are shared with the optimum tree growing environment
- Half of the streetscape stormwater is captured and infiltrated into the tree strips
- The trees and the plantings between trees are to be species native to the Mid-Atlantic
- The maintenance plan is of equal importance as the design plans and installation of these streetscapes

Two James Street Models

Figure 5.1 Existing conditions James Street

James Street is 64’ wide from building to building. Both James Street design models begin with creating an 18’ wide crowned center vehicular two-way road that is bordered by 6” tall and wide curbs. The remainder of the space is divided into a sidewalk that is at least 6’ wide and a continuous tree planting strip (CTS) at least 11’ wide.

The preparation of the soil after removing the existing asphalt is critical for the success of this project. The design requires the contractor to use the Scoop and Dump method to utilize the existing soil, remediating the soil compaction and adding organic material. This CTS, at 36" deep, provides a minimum of 1000 cubic feet of soil per tree planted at 30' intervals, ideal for a tree to grow to 30' canopy with a diameter at breast height of 16" and a 32" root crown. By growing in continuous strips, tree roots can utilize as much as 25% extra volume as the roots share the space underground. The CTSs have an underdrain set in gravel with perforations at the bottom of the hole that flows to and connects to the stormwater inlet. This ideal growing space will allow mature trees to provide an over-street canopy.

The trees are B&B, dug from the tree farm while dormant just before bud break and delivered to the planting site within a few days. The trees are specified to be 2-3" caliper and planted by a professional staff. The planting beds are mulched to 3" in depth and kept 3" away from the trunk of the tree. Careful attention is paid upon planting for evidence of circling roots or root flare that is buried in the root ball as these are conditions that will limit the growth of the tree.

Stormwater is captured by the CTSs from the existing steps and the area between the steps in front of each house as well as from the sidewalk. This area is graded to allow rainwater to flow into the CTS. The sidewalk runoff flows through a small protective curb designed with fenestrations for collecting stormwater. The surface of the CTS is set at 2" below the sidewalk grade. The surface area of the CTS is equal to the combined area of the sidewalk and steps and will allow for a two inch rain event to flow to the CTS and infiltrate through the prepared soil to provide water to the tree roots and the other plants. The overflow will travel along the surface of the CTS to the lowest grade and empty through a notched curb into the cross street near the storm drains.

Streetlights are chosen to provide light for the streets and the sidewalks, typically around 25' tall and placed at intervals 2.5 times their height. The style is an "acorn" type for historic continuity with LED illumination in the 3000 Kelvin range avoiding any light emitted greater than 45 degrees.

The surface of the CTS is shared between the growing tree trunks and the spaces designed for the residents. During the design process, the residents are encouraged to work with their neighbors and the designers to decide where the trees are placed and make the choice to have a permeable paver surface or a garden space in front of their house.

Private Model

In the Private Model, the CTS is 11' wide and is placed 5' from the edge of the building. Waterproof lining is placed along the house side of the strip. Each home has a 2' wide path leading from the steps, over the CTS, to the sidewalk. This path is supported by a suspension system that allows for the soil to remain uncompacted along the length of the CTS. If the homeowner chooses a patio surface, interlocking permeable pavers are set on gravel without compacting the soil. The patio allows for chairs, benches, picnic tables, flowerpots, and whatever other items make the space into a virtual front yard. The homeowners who chose to have a garden space are instructed to not place plants within the root ball of the tree, encouraged to plant native species of perennials and forbs instead of turf grass that interferes with optimal tree health as well as the insect habitat. Each square of “private” space is demarcated by a short fence between the homes with the understanding that the residents will feel like this space is their property despite being in the ROW.

Public Model

In the Public Model, the existing steps and sidewalk adjacent to the house is designed at 10’ wide. CTS is 12’ wide and placed between the sidewalk and the road. This model avoids the need for a path for every home, but a designated pedestrian cross over is placed every 30’. The homeowners will have the choice of garden space or patio space, or a combination, with the same considerations given to a firm surface placed over uncompacted soil and the planting guidelines for the CTS. In this model, the streetlights are designed along the edge of the CTS. The “public” nature of this space that is located across the sidewalk is designed to promote the same unencumbered tree growth and add the same social amenities as the Private Model.

<u>*James Street – Private Model*</u>

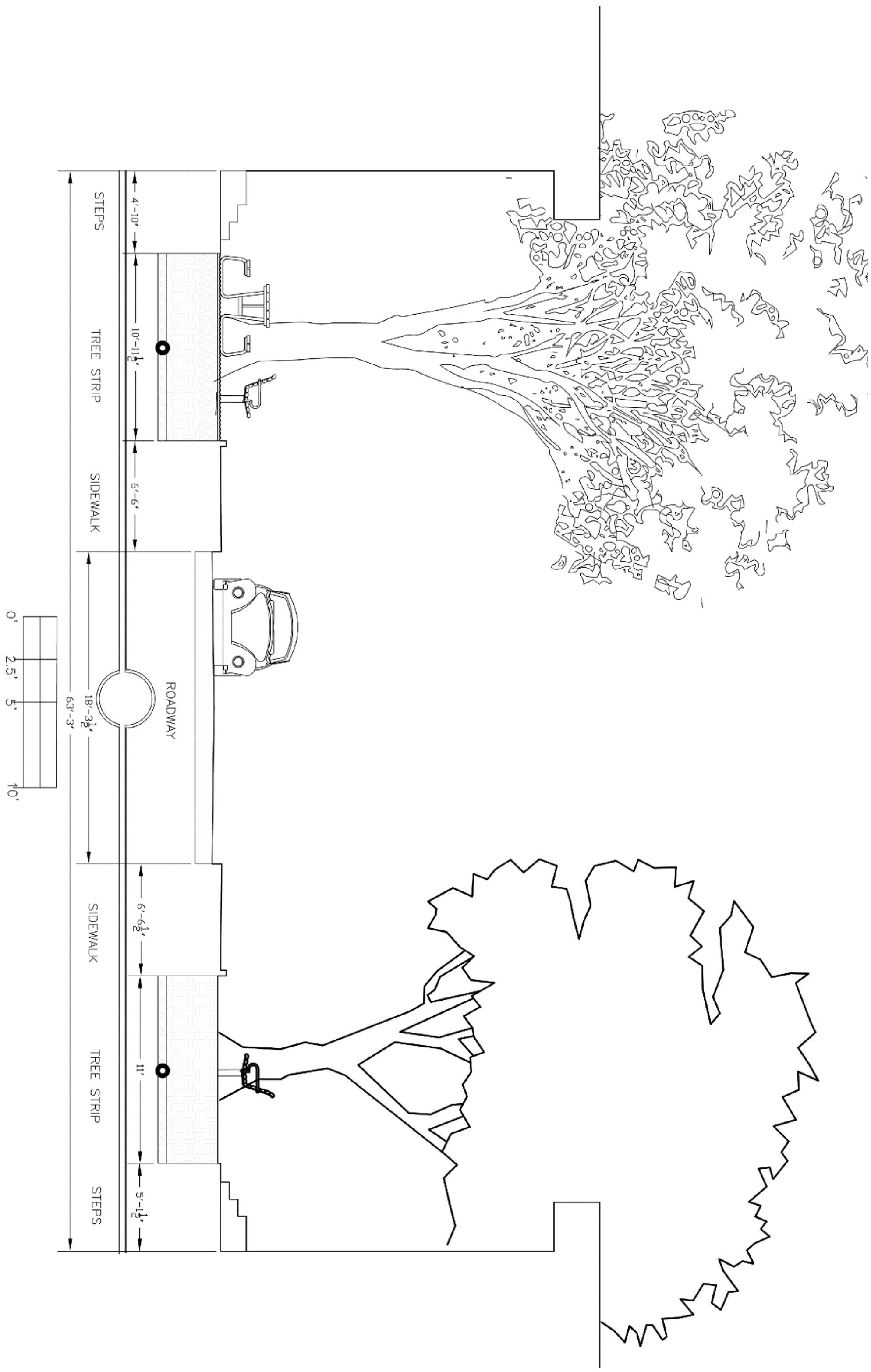


Figure 5.2 James Street private model section

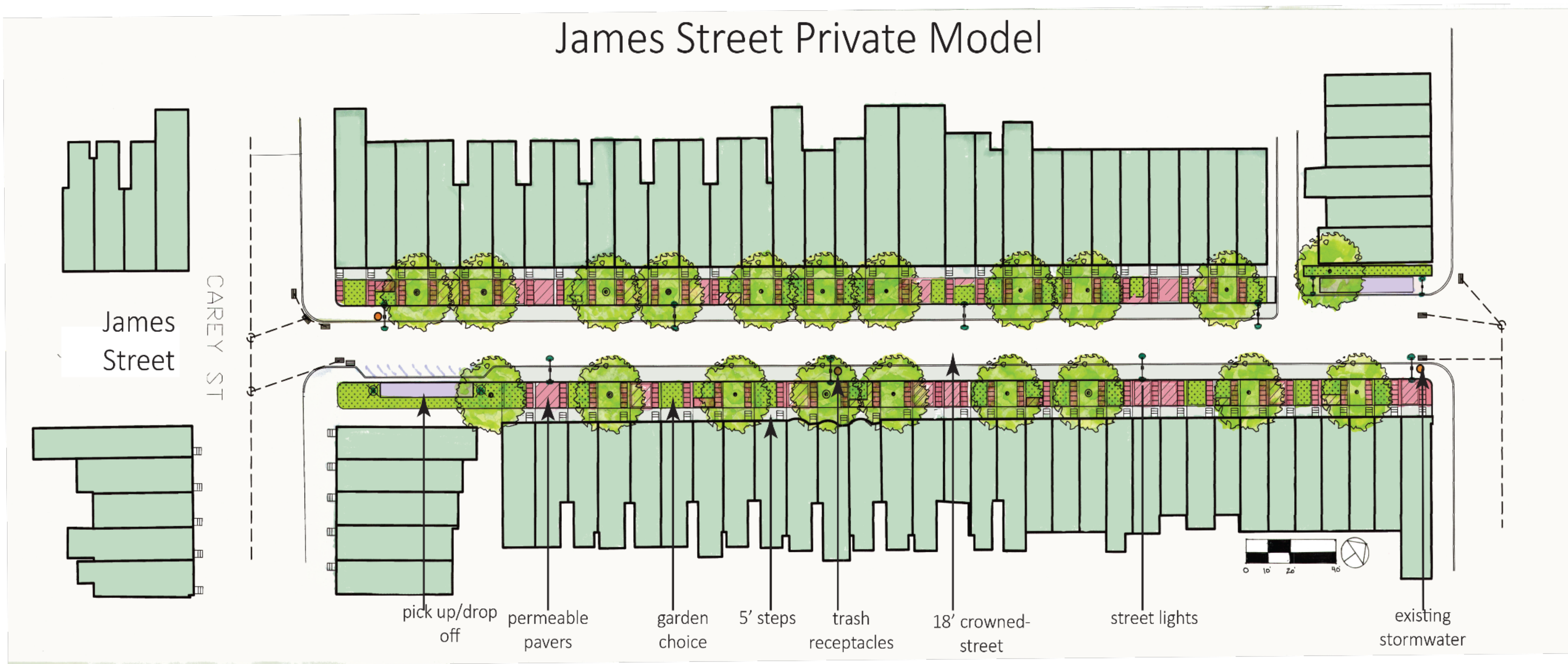


Figure 5.3 James Street Private Model site plan

James Street Private Model

Figure 5.4 Close up Private Model showing choice of tree, patio or garden in front of each home in the CTS

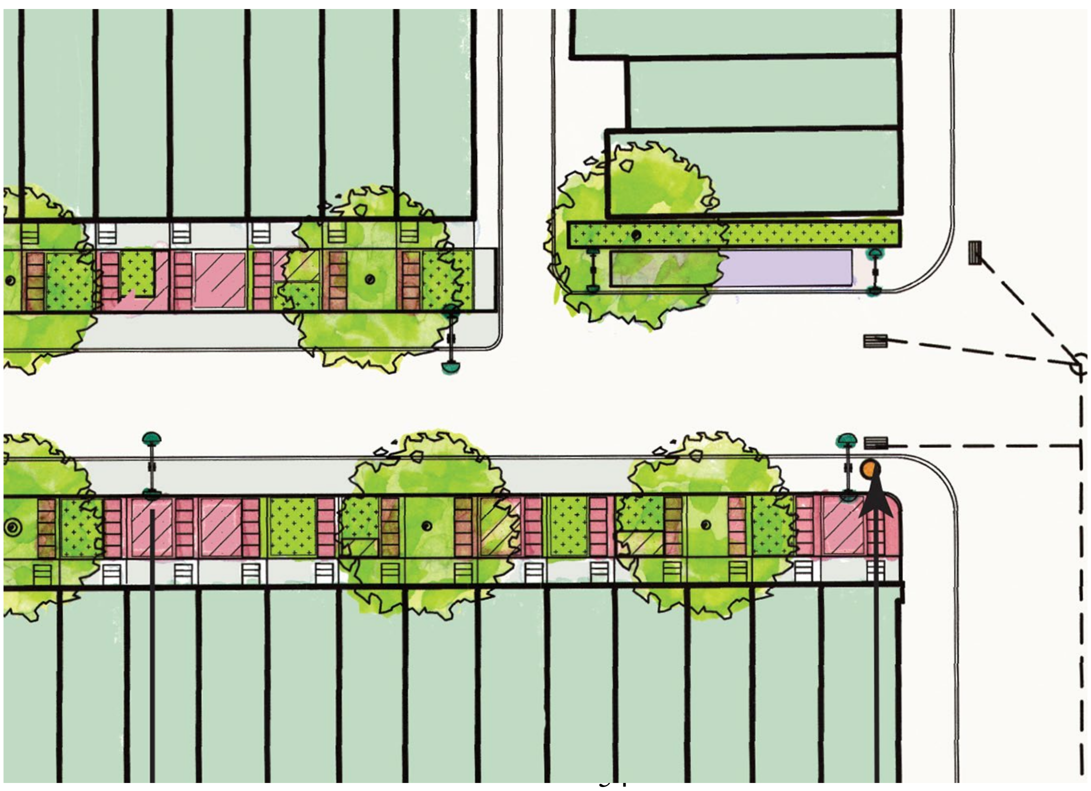


Figure 5.5 Close up Private Model showing streetlamps, trash receptacle, ride waiting area and existing stormwater drains

James Street Private Model

Figure 5.6 Turning onto James Street

Figure 5.7 Looking down James Street towards Carey Street

James Street Private Model

Figure 5.8 Young man enjoying the front yard space

Figure 5.9 Each household chooses between trees, gardens and patios. A tree every 30' is ideal.

James Street – Public Model

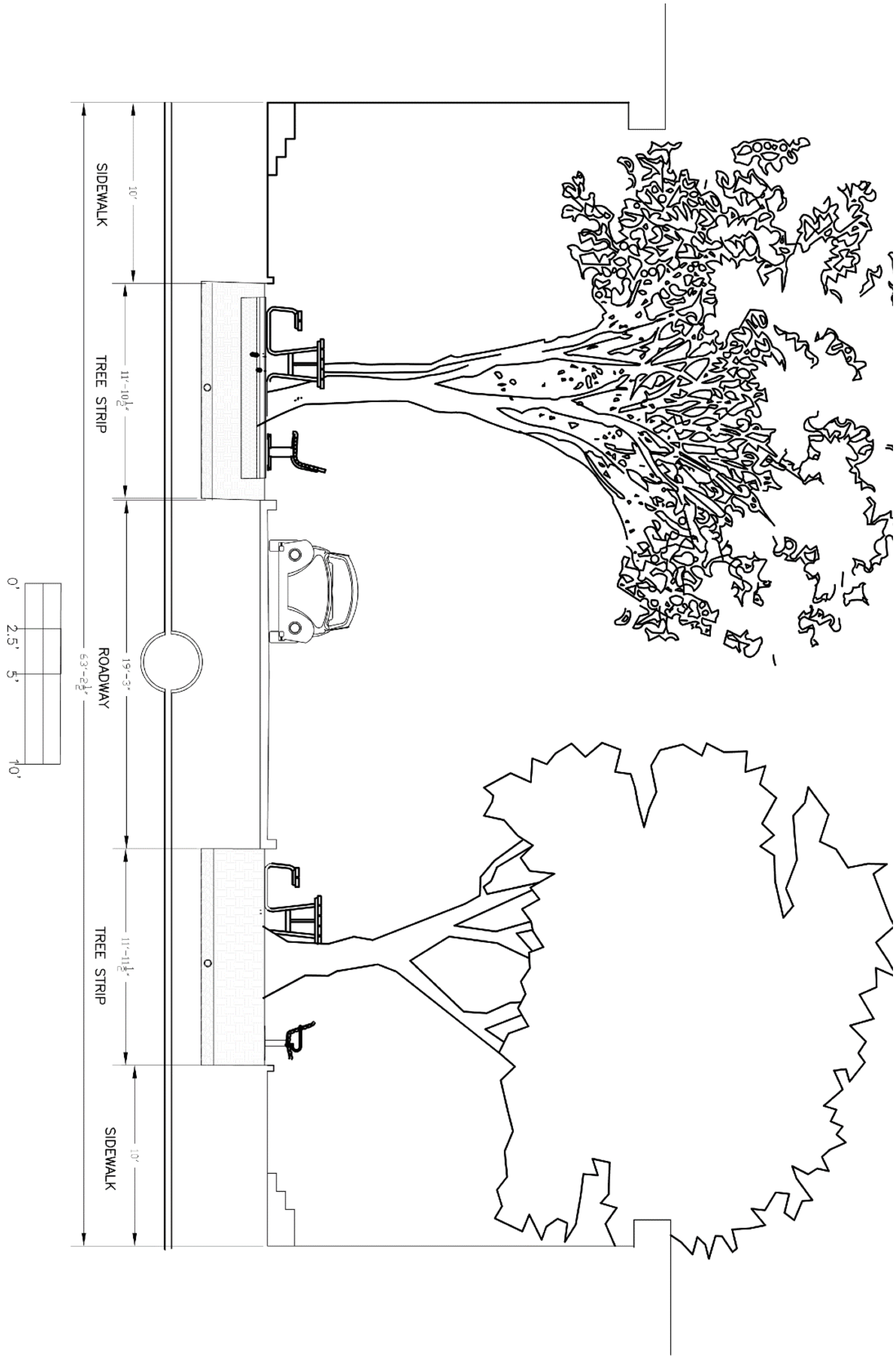


Figure 5.10 James Street Public Model section

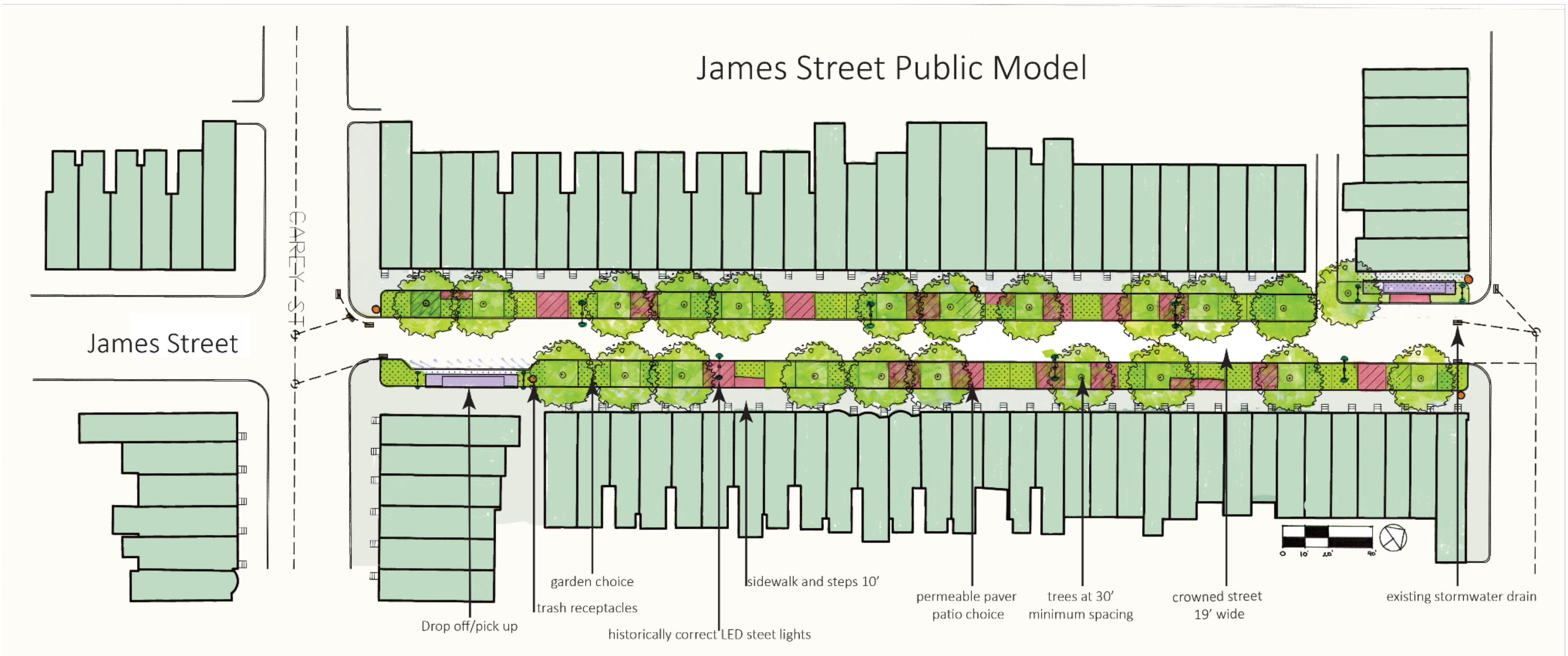


Figure 5.11 James Street Public Model site plan

James Street Public Model

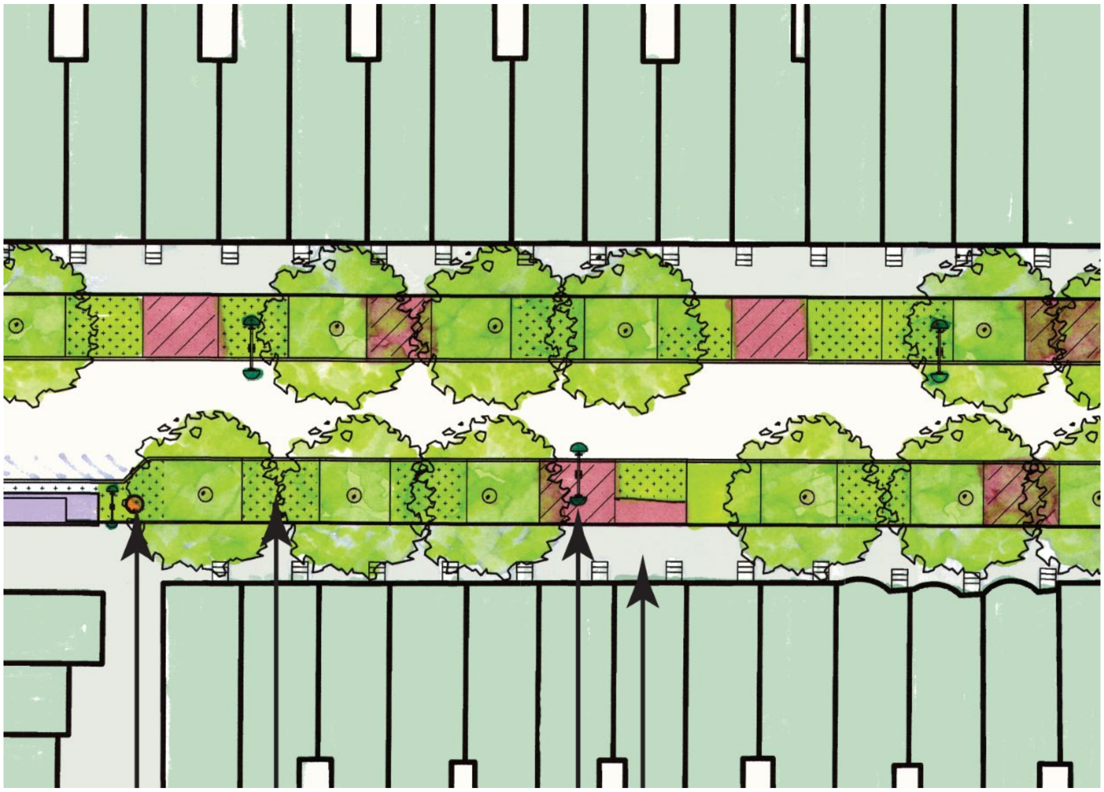


Figure 5.12 Close up Public Model showing trees, gardens and patios placed between the sidewalk and the street

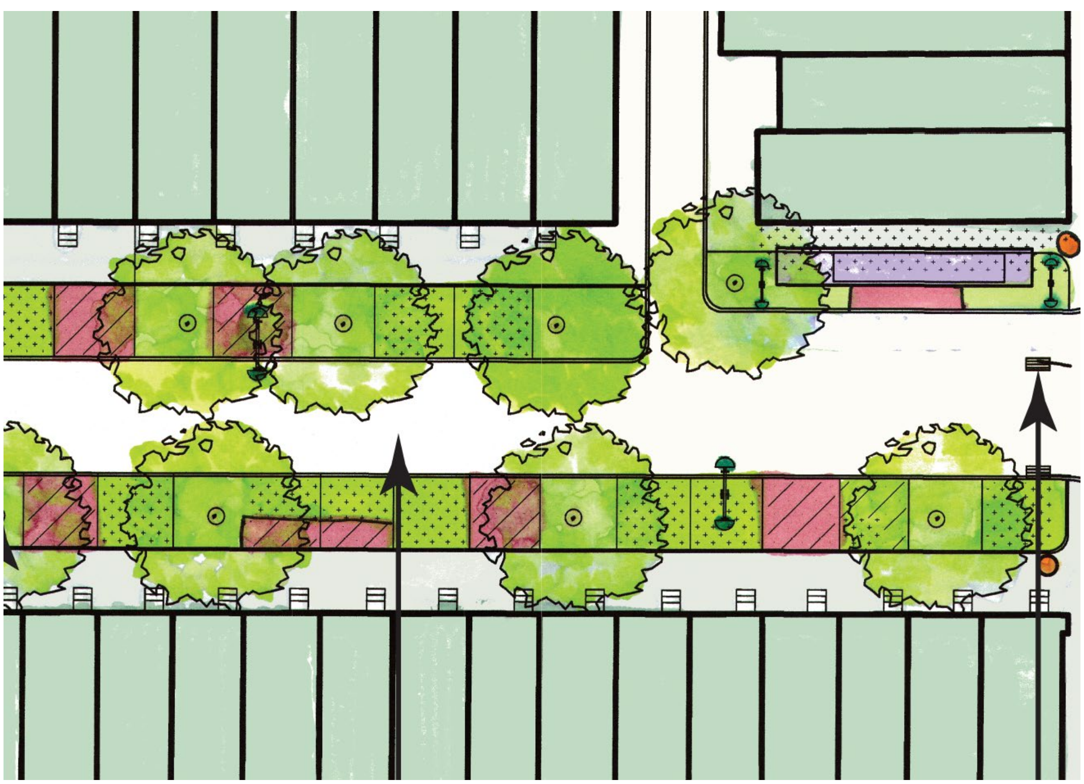


Figure 5.12 Close up Public Model showing light posts, ride waiting area and existing stormwater drain

James Street Public Model

Figure 5.13 James Street showing the tree planting/garden strip constructed between the sidewalk and the street

Figure 5.14 Looking down James Street toward Carey Street

James Street Public Model

Figure 5.15 A view of the more public space across the sidewalk

Figure 5.16 Choices of patios or gardens along with the trees

Sargeant Street – Shared Street Model

Figure 5.17 Existing conditions Sargeant Street

The narrow alley street is the perfect dimension for conversion to a shared street. A shared street is one where the pedestrians and the cars truly share the space. This type of street is designed for low vehicular volume that moves at a creeping speed due to the people, bikes and ball games in the streets as well as the chicane effect of the designed meandering of traffic flow. Signs at the entrance show a shared street symbol with children playing.

This street is 40' wide from building to building. The design for this street starts with creating a single paving surface that includes all the surface area between the bottom of the steps on each side of the street. This surface treatment removes the differentiation between pedestrian and vehicular space. The center of this surface is modestly depressed as a drainage channel. The area immediately adjacent to the bottom of the steps has a 5' wide "protected" space demarcated by bollards spaced every 20' and 16' tall streetlights spaced at 2.5x the height.

Three sections of 10.5' wide continuous tree planting strips are placed along the block of shared street in an alternating pattern that creates the chicane effect. The CTS is designed and constructed in the same manner as in the James Street model at 2" below street surface grade.

This model design leads to a more public space feeling of the streetscape. The CTS is shared between the trees and the park-like amenities to be used by the residents as an extension of their homes and as a place for play zones. The paved surfaces of the CTS are permeable pavers supported by units of suspension system where needed. Stormwater from the steps and protected areas is directed to curb cuts in the CTSs.

The residents are fully involved in the design phase of this model as well. Choices are made from the amenities available for installation between the trees planted at 30 feet intervals. Residents who elect garden spaces are given the same planting guidelines as in the James Street models. Other choices include picnic tables, table and chairs, benches, grills, swings, boulders for sitting and climbing and anything else that would add to the social space where residents can gather. An amenity for summer is a small water play area mid-block where the excess water is captured in a cistern.

Shared Street Model

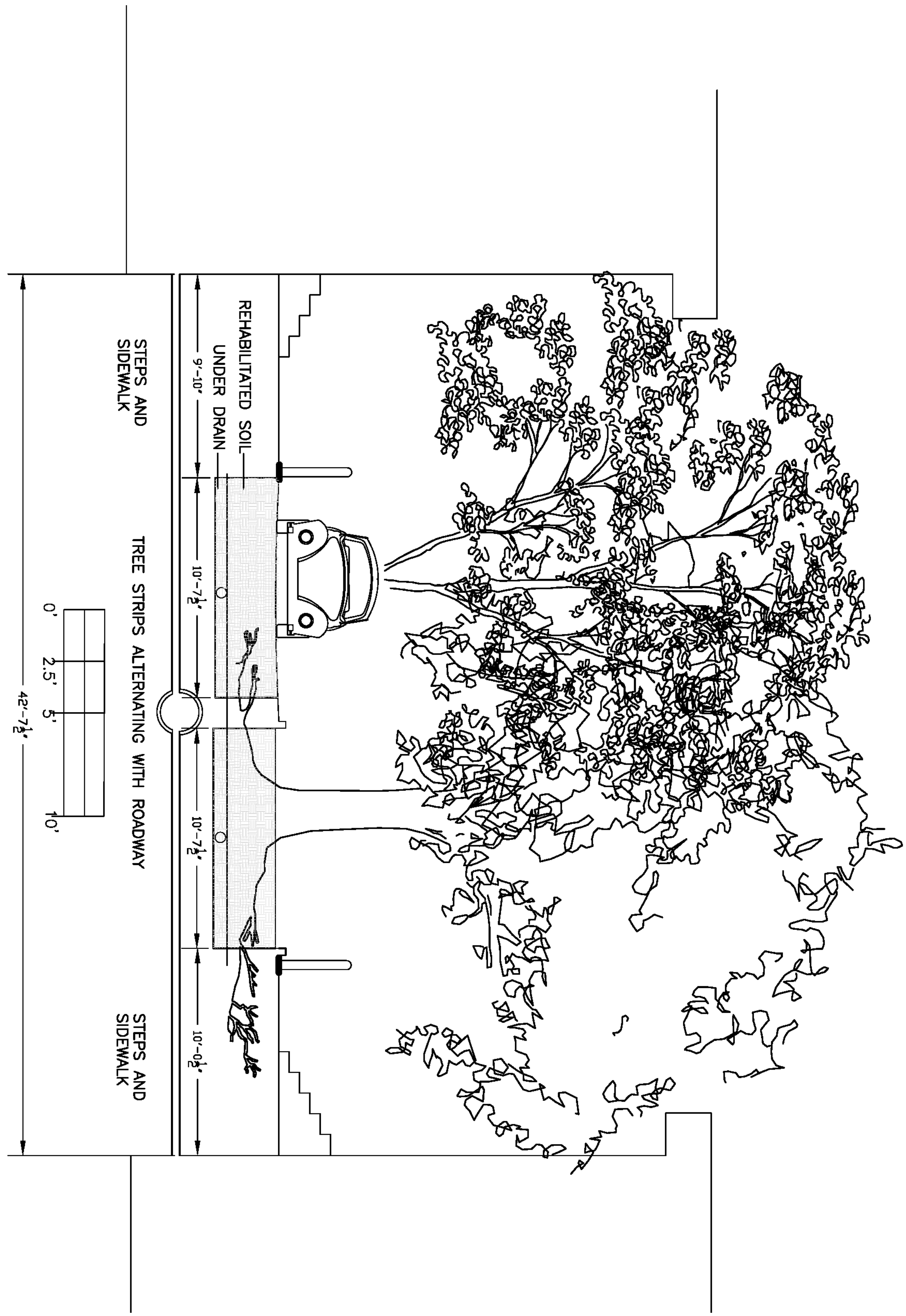


Figure 5.18 Shared Street Model section

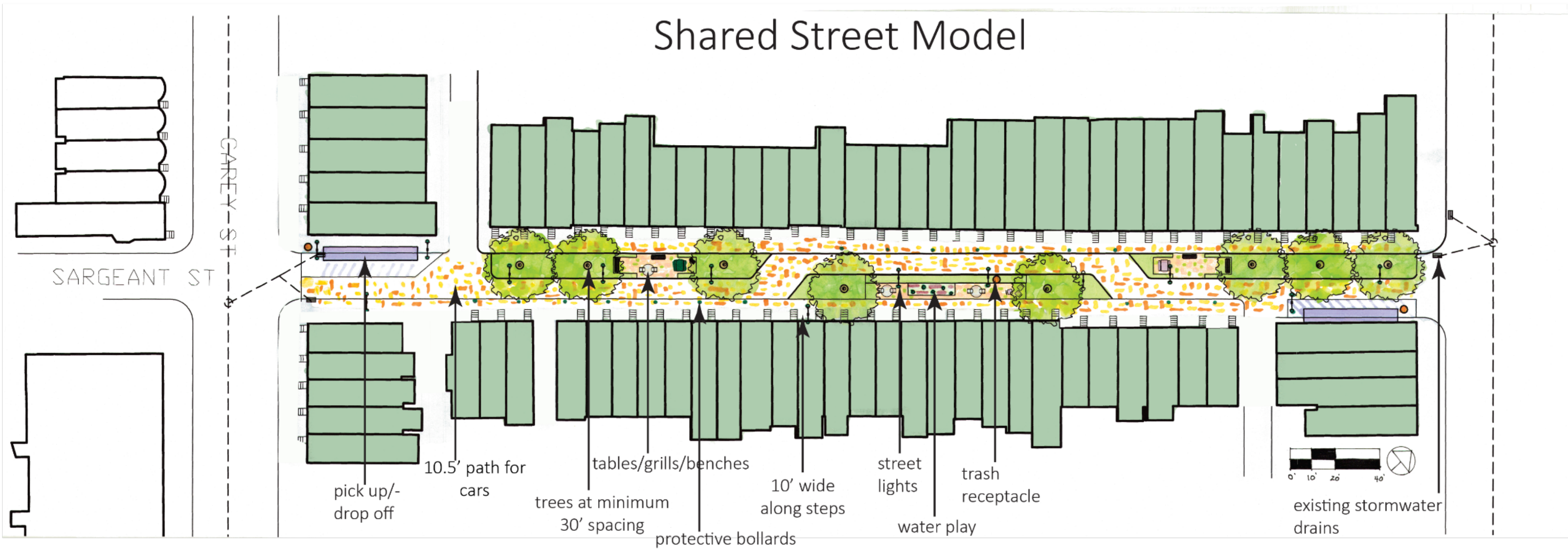


Figure 5.18 Shared Street model site plan

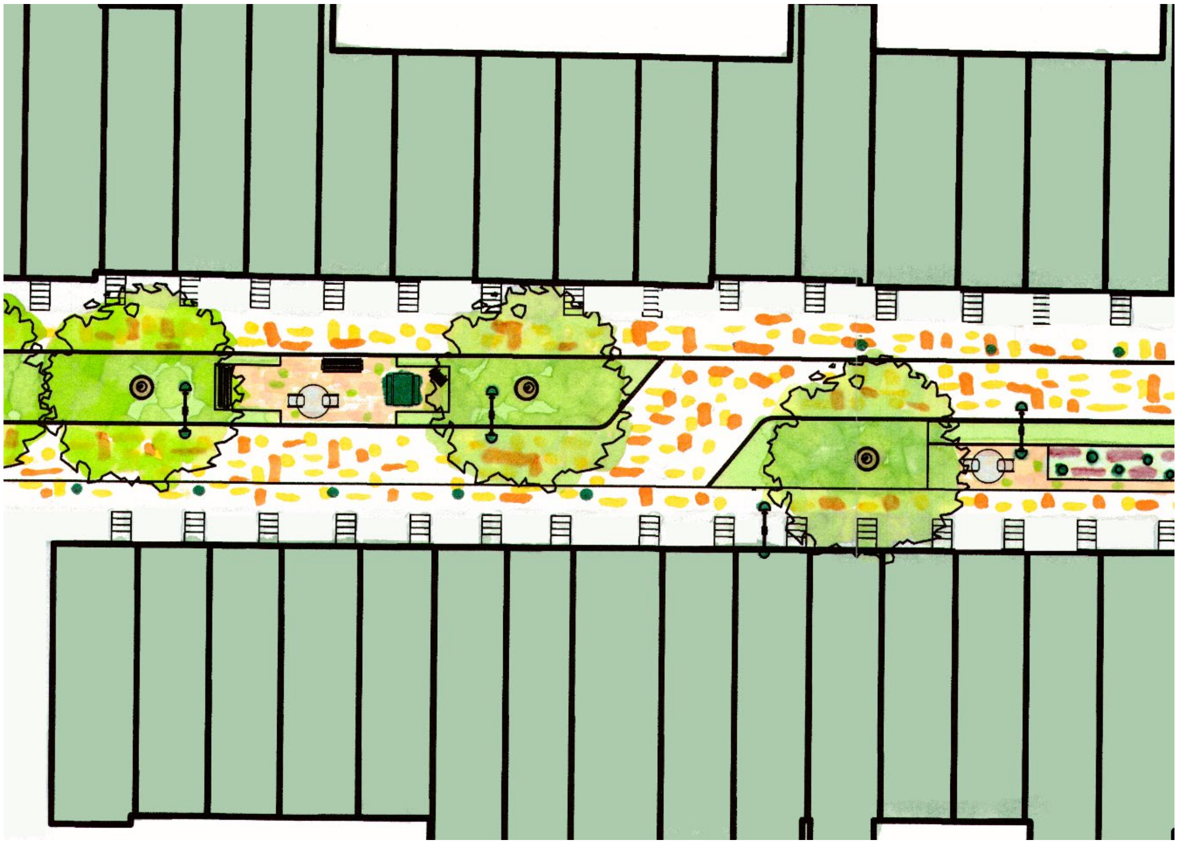


Figure 2.19 Close up Shared Street Model showing tree strips, public areas and meandering road

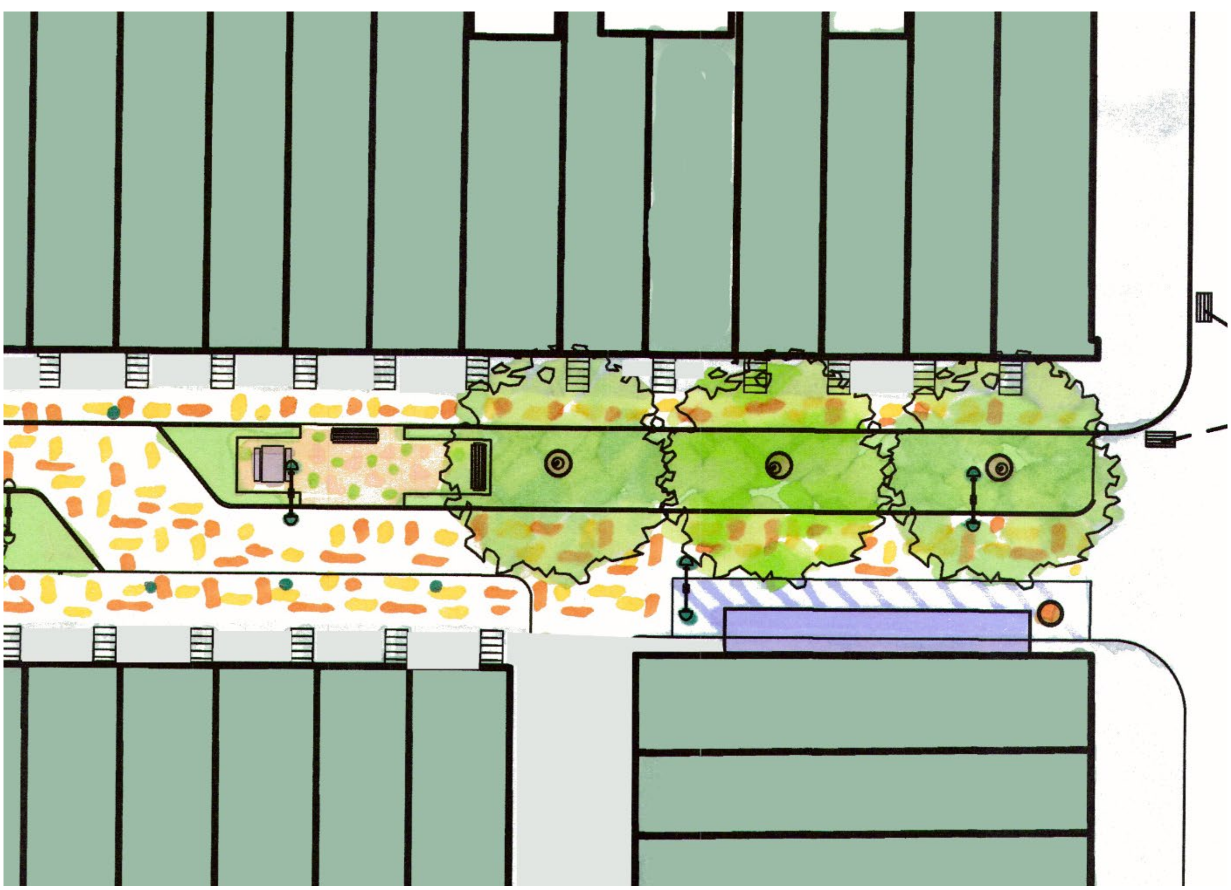


Figure 5.20 Close up Shared Street Model showing ride waiting area, trash receptacle and tree planting strip

Shared Street Model

Figure 5.21 The shared street model provides space for trees and people

Figure 5.22 View of the Shared Street garden spaces

Shared Street Model

Figure 5.23 View from the communal picnic area

Figure 5.24 Water play area on shared street

Plant Recommendations

The residents have a choice of trees to plant in their CTS. The trees included are on the existing Baltimore street tree approved list (see appendix 5.1) and limited to Mid-Atlantic natives and the beloved Ginkgo. Small native shrubs are listed as well as the native grasses, perennials and sedges that make excellent substitutes for turfgrass.

TREES	SIZE IN FEET	SHRUBS	FORBS	PERENNIALS
Cladrastus kentukea	25	*Cornus racemosa*	*Agrostis perennans*	*Baptisia australis*
Acer rubrum	60	*Aronia melanocarpa*	*Carex sp.*	*Allium cernuum*
Ostrya virginiana	25	*Callicarpa Americana*	*Panicum virgatum*	*Anemone canadensis*
Carpinus caroliniana	35	*Ceanothus americanus*	*Schizachyrium scoparium*	*Asarum canadense*
Magnolia virginiana	30	*Clethra alnifolia*	*Sorghastrum nutans*	*Asclepias tuberosa*
Nyssa sylvatica	30	*Fothergilla gardenia*		*Chrysogonum virginianum*
Ginkgo biloba (male only)	50	*Hypericum densiflorum*		*Coreopsis tripteris*
Quercus bicolor	50	*Itea virginica*		*Geranium maculatum*
Quercus coccinea	50	*Lindera benzoin*		*Heliopsis helianthoides*
Gleditsia triacanthos var. inermis	60	*Morella pensylvanica*		*Heuchera Americana*
Aesculus pavia	25	*Rhus aromatica*		*Liatris spicata*
Quercus phellos	50			*Lobelia siphilitica*
Taxodium distichum	50+			*Monarda bradburiana*
Tilia tomentosa	50			*Packera aurea*
Ulmus americana DED	70			*Penstemon digitalis*

Chapter 6: Maintenance plan

Neighborhood certified streetscape caretaker

Directives for the care and maintenance of public green space often seem to be last-minute addenda to the planning and installation documents. Public places created by community volunteers face even more challenging issues when the municipality is not obligated to help care for the new parks and gardens. In the James Street Private Model described in this paper, trees and gardening spaces are adjacent to the front of the homes and will be perceived as being part of the home's property. The other two streetscape models presented in this paper have more public-facing space. This maintenance plan provides for the ongoing care for this Enhanced Streetscape District (ESD).

Young people in the neighborhood who might not be immediately college-bound may opt for vocational educational options. Traditional studies in automotive repair, medical assistantship and culinary skills have been available through the public-school system. A basic landscape maintenance curriculum will be offered to high school near-graduates that would include mastery of young tree care, garden maintenance, the use, caring and repair of gardening tools, and the ability and knowledge to teach homeowners these skills. Summer internships in the field will provide the skills to complete a Certificate Degree in Landscape Maintenance.

These certified gardeners are to be hired as streetscape caretakers and assigned to 10 residential blocks in the ESD as their domain. Working five days a week, a half-day a week is devoted to each block in the ESD. Responsibilities include providing water and watering young trees in their first 3 years as well as other green spaces during droughts, removing litter, weeding and judicious pruning, replacing plants as needed, mulching yearly, snow removal, and loaning and repairing tools. Any homeowner who chooses to be responsible for their own garden space is encouraged to do so, with coaching and oversight by the streetscape caretaker. Spring and fall planting is facilitated by making plants available to the homeowners and providing advice. Garden competitions and garden tours will add to the pride and efforts of the ESD.

Each certified streetscape caretaker is supervised by an arborist assigned to that neighborhood, with advice available from horticulturists and designers as needed. Neighborhood employment, as well the ongoing care of the streetscape, makes a perfect answer to the maintenance concerns of the city as well as the residents of these new green spaces.

Funding and supervision

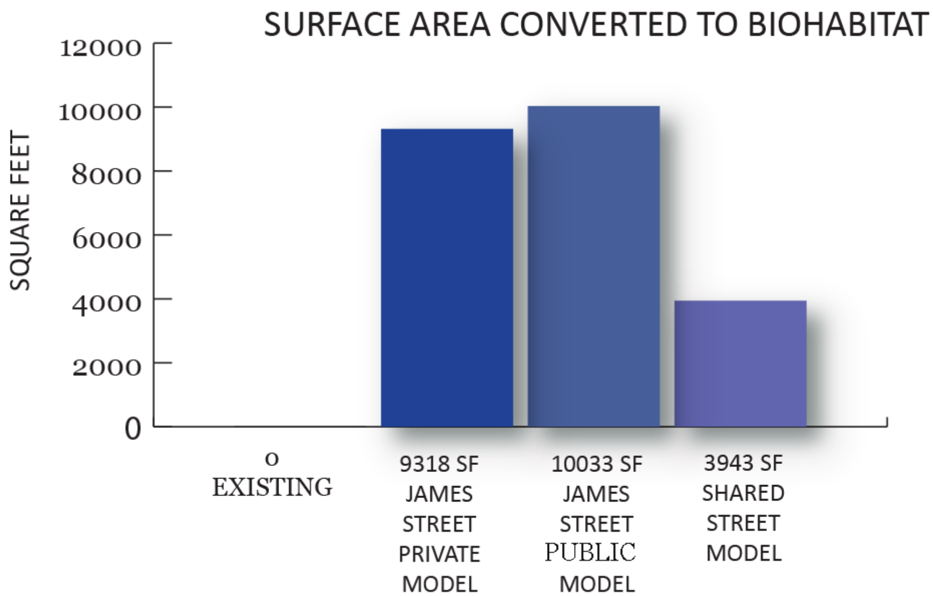
The city will create the ESD. All homeowners within the district will pay an annual fee to be used to establish and fund the Resident Maintenance Association (RMA). All paying homeowners and residents will be members of the RMA and will elect a governing board. The City will provide materials and tools to the RMA as well as employing the neighborhood arborists and horticulturists required for supervision. The RMA will hire the Certified Streetscape Caretakers and will oversee the summer training landscape maintenance programs. Storage of RMA-owned tools and bookkeeping will the responsibility of the elected board until such time as the RMA is large enough to rent a house in the ESD that is to be developed as a community gathering place. The City will audit the RMA yearly to evaluate its fiduciary efficiency as well as the status of the streetscape.

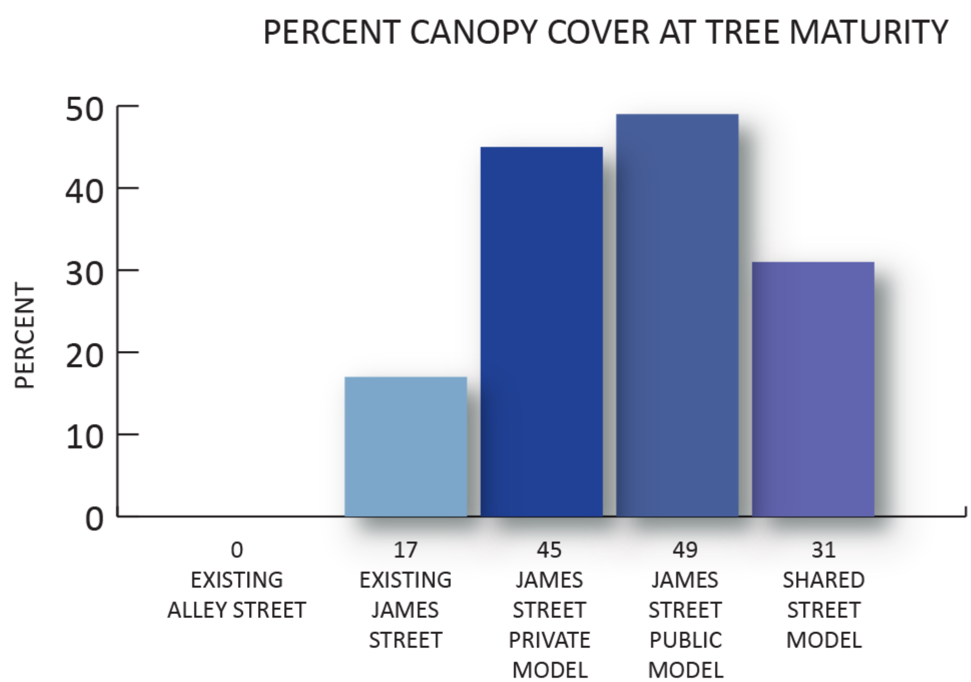
Chapter 7: Metrics, Discussion and Lessons Learned

Metrics

An assessment of the value of added trees allows the designer and the public to evaluate the cost/benefit ratio of adding trees to the landscape. The USDA Forest Service sponsors i-Tree Design, a design tool that calculates tree benefits. (USDA Forest Service 2017) The net atmospheric CO2 that will eventually be sequestered by the addition of street trees will only begin after the trees have aged in place for many years. i-Tree Design predicts more immediate CO2 savings by positioning trees near buildings. After 20 years, the 22 new James Street 3" caliper trees will have grown to 75% of their final canopy diameter. I-Tree calculates that heating and cooling reduction from these 22 new trees will result in 13,750 pounds of CO2 avoided yearly. In today's environment, one person's normal automobile driving habits creates 11,000 pounds of CO2 per year. Looking from the perspective of the future of sAVs running on renewable energy, each block of new trees, repeated all over the city, will eventually contribute to both significant carbon sequestration as well as carbon savings.

Calculating surface area converted to biohabitat in the CTSs was accomplished using AutoCAD measuring tools. Tree canopy cover was estimated by using predicted canopy for the street trees planted. Graphs depicting these statistics are presented on the next page.


SURFACE AREA CONVERTED TO BIOHABITAT
SQUARE FEET
12000
10000
8000
6000
4000
2000
0
0
EXISTING
9318 SF
JAMES
STREET
PRIVATE
MODEL
10033 SF
JAMES
STREET
PUBLIC
MODEL
3943 SF
SHARED
STREET
MODEL


PERCENT CANOPY COVER AT TREE MATURITY
PERCENT
50
40
30
20
10
0
0
EXISTING
ALLEY STREET
17
EXISTING
JAMES
STREET
45
JAMES
STREET
PRIVATE
MODEL
49
JAMES
STREET
PUBLIC
MODEL
31
SHARED
STREET
MODEL

Discussion of goals successfully met

Tree Goals

Adding more urban trees to a stark and almost treeless environment is a major ambition of this project because the roles trees can play in safety and security, physical surroundings, social relationships and health of the residents of Pigtown. The models illustrated in this thesis accomplish this ambition by designing continuous planting strips and specifying planting guidelines that will allow trees to grow to maturity. These strips provide generous, decompacted soil volumes for tree roots, a place for stormwater infiltration, an emerging biohabitat, a welcoming space that invites stewardship and a well-defined maintenance plan.

Enhancing Quality of Life Goals

1. Safety and Security
    - More trees in an urban area is associated with less crime. (Troy, Morgan Grove, and O'Neil-Dunne 2012)
    - Adding a variety of trees, perennials and forbs will add to the biodiversity of Pigtown. Ecosystem health is dependent on biodiversity.
    - Traffic lanes are narrowed and sidewalks are widened creating a safer street. The shared street allows activities to share the street with vehicles.
    - A more pleasant street should reduce vacancies and associated crime.

- Citizens gardening or using their patios allows “more eyes on the street.”

2. Physical Surroundings
    - Trees provide cooling and wind breaks to lower energy bills.
    - Trees infiltrate, clean and absorb stormwater.
    - Wider sidewalks and CTSs separate homes from the traffic
    - The beautification of the street encourages more time spent outdoors.
3. Social Relationships
    - The garden space created can be a shared activity among neighbors, with shared knowledge, tools, and pride helping to create a community spirit.
    - Each occupant of the street will need to be involved in the design of the space in front of their house. This shared endeavor may foster community spirit.
    - The design involvement of the citizens should also engender a shared stewardship of the trees and gardens.
    - The added transitional space created by the CTS and added amenities will increase the opportunities to have social interactions with neighbors and other friends. Residents and guests will have more room for sitting and lingering.
    - Wider, unobstructed sidewalks allow for easier commutes to school, shopping or church.
4. Health
    - Trees add to the health of the residents by reducing heat, decreasing particulate air pollution, and cleaning stormwater before it enters the streams.

- Mental health and stress can be improved in a greener environment.
- Safer streets will reduce accidents and injuries for pedestrians and bikers.
- New street design provides for outdoor exercise, playing in the street and gardening.

Lessons learned

It could be argued that by the time the opportunity to implement these design models and the additional twenty years needed for the trees to mature, the housing stock on this street will need to be replaced. Even if this is true, the creation of these design models is an exercise in understanding how the built environment can impact a resident's quality of life. These models are addressing the four components identified as important in human well-being by adding trees that will have longevity, by adding "soft edges" to the home with places to relax and socialize and by adding amenities to encourage social interaction and safe recreation.

The two James Street plans have relative strengths and weaknesses. The Private Model, with the CTS closer to the house may, be perceived as a front yard. If the city requires the homeowners to undertake the care and repairs of this space, then consideration should be given to request an abandonment of the ROW for this area. The trees planted in those spaces will be within 10 feet of the building and might limit the size of the trees chosen for that location. Each home needs a path to cross the CTS and thus reduces the usable space. In addition, those homes that face north will have more shade on the gardens that are close to the house.

The Public Model allows for trees of any size and is the better model for reaching full canopy. However, the homeowners may have less sense of ownership for a garden or patio across the sidewalk. The necessary participatory design planning is a way to involve the residents early to foster this sense of ownership. Having your own garden along the CTS is a way to foster the stewardship required.

The Shared Street model is one that is most unfamiliar to the residents but also has the most potential for improving quality of life on that block. Because the design creates a small park in the street, it may be so successful that visitors arrive uninvited. Rules governing access and activities will likely need to be created and enforced.

Greening and beautification are often considered a preamble to gentrification. Because the benefits of improved property values are not equitably shared, renters will be disadvantaged. In addition, the history and core community of an area can be lost when a neighborhood becomes desirable to people outside the traditional society. The single-family historically preserved small homes in this neighborhood may become attractive to wealthier people interested in living near the city core. An emerging approach to curtailing lower-income residents from being dislocated is the creation of community land trusts. ("A Surprising Tool to Slow Gentrification: Land Trusts" 2015) This is a tool that allows residents as a group to purchase the properties with grants, tax credits and investments and then set prices for rent that remain affordable into perpetuity – even if the property is sold.

Next steps

City planners are studying models and proactively planning for the transition from private car ownership to sAVs. Thinking of how to utilize the parking lanes along a rowhome street is a valuable exercise. Municipal street projects often take 6-10 years to move from planning to completion. (personal communication, Valorie LaCour, Baltimore City Department of Transportation). A 30 year lead time to plan is only 3 cycles of projects.

The following questions generated by this project deserve further investigation.

1. Do 10'-12' wide continuous tree planting strips provide the environment needed for urban trees to grow to an unrestricted maturity? Will the lack of good soil along the entire root periphery impair growth?
2. After Scoop and Dump, does the rehabilitated urban soil need to have more intervention to become biologically active? If field grown trees are harvested and planted B&B, are enough microorganisms and mycorrhizae brought into the new environment? Should additional soil gathered from areas around the now detached peripheral feeder roots be brought along with the tree to help create a biologically active soil? Are other additives like biochar beneficial?
3. Could a low-income neighborhood high school create a streetscape caretaker curriculum? Would enough young people see professional gardening as a respected profession? Professional gardeners are a rare but necessary commodity in a world where replacing lawns with native plants and vibrant habitats is the right thing to do.

In conclusion, the streetscape models proposed in this thesis significantly increase the urban forest and enhance the quality of life of the urban citizen. These intertwined goals will add not only to the health and safety of the individual, but also will add to the health and safety of the community and our endangered planet.

Appendices

2.1 The future of Autonomous vehicles

Some planners are fearful that these shared autonomous vehicles (SAVs) will be so reliable and inexpensive that riders will forego public transportation and crowd more of these AVs onto the streets. Anticipation of the demand for the SAVs and proposed restrictions and limits are being debated around the world. If the municipal and transportation planners can stay ahead of this technological advance, put rules and financial incentives firmly in place, the best-case scenario might be possible.

Predicting the years to move to 100% AV uptake was the subject of an award-winning article presented at the 2016 Australian Institute of Traffic Planning and Management Incorporated Conference.(Spinoulas, Anabelle & Davidson, Peter) The research described by these authors focused on the building of a model to determine the likely rates of uptake for AVs and to predict what year we can expect 100% AV. This new model also was the first to consider the impact of single-occupant and multi-occupant shared AVs on overall car ownership and parking requirements. The model used in this study predicts that the fleet of cars will be all AV by 2046.

Some assumptions are made regarding the AVs:

- The value of the time spent in the car will change because the time will be spent doing other activities
- AVs will most likely be plug-in-electric and therefore cost less to drive
- Lower costs and simplified parking will create more trips and will allow non-drivers (children, elderly and handicapped) to use the AVs
- The technology will eventually allow faster travel at higher density
- AVs may be sent home to park or shared among family members, potentially increasing congestion
- If mobility-as-a-service (MaaS) (like a driverless Uber or Lyft) is embraced, then automobile ownership will decrease, and transportation costs will have a different structure than upfront ownership and maintenance.

Overall trip rates will increase by 10% in 2036 and 15% in 2046. Analysis suggests there will be a reduction of 50% - 75% of the current operating costs if the fleet of AVs are electric. The problem of unoccupied vehicles driving around (going elsewhere to find cheaper parking or just driving around while you shop) is behavior too complex to model, claim the authors. They are suggesting regulations and road pricing approaches. A most intriguing idea discussed in this paper is mobility-as-a service (MaaS). This concept merges the driverless taxi used to transport a person to the transit hub on either end of their trip. Payment for the entire trip could be coordinated. Costs and congestion would fall even steeper if riders would agree to sharing rides in the AVs.

Wide-ranging economic effects are predicted with the adoption of AVs. (Clements & Kockelman, 2017) The authors write,

> "AVs may set off a revolution in transportation on a grand scale across nations and continents." (p106)

This article looks carefully at the economic effects of wide adoption of autonomous vehicles (AVs) on many industries by "synthesizing the literature and evaluating cost and sales changes." Morgan Stanley has estimated that the potential value of connected AVs will be as much as 8% of the entire US gross national product. The industries analyzed include:

- Automotive (fewer vehicles if shared AVs with less hardware – more software)
- Electronics and technology
- Trucking - Economic gains of driverless trucks would increase because savings in fuel, time and use of convoys.
- Personal transport - There is a potential decrease demand for mass transport. On-demand shared AVs would best be used for the "first mile/last mile scenario where efficient public transit can continue to operate. Currently, ridesharing aps have decreased taxi use by almost 7%.
- Auto repair
- Medical - Fewer ER visits from automobile accidents and fewer organs to transplant
- Insurance - much less need
- Legal profession - decrease liability claims
- Construction and infrastructure - fewer parking lots, smaller roads but plenty of opportunity to retrofit the old parking lots and garages
- Oil and gas
- Land development
- Driver's education

In some US cities, parking lots and garages cover more than one-third of the land area. Vehicle sharing will keep vehicles in more constant use and decrease parking demand. Land previously used for parking could be used for additional housing or parks. Putting a value on the land used for parking, it is estimated that if the parking demand decreased by just 1% each year, $45 billion in property value will be freed annually.

Kondor et al. (2017) conducted a study to add to the understanding of potential changes in parking demand as private car ownership moves to shared autonomous vehicle (SAV) systems. After an introduction reviewing the amount of space currently used in cities to park cars and the potential benefits of shared autonomous cars, as well the previously published work on this topic, the authors describe their methods. In Singapore, over one million telephone records were analyzed to show the general location of home and work for a model that simulated scenarios that compared private cars with no shared parking to shared self-driving vehicles and evaluated the need for parking.

The results of this complex modeling study predict that the demand for parking will be 52% less compared to everyone having their private parking spots at home and work. In addition, 40% fewer vehicles were required. The issue of where to locate an efficient, less expensive parking facility (cars park inches apart without passengers to exit) where the AV would park when needed, is mentioned briefly.

Principle # 10 of *The Shared Mobility Principles for Livable Cities* (www.sharedmobilityprinciples.org), developed by a coalition of cities, NGOs, academic institutions, and businesses, states, "Autonomous vehicles must be shared in dense urban areas." The strategic importance of this principal is because the adoption of privately owned AVs would have monumentally adverse effects by allowing AVs to roam the streets empty or commute from far suburbs. This would decrease the use of public transportation, increase overall travel and encourage suburban sprawl, whereas shared AVs, on the other hand, will lead to decreased travel and congestion. A mixed fleet of single and multi-occupied AVs will lead to the best safety, lowest costs and could, with the right financial incentives, create a synergy with the existing public transportation system. Adoption of SAVs may have as much "transformative effect on urban environments" as did trolley cars and automobiles in the early 20^{th} century. (Kondor et al., 2017, p. 12)

2.2 Greenspace inequity

Access to urban parks is a topic of interest to those investigating the social inequities of green space. Rigolon (2016) completed a review of the literature that looked at access to urban parks by assessing not only proximity but also acreage and quality of the parks. Forty-nine papers were identified and analyzed to determine if there is a trend or consensus among the articles about the accessibility of urban parks compared to socio-economic status (SES) and racial/ethnicity.

Three parameters were evaluated that would influence the accessibility of parks. The first is proximity: the distance from a neighborhood or the possibility of walking to a park. Second is park acreage or park acres per resident or per child. Third is the park quality**:** amenities, maintenance, crime safety, playgrounds, tree canopy and park aesthetics.

The results of the analysis showed that in most articles African American and Latino persons lived in closer proximity to inner city parks than white persons. In terms of park acreage, most of the studies clearly showed fewer parks or fewer acres of parks in low-SES and ethic/racial minority locations. Most studies in the review that focused on quality examined the quantities and types of park amenities. These articles showed advantages for white and affluent neighborhoods. Lower maintenance levels and more crime safety issues were found in areas of low SES people of color.

The distribution of urban forest in Milwaukee was evaluated by Heynen et al.(2006). The authors of this study analyzed the distribution of the urban forest of Milwaukee from aerial photography and how it related to ethnic and racial data from the United States census. In addition, 29 in-depth interviews were conducted with people involved with the urban forest management. The results showed that only 7.1% of Milwaukee is covered by canopy and only 4.3% of that is street trees that are managed by the city. There was a positive statistical correlation between census tracts with higher median household income and lower vacancy rates and the canopy cover. At publication in 2006, Milwaukee's nonprofit tree-planting program offered several hundred free trees to residents yearly, primarily to replace those infected with Dutch Elm disease. High income homeowners were the most frequent recipients. The authors conclude that the "distribution of urban canopy cover within Milwaukee should be viewed as a form of injustice requiring amelioration." (p.20)

Baltimore City
Street Tree Species List
3/23/2018

Thank you for your interest in Baltimore City's trees! Please get permission from the Urban Forestry Division before planting a tree in a public right of way. We promise to make this as easy and painless as possible. If a permit is required, it is free. We will add your new tree(s) to the Baltimore City tree inventory, plus we want to be sure you select a species that is appropriate for your location. Here are a few things to consider:

- Native species provide more benefits than non-native species. For larger plantings, at least half should be native.
- We need diversity and prefer a variety of species. For larger plantings, no single species should be more that 20% of the mix.
- Large shade trees provide more benefits than small trees and should be planted where there is room. Please remember, Baltimore's goal is to reach 40% tree canopy cover.
- Some species that are not listed are acceptable. Check with the Urban Forestry Division.
- Minimum size at planting time is a 1 inch diameter trunk. If the planting is part of a construction or development project, or for environmental mitigation, a larger size may be dictated by the applicable regulations.
- Please follow the current City specifications for tree pit size, soil, planting, and maintenance.
- Continued maintenance over several years is key to a successful planting. This includes weeding, mulching and straightening. Routine watering of your new tree is the most important thing that you can do.
- We review the species list and specifications every couple years. Please send your comments, and contact us if you have any questions or concerns.

Urban Forestry Division
Baltimore City Recreation and Parks
3001 East Drive
Baltimore, Maryland 21217
410 396-6109
http://treebaltimore.org/
Search for "Baltimore City Forestry Division"

For this list, native is a regional term. For example, Red Maples and Sweet Gums weren't orininally found in Baltimore, but are termed native because they grew in Maryland. Hybrids, redwoods and ginkgoes aren't defined.

Small Street Tree Species for Under Powerlines

Common Name	Species	Native Exotic	Spread (feet)	Height (feet)	Comments
Trident Maple	*Acer buergeranum*	E	25 to 30	25 to 30	
Hedge Maple	*Acer campestre*	E	30 to 35	25 to 30	
Amur Maple	*Acer ginnala*	E	20 to 25	20 to 30	
Three Flower Maple	*Acer triflorum*	E	20 to 30	20 to 30	
Shangtung Maple	*Acer truncatum*	E	20 to 25	20 to 25	
Red Buckeye	*Aesculus pavia*	N	15 to 25	25 to 30	
Shadblow Serviceberry*	*Amelanchier canadensis*	N	15 to 20	20 to 25	
Allegheny Serviceberry*	*Amelanchier laevis*	N	10 to 15	15 to 25	
Eastern Redbud	*Cercis canadensis*	N	15 to 25	20 to 30	Overplanted and short lived, consider alternative species
Fringetree	*Chionanthus virginicus*	N			Only one known case of attack by EAB, continue to review.
Kousa Dogwood*	*Cornus kousa*	E	15 to 20	15 to 20	
Cornelian cherry dogwood	*Cornus mas*	E	15 to 20	15 to 25	Tends to be multi-trunk and shrub like

Common Name	Species	Native Exotic	Spread (feet)	Height (feet)	Comments
English Hawthorn	*Crataegus laevigata*	E	15 to 25	20 to 25	Toba' and 'Crimson Cloud' are more resistant to hawthorn rust
Thornless Cockspur Hawthorn	*Crataegus crus-galli var. inermis*	N	20 to 30	20 to 30	Thornless
Washington Hawthorn	*Crataegus phaenopyrum*	N	20 to 25	20 to 35	
Southern Hawthorn	*Crataegus viridis*	N	20 to 30	20 to 30	
Lavalle Hawthorn	*Crataegus x lavallei*		15 to 25	20 to 30	
Crape-Myrtle*	*Lagerstroemia indica*	E	15 to 25	10 to 30	Check cultivar for height and spread
Little Gem Magnolia	*Magnolia grandiflora 'Little Gem'*	N	10 to 15	20 to 30	There are other small, narrow cultivars
Star Magnolia*	*Magnolia kobusvar. stellata*	E	10 to 15	15 to 20	
Sweetbay Magnolia\ Bay Magnolia	*Magnolia virginiana*	N	12 to 20	12 to 20	There are larger cultivars that can reach 50' tall
Saucer Magnolia*	*Magnolia × soulangeana*	E	20 to 25	20 to 30	
Persian Ironwood	*Parrotia persica*	E	20 to 30	20 to 40	'Vanessa' is a columnar form
Chinese Pistache	*Pistacia chinensis*	E	25 to 35	25 to 35	
Flowering Purple Plum	*Prunus cerasifera*	E	15 to 20	20 to 30	
Kwanzan Cherry	*Prunus serrulata "Kwanzan"*	E	15 to 25	20 to 30	Low branches can cause problems
Okame' Cherry	*Prunus x incamp'Okame'*	E	15 to 20	15 to 20	
Yoshino Cherry	*Prunus x yedoensis*	E	30 to 40	30 to 35	
Japanese Snowbell	*Styrax japonicus*	E	20 to 30	20 to 30	
Japanese Tree Lilac	*Syringa reticulata*	E	15 to 18	20 to 30	
Korean Evodia	*Tetradium danielli*	E	25 to 30	25 to 30	Recently reclassified & renamed, was *Evodia danielii*
Blackhaw Viburnum*	*Viburnum prunifolium*	N	8 to 12	12 to 15	
Rusty Blackhaw Viburnum*	*Viburnum rufidulum*	N	20 to 25	20 to 25	

** Due to naturally low or multi-limb structure, these species may only be planted in open wide areas unless trained to a single trunk. Check with the Urban Forestry Division.*

Medium and Large Street Tree Species

Red Maple	*Acer rubrum*	N	25 to 35	60 to 75	Overplanted, consider alternative species
Sugar Maple	*Acer saccharum*	N	35 to 50	50 to 75	Avoid northern cultivars\ avoid in harsh locations
Legacy Sugar Maple	*Acer saccharum "Legacy"*	N	30 to 40	40 to 50	Southern cultivar, avoid in harsh locations
Florida Maple	*Acer saccharum* var. *floridum*	N	30 to 40	40 to 50	Formerly *Acer barbatum*, sugar maple from Florida
Horse Chestnut	*Aesculus hippocastanum*	E	40 to 50		
Armstrong Maple	*Acer x freemanii "Armstrong"*		15 to 25	50 to 60	Overplanted, consider alternative species
Red Maple 'Autumn Blaze'	*Acer x freemanii "Autumn Blaze"*		30 to 50	50 to 60	Overplanted, consider alternative species
Ruby Red Horsechestnut	*Aesculus x carnea*	E	30 to 40	35 to 45	"Fort McNair" shows some resistance to leaf blotch
Allegheny Serviceberry	*Amelanchier laevis*	N	15 to 20	30 to 40	
River Birch	*Betula nigra*	N	25 to 35	40 to 50	Single trunk only. Multi-trunks may be planted in medians.
European Hornbeam	*Carpinus betulus*	E	30 to 40	40 to 60	
American Hornbeam	*Carpinus caroliniana*	N	20 to 35	35 to 50	
Common Hackberry	*Celtis occidentalis*	N	40 to 50	40 to 55	
Katsura	*Cercidiphyllum japonicium*	E	20 to 40	40 to 60	
American Yellowwood	*Cladrastis kentukea*	N	25 to 35	25 to 40	
Turkish Filbert	*Corylus colurna*	E	20 to 25	40 to 50	Nice but not always available
Hardy Rubber Tree	*Eucommia ulmoides*	E	25 to 35	40 to 60	Said to be very hardy and drought resistant
Ginkgo, male only	*Ginkgo biloba (male)*		50 to 60	50 to 75	
Honey Locust	*Gleditsia triacanthos var. inermis*	N	35 to 50	60 to 70	Only thornless varieties (i.e. inermis)
Kentucky Coffee Tree male	*Gymnocladus dioicus*	N	40 to 50	70 to 80	avoid females which drop beans

Common Name	Species	Native Exotic	Spread (feet)	Height (feet)	Comments
SweetGum	*Liquidambar styraciflua*	N	35 to 50	60 to 75	Drops sweetgum balls
'Rotundiloba' Sweetgum	*Liquidambar styraciflua 'Rotundiloba'*	N	35 to 45	50 to 70	Or other seedless cultivars\ large % revert & produce gum balls.
Osage Orange male	*Maclura pomifera*		35 to 60	35 to 60	Thornless males prefered, females produce large solid green fruits
White Shield Osage Orange	*Maclura pomifera "White Shield"*		30 to 35	30 to 35	Male, thornless, smaller
Southern Magnolia	*Magnolia grandiflora*	N	30 to 50	60 to 80	Evergreen
'Henry Hicks' Sweetbay Magnolia	*Magnolia virginiana 'Henry Hicks'*	N	15 to 25	40 to 50	Evergreen \ Smaller cultivar
Black gum \ Tupelo	*Nyssa sylvatica*	N	30 to 40	30 to 50	
American Hophornbeam	*Ostrya virginiana*	N	25 to 30	30 to 40	
American Sycamore	*Platanus occidentalis*	N	50 to 80	80 to 100	
Oriental Planetree	*Platanus orientalis*	E	50 - 60	70 - 80	
Sycamore, all species	*Plantanus spp.*				Check w\ Forestry Division, most sycamore species are acceptable
London Planetree	*Platanus x acerifolia*		50 to 70	70 to 85	
Sargent Cherry	*Prunus sargentii*	E	15 to 20	25 to 40	
White Oak	*Quercus alba*	N	60 to 80	80 to 90	Maryland State Tree
Swamp White Oak	*Quercus bicolor*	N	50 to 70	50 to 70	Establishes well
Northern Red Oak	*Quercus rubra*	N	50 to 60	75 to 90	Avoid in harsh locations
Scarlet Oak	*Quercus coccinea*	N	60 to 75	50 to 75	
Southern Red Oak	*Quercus falcata*	N	60 to 70	60 to 80	
Shingle Oak	*Quercus imbricaria*	N	40 to 60	40 to 60	
Laurel Oak	*Quercus laurifolius*	N	35 to 45	60 to 80	
Overcup Oak	*Quercus lyrata*	N	30 to 40	30 to 40	
Burr Oak	*Quercus macrocarpa*	N	60 to 80	70 to 90	
Chinquapin Oak	*Quercus muehlenbergii*	N	60 to 80	40 to 50	
Nuttall oak	*Quercus nutallii*	N	35 to 50	60 to 80	
Pin Oak	*Quercus palustris*	N	40 to 50	60 to 80	Lower branchs must be repeatedly pruned
Willow Oak	*Quercus phellos*	N	40 to 50	50 to 75	
Chestnut Oak	*Quercus prinus*	N	50 to 70	50 to 70	
English Oak	*Quercus robur*	E	40 to 60	50 to 60	Check cultivar for height and spread
Shumard Oak	*Quercus shumardii*	N	40 - 60	40 - 60	
Oak Species	*Quercus spp.*				Oaks promote biodiversity \ Most species are acceptable
Regal Prince Oak	*Quercus x warei "Regal Prince"*	E	20 to 25	40 to 60	Columnar
Pond Cypress	*Taxodium ascendens*	N	20 to 25	40 to 60	Similar to Bald Cypress with less spread.
Bald Cypress	*Taxodium distichum*	N	20 to 30	50 to 100	Deciduous conifer
Silver Linden	*Tilia tomentosa*	N	40 to 60	50 to 70	
American Linden	*Tilia americana*	N	30 to 45	75 to 90	
Crimean Linden	*Tilia X euchlora*		20 to 30	40 to 60	
American Elm	*Ulmus americana DED* resistant cultivars	N	50 to 70	70 to 90	
Slippery Elm	*Ulmus rubra*	N	30 to 50	60 to 80	
Zelkova	*Zelkova serrata*	E	50 to 60	60 to 80	Overplanted, consider alternative species

Trees for Wide Medians--15' or Wider (all species listed above may also be planted on medians)

Yellow Buckeye	*Aesculus flava*	N	30 to 50	60 to 75	Drops nuts, good for less trafficed areas
Ohio buckeye	*Aesculus glabra*	N	40 to 50	50 to 75	Drops nuts, good for less trafficed areas
Catalpa (southern)	*Catalpa bignonioides*	N	20 to 40	40 to 60	Drops flowers, big leaves and pods

Bibliography

"A Surprising Tool to Slow Gentrification: Land Trusts." 2015. *Grist* (blog). February 13, 2015. https://grist.org/cities/a-surprising-tool-to-slow-gentrification-land-trusts/.

Appleyard, Donald, M. Sue Gerson, and Mark Lintell. 1981. *Livable Streets*. Berkeley: University of California Press.

Baltimore City Health Department. 2017. "NHP 2017 - 54 Washington Village-Pigtown." 2017. https://health.baltimorecity.gov/sites/default/files/NHP%202017%20-%2054%20Washington%20Village-Pigtown%20(rev%206-9-17).pdf.

Bassuk, Nina. 2019. "Urban Soils Remediation and Use of Organic Amendments." 2019. http://www.hort.cornell.edu/uhi/outreach/pdfs/scoop-and-dump-short.pdf.

Battaglia, Michael, Geoffrey L. Buckley, Michael Galvin, and Morgan Grove. 2014. "It's Not Easy Going Green: Obstacles to Tree-Planting Programs in East Baltimore."

"Bell Street Park Shared Street, Seattle." 2016. National Association of City Transportation Officials. April 29, 2016. https://nacto.org/case-study/bell-street-park-seattle/.

"Broadway Boulevard: Transforming Manhattan's Most Famous Street." n.d. Accessed December 3, 2019. https://www.pps.org/article/broadway-boulevard-transforming-manhattans-most-famous-street-to-improve-mobility-increase-safety-and-enhance-economic-vitality.

Brower. 1973. "Streetfront and Sidewalk." *Landscape Architecture* 63 (4): 364–69. http://docdel.umd.edu/illiad/illiad.dll?Action=10&Form=75&Value=1209116.

Brower, Sidney N. 2011. *Neighbors and Neighborhoods: Elements of Successful Community Design*. The Citizens Planning Series. Chicago, IL: APA Planners Press. http://catdir.loc.gov/catdir/enhancements/fy1206/2011909374-b.html.

Clements, Lewis M., and Kara M. Kockelman. 2017. "Economic Effects of Automated Vehicles." *Transportation Research Record*, no. 2606: 106–14. https://doi.org/10.3141/2606-14.

"Comprehensive Master Plan." 2016. Department of Planning. January 7, 2016. https://planning.baltimorecity.gov/planning-master-plan.

Fagnant, Daniel J., and Kara Kockelman. 2015. "Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations." *Transportation Research Part A: Policy and Practice* 77 (July): 167–81. https://doi.org/10.1016/j.tra.2015.04.003.

Gehl, Jan. 2010. *Cities for People*. Washington, DC: Island Press.

Global Designing Cities Initiative. 2015. *Global Street Design Guide*.

Grove, J. Morgan, J. Morgan Grove, and Dexter Locke. 2011. "Urban Tree Canopy Prioritization (UTC): Experience from Baltimore." *Nature Precedings*, September. https://doi.org/10.1038/npre.2011.6368.1.

Hayward & Belfoure. 1999. *The Baltimore Rowhouse. New York: Princeton Architectural Press.*

Hayward, Mary Ellen. 2008. *Baltimore's Alley Houses: Homes for Working People since the 1780s*. Creating the North American Landscape. Baltimore: Johns Hopkins University Press. http://catdir.loc.gov/catdir/toc/ecip086/2007050037.html.

Heynen, Nik, Harold A. Perkins, and Parama Roy. 2006. "The Political Ecology of Uneven Urban Green Space: The Impact of Political Economy on Race and Ethnicity in

Producing Environmental Inequality in Milwaukee." *Urban Affairs Review* 42 (1): 3–25. https://doi.org/10.1177/1078087406290729.
Hirons, Andrew D, and Henrik Sjöman. 2019. "Tree Species Selection for Green Infrastructure." *The Tree*, no. 1 (January): 375.
Krueger, Rico, Taha H. Rashidi, and John M. Rose. 2016. "Preferences for Shared Autonomous Vehicles." *Transportation Research Part C: Emerging Technologies* 69 (August): 343–55. https://doi.org/10.1016/j.trc.2016.06.015.
Kweon, Byoung-Suk, William C. Sullivan, and Angela R. Wiley. 1998. "Green Common Spaces and the Social Integration of Inner-City Older Adults." *Environment and Behavior* 30 (6): 832–58. https://doi.org/10.1177/001391659803000605.
Landry, Shawn M, and Jayajit Chakraborty. 2009. "Street Trees and Equity: Evaluating the Spatial Distribution of an Urban Amenity." *Environment and Planning A* 41 (11): 2651–70. https://doi.org/10.1068/a41236.
Layman, Susan D. Day, David K. Mitchell, Yujuan Chen, J. Roger Harris, and W. L. Daniels. 2016. "Below Ground Matters: Urban Soil Rehabilitation Increases Tree Canopy and Speeds Establishment." *Urban Forestry & Urban Greening* 16 (January): 25–35. https://doi.org/10.1016/j.ufug.2016.01.004.
Layman, Rachel Montgomery. 2010. "Rehabilitation of Severely Compacted Urban Soil to Improve Tree Establishment and Growth."
Leff, Michael. 2016. "The Sustainable Urban Forest," 109.
Levin, Michael W., and Stephen D. Boyles. 2015. "Effects of Autonomous Vehicle Ownership on Trip, Mode, and Route Choice." *Transportation Research Record: Journal of the Transportation Research Board* 2493 (January): 29–38. https://doi.org/10.3141/2493-04.
Lu, Jacqueline, Erika Svendsen, Lindsay Campbell, Jennifer Greenfeld, Jessie Braden, Kristen King, and Nancy Falxa-Raymond. 2011. "Biological, Social, and Urban Design Factors Affecting Young Street Tree Mortality in New York City." *Cities and the Environment (CATE)* 3 (1). http://digitalcommons.lmu.edu/cate/vol3/iss1/5.
Mattocks, R. H. 1924. "Street Trees: Their Selection, Planting and After-Care." *The Town Planning Review* 10 (4): 253–68. http://www.jstor.org/stable/40101414.
Millennium Ecosystem Assessment, United Nations. 2004. "Ecosystems and Human Well-Being: A Framework for Assessment." *Choice Reviews Online* 41 (08): 41-4645-41–4645. https://doi.org/10.5860/CHOICE.41-4645.
———. 2005. "Millennium Ecosystem Assessment." 2005. https://www.millenniumassessment.org/en/Framework.html.
Mullaney, Jennifer, Terry Lucke, and Stephen J. Trueman. 2015. "A Review of Benefits and Challenges in Growing Street Trees in Paved Urban Environments." *Landscape and Urban Planning* 134 (February): 157–66. https://doi.org/10.1016/j.landurbplan.2014.10.013.
Office for National Statistics, United Kingdom. 2013. "What Matters Most to Personal Well-Being? - Short Story." May 30, 2013. https://webarchive.nationalarchives.gov.uk/20160107113217/http://www.ons.gov.uk/ons/rel/wellbeing/measuring-national-well-being/what-matters-most-to-personal-well-being-in-the-uk-/sty-personal-well-being.html.

Olmsted, Frederick Law, and Charles E. Beveridge. 2015. *Writings on Landscape, Culture, and Society*. Library of America; 270. New York, N.Y.: Library of America. http://www.loa.org.

Peters, Adele. 2017. "It Could Be 10 Times Cheaper To Take Electric Robo-Taxis Than To Own A Car By 2030." Fast Company. May 30, 2017. https://www.fastcompany.com/40424452/it-could-be-10-times-cheaper-to-take-electric-robo-taxis-than-to-own-a-car-by-2030.

Petri, Aaron C., Andrew K. Koeser, Sarah T. Lovell, and Dewayne Ingram. 2016. "How Green Are Trees?—Using Life Cycle Assessment Methods to Assess Net Environmental Benefits." *Journal of Environmental Horticulture* 34 (4): 101–110.

Pham, Thi-Thanh-Hien, Philippe Apparicio, Anne-Marie Séguin, Shawn Landry, and Martin Gagnon. 2012. "Spatial Distribution of Vegetation in Montreal: An Uneven Distribution or Environmental Inequity?" *Landscape and Urban Planning* 107 (3): 214–24. https://doi.org/10.1016/j.landurbplan.2012.06.002.

Rigolon, Alessandro. 2016. "A Complex Landscape of Inequity in Access to Urban Parks: A Literature Review." *Landscape and Urban Planning* 153 (September): 160–69. https://doi.org/10.1016/j.landurbplan.2016.05.017.

Roman, Lara A., and Frederick N. Scatena. 2011. "Street Tree Survival Rates: Meta-Analysis of Previous Studies and Application to a Field Survey in Philadelphia, PA, USA." *Urban Forestry & Urban Greening* 10 (4): 269–74. https://doi.org/10.1016/j.ufug.2011.05.008.

Ryer, Chris, and Catherine E Pugh. n.d. "Baltimore City Historic Preservation Design Guidelines," 75.

Sax, Miles Schwartz, Nina Bassuk, Harold van Es, and Don Rakow. 2017. "Long-Term Remediation of Compacted Urban Soils by Physical Fracturing and Incorporation of Compost." *Urban Forestry & Urban Greening* 24 (May): 149–56. https://doi.org/10.1016/j.ufug.2017.03.023.

Sipe, Neil. 2017. "Freeing up the Huge Areas Set aside for Parking Can Transform Our Cities," 5. https://theconversation.com/freeing-up-the-huge-areas-set-aside-for-parking-can-transform-our-cities-85331.

Spinoulas, and Davidson. 2016. "Title: Driving Alone versus Riding Together - How Shared Autonomous Vehicles Can Change the Way We Drive." *Road & Transport Research* Vol 25 (3): 51–66.

Spirn, Anne Whiston. 1984. *The Granite Garden: Urban Nature and Human Design*. New York: Basic Books.

Torres, Alexandra Olivia. 2011. "Sustainability of An Urban Tree Planting Group: Assessing The Condition And Benefits Associated With Recently Planted Trees In Washington, D.C." Thesis. http://drum.lib.umd.edu/handle/1903/12536.

Troy, Austin, J. Morgan Grove, and Jarlath O'Neil-Dunne. 2012. "The Relationship between Tree Canopy and Crime Rates across an Urban–Rural Gradient in the Greater Baltimore Region." *Landscape and Urban Planning* 106 (3): 262–70. https://doi.org/10.1016/j.landurbplan.2012.03.010.

"UN DESA | United Nations Department of Economic and Social Affairs." 2018. UN DESA | United Nations Department of Economic and Social Affairs. May 16, 2018. https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html.

Urban, James. 2008. *Up by Roots: Healthy Soils and Trees in the Built Environment*. Champaign, Ill.: International Society of Arboriculture.

Urban, James. n.d. “Growth Rates and Performance of Trees in Silva Cells.” http://www.deeproot.com/silvapdfs/resources/SC2/articles/Growth-Rates-and-Performance-of-Trees-in-Silva-Cells.pdf.

USDA Forest Service. 2017. “I-Tree Design.” 2017. https://design.itreetools.org/.

Weinberger, Rachel. 2012. “Death by a Thousand Curb-Cuts: Evidence on the Effect of Minimum Parking Requirements on the Choice to Drive.” *Transport Policy*, URBAN TRANSPORT INITIATIVES, 20 (March): 93–102. https://doi.org/10.1016/j.tranpol.2011.08.002.

Young, Robert F. 2011. “Planting the Living City: Best Practices in Planning Green Infrastructure—Results From Major U.S. Cities.” *Journal of the American Planning Association* 77 (4): 368–81. https://doi.org/10.1080/01944363.2011.616996.

Zhang, Wenwen, and Subhrajit Guhathakurta. 2017. “Parking Spaces in the Age of Shared Autonomous Vehicles: How Much Parking Will We Need and Where?” *Transportation Research Record: Journal of the Transportation Research Board* 2651 (January): 80–91. https://doi.org/10.3141/2651-09.

Zhang, Wenwen, Subhrajit Guhathakurta, Jinqi Fang, and Ge Zhang. 2015. “Exploring the Impact of Shared Autonomous Vehicles on Urban Parking Demand: An Agent-Based Simulation Approach.” *Sustainable Cities and Society* 19 (December): 34–45. https://doi.org/10.1016/j.scs.2015.07.006.