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Assessment of Knoxville, TN’s Urban Landscape Qualities Related to Bikeability Utilizing Cognitive Maps and Visual Assessments

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To the Graduate Council:

I am submitting herewith a thesis written by Beth Anne Hawkins entitled "Assessment of Knoxville, TN's Urban Landscape Qualities Related to Bikeability Utilizing Cognitive Maps and Visual Assessments." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science in Landscape Architecture, with a major in Landscape Architecture.

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Assessment of Knoxville, TN's Urban Landscape Qualities Related to Bikeability Utilizing Cognitive Maps and Visual Assessments

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ABSTRACT

How is the urban landscape experienced? Can an assessment of experiential perceptions of specific user groups be beneficial for urban design and planning purposes? The approach presented in this thesis includes a subjective analysis based on perceptions of bicyclists that entail a cognitive mapping exercise and surveys; and an objective analysis based on a visual assessment of routes documented by survey respondents. The intent is to identify perceptual qualities that incite a behavioral response based on physical characteristics of the urban landscape. Three behavioral responses are ubiquitous within the bikeability literature, i.e. ease of access, sense of comfort or safety and attractiveness of a place or "sense of place." These responses are documented to impact decisions associated with route choice preference. However, this research, which involves cognitive map theory and a community participation planning process to a localized bikeability assessment, fills a missing gap in current methods utilized in the U.S. Tapping into the individual strengths of these existing methodologies as well as incorporating a "real-time" analysis of experiential perceptions could produce a more accurate picture of bikeability to assist with redesigning our cities on a human scale.

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1.0 INTRODUCTION

The goal of this thesis is to explore an alternative bikeability assessment method that takes into consideration perceptions of the user group and their subsequent behavioral response to their physical environment. Can an assessment of experiential perceptions be beneficial for urban design and planning purposes? To answer these questions, a community participation planning process was utilized which included a survey tool complimented by a cognitive map exercise. Cognitive maps provide empirical data to capture an individual's perceptions of a specific geographical location. In this context, cognitive maps can be used to demonstrate the street networks' potential for bicycling which could be useful for proposing infrastructure improvements. Utilizing cognitive mapping to assess bikeability in a real-time, real-place scenario can provide powerful anecdotal findings.

Determining how existing traffic operations and geometric conditions impact a bicyclist's decision to use specific roadways is an important step in determining the bicycle compatibility of the roadway."[1] Efforts of developing and utilizing quantitative models to systematically assess bikeability have come close to developing a practical roadway standard for bicycle use. However, evaluating objective measures to rank a location's bicycle compatibility based on physical characteristics of the urban landscape is not enough; a subjective method needs to be considered to capture "true" bikeability as it relates to perceptions of the user group. For this thesis, the subjective analysis utilized focuses on perceptual qualities that incite a behavioral response associated with a sense of safety, sense of place and ease of access.

Physical features of urban design elements, perceptual qualities, and individual reactions all influence the way that an individual feels about the urban environment. By assessing these intervening variables, we can better understand the relationship between physical features of the built environment and route choice. By tapping into the individual strengths of the aforementioned objective analyses, in addition to an analysis of experiential perceptions, a more accurate picture of bikeability could be produced. These rich findings would significantly improve the ability to redesign our cities on a human scale and identify specific areas that need improvements. For the purposes of this thesis, North of Downtown Knoxville was selected as the area of interest due to the heavy concentration of survey respondents residing in this area.

Section 2.0 will provide examples of traditional methods of bikeability assessments through quantitative models. In Section 3.0 a discussion will be provided regarding the influence of environment upon behavior and cognitive mapping theory. Strategies for interpreting cognitive maps are discussed in Section 4.0. Presentation of the research conducted for this thesis begins in Section 5.0; site context is provided in Section 5.0, methodology in Section 6.0, findings in Section 7.0. Lastly, a brief conclusion is provided in Section 8.0.

[1] (Harkey, 1998)

2.0 TRADITIONAL TRANSPORTATION PLANNING

Land use planning has traditionally focused on the orientation of built structures and access by automobile; the consideration of infrastructure that supports access and usability by bicyclists is typically overlooked. In 1990, the Federal Highway Administration (FHWA) recognized federal transportation funds spent on bicycle infrastructure were minimal and described bicycling as a forgotten mode of transportation. In the same year, the U.S. Department of Transportation (DOT) adopted a policy that specifically addressed the need to increase use of bicycling as a mode of transportation and encouraged land-use planners to accommodate bicycles while designing, and adapting, infrastructure needs for urban and suburban areas.[2] In order to meet the goals as mandated by this policy a method needed to be developed to assess the transportation infrastructure for bikeability. In 1998, Harkey stated, “no methodology had been widely accepted by engineers, planners, or bicycle coordinators that will allow them to determine how compatible a roadway is for allowing efficient operation of both bicycles and motor vehicles. Determining how existing traffic operations and geometric conditions impact a bicyclist's decision to use or not use a specific roadway is the first step in determining the bicycle compatibility of the roadway.”[3] However, it is not enough to only evaluate objective measures to rank a location’s bicycle compatibility based on physical characteristics of the urban landscape; a subjective method needs to be considered as well. Studies found in literature from transportation, design and planning disciplines, support the theory that the perceptions of urban landscape is associated with an individual’s choice of transport and route choice.[4]

2.1 Methods of assessment, quantitative models

Over the years quantitative models have been developed to systematically assess bikeability. Each of these models produces a value or score that can be compared with a subjectively developed rating scale to assess the specific roadway segment or intersection. These efforts have come close to developing a practical roadway standard for bicycle use. Five distinct models with varied criteria were found during a thorough literature review and are discussed below; safety index rating, roadway condition index, bicycle interaction hazard score, bicycle compatibility index, and bicycle stress levels. However, each of these evaluation methods lacks the recognition of the relationship between level of service (LOS) values and bicyclists’ perspectives.[5] After all, these are the user groups who will ultimately decide if a roadway is safe and comfortable for them to ride as well as meeting their needs for amenities and accessibility to reach their destination.

[2] (The National Bicycling and Walking Study – Transportation Choices for a Changing America, 2004) http://katana.hsrc.unc.edu/cms/downloads/NBWS_10yr_Progress_Report.pdf

[3] (Harkey, 1998)

[4] (Saelens, 2003)

[5] (Epperson B. , 1994)

Bicycle Safety Index Rating (BSIR) – Davis

One of the first modeling attempts was the bicycle safety index rating (BSIR) which was part of a case study conducted by Davis in 1987.[6] The purpose of the model was to relate bicycle safety to the physical and operational features of the roadway. The BSIR is comprised of a roadway segment index and an intersection evaluation index. Existing literature does not specify how the association of variables was determined although general designations were assigned to roadway and intersection characteristics in attempt to determine bicycle routes, prepare bicycle maps, or prioritize improvements for bicycling. Variables had to directly apply to motor vehicle operations, be quantifiable and be consistent with established data collection practices of local transportation departments.[7]

Criticisms within existing literature state that Davis tested his BSIR on seven Chattanooga roads but the rating system was never validated against cyclist perceptions of safety or actual bicycle accident statistics.[8] Furthermore, the BSIR may not be transferable to other cities or even other locations within the city since the relative differences between the sites within the case study played a large part in developing the index rating (See Table 2.1).[9]

Table 2.1 Rating classifications for the bicycle safety index rating (BSIR) (Davis, 1987).

Index Range	**Classification**	**Description**
0 to 4	Excellent	Denotes a roadway extremely favorable for safe bicycle operation.
4 to 5	Good	Refers to roadway conditions still conducive to safe bicycle operation, but not quite as unrestricted as in the excellent case.
5 to 6	Fair	Pertains to roadway conditions of marginal desirability for safe bicycle operation.
6 or above	Poor	Indicates roadway conditions of questionable desirability for bicycle operation.

[6] (Davis, 1987)
[7] (Development of the Bicycle Compatibility Index, 1998)
[8] (Turner, 1997)
[9] (The Bicycle Compatibility Index: A Level of Service Concept, Implementation Manual, 1998)

Modified Roadway Condition Index (RCI) - Epperson-Davis

In 1991, the bicycle programs in Broward County and Hollywood, Florida, were met with the challenge of developing objective bikeability ratings for their roadway system. Davis' BSIR, discussed above, was used as a starting point with some minor revisions. First, the roadway segment index of the BSIR remained but the intersection evaluation portion was not rated as part of this effort. Second, the values used for some of the pavement and location factors were modified so they contributed less in determining the RCI value. An examination of the results from the Chattanooga case study revealed that, on average, type of pavement and location factors accounted for 30 percent of the BSIR.[10]

The modified Epperson-Davis RCI was compared to bicycle accident statistics in Hollywood, FL; it was found that the "modified RCI rating could only explain 18 percent of the variation in bicycle accident rates, thus implying a weak link between the modified RCI rating and actual bicycle safety of streets. Epperson concluded that the amount of bicycle use and patterns of use were contributing factors to bicycle accidents, and he considered neither in his analysis. He recommended increased use of subjective input from bicyclists in combination with objective data about route choices to develop more meaningful LOS criteria for bicycle facilities."[11]

Bicycle Interaction Hazard Score (IHS) - Landis

The interaction hazard score (IHS), a theoretical model developed by Landis in 1994, was based heavily on the prior models and was developed in an attempt to overcome subjectivity used in estimating values for identified variables.[12] Several variables associated with suitability criteria were chosen and divided into two groups: those that could affect bicyclist's perception of roadway hazard (i.e. traffic volume and speed, size of the motor vehicles, proximity of bicyclist to vehicles, pavement condition); and those that represent uncontrolled vehicular movements (i.e. frequency of driveways, usable width of outside lanes, and on-street parking and turnover.)[13] Landis then obtained bicyclists' input regarding the overall values he had designated for each variable; through this input calibration coefficients were developed so as to adjust IHS values to these bicyclists' comments and perceptions. A critique of this method opines that values established for the coefficients are valid on the basis of interviews with bicyclists; although, no results from the interviews were provided to assess the actual validity.[14]

[10] (Development of the Bicycle Compatibility Index, 1998)
[11] (Turner, 1997)
[12] (Landis B. , 1994)
[13] (Harkey, 2007)
[14] (Development of the Bicycle Compatibility Index, 1998)

Bicycle Stress Level

Sorton and Walsh (1994) embarked on a small-scale research effort that aimed to assess bicyclists' perspectives on various roadway types and traffic conditions.[15] The resulting concept was referred to as the bicycle stress level. This research was the first of its type that did not utilize a subjective interpretation from research team members. The study requested three groups of bicyclists (experienced, casual, and youth), a total of 61 cyclists, to view video clips filmed from 23 different street segments taking into consideration three different stress level factors (traffic volume, lane width, and vehicle speed). Each were asked to rate these roadway segments reflecting how uncomfortable they would be (i.e. stress level) riding in that location (See Table 2.2). An aggregated value produced a ranking of each street segment and identified areas where bicycle facility improvements (e.g. widening a curb lane or adding a bicycle lane) could be beneficial. A criticism of this method stated that the results of the analysis were based not an actual experiences but on projected perceptions; although, the general patterns from the study indicated that bicyclists recognize variations in traffic volume, lane width, and vehicle speed that influence their perceptions of stress.[16]

Table 2.2 Rating classifications for Bicycle Stress Level - (Turner, 1997)

Stress Level	**Interpretation**
1-Very Low	Street is reasonably safe for all types of bicyclists (except children under 10).
2-Low	Street can accommodate experienced and casual bicyclists, and/or may need altering[1] or have compensating conditions[2] to fit youth bicyclists.
3-Moderate	Street can accommodate experienced bicyclists, and/or contains compensating conditions to accommodate casual bicyclists. Not recommended for youth bicyclists.
4-High	Street may need altering and/or have compensating conditions to accommodate experienced bicyclists. Not recommended for casual or youth bicyclists.
5-Very High	Street may not be suitable for bicycle use.

[15] (Sorton, 1994)
[16] (Turner, 1997)

Bicycle Compatibility Index (BCI)

The Bicycle Compatibility Index (BCI) is the most recent bikeability assessment tool expanding upon the stress level work of Sorton and Walsh.[17] According to existing literature the BCI model was intended to be used for the purpose of: 1) evaluating roadway segments to determine bicyclist compatibility; 2) identify and prioritize areas that need improvement based on resulting index values; and 3) establish which improvements should be made to improve upon the bicycle compatibility of a roadway.[18] The BCI, just like the prior models discussed, is intended to provide the user with a mechanism to quantitatively define and assess the bikeability of roadway segments but also intended to be used as an assessment tool for future improvements. The BCI model only addressed midblock street segments and do not take intersections into consideration. The approach used in developing the BCI was similar to the methodology utilized for the bicycle stress level concept which was to obtain the perspectives of bicyclists by having them view videotapes of numerous random roadway segments and rate them with respect to how comfortable they would be riding there.[19]

Motorist behavior is altered by the physical presence of an actual bicyclist on the road; therefore, the distance between a vehicle and bicyclist in a "true" scenario is different from the distance from a vehicle to a curb-side video camera. This unrealistic scenario could bias the findings toward bicyclists that are in favor of a bike lane (BL) or wider curb-lane. Pein (2007) critiqued this research method and stated that "if the camera had been placed in the roadway the camera would have caused a large left shift [and a decrease in speed] in motor vehicle tracking on a non-BL road, affording study subjects a real world view of the position of overtaking traffic in the films. Motor vehicles first entering the film would have appeared smaller and further away on roads than on BL roads, the opposite of what the films did show. Arguably, the best way to produce the films would have been to have the camera mounted to a bicycle moving at typical bicyclist speed of 14 mph in typical bicyclist in-road location."[20] Therefore, this method can only produce findings based on *projected* comfort rather than *experiential* perceptions; although, the researchers made the claim, and incorrectly assumed, that the real perceptions of comfort by actual bicyclists riding on that specific roadway segment was the same as the projected comfort of the study subjects.[21]

All five models were successful in identifying several roadway characteristics that could potentially impact a bicyclists' perception of comfort and safety. Although, in all cases researchers interpreted the indexes, examined them in relation to each other, and established the

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[17] The BCI was produced by the University of North Carolina Highway Safety Research Center for the Federal Highway Administration (FHWA) in 1998.
[18] (The Bicycle Compatibility Index: A Level of Service Concept, Implementation Manual, 1998)
[19] The ratings provided by subjects were used to weight variables used to quantifiably establish bikeability of a roadway segment.
[20] (Pein, 2007)
[21] Ibid.

weight of the values so as to establish rating classifications. With each study investigators recognized the need to further modify their assessments so as to better understand the needs of the bicyclists. In order to do that it is necessary to supplement these quantitative analyses with a qualitative one, the perceptions of those that are actually choosing the routes, and what perceptual qualities influence their decisions.

3.0 INFLUENCE OF ENVIRONMENT UPON BEHAVIOR

> "*Everything you see or hear or experience in any way at all is specific to you. You create a universe by perceiving it, so everything in the universe you perceive is specific to you.*" – Douglas Adams

In the academic world, environmental influences on behavior oft times is referred to as "environmental determinism." This concept came into popularity in the late nineteenth century and gained respectability with Ratzel's [22]*Anthropo-geographie* (1882-1991) which posed the idea that physical attributes of a place determine humans' actions that occur within them, environmental influences are rarely direct and obvious, and people react to an environment only as they perceive it.[23] The term "environment" can be defined in a variety of ways most likely depending on the discipline; sociologists consider one's environment their social network, to geographers it could mean the physical world of landforms and climate, to architects and urban planners it could mean solely the built structures, and landscape architects could define environment as either natural or human-built. For the sake of this thesis, inspired by the writings of Porteous (1977), I will expound on this environmental terminology within a modified nested hierarchy: anything external to an individual is the objective *geographical environment* whether it be natural or human-built; the portions of the universe that have an impact on an individual is the less objective (or more subjective) *perceptual environment*; and features of the perceptual environment that elicit a behavioral response towards it is the subjective *behavioral environment.* These three terms and concepts they embody will provide the framework for the methodological approach utilized for this thesis. The distinctions between these three concepts will be discussed in detail in Section 4.2.

These aforementioned environments are applicable to bicyclists' decision making processes with regard to perceptions surrounding bikeability and subsequently, their route choices. If one *perceives* that an area (*geographical environment*) is not accessible, safe, or pleasant they simply will choose another route, regardless of the bikeability ranking that a quantitative model produces. Urban planners and designers need to be aware of *perceptual environments* and recognize that a user's response to place is based on one's *behavioral environment*.

Perceptions of urban landscapes can be altered depending on an individual's mode of transport and are distinctly different between user groups and "experts" (i.e. planners, urban designers, transportation engineers). Within the United States, perceptions of safety by transportation system users have not been definitively proven to correlate with actual safety.

In an attempt to provide a logical behavioral framework to move away from abstract theory to a purposive concept, one could breakdown these theories: 1) a perception is interpreted in the light

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[22] Freidrich Ratzel was a central figure in the late nineteenth century shaping two major fields of knowledge: geography and anthropology.
[23] (Porteous, 1977)

of experience or awareness of the geographical environmental through physical exposure; 2) the perception is then interpreted to produce an impression of an object obtained by use of the senses; 3) once understood the impression becomes a cognition, something that is known, understood, and remembered; 4) if a response to the perceptual environment occurs, it is made with reference to the cognized image. Basically, action in the geographical environment takes place on the basis of the cognition of this physical realm held by an individual.[24]

3.1 Cognitive Mapping and Spatial Behavior

Knowledge of our spatial environment and the way in which we visualize and symbolize it, is a consequence of our experience in it and with it. As individuals our experiences vary as well as how we collect, organize, recall and manipulate information about our environment.[25] Well-known urban planner Kevin Lynch, in his book *The Image of the City* (1960), put into practice a research method that successfully discovered the social experience of a town through cognitive map theory.[26] A cognitive map is an abstraction which refers to a cross-section, at one point in time, of the environment as people believe it to be; it is not a cartographic map, although this information corresponds, at least to a reasonable degree, to the environment it represents.[27]

Lynch held in-depth interviews with city residents and then had these subjects sketch a cognitive map representing their spatial environment with the goal of understanding how individuals perceive and navigate the urban landscape. His goal was to understand the relation between environmental images and urban life, at the basis of urban design principles. He states that a city can be viewed as an object that can either give an individual a sense of security or a sense of chaos. He refers to the abstract concept of cognitive maps as a set of images which are more or less interconnected that an observer holds onto and references while mentally navigating a city. Lynch emphasizes perceptual qualities that impact "way-finding". A system without connections can be disconcerting, therefore, a system with structure, identification cues, and meaning increases the depth and intensity of experience."[28]

Lynch states that the contents of these city images can be classified into five structural elements. These elements make up the parts, the raw materials of the geographical environmental. Lynch used these elements to provide guidelines for creating more legible environments.[29] Lynch's structural elements are:

1- Paths- channels of circulation
2- Edges-boundaries or linear breaks in continuity

[24] (Porteous, 1977)
[25] (Downs, 1977)
[26] (Lynch, 1960)
[27] (Downs and Stea, 1973)
[28] (Lynch, 1960)
[29] (Devlin, 2001)

3- Districts-sections of the city that an observer mentally enters that are recognized as having a common character.
4- Nodes-strategic spots, or foci to which and from one travels
5- Landmarks-a reference point that is an external, defined physical object

Lynch's research brought to light the importance of a citizen's role in the success of design. The adage, "If you want to know how the shoe fits, ask the person who is wearing it, not the one who made it", rings true in this context. Given the fundamental link between cognitive maps and decisions as to what to do where, cognitive maps could be used as an additional tool to assist designers, planners and developers as to where suitable locations are for green spaces, bike lanes, sidewalks, all the way down to curb cuts that provide safe access for bicyclists to shopping centers, businesses, and housing. Devlin (2001) states that other authors have "stressed the importance of perceptual theory in environmental design, but Lynch has done more to advance the relationship between cognition and urban planning than any other designer."[30]

[30] (Devlin, 2001)

4.0 VISUAL ASSESSMENTS

Utilizing cognitive mapping to assess bikeability in a real-time, real-place scenario can provide powerful anecdotal findings. However, as mentioned in the above section, cognitive maps are not cartographic and are not limited to identifying features of the geographical environments. A method of systematically identifying and characterizing the qualities of the perceptual environment eliciting behavioral responses is necessary.

In practice, if bicyclists' were recruited to sketch cognitive maps most likely this exercise would take place during a community participatory planning process facilitated by stakeholders and planners. The expertise and local knowledge that can be shared by community members, especially specific user groups can be extremely valuable. "It is characteristic of experts to be unaware that their perception of a situation differs from the perceptions of those that do not share [the same] expertise…affected groups have different knowledge, perceptions, and needs."[31] However, in general, the exchange of information from one person to the next within these forums does not always result in a successful information transfer. To assist the expert in the interpretation of cognitive maps additional analyses need to be incorporated.

Several methods have been utilized for cognitive map interpretation; although, overall strategies have been identified and grouped into two categories: 1) *system identification* - involves a description of overall system, identification of interactions between segments of the spatial environment and cognitive response typologies; and 2) *system analysis* - analysis of the system taking into consideration interactions between variables with the use of quantitative methods of data analysis.[32]

For this discussion a system identification strategy will be utilized. Visual assessment studies have been used as a system identification tool within many disciplines (e.g. architects, landscape architects, and environmental psychologists.)[33] Ewing (2005) stated that "there is sufficient literature on visual assessment methods [within design fields] to have inspired four books (Kaplan and Kaplan, 1989; Nasar, 1998; Sanoff, 1991; Stamps, 2000."[34] A visual assessment study consists of a critical analysis and documentation of scenes. These scenes are then assessed to identify perceptual qualities that contribute to route choice based on preference. Using visual assessments to interpret cognitive maps is an effective method for categorizing perceptual environments into identifiable patterns.

[31] (Kaplan, 1998)
[32] (Downs and Stea, 1973)
[33] (Ewing, 2005)
[34] Ibid.

4.1 Qualities of Perceptual Environments

Perceptual qualities that may influence choices about mode of transportation were compiled through a comprehensive review of urban design literature (Alexander, 1977; Gehl, 1987; Hedman, 1984; Jacobs, A., 1993; Lynch, 1960; Trancik, 1986; Whyte, 1988). These qualities are summarized by Ewing and Clemente (2005).[35] Ewing refers to these qualities as "*perceptual qualities* of the urban environment" and further differentiates these perceptual qualities from qualities associated with accessibility, sense of safety, and sense of place that "reflect how an individual reacts to a place and how they assess the conditions there, given their own preferences and perspectives…perceptions may produce different reactions and decisions in different people…[which] may be assessed with a degree of objectivity by outside observers. All of these factors—physical features, perceptual qualities, and individual reactions—influence the way that an individual feels about the urban environment…by [assessing] these intervening variables, we can better understand the relationship between physical features of the built environment" and chosen mode of transportation in addition to route choice.

Although there is a long list of perceptual qualities[36] found within the aforementioned urban design literature, eight were chosen to be utilized for the purposes of this thesis and are defined below[37]. Also provided are examples of physical characteristics of the geographical environment that assist with objective identification and citations from well-known authors in the field.

1. **Legibility-** a network that provides bikers with a sense of orientation and relative location; defines an area.

Physical characteristics that connote legibility in the geographical environment include:

- Signage
- Landmarks
- Visual termination – focal points

Kevin Lynch (1960) defines legibility as the "ease by which its parts can be recognized and can be organized into a coherent pattern." As mentioned earlier in Section 3.1, Lynch claims that places with strong edges, distinct landmarks, and identifiable nodes allow people to form detailed and relatively accurate mental maps. Without these features places will be difficult to

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35 (Ewing and Clemente, 2005)

36 Adaptability, Ambiguity, Centrality, Clarity, Compatibility, Comfort, Complementarity, Continuity, Contrast, Deflection, Depth, Distinctiveness, Diversity, Dominance, Expectancy, Focality, Formality, Identifiability, Intelligibility, Interest, Intimacy, Intricacy, Meaning, Mystery, Naturalness , Novelty, Openness, Ornateness, Prospect, Refuge, Regularity, Rhythm, Richness, Sensuousness, Singularity, Spaciousness, Territoriality, Texture, Unity, Upkeep, Variety, Visibility, and Vividness.

37 Most of the perceptual qualities chosen for discussion and details surrounding them were adopted from Ewing and Clemente's (2005) study entitled "Measuring Urban Design Qualities Related to Walkability." The descriptors of these qualities and conceptual framework (Section 6.2) were adopted and modified for the purpose of conducting a visual assessment related to bikeability rather than walkability.

make sense of and to remember. Allan Jacobs (1993) suggests that for roads to be legible and give a sense of definition to an area they should have clearly defined end points that would serve as reference points; such as, landmarks or some type of visual termination.

2. **Linkage-** features that promote interconnectedness of different places and provide accessibility.[38]

Physical characteristics that connote linkage in the geographical environment include:

- Sidewalk connections or bike/curb lane continuity
- Continuous tree lines
- Marked crossings
- Can occur longitudinally along a street or laterally across a street

The relationship between paths and nodes defines the degree of access in an area. Henry Arnold (1993) suggests that continuous tree rows can provide linkages; "[trees] can psychologically connect places at either end, and tree patterns that reflect or amplify building geometry can psychologically link buildings to the street."[39] Jacobs (1993), Alexander (1977), Duany and Plater-Zyberk (1992) all make recommendations with regard to street blocks size and appropriate distances between road crossings and sidewalk connections to maximize accessibility.

3. **Human Scale –** "refers to a size, texture, and articulation of physical elements that match the size and proportions of humans."[40]

Physical characteristics that connote human scale elements in the geographical environment include:

- Small signs with small lettering (designed for slower speeds)
- Long sight lines
- Windows at street level
- Building details
- Accessible amenities
- Pavement texture
- Street trees/landscaping elements
- Small-scale elements

Jane Holtz Kay (1997) provides a discussion surrounding urban design elements being geared toward the "bulk and speed" of vehicles. Some design elements, such as signage in large scale with large lettering, if approached at human speed, can overwhelm the senses, creating

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[38] (Ewing and Clemente, 2005)
[39] Ibid.
[40] Ibid.

disorientation.[41]According to Henry Arnold (1993), street trees can minimize the scale of wide streets and tall[42] buildings; "a canopy of leaves and branches allows for a simultaneous experience of the smaller space within the larger volume." Small-scale elements, such as planters, landscaping touches, ornamentation of buildings, and intricacy of paving patterns and texture (e.g. patterned brickwork) are also characteristics of areas that have a human proportion.

4. **Transparency –** "degree to which people can see or perceive what lies beyond the edge of a street or other public space."[43]

Physical characteristics that connote transparency in the geographical environment include:

- Doors
- Fences
- Landscaping
- Openings into midblock spaces (streets with many entryways)
- Windows at street level
- Small trees work *against* transparency

Blank walls, tall fences, small trees and reflective glass buildings work against transparency. Allan Jacobs (1993) stated that many openings into midblock spaces, such as doorways or entryways can "contribute to the perception of human activity beyond the street, whereas those with blank walls and garages suggest that people are far away. Even blank walls may exhibit some transparency if overhung by trees or bushes, providing signs of habitation."

5. **Complexity – "**refers to the visual richness of a place… [is] related to the number of noticeable differences to which a viewer is exposed per unit of time. "[44]

Physical characteristics that connote complexity in the geographical environment include:

- Primary building colors
- Accent colors (street furniture, awnings, business signs, and building trim)
- Public art (and ornamentation)
- Manipulation of light
- Presence and activity of people

Amos Rapoport (1990) summarized the term complexity with the statement, "too little information equals sensory deprivation and too much information equals sensory overload." However, there is an innate human desire to resolve visual stimuli into ordered patterns[45]; order and comprehension impacts this principle. Jan Gehl (1987) stated that if a trip is visually

[41] (Ewing and Clemente, 2005)
[42] Alexander (1977) defines a tall building as any above four stories.
[43] (Ewing and Clemente, 2005)
[44] Ibid.
[45] A principle of Gestalt psychology. (Wallace, 1998)

interesting that it will seem shorter than it actually is; that with complexity the trip is "divided naturally, into manageable stages." Presence of people adds complexity as well. Gehl (1987) wrote that "people are attracted to other people. They gather with and move about with others and seek to place themselves near others. New activities begin in the vicinity of events that are already in progress." According to Henry Arnold (1993), "one function of trees is to restore the rich textural detail missing from modern architecture. Light filtered through trees gives life to space. Manipulation of light and shade transforms stone, asphalt, and concrete into tapestries of sunlight and shadow."

6. **Upkeep -** refers to the level of attention to cleanliness in bicyclists' chosen pathway as well as surrounding areas.

Physical characteristics that connote the perception of upkeep in the geographical environment include:
- Pavement condition
- Presence of debris in bike path
- Landscape condition
- Presence of graffiti

Rapoport (1982) suggested cleanliness to be one of the major associational factors in judging aesthetic preference of a place. For a bicyclist upkeep of a roadway can have a significant impact on trip safety and the sense of security.

7. **Enclosure –**the degree of visual definition of a street or space by buildings, walls, trees, and other elements."[46] Heights of vertical elements add (or subtract) from a sense of comfort and pleasure.

Physical characteristics that connote the perception of enclosure in the geographical environment include:
- Building walls or fences (provide spatial definition)
- Street width proportion to building walls
- Non-active spaces (do not generate human activity and presence)
- Large building setbacks (destroy the street as social space)
- Closely spaced street trees (define space)
- Visual termination points

Alexander (1977) professed that "an outdoor space is considered positive when it has a distinct and definite shape, as definite as the shape of a room, and when its shape is as important as the shapes of the buildings which surround it." Cullen (1961) stated that "enclosure, or the outdoor room, is perhaps the most powerful, and most obvious, of all the devices to instill a sense of

[46] (Ewing and Clemente, 2005)

position [and] identity with the surroundings." Henry Arnold (1993) explains that trees can shape a space, visually complete an open area, and humanize the scale of the area. According to Duany and Plater-Zyberk (1992) streets that are visually terminated in some fashion increase the feeling of being enclosed.

8. **Imageability –** captures attention, evokes feelings, creates a memorable impression and is influenced by all the aforementioned urban design perceptual qualities.

Physical characteristics that connote imageability in the geographical environment include:

- Presence of courtyards, plazas, and parks
- Major landscape features
- Landmarks
- Outdoor places to gather
- Noise level

According to Kevin Lynch (1960) a well-formed city contains distinct parts, and is instantly recognizable to anyone who has visited or lived there, "it is that shape, color, or arrangement which facilitates the making of vividly identified, powerfully structured, highly useful mental images of the environment." Landmarks can serve as an orientation point; a visual termination point, a singular moment, or just a point of contrast in the urban setting.[47] Perhaps they become a city or district trademark. Imageability contributes to a space having a "sense of place", a pleasant place in which to be.

4.2 Qualities of Behavioral Environments

As described in Section 3.0, qualities of the perceptual environment elicit some type of behavioral response; this becomes the subjective *behavioral environment*. Three behavioral responses, based on perceptions, are ubiquitous within bikeability literature. These responses impact decisions associated with route choice, i.e. sense of place, sense of safety/comfort, and "ease of access".

The perceptual qualities can be loosely grouped within these behavioral responses. However, some perceptual qualities have potential to incite more than one response. Figure 4.1 presents a diagram demonstrating these relationships followed by a discussion surrounding behavioral environments based on existing literature within the field.

[47] Ibid.

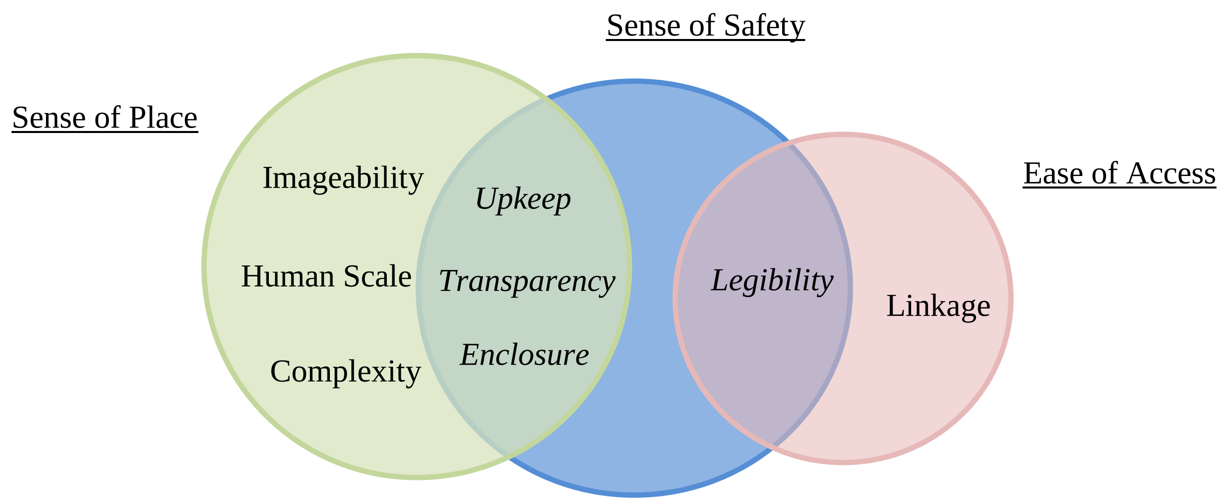

Figure 4.1 Relationship between perceptual qualities and behavioral responses. The eight perceptual qualities are loosely grouped within the three behavioral responses.

1. **Accessibility**

Ease of access increases the ability with which people in different locations, and mode of transport, can readily access different types of facilities. An individual's perception of accessibility can impact route choice. Several physical characteristics of roadway segments (discussed in Section 2.0) are influential; thereby, supporting the benefit of incorporating quantitative models into a bikeability assessment. However, the perceptual environment, and the psychological factors attached to the physical characteristics, come into play. Does it *feel* accessible? Is there anything along the way that I am actually interested in accessing (i.e. spatial distribution of activities)? If so, can I get to it safely? Other factors that impact route choice (e.g. topography, distance, visibility) are not included as variables within quantitative models. For example, Duncan (2003) stated that "ignoring topography means that associated variables, such as road designs, included in a predictive model end up absorbing the influences of this omitted but relevant variable."

Another variable is the time consuming effect of intersections. Bicyclists might choose routes specifically to avoid traffic lights for time-efficiency or for safety. A term mentioned within bikeability literature is *continuity*, in terms of angular minimization or least angular change, can be an attractive bicycle route. In order to not lose speed a bicyclists will try to smooth sharp corners on routes.

2. **Sense of safety**

Personal safety (avoiding injury from infrastructure interaction and human interaction) is fundamental to the success of a space becoming a public place; programming for the **use** of spaces to ensure safety is vitally important. Elements of safety can be associated with accessibility factors listed above but also include:

- Visibility (e.g. blocked by parked cars, poorly designed intersections, blind hills)
- Lighting
- Crime potential
- Pavement conditions
- Infrastructure design

3. **Sense of place**

Urban landscapes that could be perceived as having a sense of place attract people moving through them and to them. Wallace Stegner professed, “no place is a place until two things have happened; one, things that have happened there are remembered and two, it has had that human attention that at its highest reach we could call it poetry.” Notable characteristics mentioned within urban design literature include:

- Ability to use and enjoy the space
- Opportunities for cultural interactions
- Presence of cultural artifacts or elements
- Micro-design attributes - landscaping, amenities
- Views/scenery

5.0 RESEARCH STUDY CONTEXT

This section presents the context for which this thesis was conducted. A geographical (See Figure 5.1) and topographic map of the region (See Figure 5.2), case study area (See Figure 5.3), and select aerial maps of case study area (See Figures 5.4, 5.5 and 5.6) is provided.

5.1 Site Context

The study area chosen was Knoxville, Tennessee. The state of Tennessee is located in the southeast region of the United States; the eastern third of the state which includes Knoxville is located within a geographical region referred to as Appalachia. The term comes from the presence of the Appalachian Mountains - a mountain system coursing through eastern North America extending about 1,600 miles southwest from Newfoundland, New Brunswick, and southern Quebec, Canada, to central Alabama. The range includes the physiographic provinces of the Allegheny, Blue Ridge, and Cumberland mountains. However, the Appalachian region typically refers only to the central and southern portions of the range – from southern New York State to northern Alabama, Mississippi, and Georgia. East Tennessee is home to the Blue Ridge Mountain province which includes the Great Smoky Mountain National Park which is about 40 miles southeast of Knoxville.

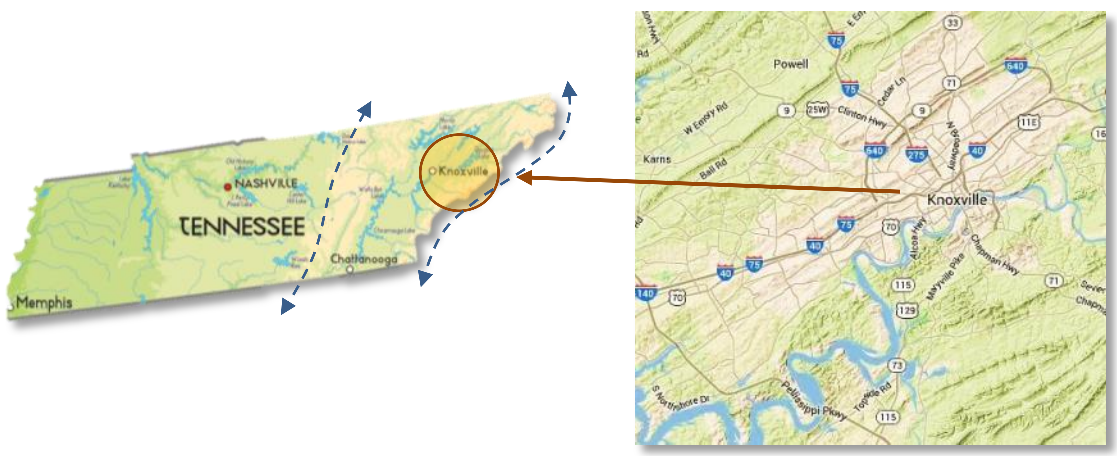

Figure 5.1: Location of Knoxville within the State of Tennessee and the Appalachian region.

Figure 5.2: U.S. Geological Survey - Knoxville Quadrangle Topographic Map
with case study area highlighted. Scale, 1:24,000

Figure 5.3: Case study area, approximately 2.5 miles north to south at longest point;
Downtown Knoxville marked with yellow dot, University of Tennessee marked with red dot.

Figure 5.4: Aerial view of Knoxville and call-out of case study region.
Downtown Knoxville and the University of Tennessee identified with yellow and red dots, respectively.

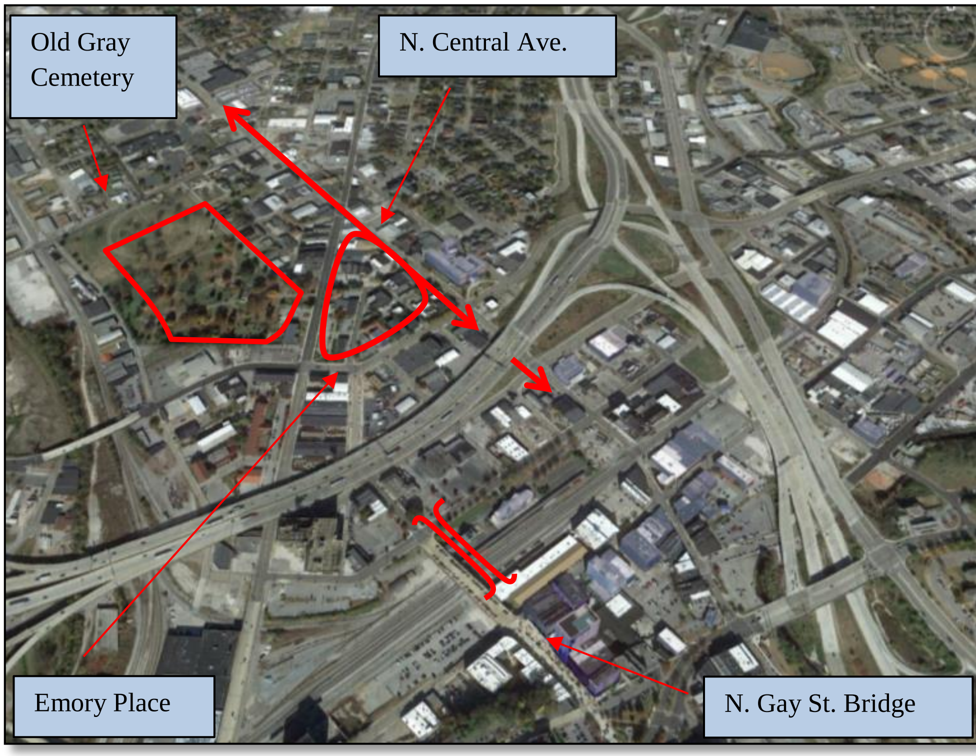

Figure 5.5: Google Earth 3-D building image of North Downtown Knoxville.

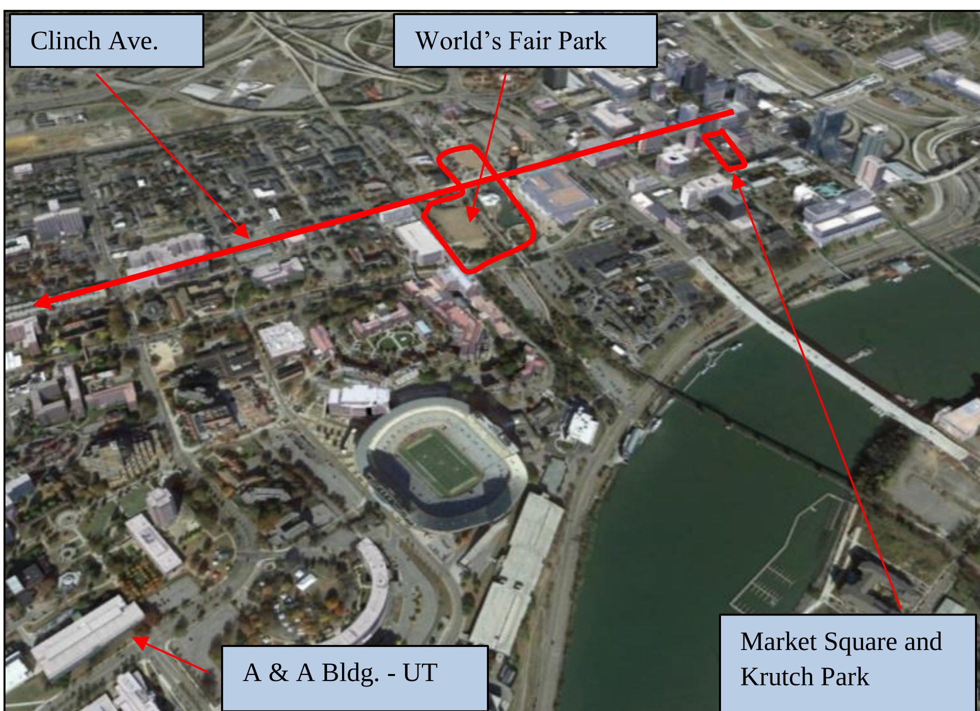

Figure # : Google Earth 3-D building image of Downtown Knoxville and University of Tennessee (UT).

6.0 METHODOLOGY

6.1 Research Study Design

The cornerstone for this thesis was the survey and cognitive mapping exercise as they provide the critical data on perceptions of the user groups. A survey tool with open-ended questions and instructions for cognitive maps were developed based on personal insight and experience as a seasoned bicycle commuter. The short survey included questions related to demographics, bike commute route preferences and descriptions, as well as detailed instructions for the mapping exercise (See Appendix A).

In order to recruit bicycle commuters[48] to take part in this study, several different outreach attempts were made. Initially, the Knoxville Regional Transportation Planning Organization's (TPO) Bicycle Program Coordinator was contacted requesting a notice be posted on a local bike blog she managed[49]. Other attempts included a group email on a University of Tennessee - Knoxville (UT) listserv, surveys posted at local bike shops, and in-person requests for participation of fellow classmates.

Ultimately, the in-person requests resulted in the highest rate of return, followed by the listserv email. No responses were received from the blog post or local bike shops. The number of surveys and maps received in total were fifteen. Due to illegibility of maps and/or not following instructions for the mapping exercise, the number of surveys and cognitive maps that were able to be utilized for this thesis were eleven.

It should be noted that the case study area was initially identified as a 3 mile radius around Downtown Knoxville. It was requested that only bicycle commuters that had an origin and destination point located within this identified radius should respond. Interestingly, and conveniently, all eleven respondents' origins were located in one general area, north of Downtown Knoxville. All destinations were either in Downtown Knoxville or on the UT campus. The resulting case study area became an organic shape of its own making spreading approximately 2.5 north of UT (Refer to Figures 5.1, 5.2, 5.3 in previous section).

Cognitive maps, as defined in Section 3.1, are abstractions that refer to a cross-section, at one point in time, of the environment as people believe it to be; they are not cartographic maps. Although this information corresponds, at least to a reasonable degree, to the environment it represents. However, in order to perform system identification (Refer to Section 4.0) and discover route choice patterns it was necessary to synthesize the cognitive maps. Therefore, elements from each cognitive map (See Appendix B) were transferred and layered upon a cartographic base map resulting in a composite of clearly defined bike routes and areas of

[48] For the purposes of this thesis, a commuter is defined as an individual that commutes by bike at least two times a week.
[49] http://bikeknoxville.blogspot.com/

interest for subsequent analyses (See Appendix C). As discussed in Section 4.0, there are two general strategies for overall interpretation of cognitive maps; the method utilized for this study is what is referred to in the literature as system identification[50]. This method involves identification of segments of the spatial environment and cognitive response typologies.

First, segments were identified based on nodes or intersections where a directional decision was required, also referred to as decision trees. Sixteen segments were identified within the system. Segments were numbered, labeled with street name(s) and further defined by identifying cross-streets at beginning and end. Some segments were the “road less traveled” where only one respondent chose that path as part of their preferred route, other segments were chosen by several of the respondents. Second, a visual assessment study was used as a system identification tool which consisted of documentation of the geographical environment along route segments followed by critical analysis which included the identification of perceptual qualities (i.e., cognitive response typologies) that contributed to route choice based on preference and the subsequent associated behavioral responses.

6.2 Conceptual Framework

In order to provide a framework for this thesis, a conceptual model (See Figure 6.1) was modified from a walkability study conducted by Ewing (2005) that weighed heavily on perceptual qualities for its analysis.[51] This thesis assesses how and to what degree a bicyclists’ perception of urban landscape elements affects route choice and reflects upon the general way in which people perceive and interact with this geographical environment.

Upon review of the conceptual model, the box on the left in Figure 6.1 includes examples of physical elements found in the urban landscape; e.g. bike lanes, curb cuts and pavement condition, but also elements of the environment that could potentially impact a cyclist; e.g. traffic speed and volume, low visibility due to topography or obstructions, and presence of right-turn lanes.[52] The visual assessment was conducted to document these elements. The cognitive maps and surveys provided the specific locations for the visual assessment. Sections along road segments were intuitively categorized as exhibiting one or more perceptual qualities based on the presence or absence of these urban landscape elements. The middle box in the conceptual model lists the eight different perceptual qualities utilized in this thesis (Refer to Section 4.1).

The perceptual quality, or perceptual environment, elicits one of three types of behavioral responses[53] by the user groups. These are listed in the third box. The individual’s response, based

[50] (Downs and Stea, 1973)
[51] (Ewing, 2005)
[52] Bicyclists tend to travel in the lane farthest to the right. If a right-turn lane is present and the bicyclist is traveling forward through the light this introduces an element of danger when the motorist is turning right in front of the bicyclist.
[53] Due to the ubiquitous usage within bikeability literature these three behavioral responses were chosen to be utilized for the purposes of this thesis.

on their perceptions defines the segment's overall bikeability. Ultimately, this framework reflects these relationships as a feedback mechanism which is inherently a dynamic system; the interpretation of the results can provide valuable information that can be utilized to inform future bikeability planning decisions.

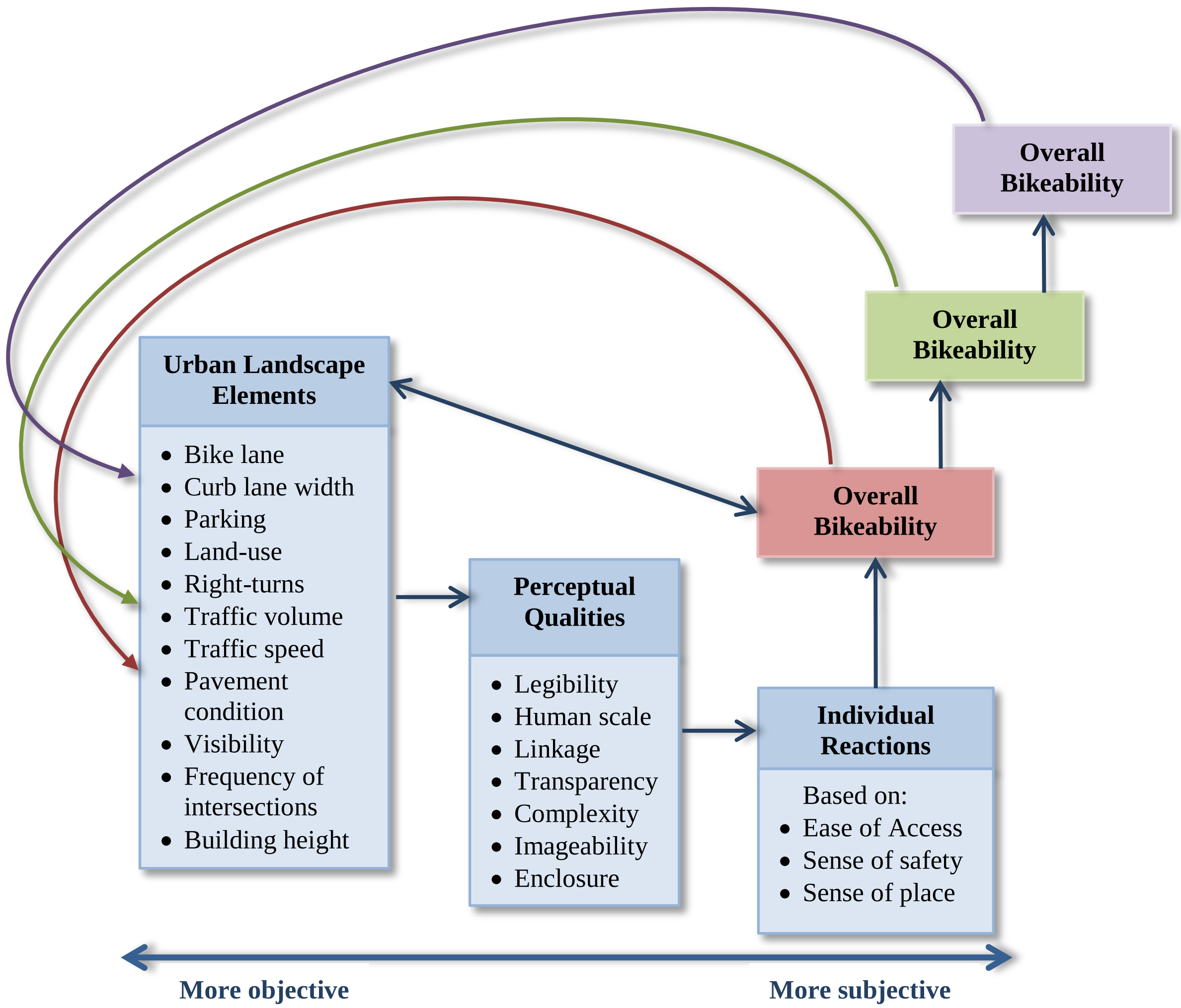

Figure 6.1: Conceptual Model

7.0 RESEARCH FINDINGS

Findings from the visual assessment and segment analysis that entailed tallying perceptual qualities and associated potential behavioral responses for each segment are presented in this chapter. Of the sixteen segments identified, three will be highlighted in Section 7.1.[54] These three segments were chosen as illustrative examples of route choice based on an individual's behavioral response to existing perceptual qualities. Several bicyclists chose at least one of these three segments regardless of the lack of bike lanes, even though there are bike lane options along segments close in proximity. Nor are they the most direct route choice. It appears that in these three cases at least, ease of access is not the driving force behind route choice. These routes were chosen based on being perceived as having either a high sense of safety or a strong sense of place.

Provided for each of the three segments is a complete map of all routes with call-outs identifying the location of visual assessments along each segment; the corresponding perceptual qualities and behavioral responses; and a description of specific physical characteristics that satisfy components of said perceptual qualities. It should be noted that the three segments are not in numerical order; they are listed by the segment number initially assigned for the analysis.

An overview of the analysis findings will be presented in Section 7.2. Lastly, an overview of survey responses is presented in Section 7.3 that includes demographics of the sample; information specific to the respondents' chosen route that could not be captured on cognitive maps; and general information about their biking experiences.

[54] The visual assessments of the remaining thirteen segments are located in Appendix D.

7.1 Visual Assessment

Segment 1

Riders number three and five chose segment one to be included in their preferred route, regardless of its lack of interconnectedness. It is not the most direct route to their destination; in fact it goes in the opposite direction. Through the visual assessment and subsequent segment analysis, this route was found to be less accessible than other nearby segments due to this low assessment of linkage. The most direct route would include a segment two blocks south; referring to the map below, this segment (N. Central Ave.) is denoted by the heavy red line. It hosts a bike lane and directional signage and is rated high in legibility, linkage and ease of access. Analysis of segment one reveals this is a scenic route chosen due to its strong sense of place.

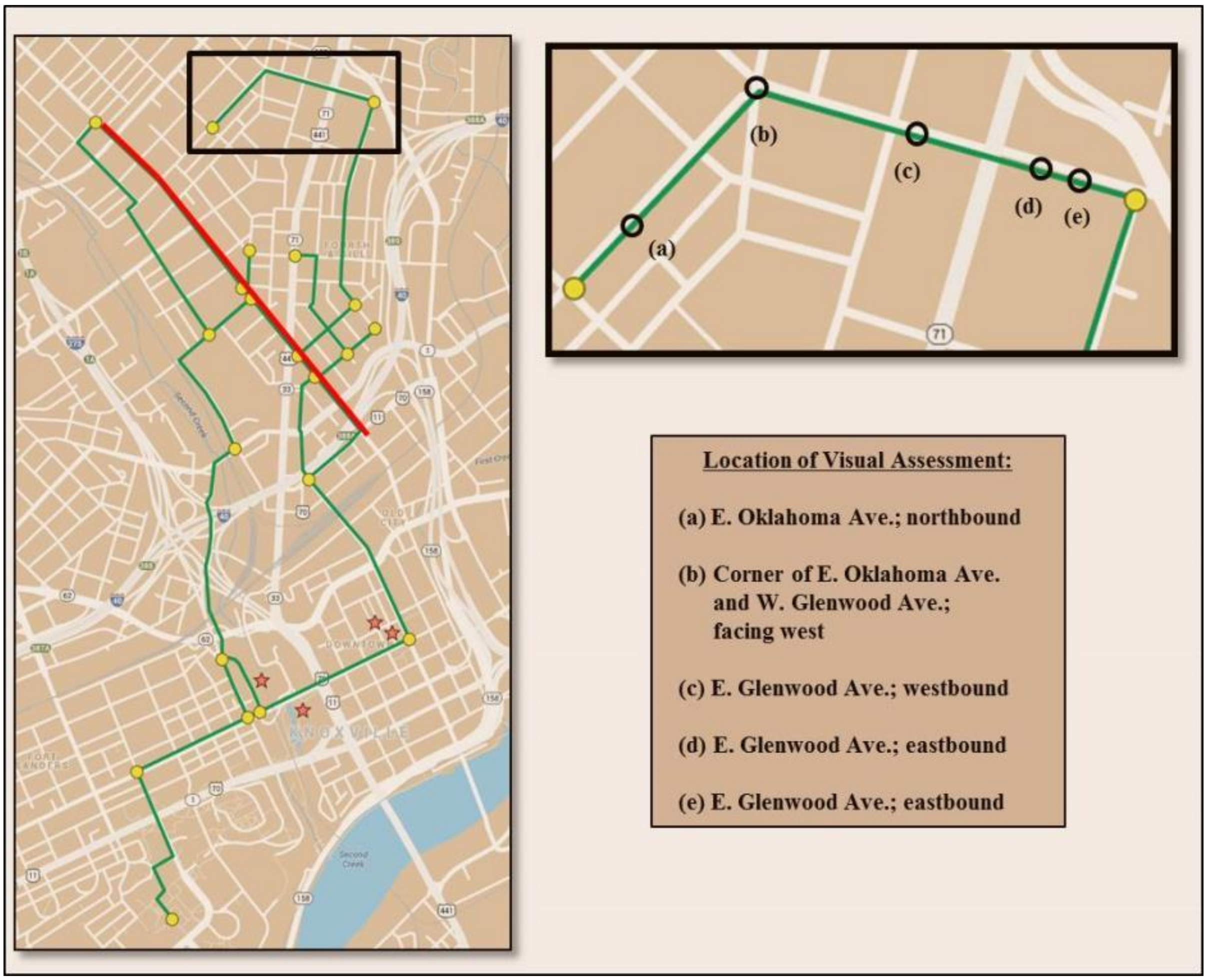

Figure 7.1: Segment 1 - E. Oklahoma Avenue and W. Glenwood Ave.
Start cross-street, Cornelia St; end cross-street, Luttrell St.

Figure 7.2: (a) – Human Scale / Sense of place
Manicured hedge and arched entryway with gate, as well as small-scale landscaping details and small trees provide character and a sense of place.

Figure 7.3: (b) - Imageability and Human Scale / Sense of place
Building details and character of old home on corner along with large tree provide a strong focal point capturing attention. Streetlight on corner is low enough to provide light at a human scale.

Figure 7.4: (c) – Transparency and Upkeep / Sense of place and Sense of safety
Mid-block openings, space between houses and trees provide plenty of visibility. Visibility and openness promote a sense of safety. Pavement is smooth and neighborhood is well kept.

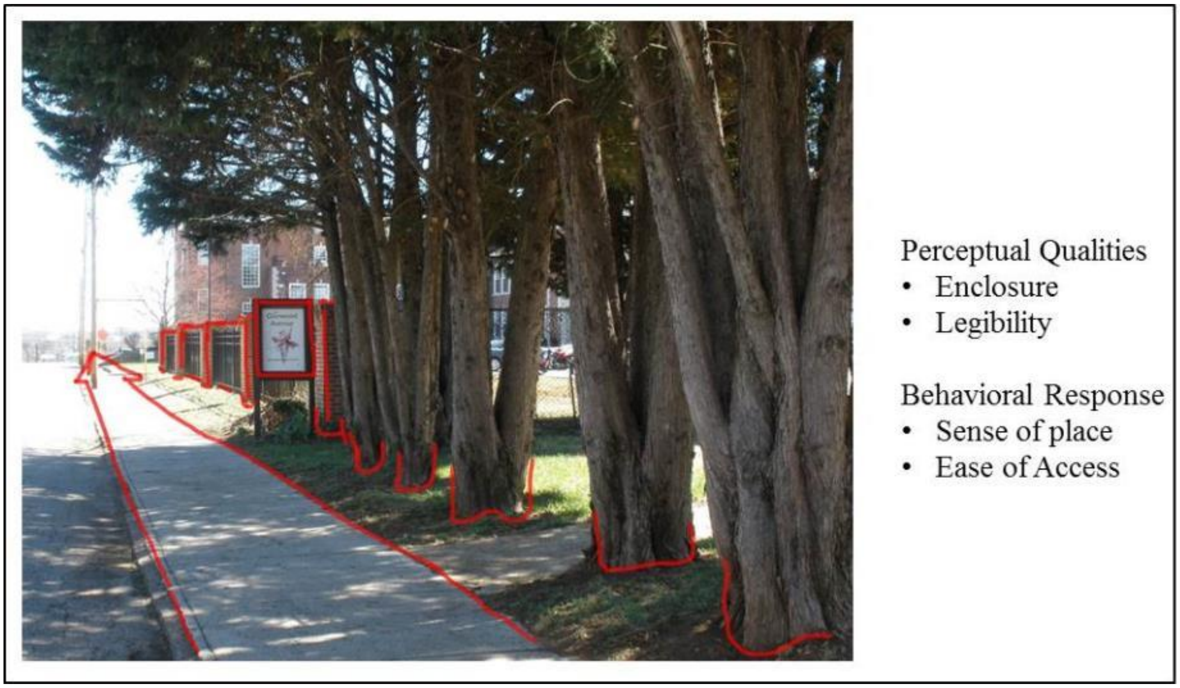

Figure 7.5: (d) – Enclosure, Legibility and Transparency / Sense of place and Ease of Access
Close-spaced trees and tall fence bordering continuous sidewalk provides both enclosure and transparency that defines space. Signage identifying the neighborhood provides the perception of legibility, assisting with way-finding and easy access.

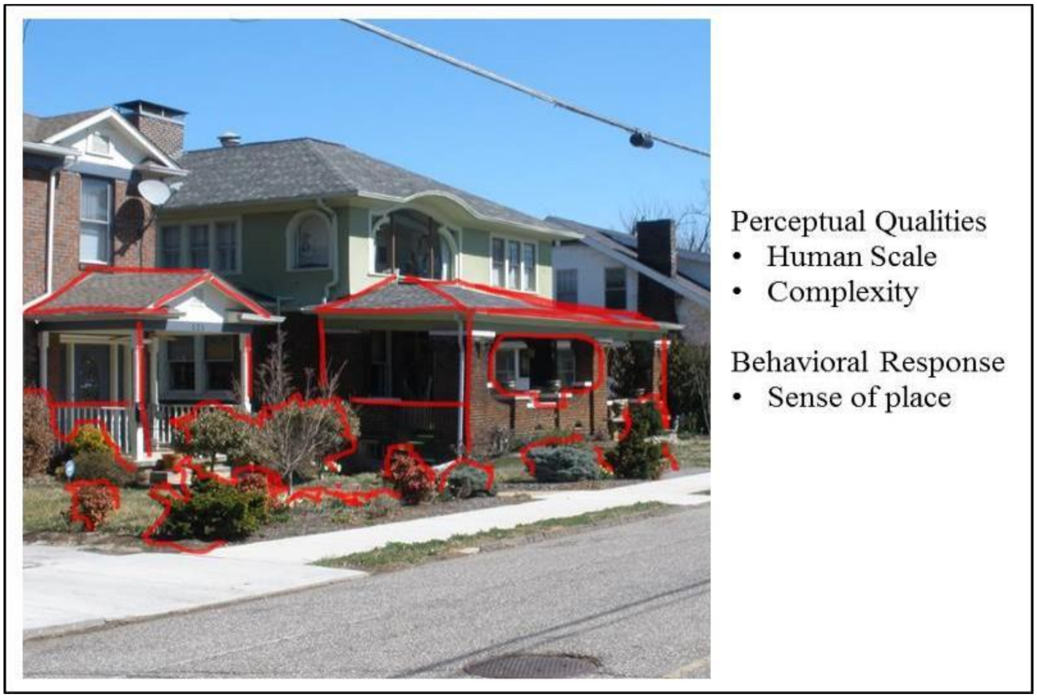

Figure 7.6: (e) – Human Scale and Complexity / Sense of place
Attractive small-scale landscape features and porches, homes with accent colors and architectural details provide visual complexity and richness to this area.

Segment 10

Three riders chose this segment although it appears it is off the beaten path. Again, these bicyclists choose to opt out of utilizing another route close by that is more accessible as a bike lane and directional signage are present (N. Central Ave.). This route is denoted by a heavy red line on the map below. Through the visual assessment and subsequent segment analysis, findings reveal that this segment has a high sense of safety and sense of place as it exhibits the following perceptual qualities: transparency, enclosure, imageability and human scale.

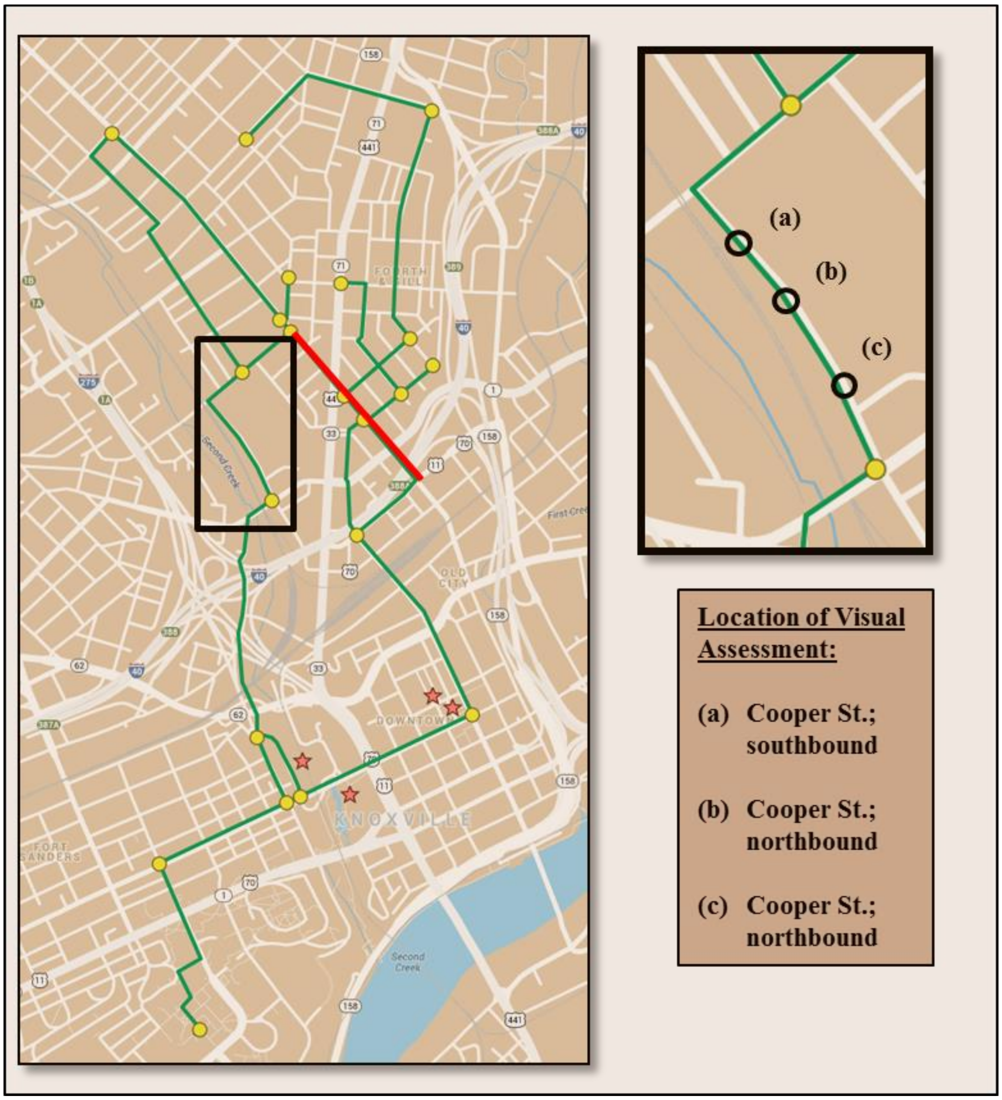

Figure 7.7: Segment 10 – Bernard Ave. and Cooper St.
Start cross-street, N. Central Ave.; end cross-street, W. Fifth Ave.

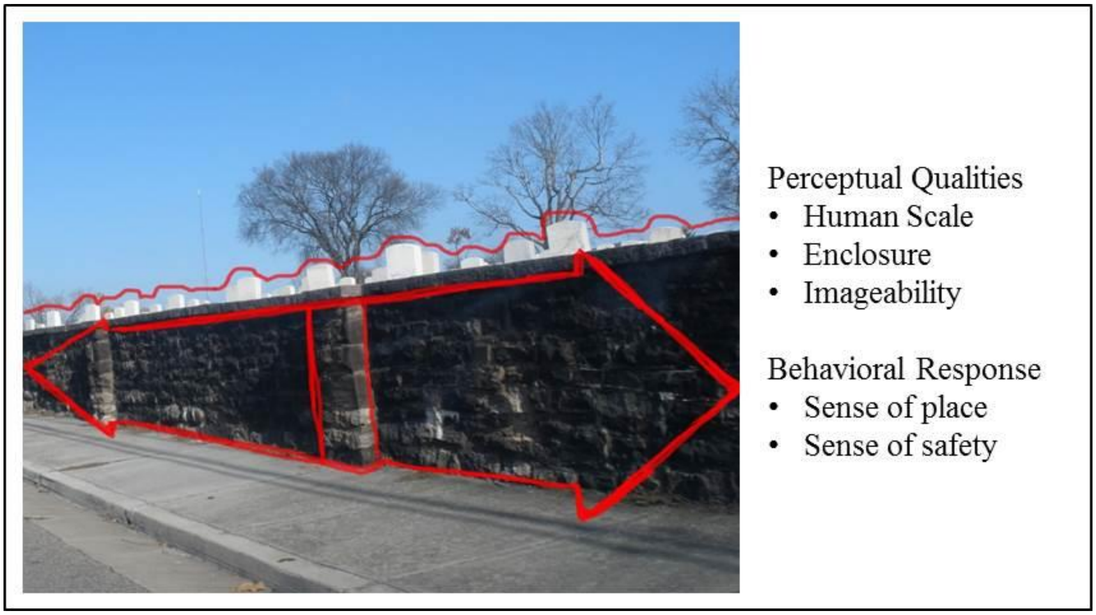

Figure 7.8: (a) – Human Scale, Enclosure and Imageability / Sense of place and Sense of safety
Gravestones within Old Gray Cemetery are at eye level having emotional impact; texture of rough rock wall provides human-scale visual stimulation. Continuous boundary provides spatial definition and perception of safety.

Figure 7.9: (b) – Enclosure / Sense of safety and Sense of place
Continuous tree line and boundary wall and narrow street with buildings minimally set-back provide perception of enclosure and defined space increasing the sense of safety.

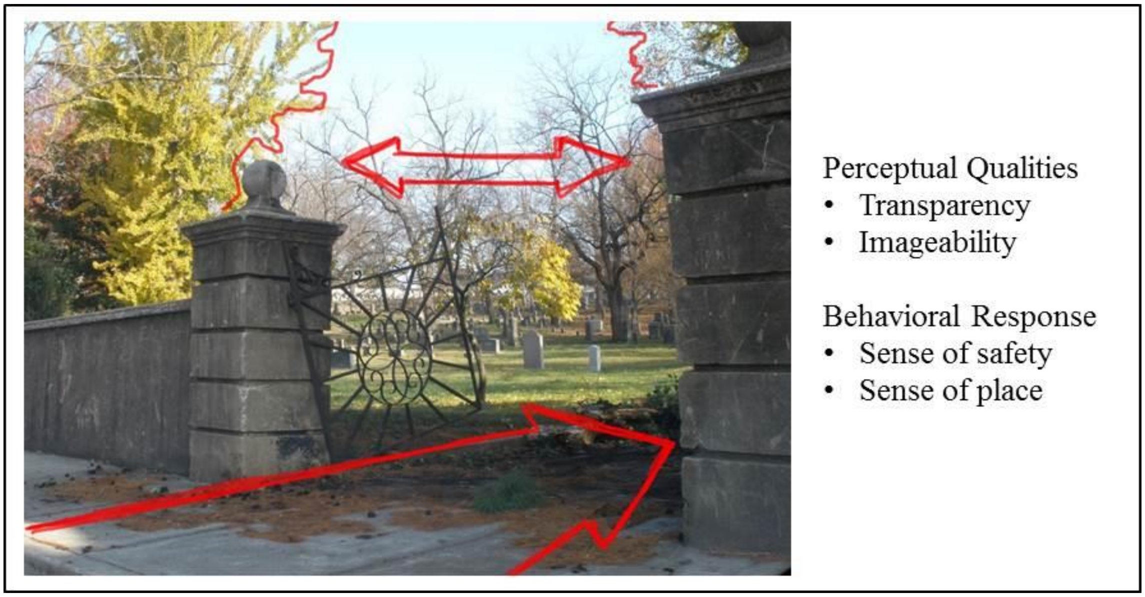

Figure 7.10: (c) – Transparency and Imageability / Sense of safety and Sense of place
Unobstructed views in all directions with minimal presence of trees provide ability to see surroundings thus increasing sense of safety. Detail of wall columns and broken gate and the view between them create a poetic image and sense of place.

Segment 11

Four riders chose this segment regardless of its lack of directional signage and landmarks; through the visual assessment it was assessed as exhibiting minimal legibility and imageability. Perceptual qualities that led to a sense of place; i.e. human scale, complexity, and enclosure, were quite low as well. It appears that the draw to this segment is simply that it provides the most direct linkage from segment number ten to their destination. In addition, the perception of transparency was strongly present which was interpreted to provide a high sense of safety.

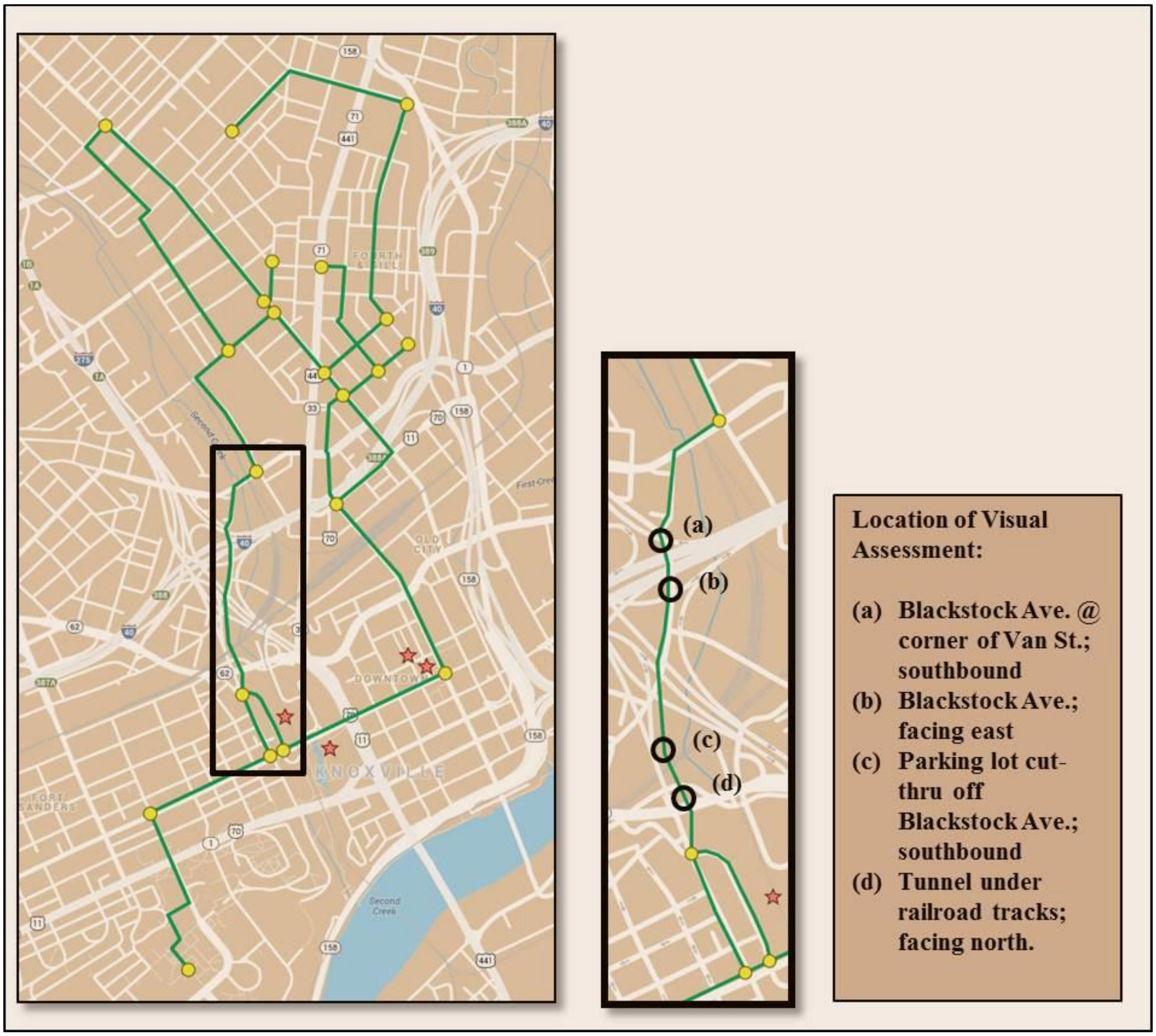

Figure 7.11: Segment 11 – Van St. / Blackstock Ave. / cut-through parking lot, thru tunnel under railroad tracks next to Foundry / Grand Ave.
Start cross-street, Cooper St.; end cross-street, World's Fair Park Dr.

Figure 7.12: (a) – Linkage and Transparency / Ease of access and Sense of safety
Lack of obstacles, cross-streets and stop signs allow for continuous, uninterrupted travel providing increased ease of access and sense of safety. Wide-open views provide the perception of transparency adding to the sense of safety.

Figure 7.13: (b) – Transparency / Sense of safety
Wide-open views without underbrush, trees or structures, in addition to large opening in overpass, provide light and views of the sky adding to the perception of transparency and a sense of safety.

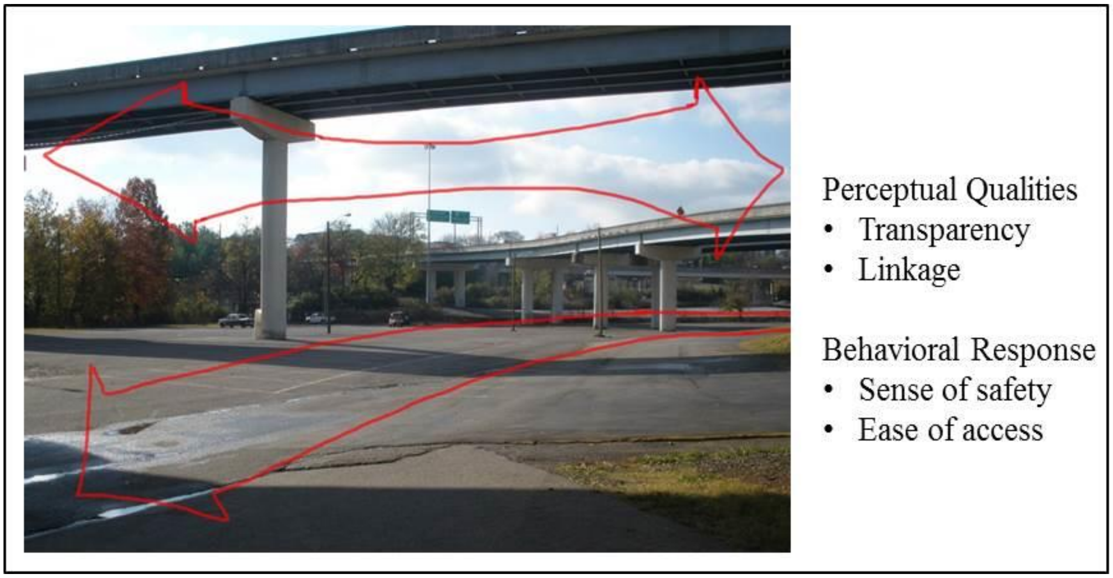

Figure 7.14: (c) – Transparency and Linkage / Sense of safety and Ease of access
Unobstructed views in all directions increases sense of safety. Parking lot free from obstacles can be used as a cut-thru, serving as a convenient linkage.

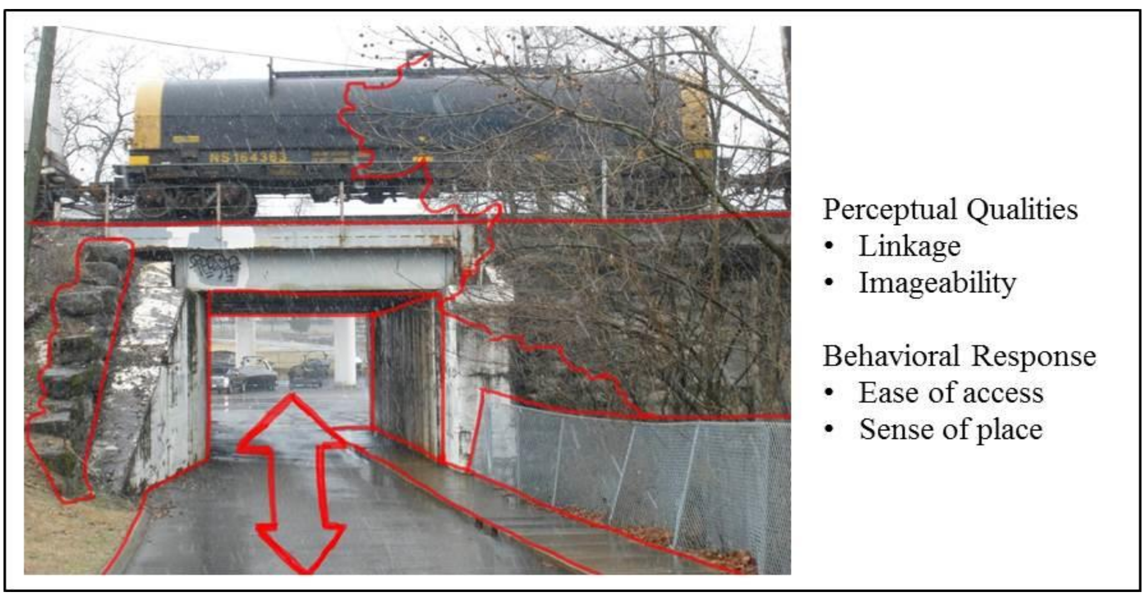

Figure 7.15: (d) – Linkage and Imageability / Ease of access and Sense of place
Tunnel under railway provides an accessible link from parking lot to backside of World's Fair Park saving significant travel time. Trains passing by and tunnel framed by rock wall provides visual and auditory stimulus creating place-based character.

7.2 Segment Analysis

An analysis was conducted based on the visual assessment that entailed taking a tally of perceptual qualities and associated potential behavioral responses for each segment (See Table 7.2 at the end of this section). It should be noted that since more pictures were taken on longer segments the count of the tallies could not be used to compare segments. However, for each segment a ratio of each of the three behavioral responses was calculated allowing for a comparative analysis to be conducted (See Table 7.1 on the following page).

These results increase the understanding as to why a bicyclist chose a particular segment for their commute, and what each segment has to offer per se. Figure 7.16 reveals if a segment was assessed to have the potential to incite more, or less, of each of the three behavioral responses; i.e. sense of safety, sense of place or ease of access. A map with numbered segments can be used to reference the physical location of each segment.

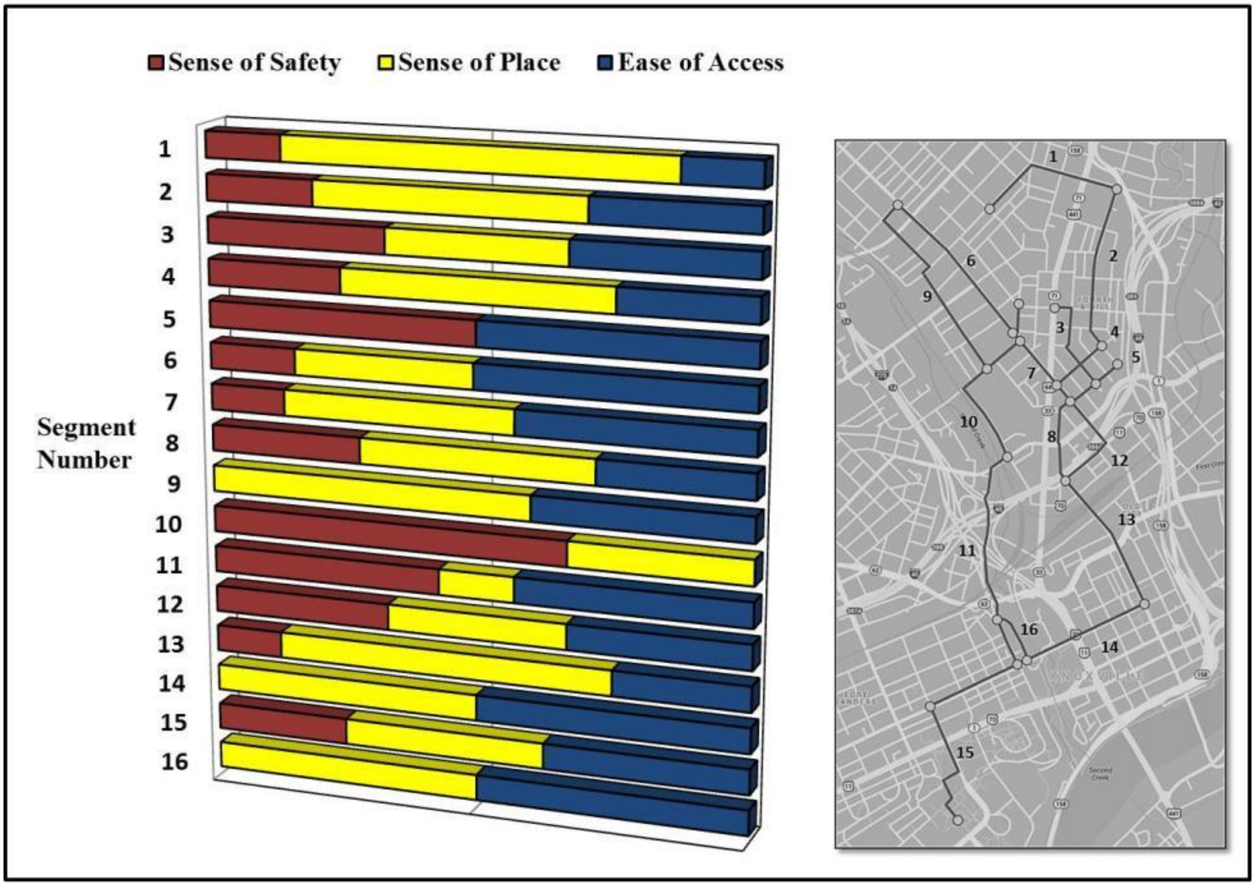

Figure 7.16: Perceptual qualities associated with each segment based on visual assessment.

Table 7.1: Comparison of ratios between the three behavioral responses.

Segment #	Sense of Safety	Sense of Place	Ease of Access
1	0.14	0.71	0.14
2	0.22	0.55	0.33
3	0.33	0.33	0.33
4	0.25	0.5	0.25
5	0.5	0	0.5
6	0.16	0.33	0.5
7	0.14	0.43	0.43
8	0.28	0.43	0.28
9	0	0.6	0.4
10	0.66	0.33	0
11	0.43	0.14	0.43
12	0.33	0.33	0.33
13	0.125	0.625	0.25
14	0	0.5	0.5
15	0.25	0.375	0.375
16	0	0.5	0.5
Sum of behavioral response scores	3.8	6.7	5.5
# of times had highest score or equal	5	12	9

Upon summation of the behavioral response scores, it appears sense of place scores the highest for the entire system. Table 7.2 on the following page presents tallies of the perceptual qualities that ultimately produced these scores. Human scale is the perceptual quality that is by far the most significant contributing quality for inciting a sense of place. Linkage and legibility were found to be the second and third most frequently identified perceptual qualities, respectively, contributing to ease of access and sense of safety.

Table 7.2: Tally of perceptual qualities and associated potential behavioral responses for each segment based on visual assessment.

Seg. #	Rider #	Ease of access	Sense of Place	Sense of Safety	Legibility	Linkage	Human Scale	Transparency	Complexity	Upkeep	Enclosure	Imageability
1	3, 5	1	5	1	1		4	1	1	1	1	1
2	3, 5	3	5	1	2	1	4		1		1	1
3	2	1	1	1		1	1	1	1			
4	4	1	2	1	1		2		1			
5	2, 3, 5, 9	1		1	1						1	
6	6, 7	3	2	1	1	2	2		2			1
7	4, 6, 7	3	3	1	2	3	1	1	2			
8	2, 3, 4, 5, 6	2	3	2	1	1	2	1	1	1		2
9	8	1	2		1						1	2
10	1, 8, 11		2	4			1	2			2	2
11	1, 8, 10, 11	3	1	3		3		3				1
12	7, 9	1	1	1	1		1				1	
13	2, 3, 4, 5, 6, 7, 9	2	5	1	2	1	3		1	2	2	
14	1, 2, 5, 7, 9, 10, 11	3	3		2	2				1	1	1
15	1, 2, 5, 9, 10, 11	3	3	2		4	1	2	2			
16	8, 11	1	1		1		1	1				
Sum of scores		29	39	20	16	18	23	12	12	5	10	11

7.3 Surveys

This section presents the lean data gleaned from the survey responses. It was found that improvements could have been made to the survey tool regarding the actual questions posed; the wording for some of the questions seems to have been confusing as well. Questions could be more specific to the bikers' route choice in order to complement the cognitive maps rather than general bikeability questions. In some cases, suggested areas of improvement were identified which is beneficial but did not explicitly support the cognitive mapping exercise.

Results

Of the eleven respondents, the majority were White males under the age of 25.[55] When asked to rate their level of biking experience, five reported to be experienced, four moderately experienced and two stated they were beginners.

None of the bicyclists reported their commute exceeded 25 minutes; but six claimed it took between 16-25 minutes to reach their destination, four stated between 6-15 minutes and one spent less than five minutes on their commute. However, three stated there was a shorter route available but they chose not to take it. The following are the areas they identified to not include in their route and reasons why:

- N. Broadway, because it is "too dangerous even though there is less topography to traverse [than the route I choose]."
- Hall of Fame Dr. because "it is too boring; there is nothing interesting or attractive to look at."
- Both N. Broadway and Cumberland Ave. because there is "just too much traffic and it makes me feel unsafe."
- N. Broadway, "too sketchy at night and it is a dangerous area."

Even though only three respondents explicitly stated they avoid biking these segments not one of the eleven respondents chose to travel them. Referring to the route map in Figure 7.17 one can see that N. Broadway is a straight shot, traveling due south connecting North Knoxville to Downtown and for many of the riders would be the most direct and least complex route choice. Hall of Fame Dr. hosts a bike lane, although for most of the riders in this study it is not as accessible as N. Broadway due to its location on the east side. Cumberland Ave. is somewhat out of the way for these respondents as well as it travels on the south side of the study site.

[55] Nine respondents are White males; two are Asian females, with seven of the eleven being under the age of 25.

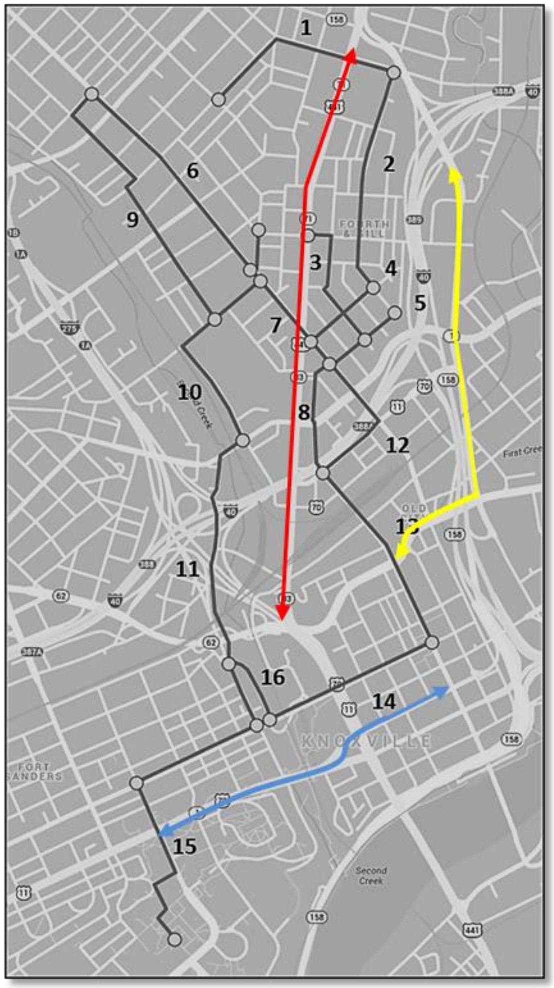

Figure 7.17: Segments identified by three survey respondents as roads less traveled due to perception of lack of safety and sense of place. Red line denotes N. Central Ave., yellow line is Hall of Fame Dr., and the blue line is Cumberland Ave.

Places that at least one respondent stated they felt very uncomfortable and unsafe riding a bicycle are listed below; however, reasons were not provided. (See Figure 7.18 on the following page):

- Intersection of N. Central Ave. and W. Magnolia Ave.
- Intersection of Volunteer Blvd. and Cumberland Ave.

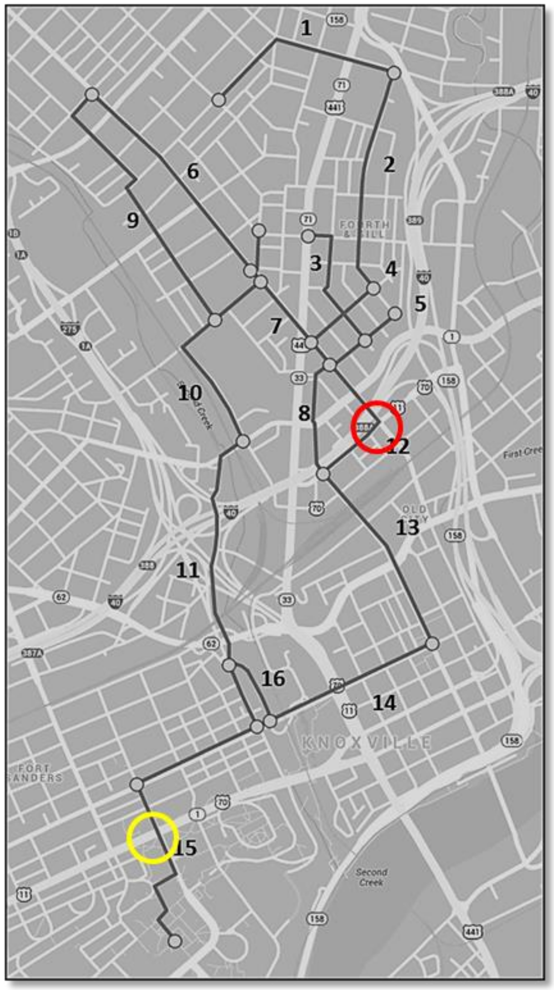

Figure 7.19: Intersections perceived as unsafe.
Intersection of N. Central Ave. and W. Magnolia Ave is circled in red.
Intersection of Volunteer Blvd. and Cumberland Ave. is circled in yellow.

Time of day and amount of lighting provided is shown to have an impact on route choice. At least one respondent stated that at night there were areas along their route that made them feel unsafe. These specific areas would deter them from riding after dark:

- Cooper St. (Segment 10); "not enough light."
- Blackenstock Ave. (Segment 11); "not enough light [at a human scale]."
- Clinch Ave (Segment 14); "because there is not enough space, and cars tend to pull out in front of bikers."

8.0 CONCLUSIONS

The main question I aimed to answer through this thesis was: "Can an assessment of experiential perceptions of specific user groups be beneficial for urban design and planning purposes?" To explore this question I designed a community participation planning process which included a cognitive map exercise and surveys. Through the interpretation of the cognitive maps and the subsequent visual assessment and segment analysis, I was able to identify perceptual qualities based on physical characteristics of the urban landscape that incited a behavioral response by bicycle commuters and to what degree these responses impact route choice. The geographical, perceptual and behavioral environments all influence the way that an individual interacts with the urban environment. However, this method reveals that behavioral responses regarding bikeability are in some cases independent from the presence, or absence, of urban design elements that are quantified through traditional planning models and can be complex and individually based. Through the assessment of the relationship between these variables a more accurate picture of bikeability can be produced.

The methodology utilized in this thesis revealed that, in this context, sense of place as a behavioral response has the most impact on route choice determination. Furthermore, human scale is the perceptual quality that was found to be the most significant contributing quality for inciting a sense of place. Linkage and legibility were found to be the second and third most frequently identified perceptual qualities, respectively, contributing to ease of access and sense of safety.

One could argue that this alternative assessment method is effective and beneficial as it does in fact provide complex, rich data. This method can provide a continual feedback loop informing designers and planners on perceptions of bikeability by the user group. These findings can significantly improve the ability to redesign our cities on a human scale and identify specific areas that need improvements. The method utilized in this thesis provides an additional layer of information to be taken into consideration and fills a missing gap in current methods utilized in traditional transportation analyses in the U.S.

Sample Recommendations

- First and foremost, create an urban landscape design that includes human scale elements along segments identified as inciting a low level of sense of place. For example, Segment 11 could draw more bicyclists if lighting was improved and human scale amenities and landscaping touches were added.
- A suggestion stated directly from the survey - Segment 10 could be improved by installing human scale lighting thereby increasing sense of safety.

- Provide adequate signage along segments that rate low on legibility (both Section 10 and 11), which would increase ease of access.
- Bushes or trees can be planted in a linear fashion and landscaping features and/or walls can be constructed along segments that rate low on linkage (Segment 1 and 10). The perception of interconnectedness can increase sense of safety and accessibility.

9.0 EPILOGUE

The methodology presented in this thesis was utilized specifically for the purpose of assessing bikeability; however, it should be considered that this approach has broader applications in the urban design field. As discussed throughout this thesis, people react to an environment only as they perceive it. Urban planners and designers; i.e. Landscape Architects and Architects, need to be aware of *perceptual environments* and recognize that a user's response to place is based on one's *behavioral environment*. Planners and designers could benefit from reflecting on the principles of environmental psychology; becoming more familiar with the multitude of perceptual qualities; and be cognizant of the impact these perceptions have on decision making processes.

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APPENDICES

Appendix A: Research Survey Tool

I am interested in a bicyclist's perception of their urban environment and subsequent bike route choice.

1. Read all of A, B and C before starting this exercise:

   A) Visualize yourself biking along the route you would typically choose for your commute. I am interested in the things that you would feel, hear, see or smell along the way (pleasant and unpleasant); the sequence of physical features that you encounter and your associated perceptions.

   B) Now sketch your "perception" map of your route on blank letter size paper using a black pen. Do not concern yourself with accurate distances. You can draw your map consisting of streets, districts, landmarks or a combination of elements. Label your origin and pick a specific destination.

   C) Now go back and, using the supplied legend at the end of this survey, place symbols on your map. Please be thorough, try to remember as many features as you possibly can. Then, label the names of streets, landmarks and places of interest.

2. How long does it take to reach your destination?

3. Is there a route that would be faster or easier for you to take?
   3a. If so, how much faster and why do you not take this route?

4. Are there areas that you prefer to avoid that impact your route decisions?
   4a. Please explain.

5. Does your route change while biking at night?
   5a. Please explain.

6. What is your favorite part of your commute?
   6a. Why?

7. What is your least favorite part of your commute?
   7a. Why?

8. Have you referred to the City of Knoxville's bike map?
   8a. If so, do you follow the recommended route in your area?
   8b. Why or why not?

9. From your experiences, are drivers in Knoxville courteous to bikers while sharing the road?

10. If you care to share a personal story, briefly describe a specific Knoxville biking experience, negative or positive.

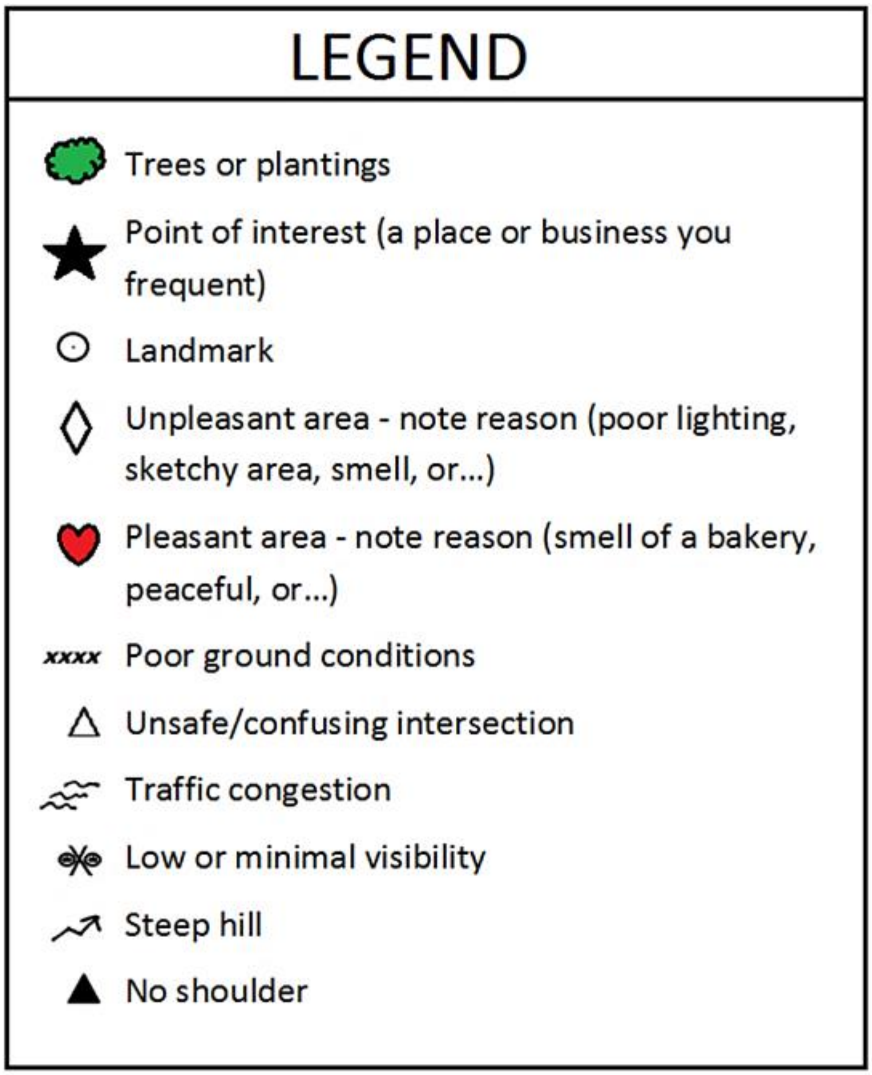
11. How long have you lived in the area that you are currently commuting?

12. Please rate your level of biking experience as advanced, intermediate, or beginner.

13. How old are you?

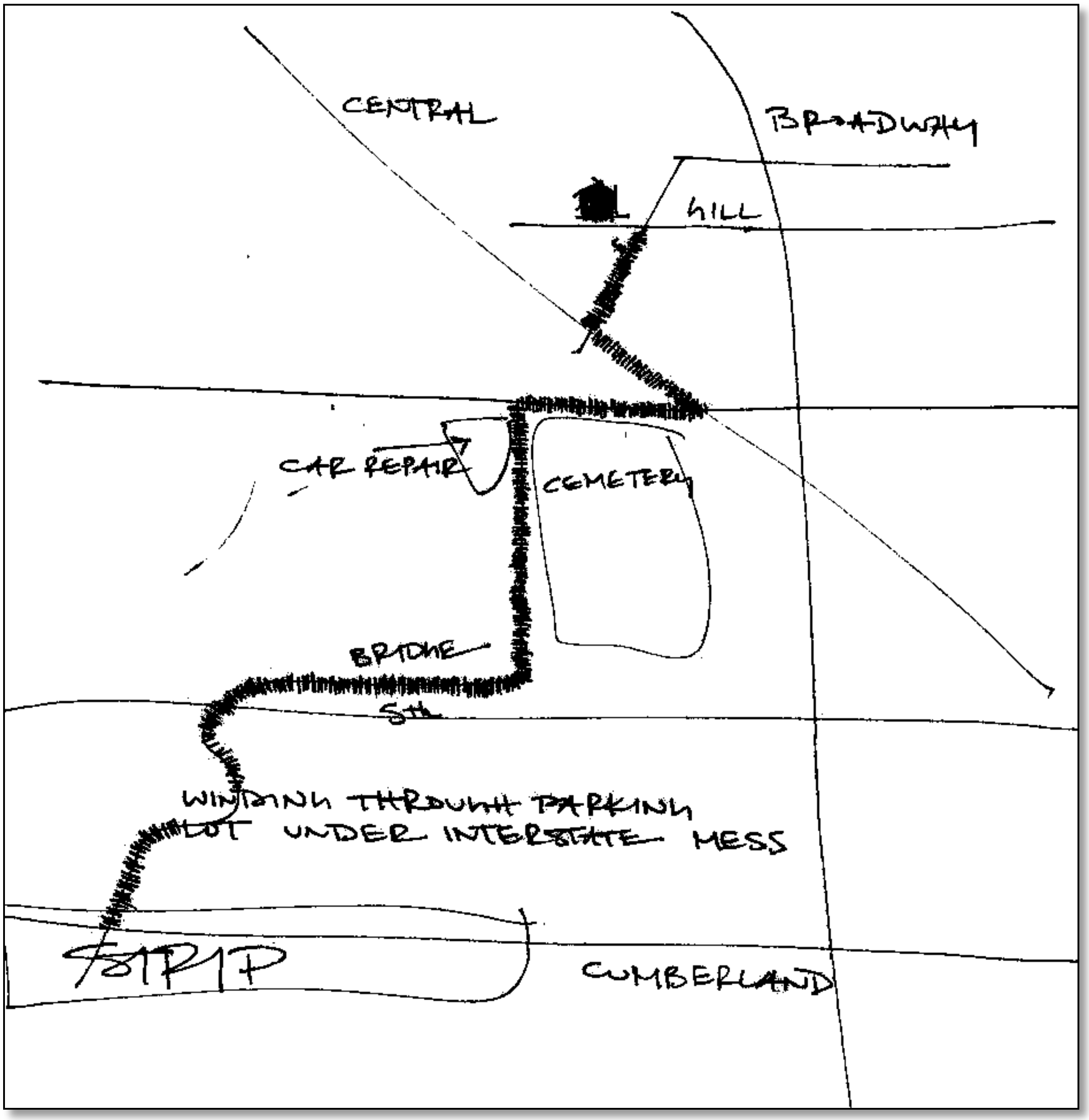
14. Are you male or female?

Please use the symbols from the legend below for use for the cognitive mapping exercise.

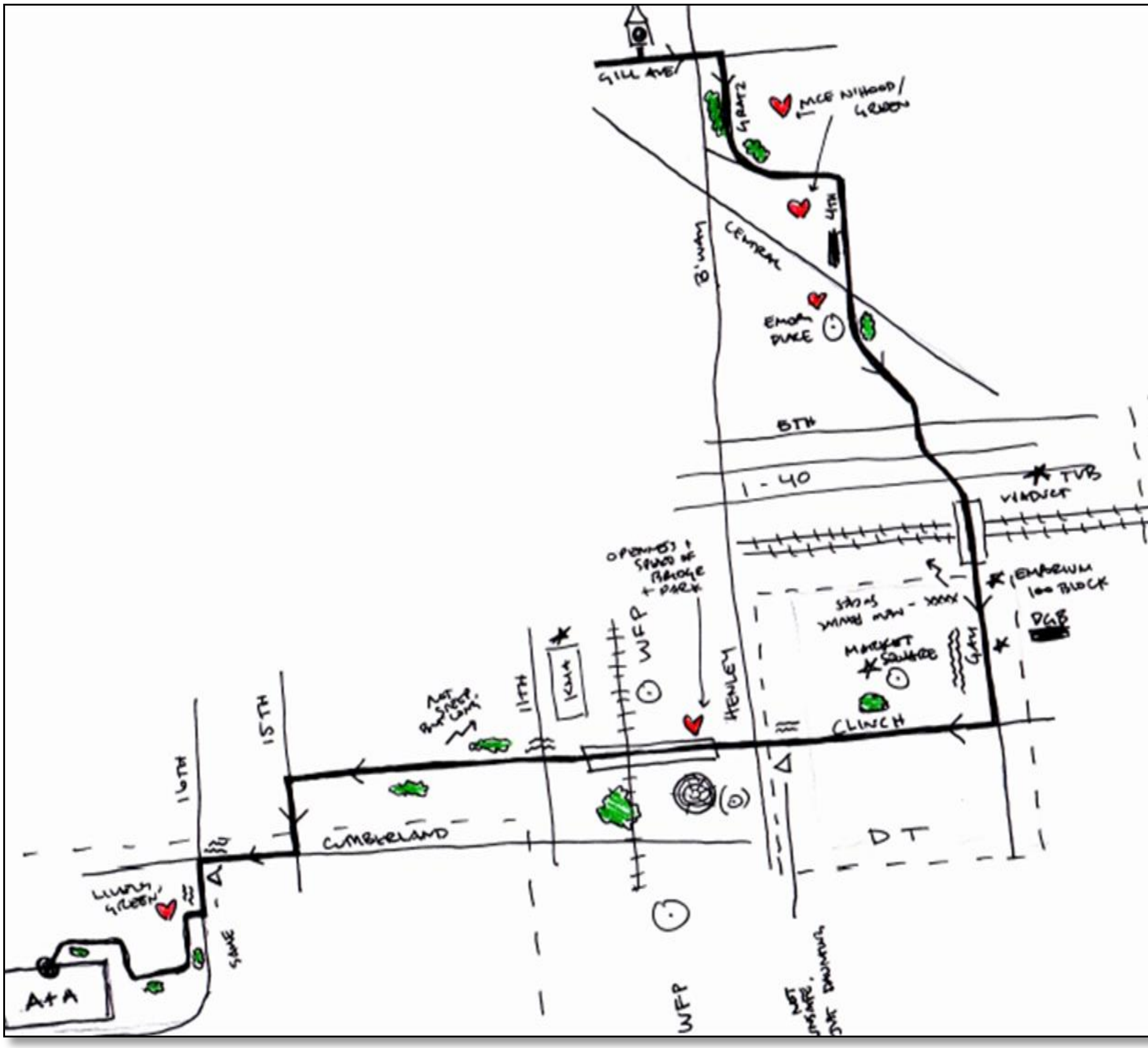


Appendix B: Cognitive Maps

Rider 1

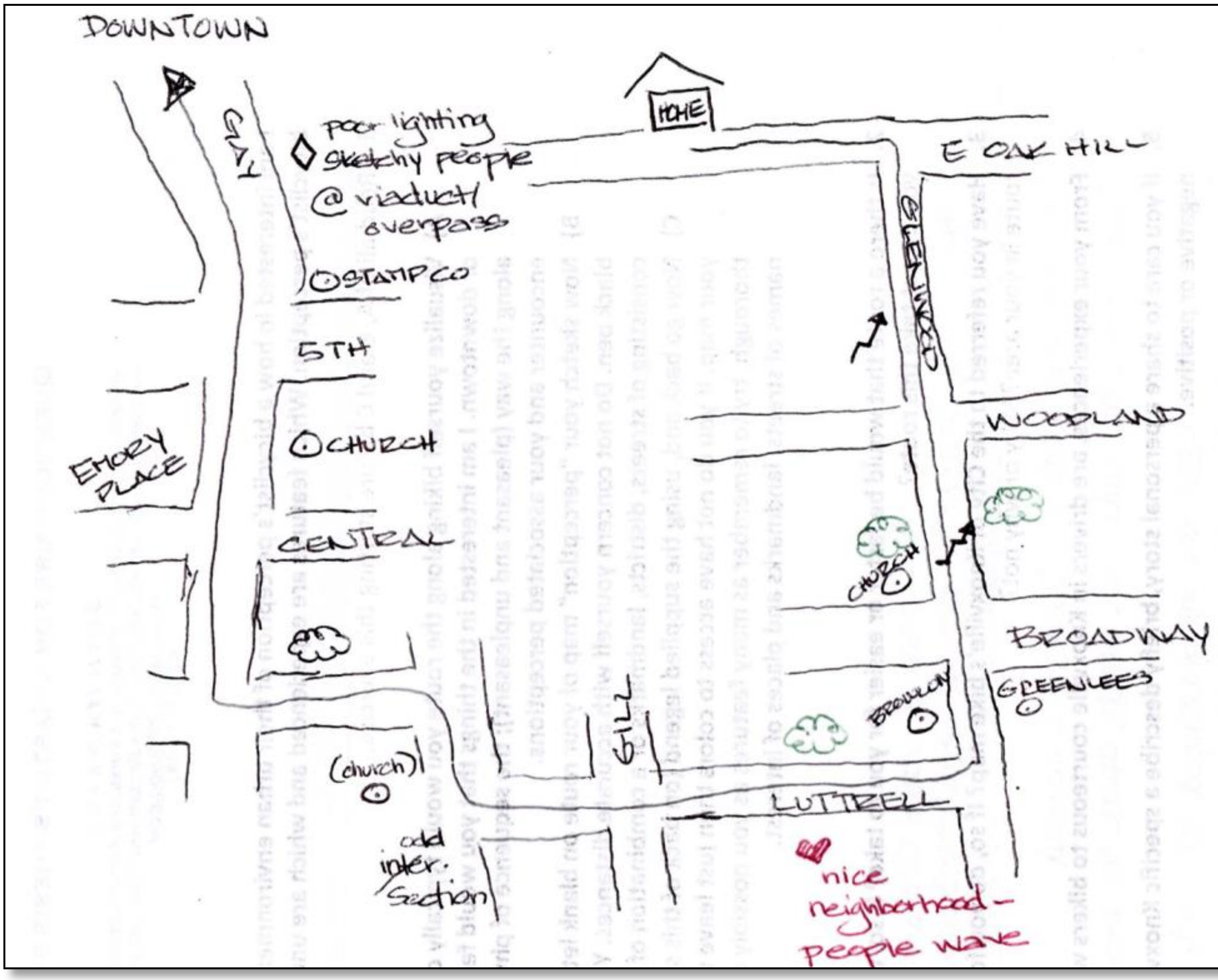


Rider 2



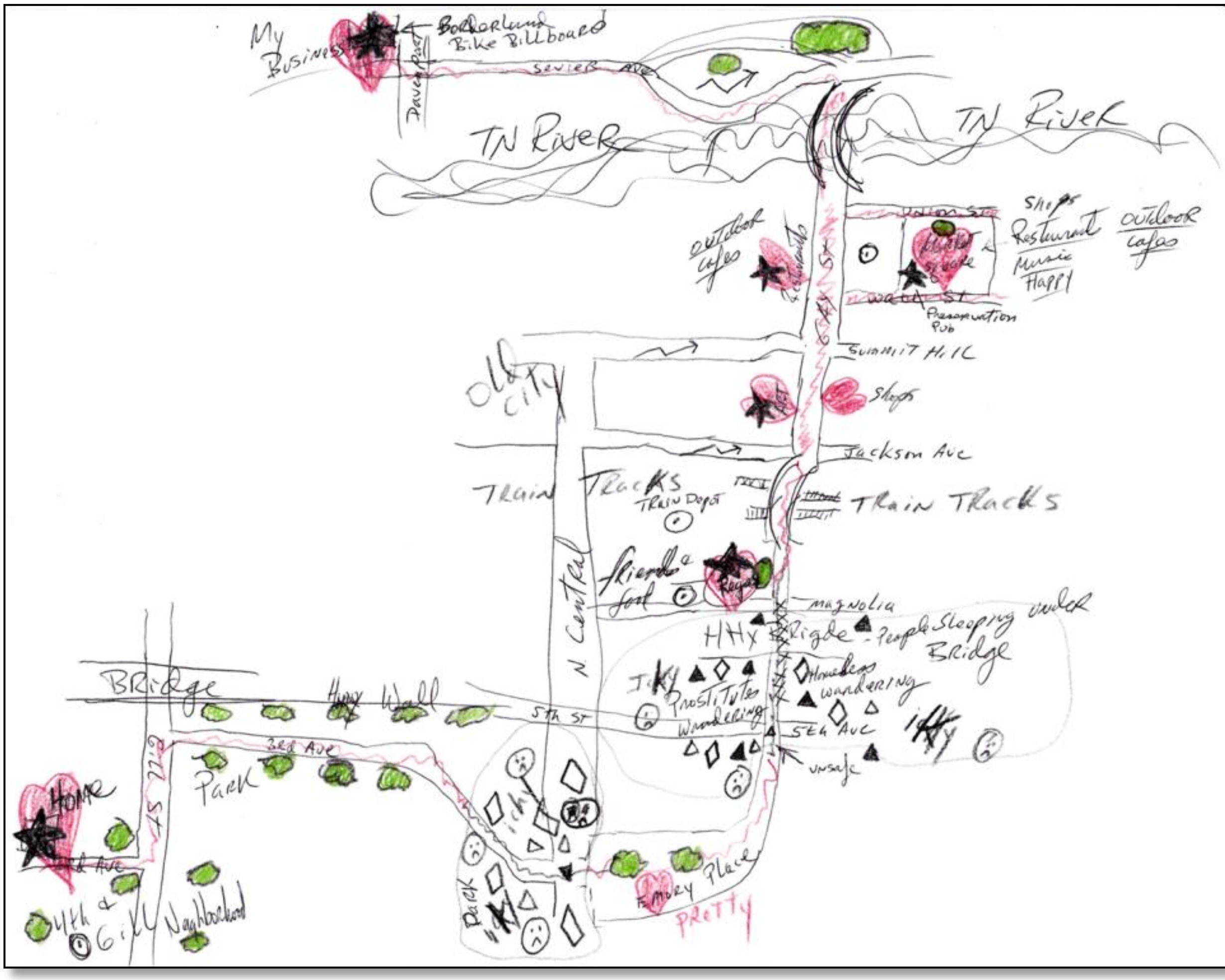
GILL AVE
GRATZ
4TH
CENTRAL
B'WAY
EMORY PLACE
5TH
I-40
TVB
VIADUCT
EMPORIUM
100 BLOCK
PGB
MARKET SQUARE
GAY
CLINCH
HENLEY
WFP
KMA
11TH
15TH
16TH
CUMBERLAND
DT
A+A
WFP

Rider 3

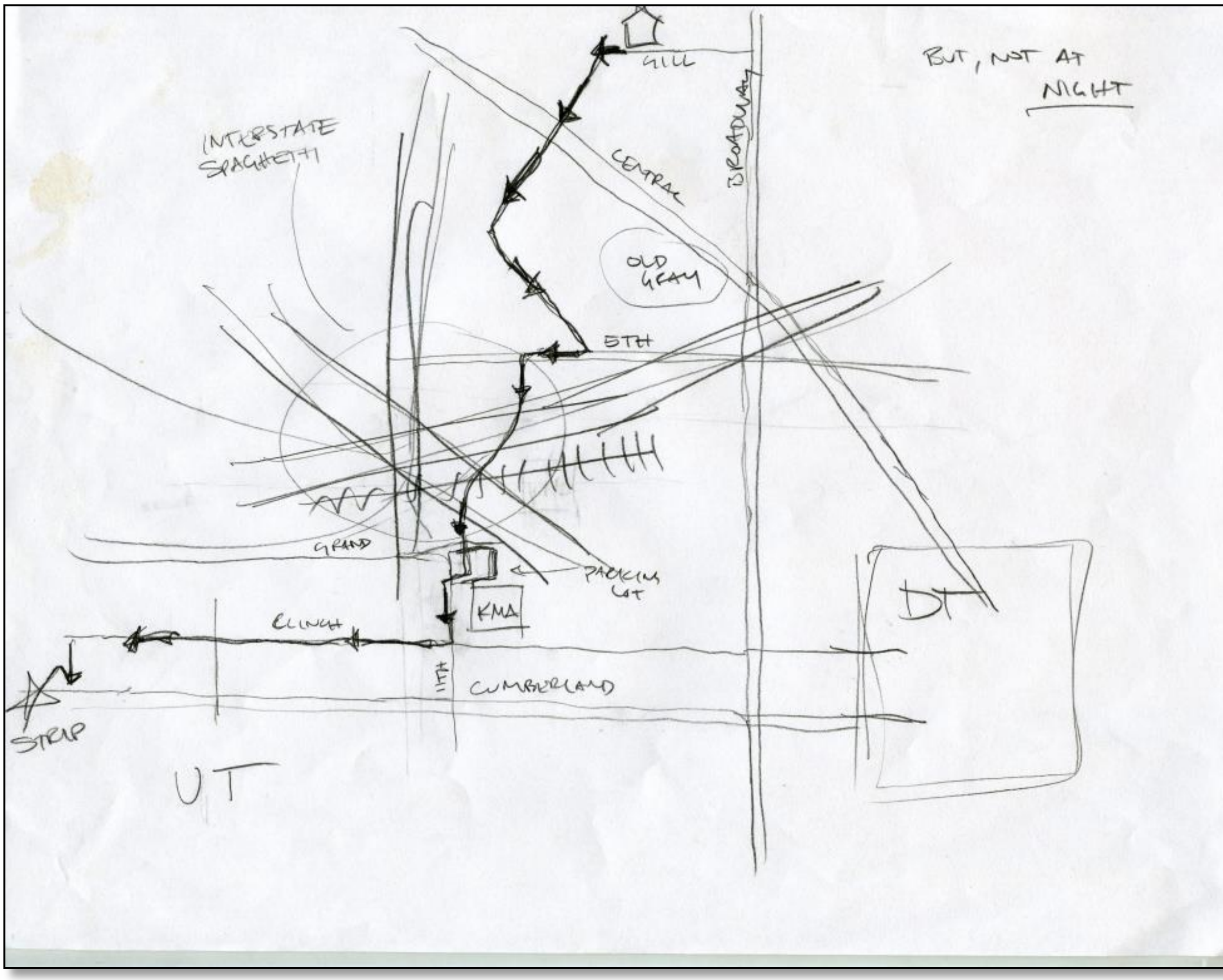


DOWNTOWN
GAY
poor lighting
sketchy people
@ viaduct/
overpass
HOME
E OAK HILL
GLENWOOD
STAMPCO
5TH
EMORY
PLACE
CHURCH
CENTRAL
WOODLAND
CHURCH
BROADWAY
GREENLEE
GILL
(church)
LUTTRELL
odd
inter.
section
nice
neighborhood -
people wave

Rider 4

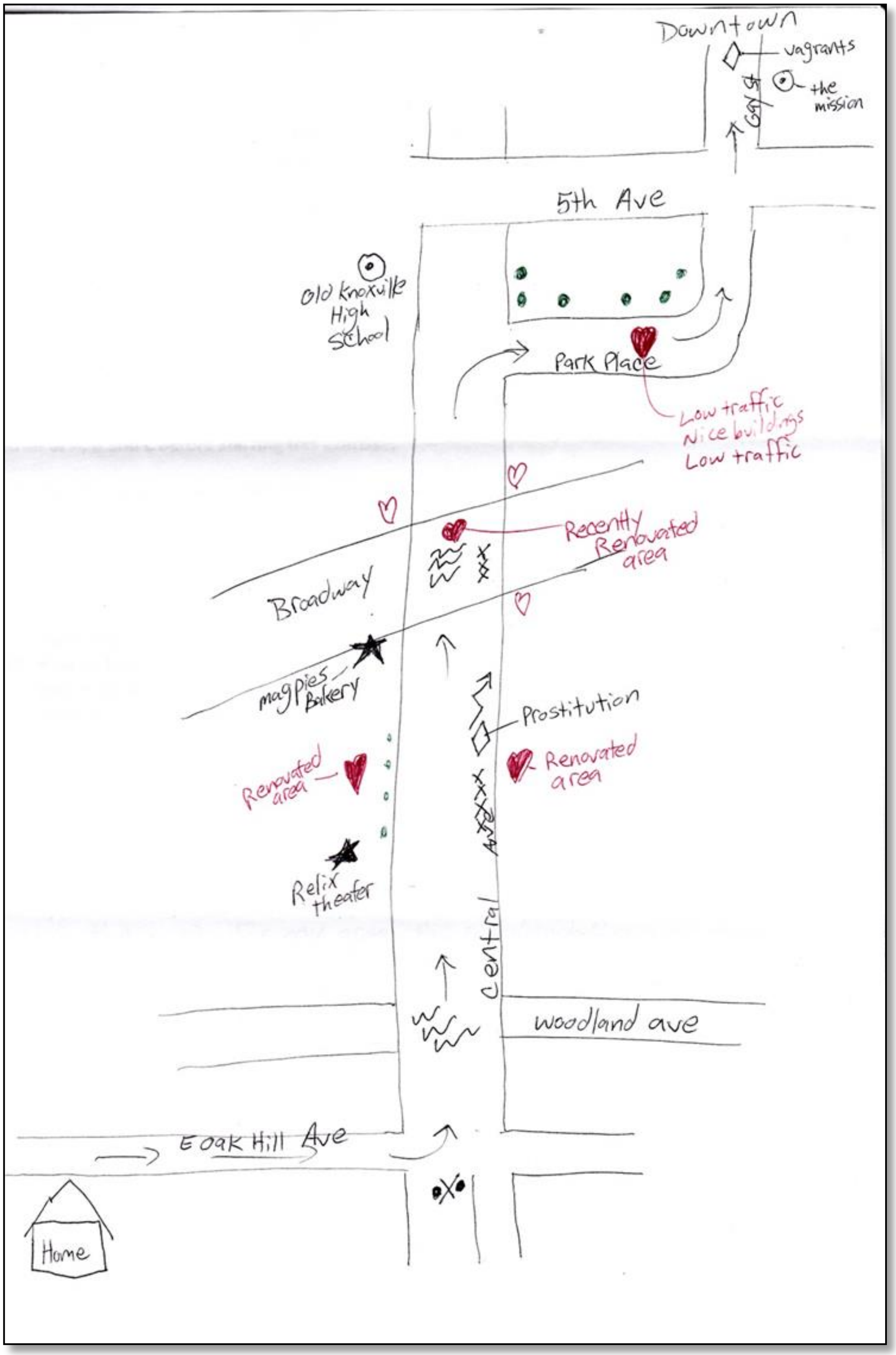

My Business
Borderland Bike Billboard
Sevier Ave
TN River
TN River
outdoor cafes
Shops
Restaurant
Music
Happy
outdoor cafes
Preservation Pub
Summit Hill
Old City
Shops
Jackson Ave
Train Tracks
Train Depot
Train Tracks
N Central
magnolia
People Sleeping under Bridge
Prostitutes wandering
Homeless wandering
5th Ave
unsafe
Bridge
5th St
3rd Ave
Park
Home
Park
Emory Place
Pretty
Neighborhood

Rider 5



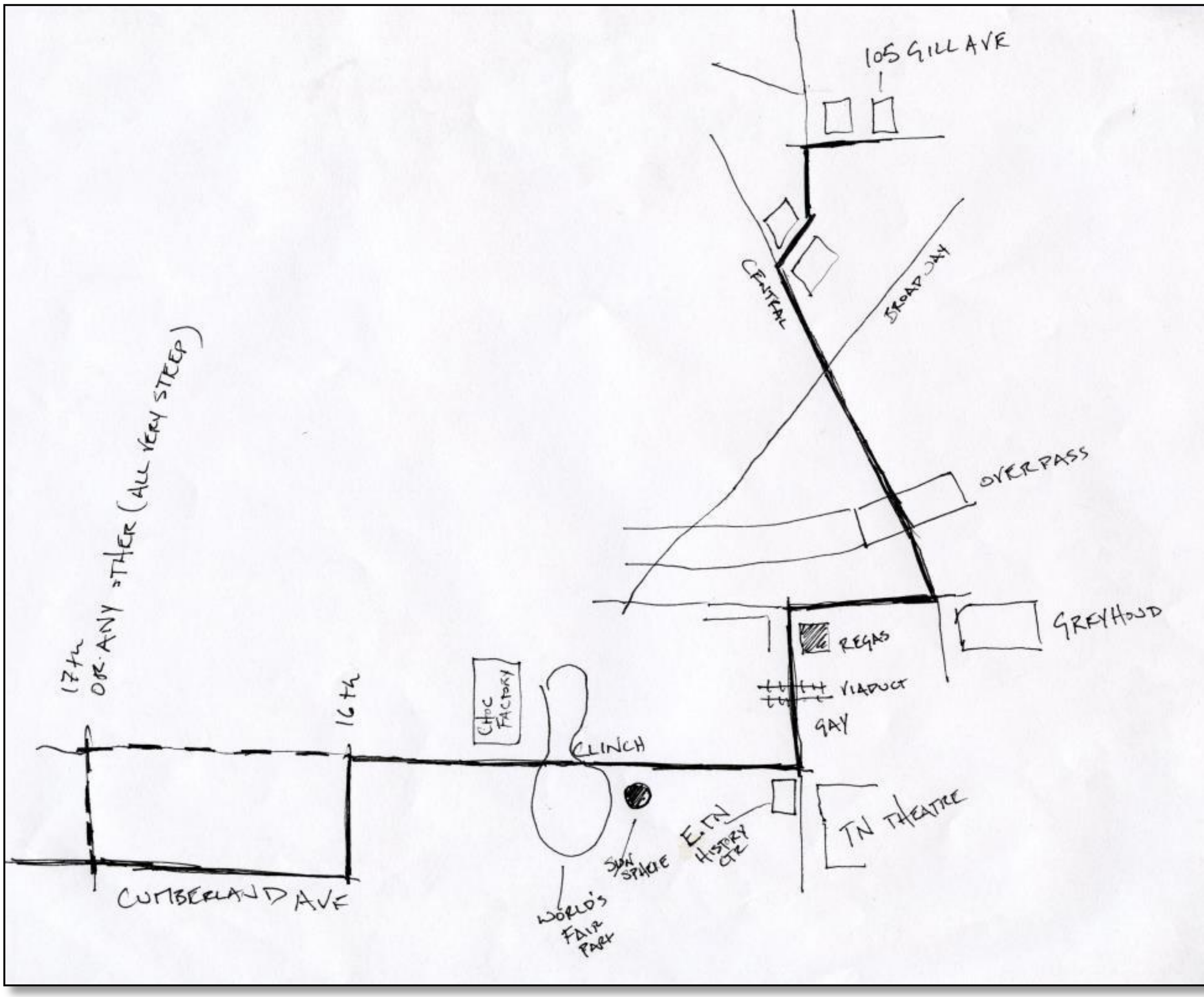
GILL
BUT, NOT AT NIGHT
INTERSTATE SPAGHETTI
CENTRAL
BROADWAY
OLD GRAY
5TH
GRAND
PARKING LOT
KMA
CLINCH
CUMBERLAND
STRIP
UT
DT

Rider 6

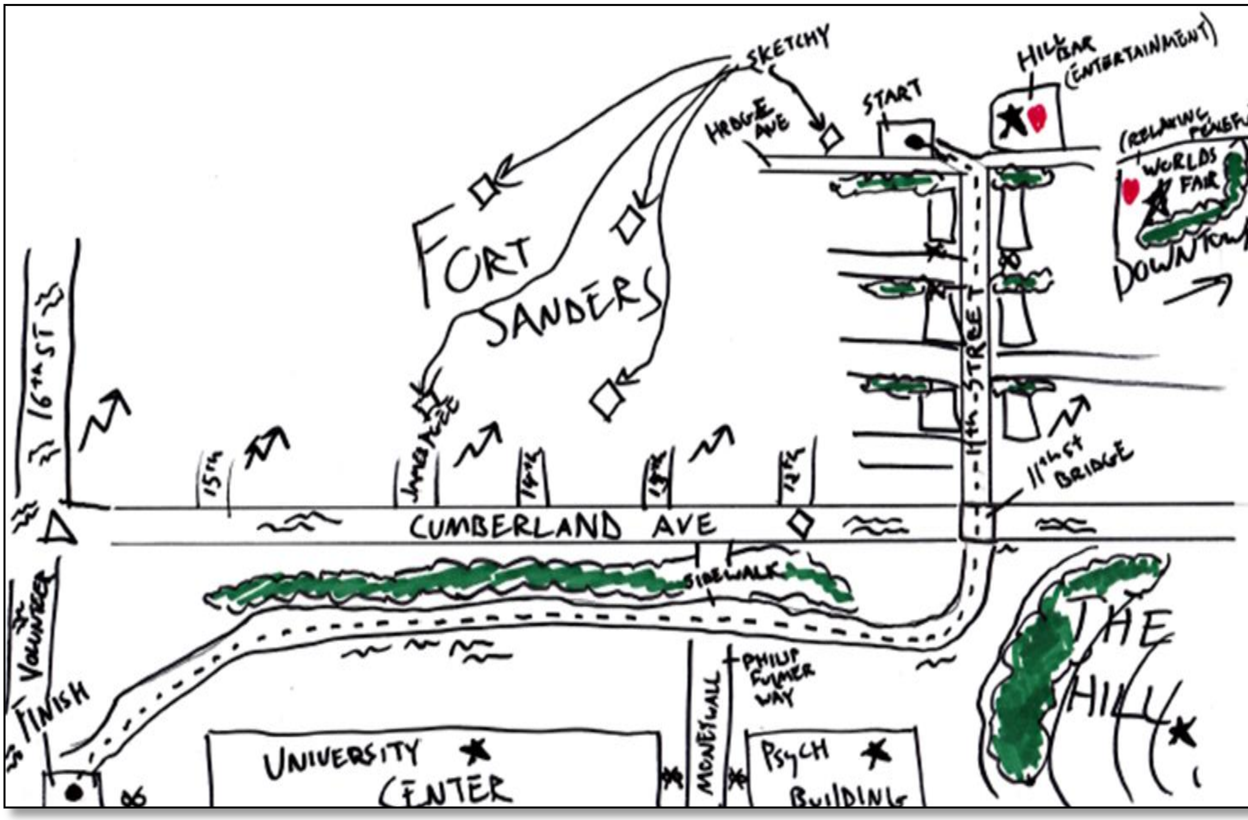


Downtown
vagrants
the mission
Gay St
5th Ave
Old Knoxville High School
Park Place
Low traffic
Nice buildings
Low traffic
Recently Renovated area
Broadway
magpies Bakery
Prostitution
Renovated area
Renovated area
Relix theater
Central
woodland ave
E Oak Hill Ave
Home

Rider 7


105 GILL AVE
CENTRAL
BROADWAY
OVERPASS
GREYHOUND
REGAS
VIADUCT
GAY
TN THEATRE
CLINCH
CHOC FACTORY
17th OR ANY OTHER (ALL VERY STEEP)
16th
CUMBERLAND AVE
WORLD'S FAIR PARK
SUN SPHERE
E.TN HISTORY CTR

Rider 9[56]



[56] Cognitive maps provided by Rider 8, 10, and 11 were drawn on back of survey document and were close to illegible after scanning.

Appendix C: Composite Sketch of Cognitive Maps

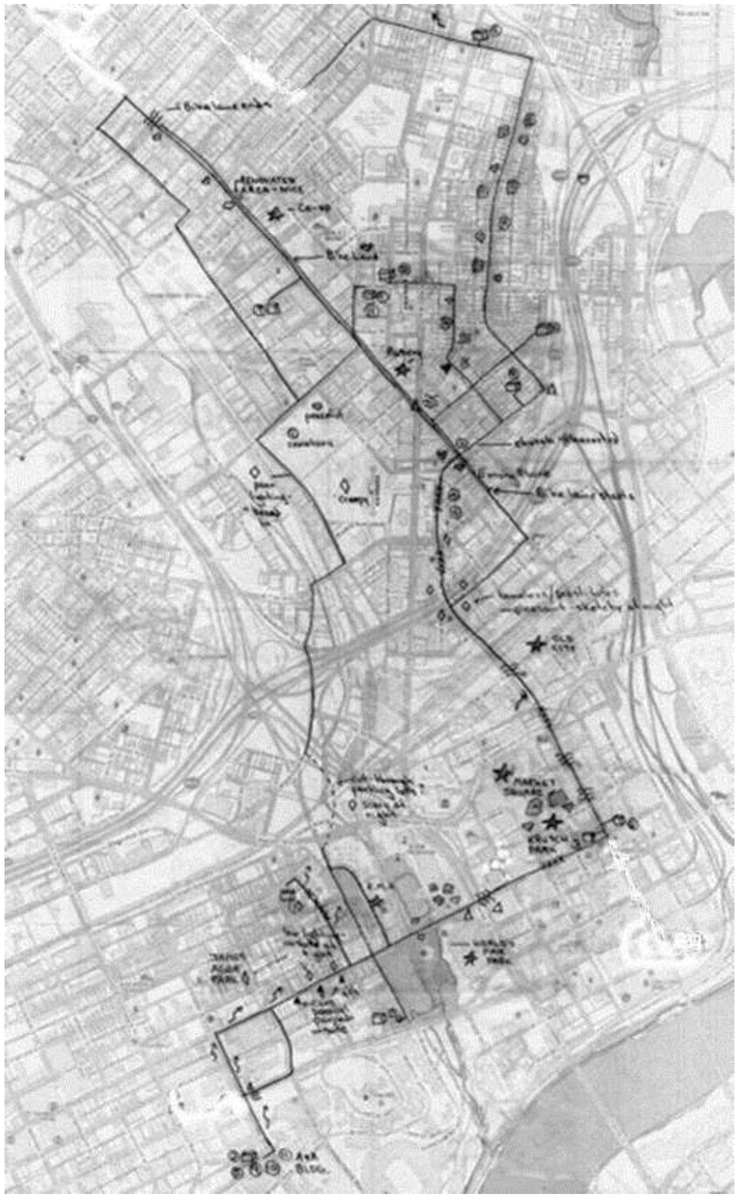


Figure B.1: Composite Sketch Synthesizing Cognitive Maps

Appendix D: Visual Assessment of Remaining Segments

Segment 2

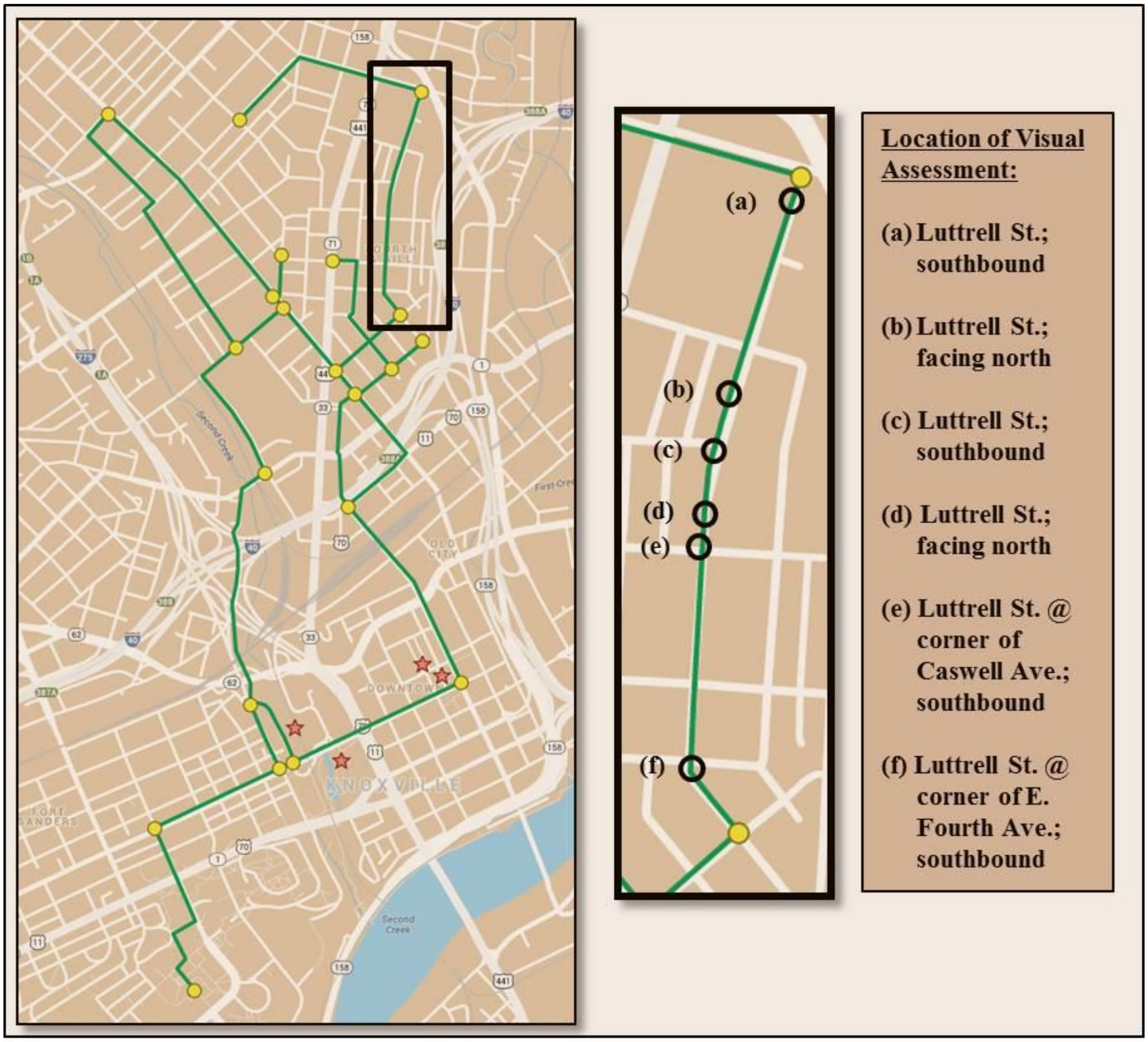


Figure D.1: Segment 2 - Luttrell St.
Start cross-street, E. Glenwood Ave.; end cross-street, E. Fourth Ave.

Figure D.2: (a) - Human Scale and Legibility / Sense of place and Ease of access
Small-scale landscaping details provide the opportunity for appreciation when traveling at slower speeds. Signage defines the district providing a sense of definition to the area, thus accessibility.

Figure D.3: (b) Enclosure and Linkage / Sense of safety and Ease of access
Trees and foliage enclose usable space providing sense of safety and comfort. Continuous sidewalks, patterns of trees links segment ends providing accessibility.

Perceptual Qualities
- Human Scale

Behavioral Response
- Sense of place

Figure D.4: (c) – Human scale / Sense of place
Tidy landscaping with several small details (i.e. texture, rhythm and color) as well as architectural details of the residence provides character and a sense of place.

Perceptual Qualities
- Human Scale

Behavioral Response
- Sense of place

Figure D.5: (d) - Human Scale / Sense of place
Small trees, landscaping elements and architectural details encourage enjoyment of being in a smaller space within a larger area.

Figure D.6: (e) – Imageability and Human Scale/ Sense of place
Landscaped roundabout creates an attractive focal point and a memorable impression. Light post is lower to the ground providing light in human proportions.

Figure D.7: (f) – Legibility and Complexity/Ease of access and Sense of place
Segment visually terminates at neighborhood landmark creating identifiable node at intersection; assists with way-finding and ease of access. Residences have contrasting coloring, adjacent church has attractive architectural features creating a sense of place.

Segment 3

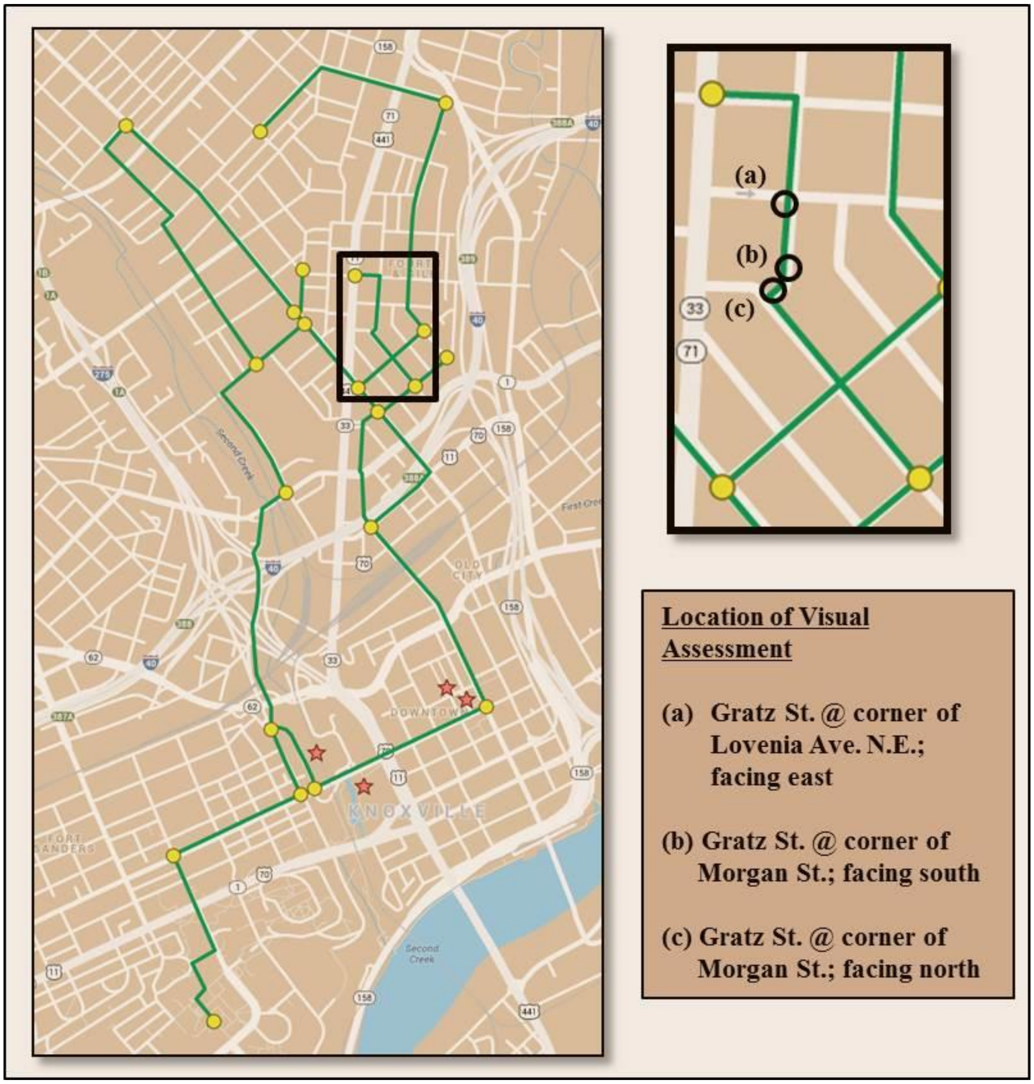


Figure D.8: Segment 3 - Gratz St. / Morgan St.
Start cross-street, Irwin St.; end cross-street, Third Ave.

Figure D.9: (a) – Linkage / Ease of Access
Close-spaced trees and sidewalks frame and define the space creating perception of continuity and linkage. Curb cuts and defined crossings maximize accessibility.

Figure D.10: (b) Transparency / Sense of Safety
Wide street, short trees and short fences provide unobstructed views in all directions resulting in the perception of transparency which cultivates a sense of safety.

Figure D.11: (c) - Complexity and Human Scale / Sense of place
Small-scale architectural details, landscaping elements at human proportion, and colorful residences attract attention when moving at lower speeds all of which foster place-based character.

Segment 4

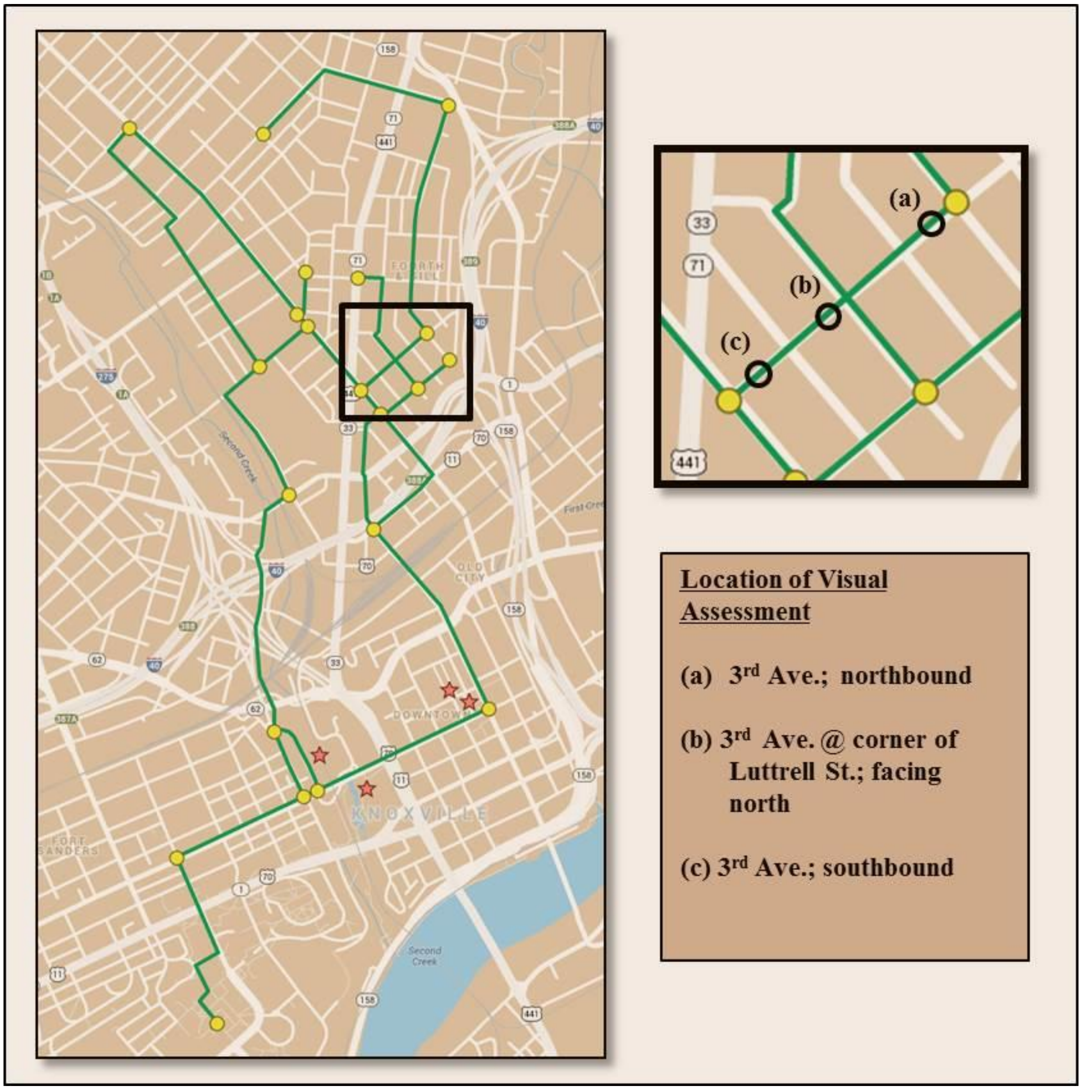


Figure D.12: Segment 4 – Third Ave.
Start cross-street, Luttrell Ave.; end cross-street, N. Central Ave.

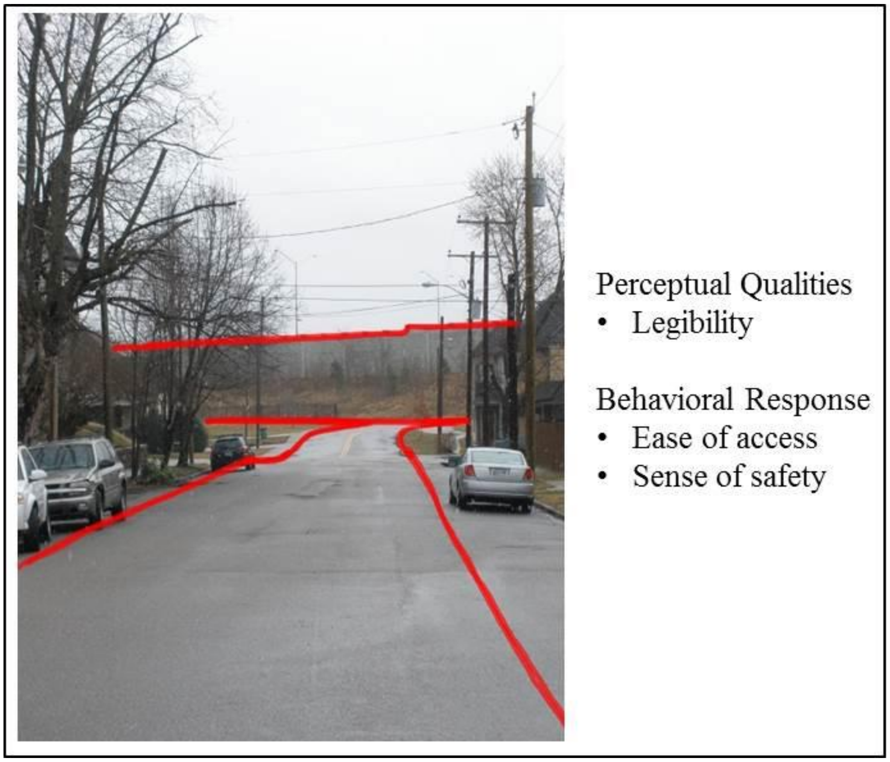


Figure D.13: (a) – Legibility / Ease of access and Sense of safety
Places with strong edges and a clearly defined end point serving as a reference point assist with way-finding encouraging a sense of safety.

Figure D.14: (b) – Complexity and Human Scale / Sense of place
Colorful residences and small-scale architectural details (i.e. front porches, brickwork, stone walls) at human proportion attract attention and promotes place-based character.

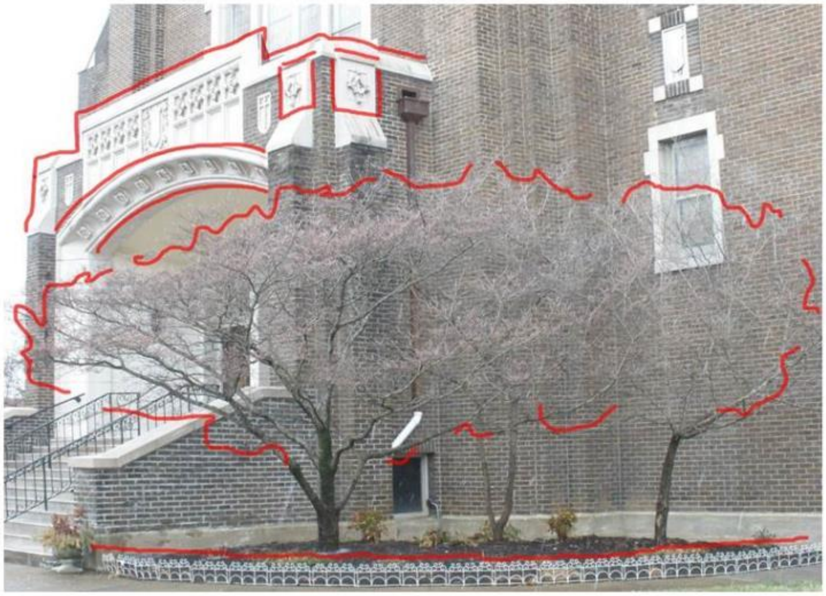


Figure D.15: (c) – Human Scale / Sense of place
Landscaping with a variety of texture, size and color as well as architectural details provide character and a sense of place.

Segment 5

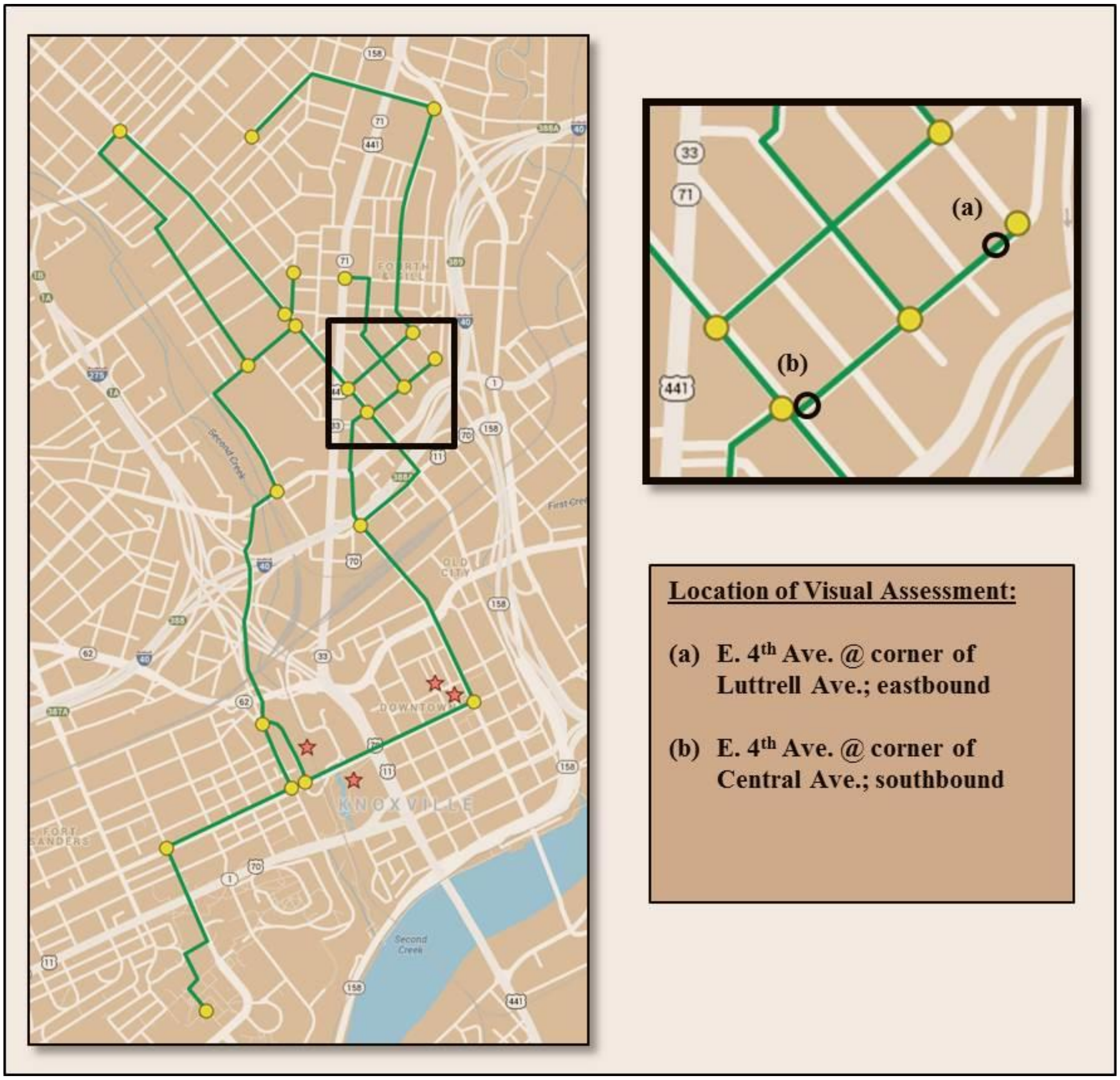


Figure D.16: Segment 5 – E. Fourth Ave.
Start cross-street, Luttrell St.; end cross-street, N. Central Ave.

Figure D.17: (a) – Enclosure / Sense of safety
Sound barrier runs along edge of segment providing spatial definition instilling a sense of safety and protection.

Figure D.18: (b) – Legibility / Ease of access
Visual termination at noticeable and attractive landmark, St. John's Lutheran Church along with signage provide spatial placement and assists with way-finding.

Segment 6

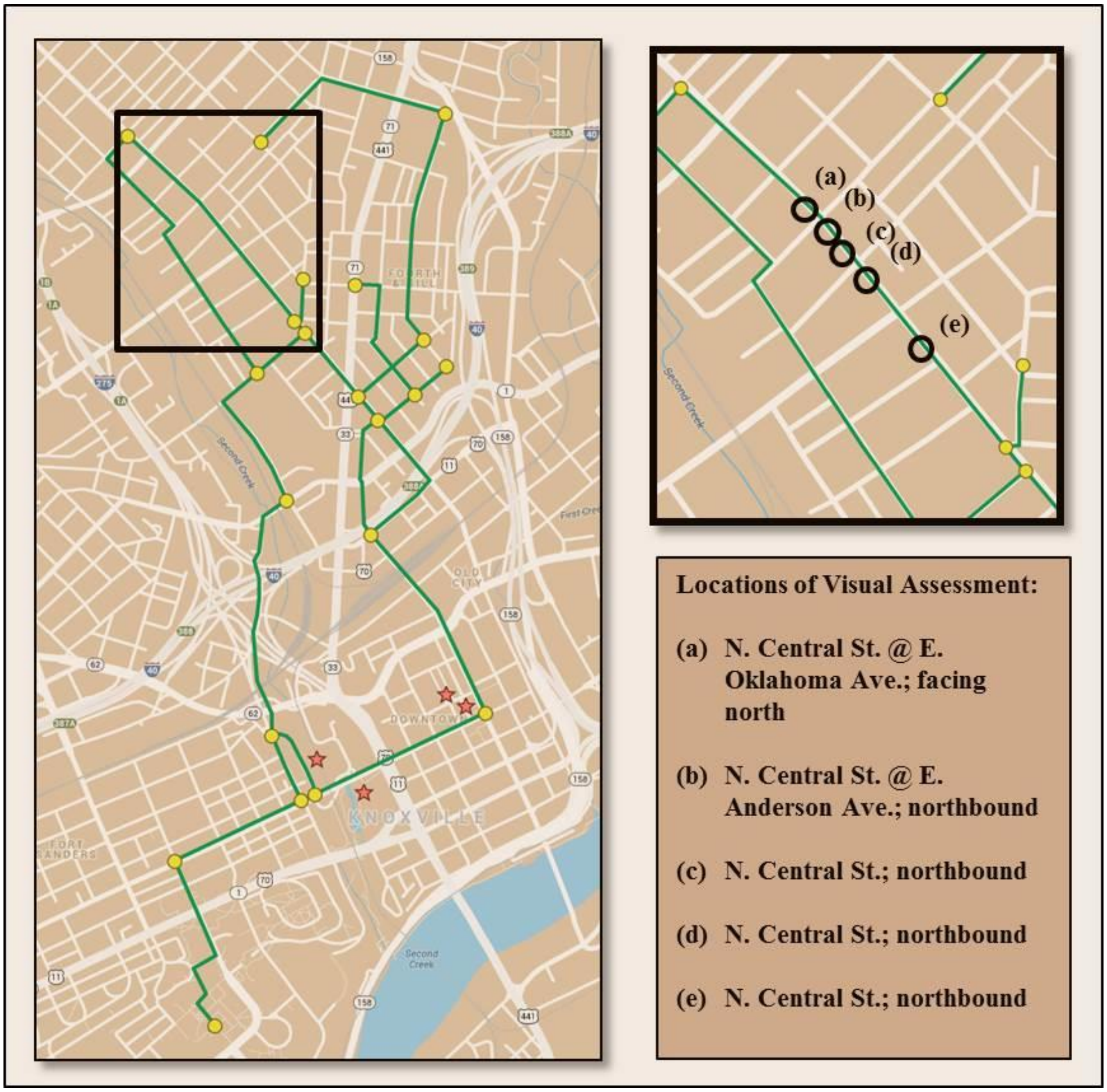


Figure D.20: Segment 6 – N. Central Ave.
Start cross-street, W. Oldham Ave.; end cross-street, Bernard Ave.

Perceptual Qualities
- Imageability

Behavioral Response
- Sense of place

Figure D.21: (a) – Imageability / Sense of place
Landmarks serve as an orientation point and create memorable impressions. The Original Freezo is a neighborhood fixture.

Perceptual Qualities
- Legibility

Behavioral Response
- Ease of access

Figure D.22: (b) – Legibility / Ease of access
Identification of districts through signage assists with way-finding and ease of access.

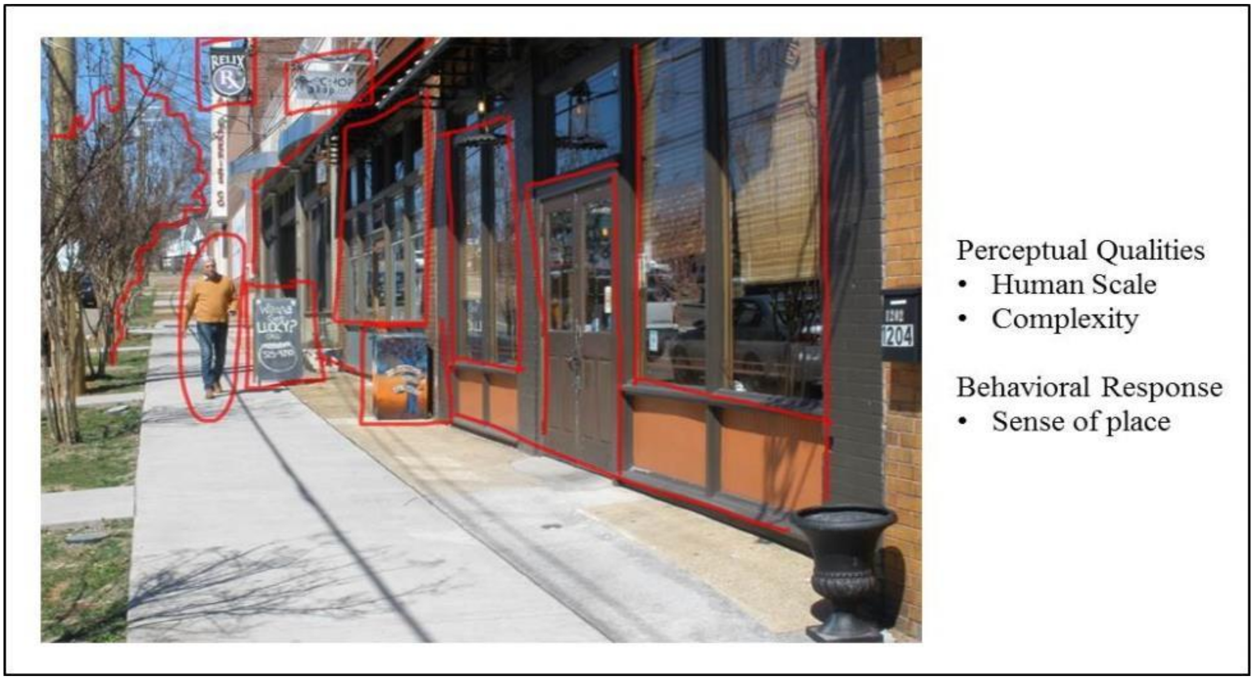


Figure D.23: (c) – Human Scale and Complexity / Sense of place
Street level windows, small signs and trees can be noticed passing by at slower speeds. Renovated area draws business, people watching provides interest. Bright colors provide visual stimulation.

Figure D.24: (d) – Complexity, Human Scale, and Linkage / Sense of place and Ease of access
Clusters of business signs, colors and activity create a visually stimulating scene. Bike lanes on both sides of the street provide accessibility. Businesses with windows at street level and landscaping details are at human scale.

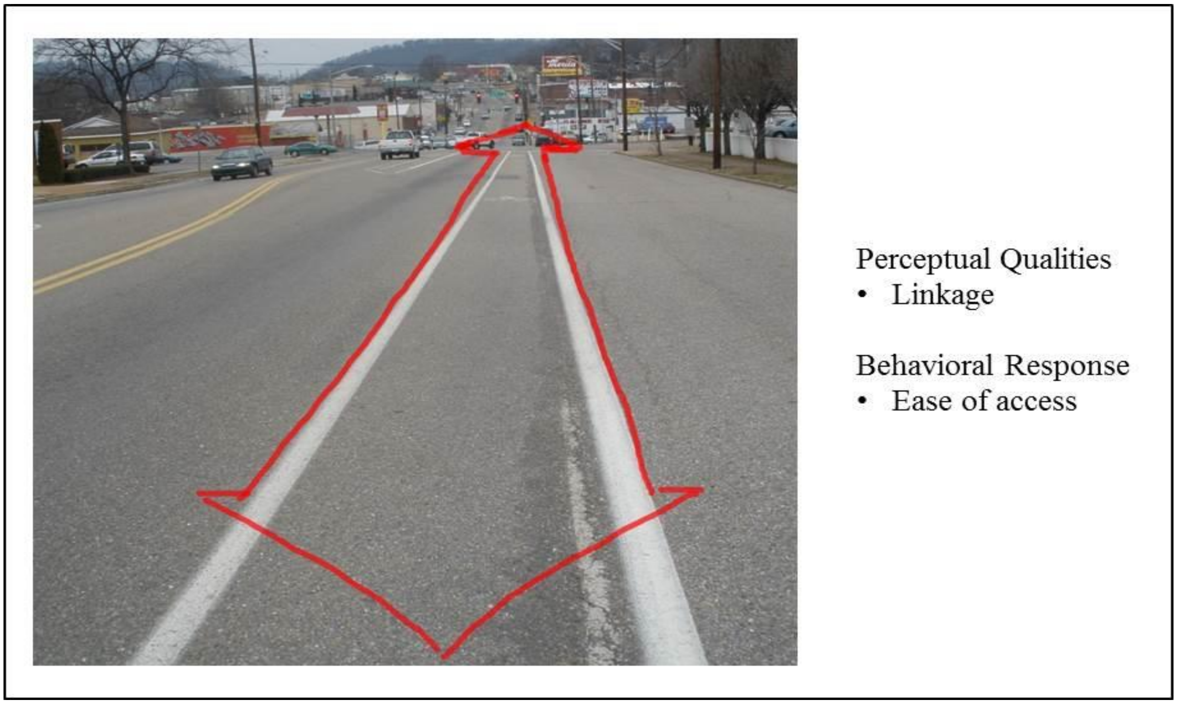


Figure D.25: (e) – Linkage / Ease of access
Presence of a continuous bike lane promotes interconnectedness of places and provides ease of access.

Segment 7

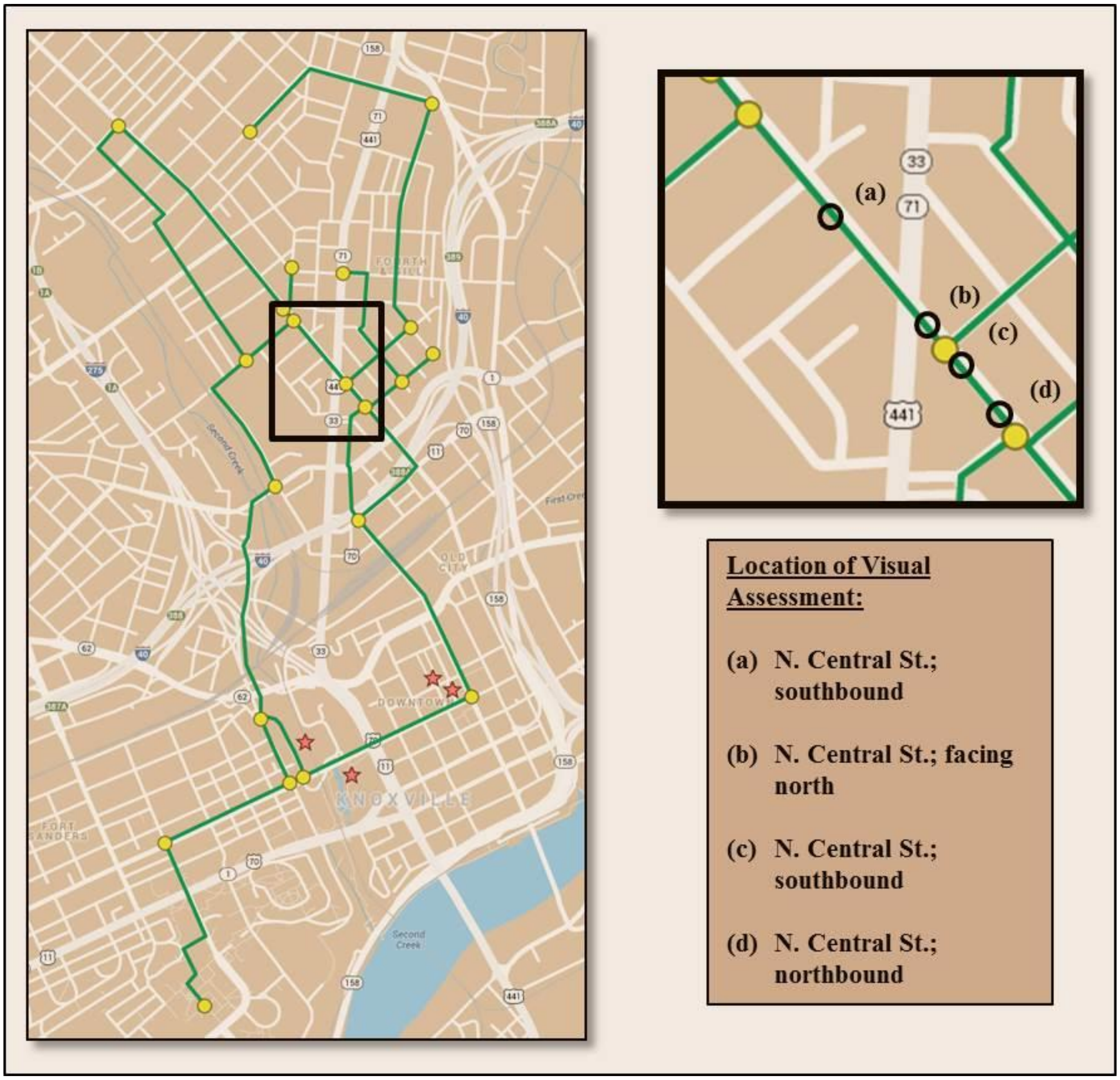


Figure D.26: Segment 7 - N. Central Ave.
Start cross-street, Bernard Ave.; end cross-street, Emory Place

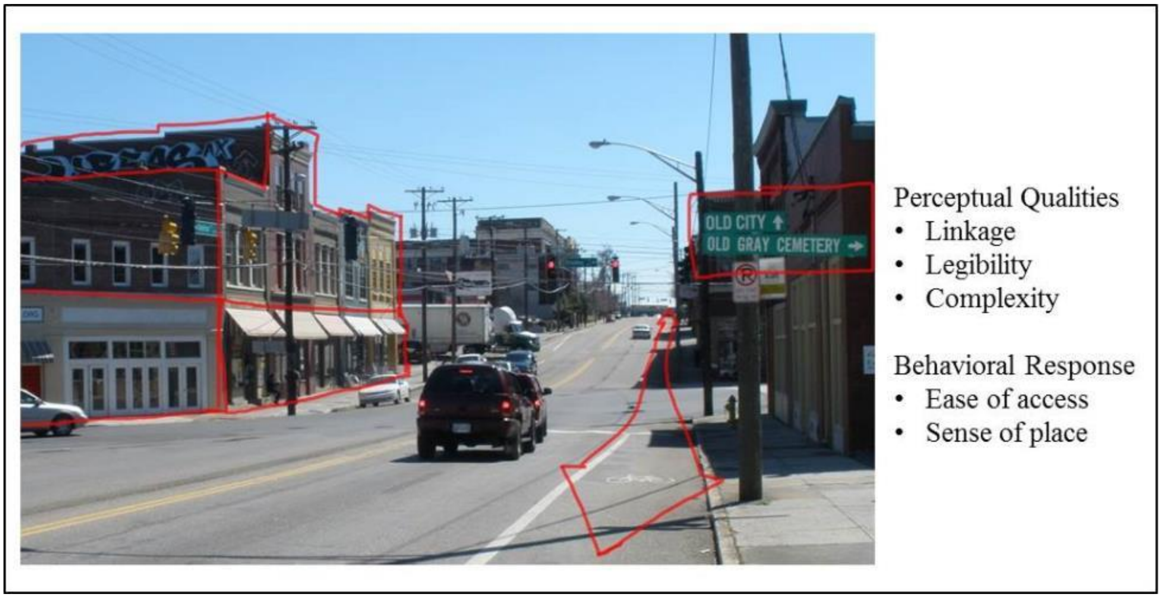


Figure D.27: (a) – Linkage, Legibility and Complexity / Ease of access and Sense of place
Presence of bike lane promotes interconnectedness of places and provides easy accessibility. Directional signage assists with way-finding, creating perception of legibility. Contrasting colors of buildings provides perception of visual complexity.

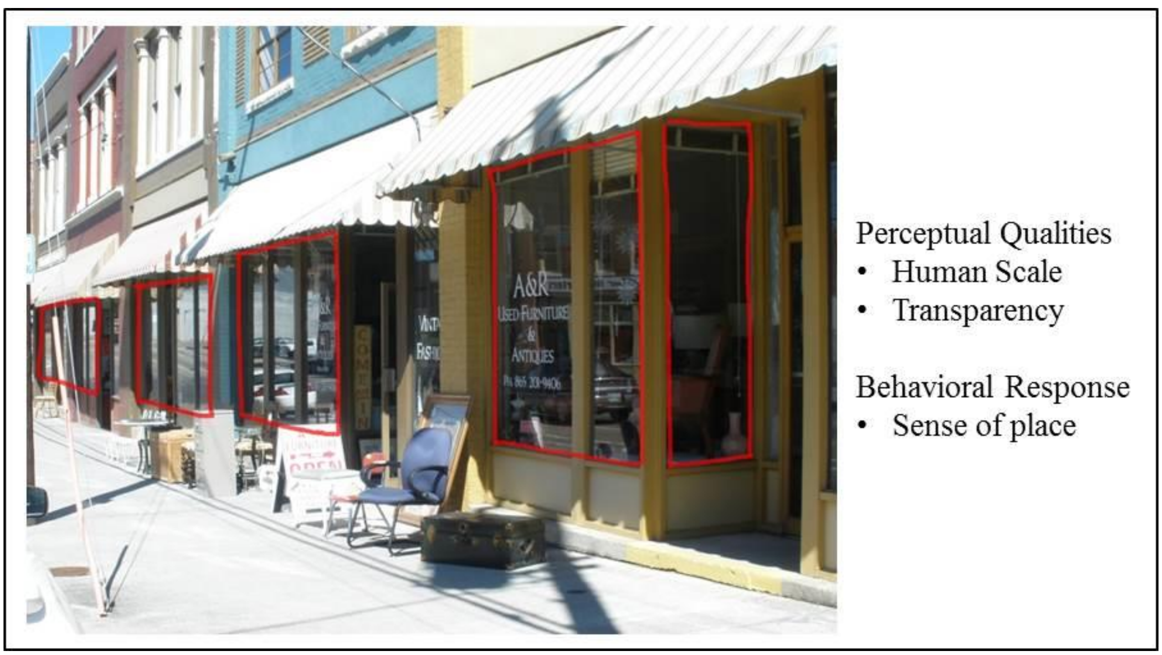


Figure D.28: (b) – Human Scale and Transparency / Sense of place and Sense of safety
Objects for sale along street promote interest and provide character. Windows at street level allow for opportunities to observe people creating further interest.

Figure D.29: (c) – Linkage and Complexity / Ease of access and Sense of place
Presence of bike lane assists with ease of access. Contrasting colors of adjacent buildings provide character and a sense of place.

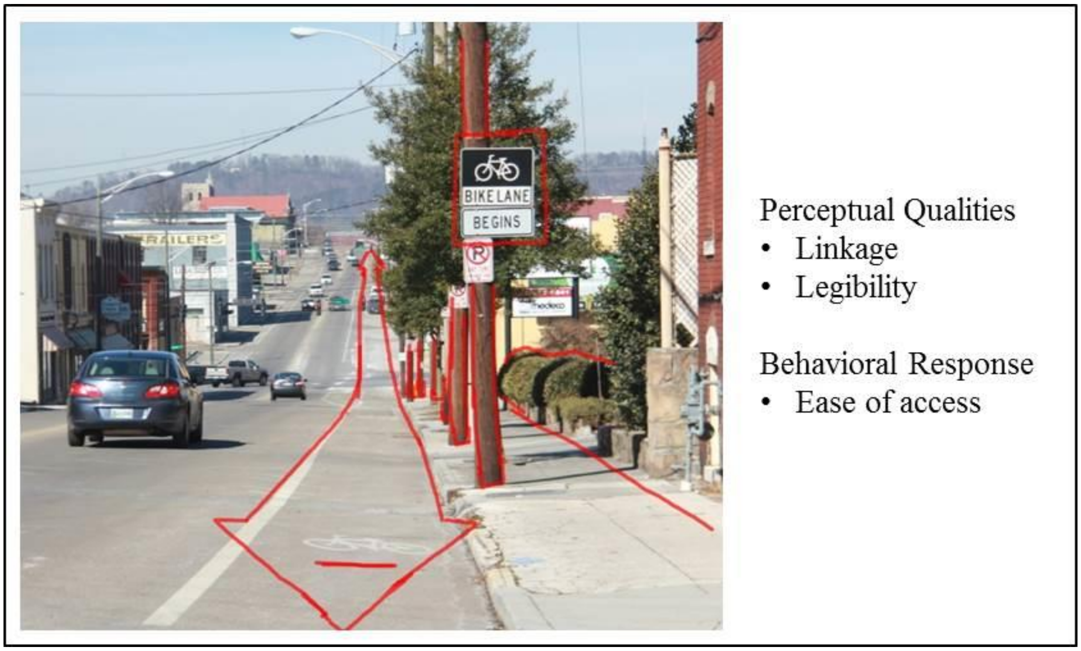


Figure D.30: (d) – Linkage and Legibility / Ease of access
Presence of bike lane creates the perception of linkage; signage assists with way-finding and legibility promoting accessibility.

Segment 8

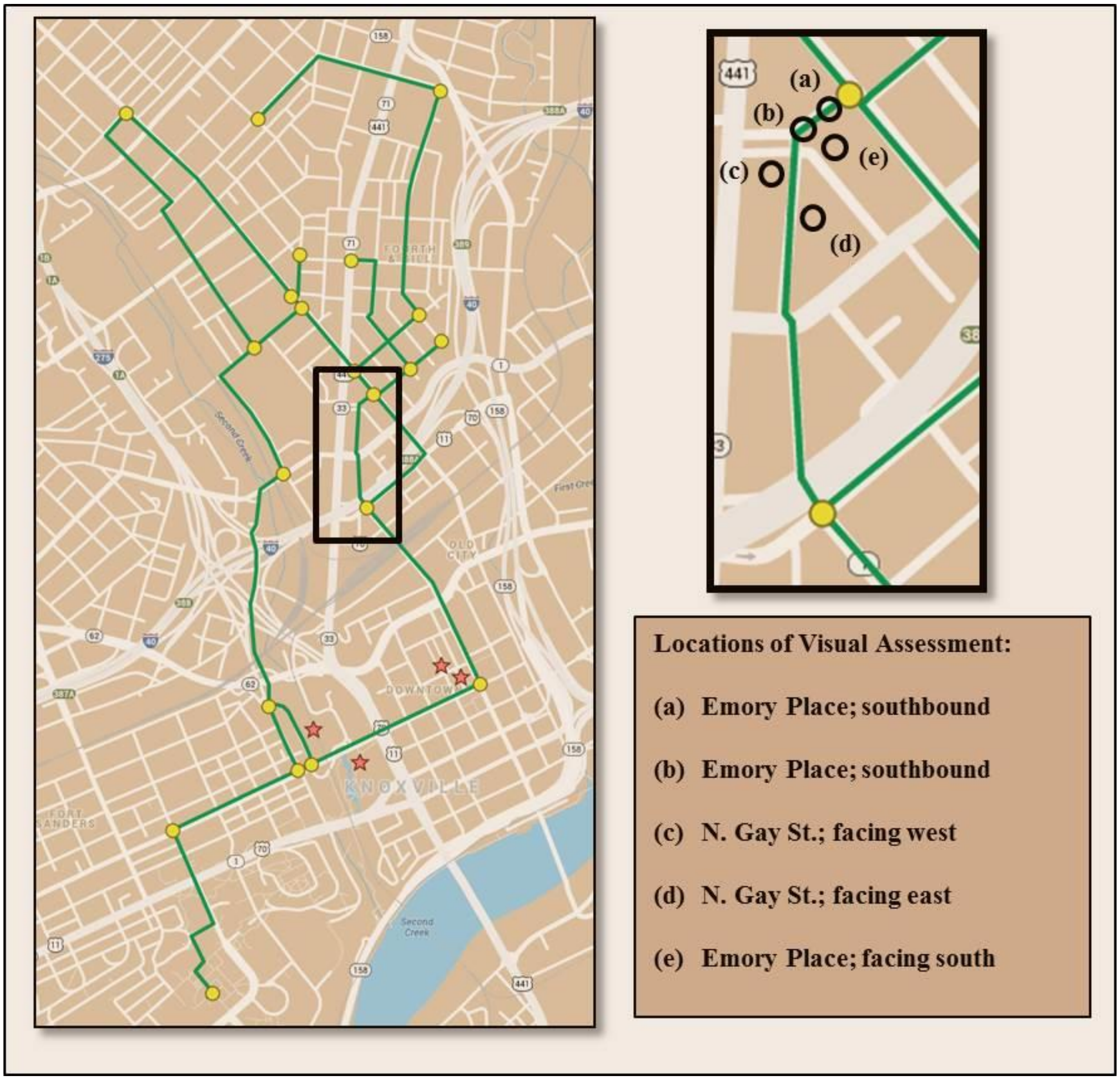


Figure D.31: Segment 8 – Emory Place and N. Gay St.
Start cross-street, N. Central Ave.; end cross-street, W. Magnolia Ave.

Figure D.32: (a) – Legibility and Human Scale / Ease of access and Sense of safety
Signage increases ability to navigate an area resulting in a more understandable, legible area. Lighting at a human scale draws more bicycle and foot traffic increasing a sense of safety.

Figure D.33: (b) – Transparency and Linkage / Sense of safety and Ease of access
Wide open area and several business windows contribute to an area's transparency; promoting awareness of surroundings and people. Wide roads with very low traffic speed promotes ease of access and safety.

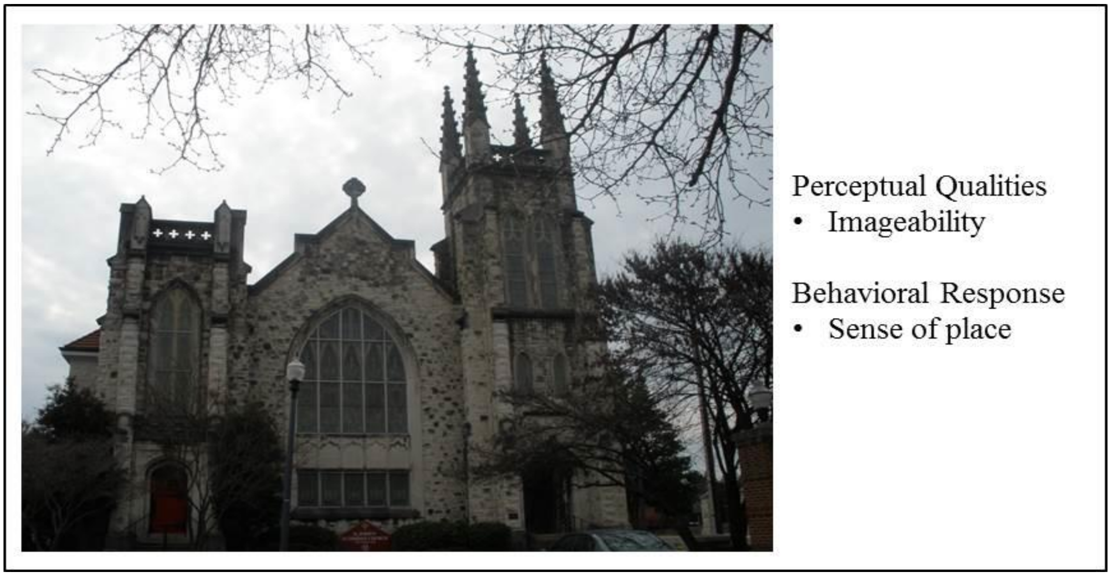


Figure D.34: (c) – Imageability / Sense of place
St. John's Lutheran Church is an attractive landmark capturing attention and interest.

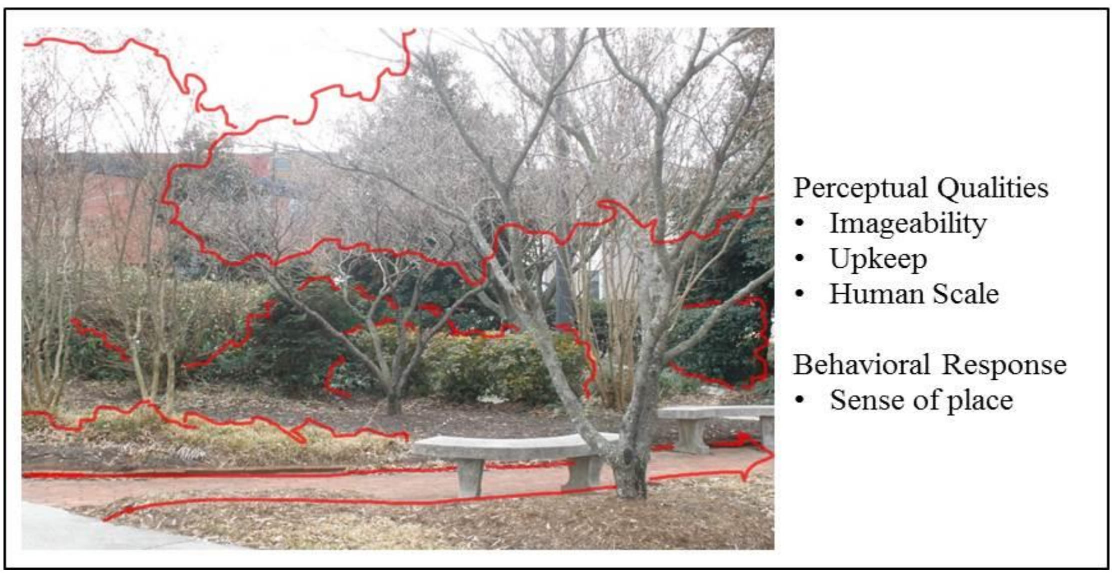


Figure D.35: (d) – Imageability, Upkeep and Human Scale / Sense of place
Well-kept, pleasant nook with accessible amenities stands apart from surrounding commercial land use.

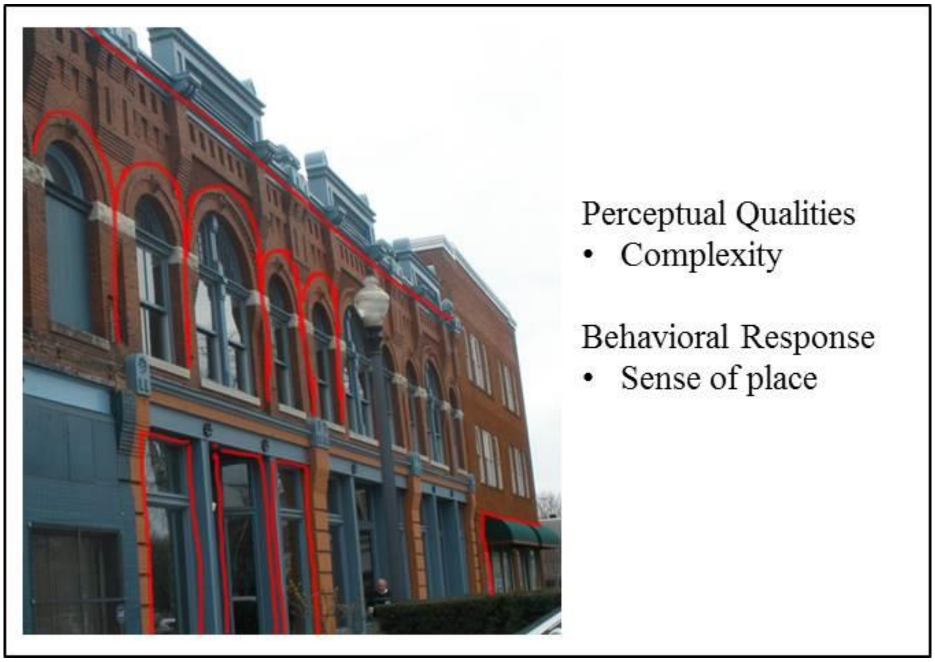


Figure D.36: (e) – Complexity / Sense of place
Contrasting colors and architectural details of building facade attract attention, provide character; thus, a sense of place.

Segment 9

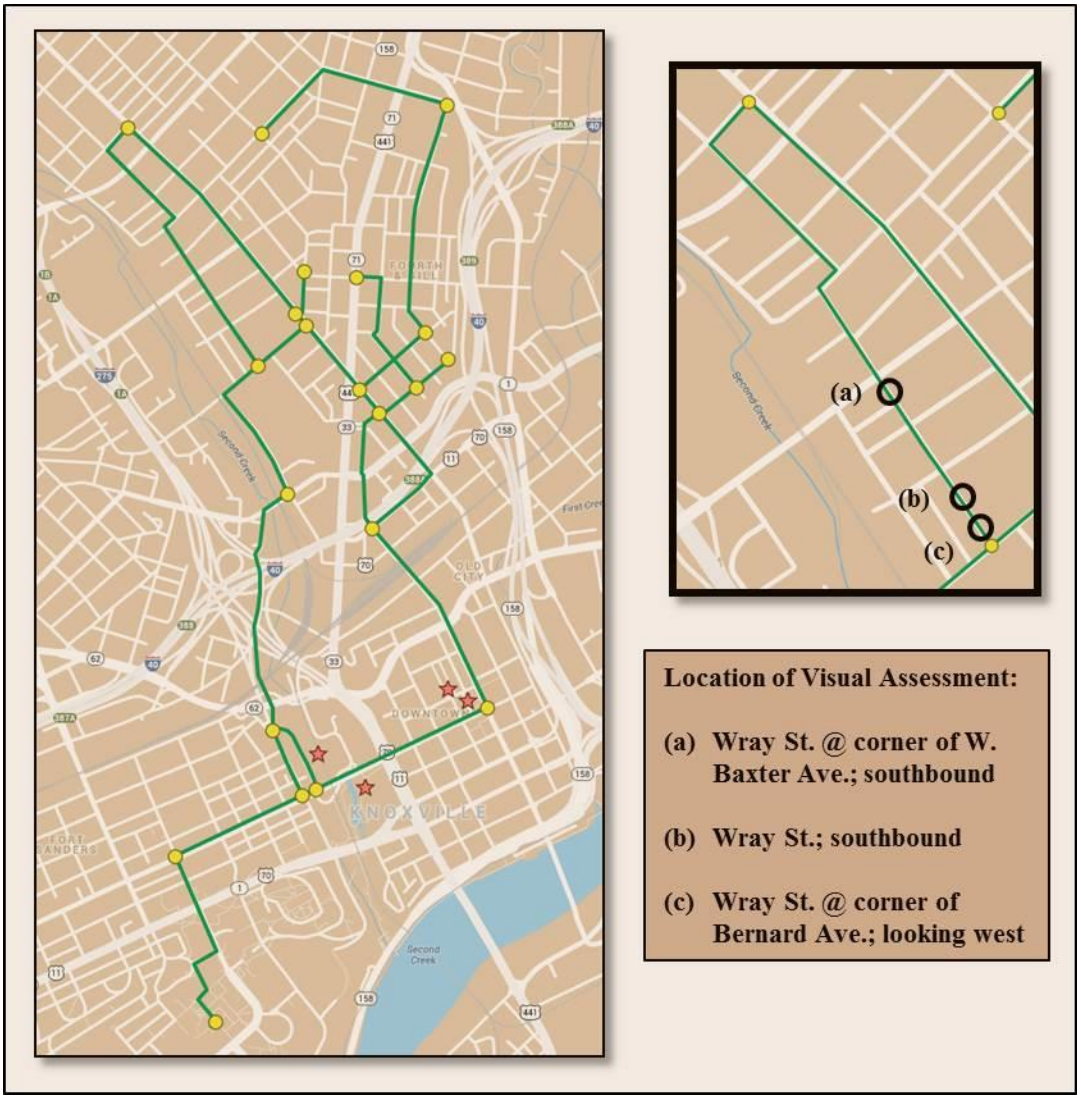


Figure D.37: Segment 9 – W. Oldham Ave. and Branner St. and Wray St.
Start cross-street, N. Central Ave.; end cross-street, Bernard Ave.

Figure D.38: (a) – Legibility / Ease of access
Strongly defined visual termination and focal point provides sense of direction thereby increasing accessibility.

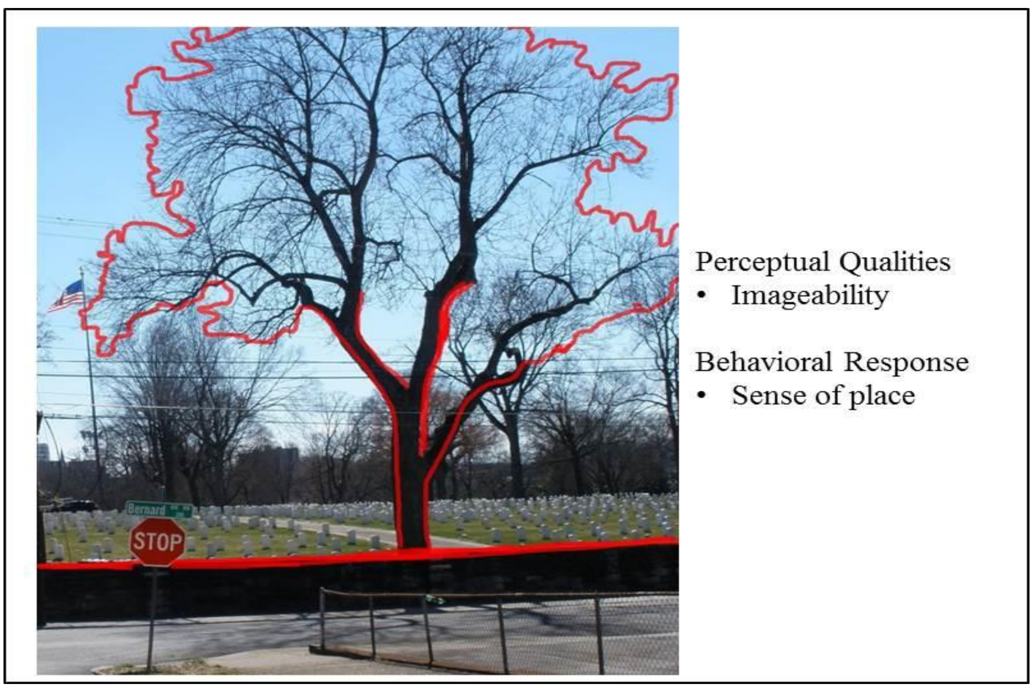


Figure D.39: (b) – Imageability / Sense of place
Large tree standing within a field of gravestones in historic Old Gray Cemetery creates a lasting image inciting a sense of place.

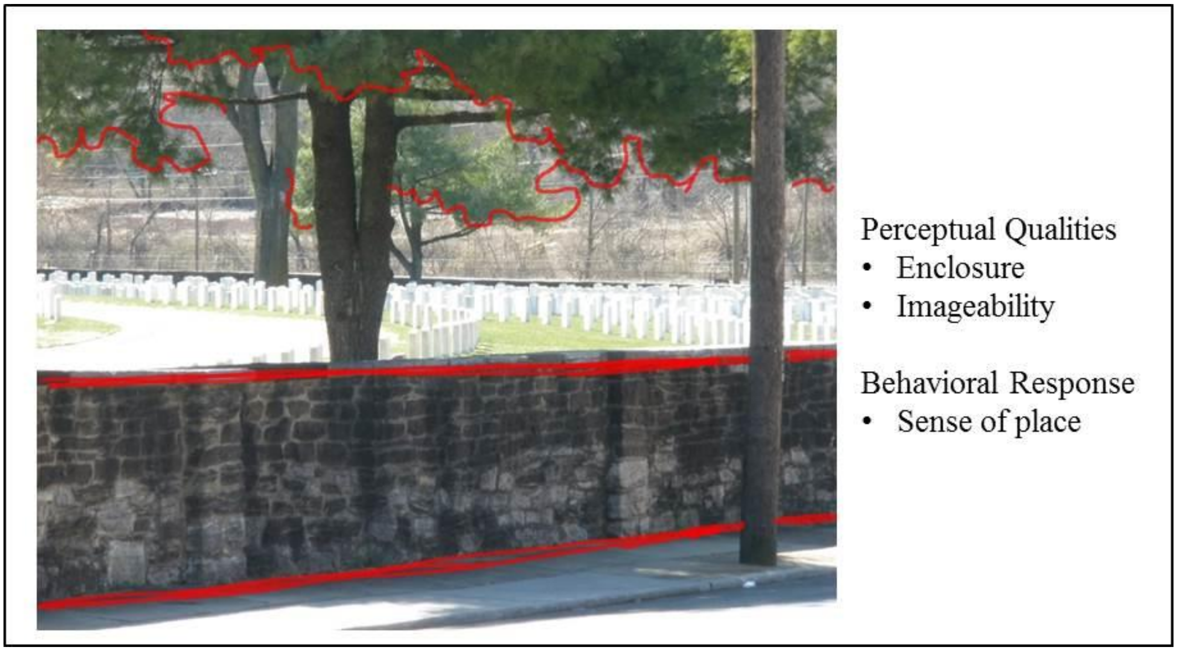


Figure D.40: (c) – Enclosure and Imageability / Sense of place
Continuous rock wall and low tree canopy defines and frames the space providing a sense of enclosure. Old Gray Cemetery and its curvilinear pattern of gravestones evoke emotion.

Segment 12

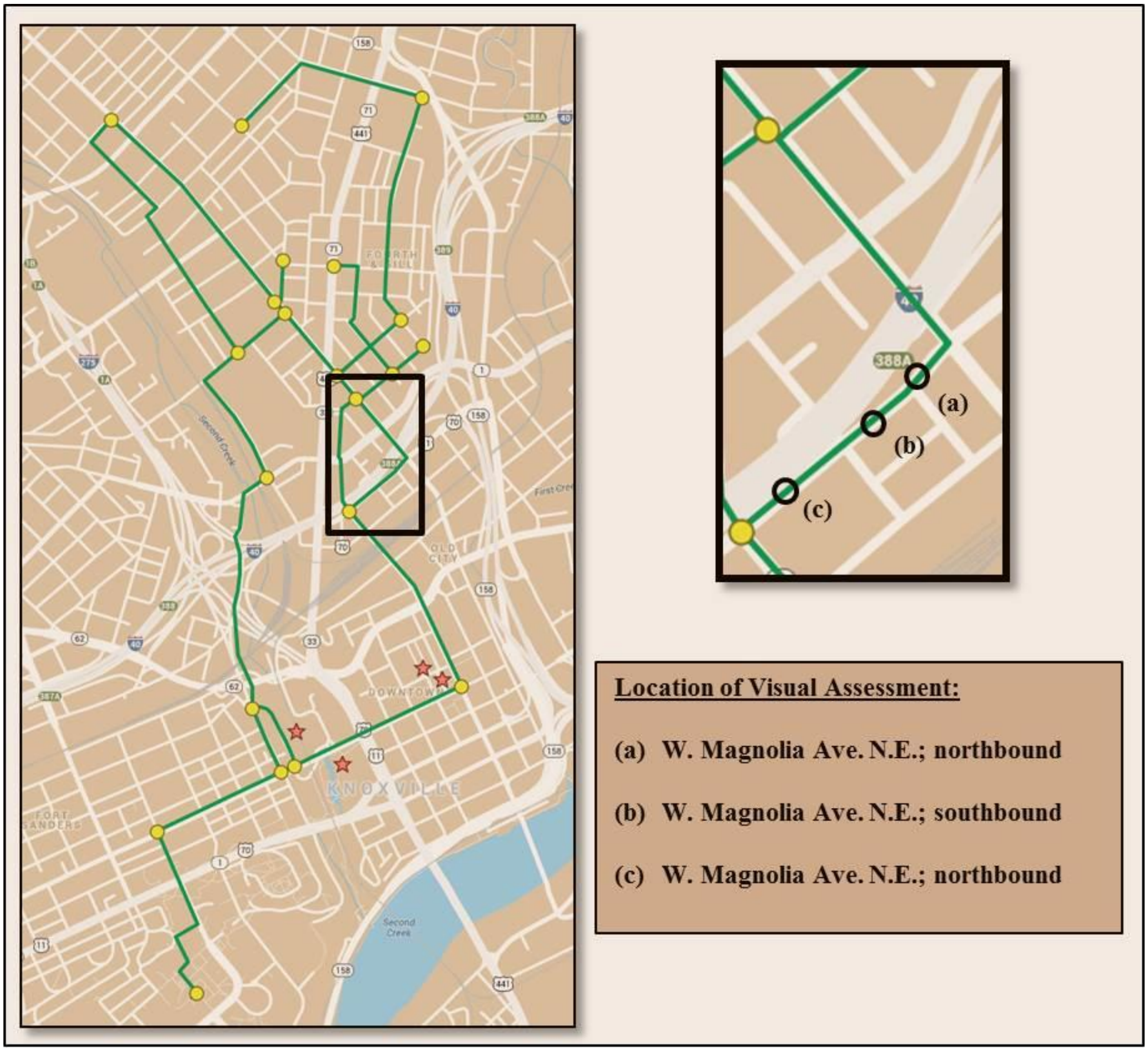


Figure D.41: Segment 12 – N. Central Ave. and W. Magnolia Ave.
Start cross-street, Emory Place. / E. Fourth Ave.; end cross-street, N. Gay St.

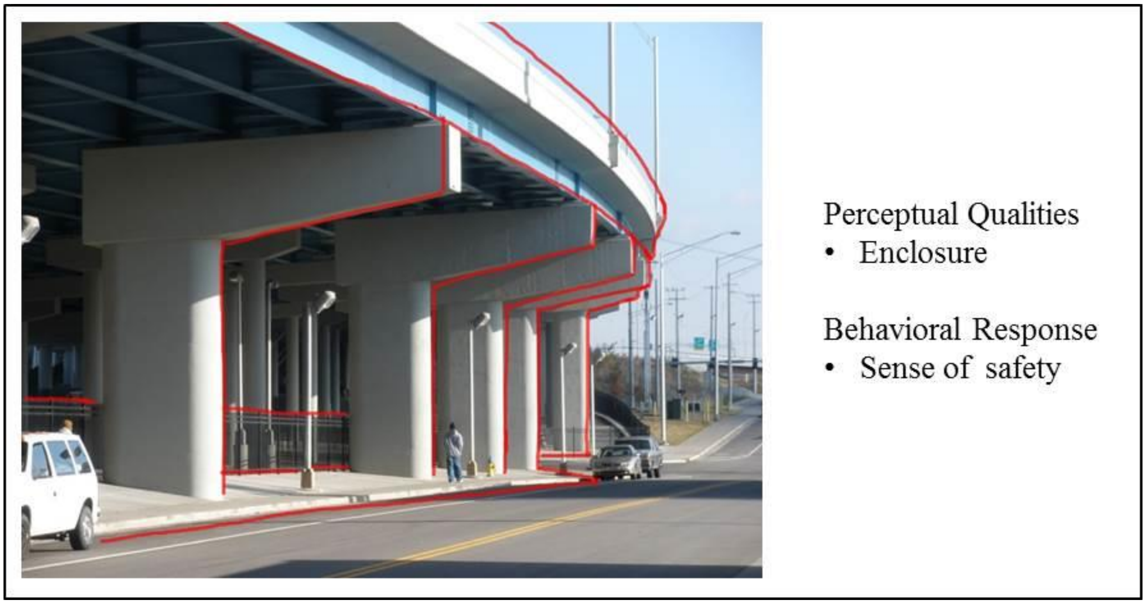


Figure D.42: (a) – Enclosure / Sense of safety
Overpass with its imposing vertical dimension along with continuous fence along edge of sidewalk provide a boundary which increasing the perception of being enclosed and protected.

Figure D.43: (b) – Human Scale / Sense of place
Place of local interest with accessible amenities (i.e. bike rack, bench, beverages, tire pump) provide a sense of place.

Perceptual Qualities
- Legibility

Behavioral Response
- Ease of access

Figure D.44: (c) – Legibility / Ease of access
Regas restaurant, a neighborhood institution, provides a familiar landmark to assist with way-finding and ease of access.

Segment 13

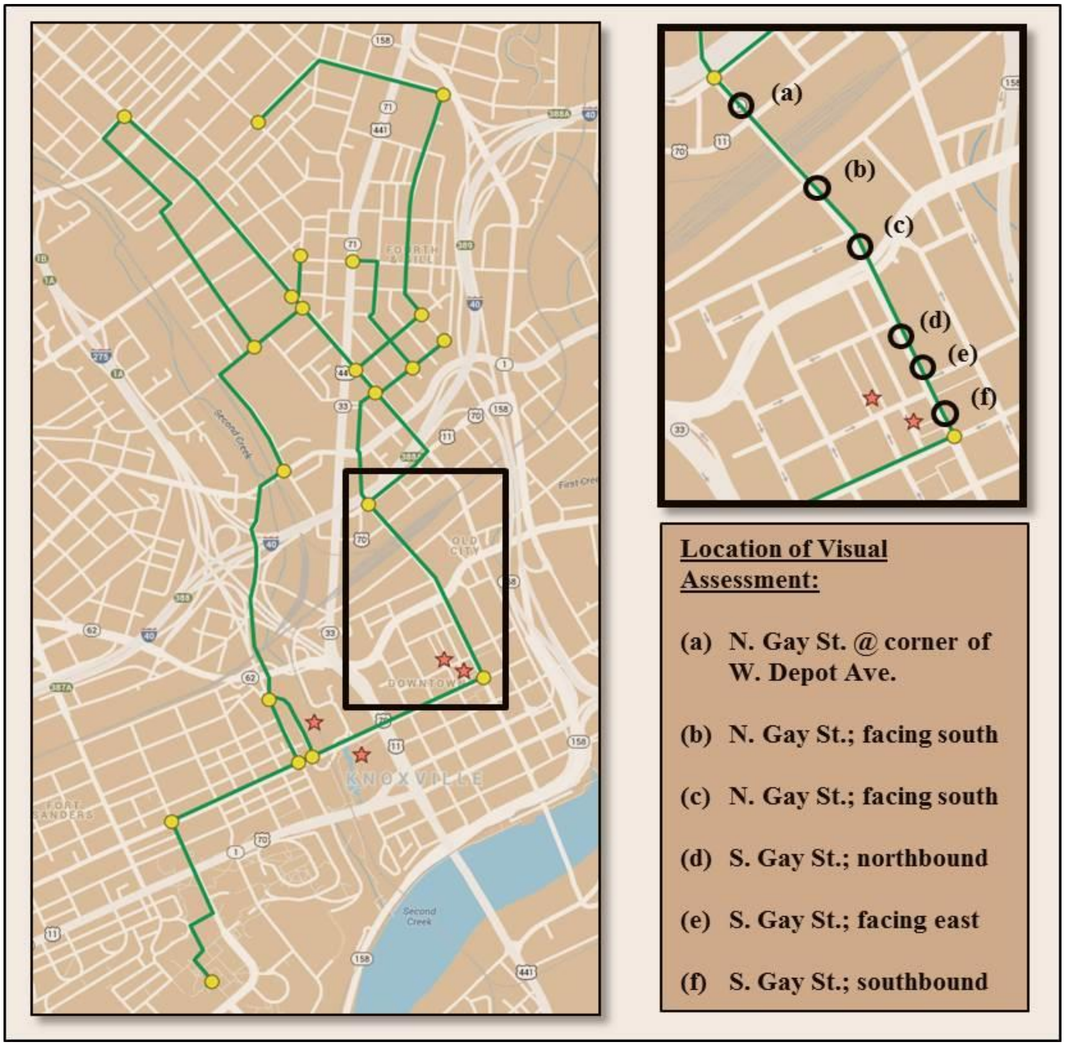


Figure D.45: Segment 13 – N. Gay St. / S. Gay St.
Start cross-street, W. Magnolia Ave.; end cross-street, Clinch Ave.

Figure D.46: (a) – Linkage and Legibility / Ease of access
N. Gay St. Bridge connects North Knoxville to Downtown, crossing over railroad tracks thereby increasing accessibility. Sterchi Lofts serve as a reference point increasing legibility as landmark is visible through most of the downtown district.

Figure D.47: (b) – Human Scale and Upkeep / Sense of place
Pavement pattern and colors serve as urban design element capturing interest as a small-scale detail. Amenities are available, i.e. bike racks, benches, and local businesses. Condition of flower planters and sidewalk contribute to sense of place.

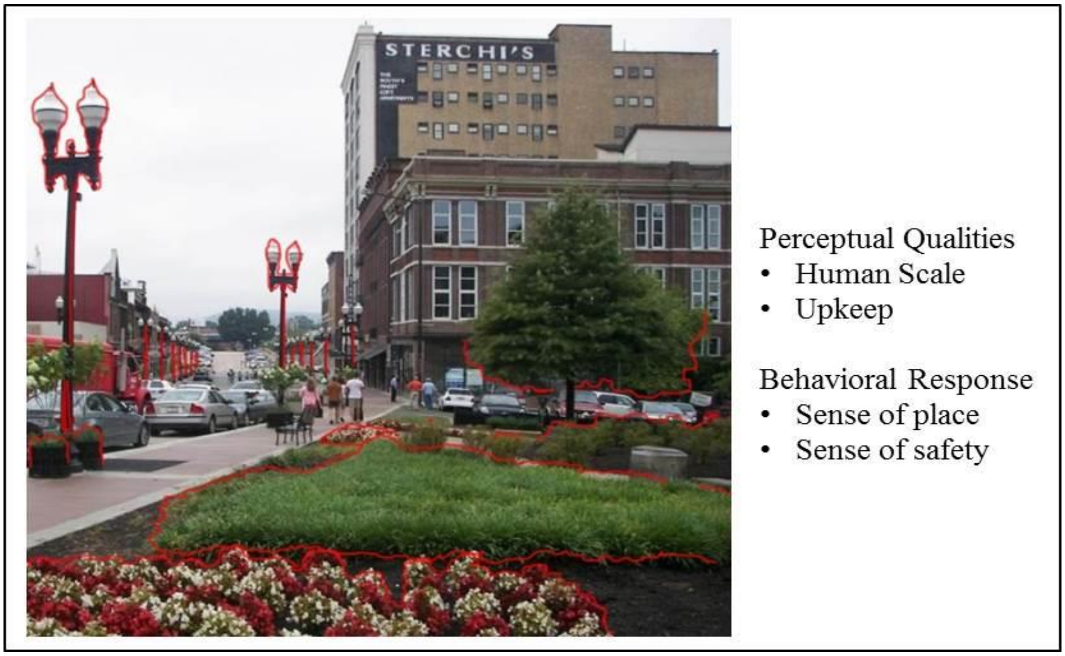


Figure D.48: (c) – Human Scale and Upkeep / Sense of place
Large area of tidy landscaping at edge of colorful, patterned sidewalk. Nicely designed, low street lamps line the sidewalk encouraging sense of place and sense of safety.

Figure D.49: (d) – Enclosure / Sense of place
Street width is narrow in proportion to building height and building at end of street provides a visual termination point, both of which create the perception of enclosure and provide a sense of place.

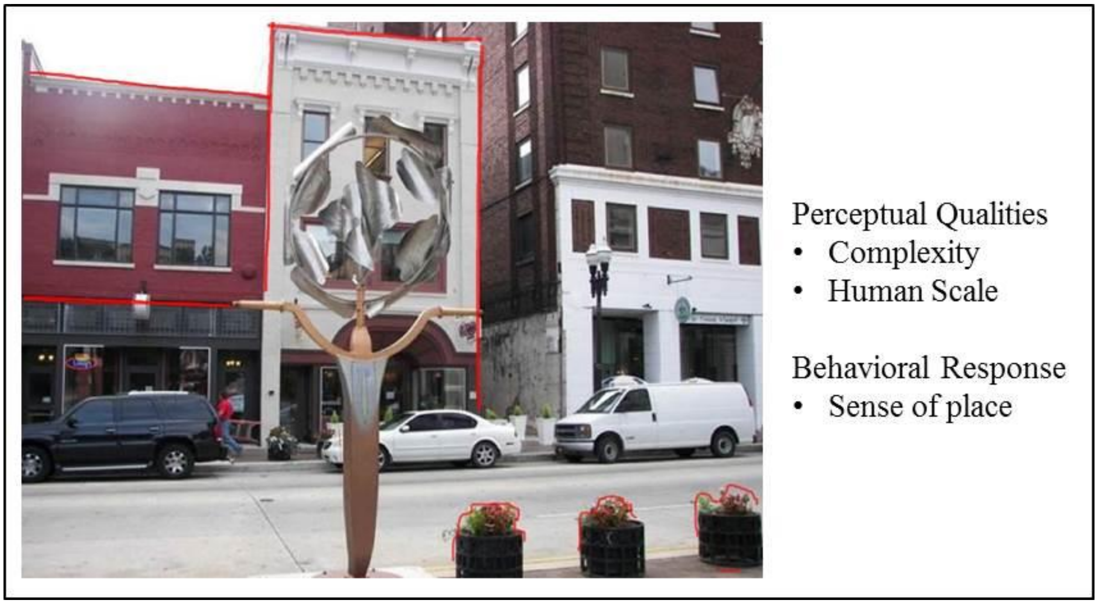


Figure D.50: (e) – Complexity and Human Scale / Sense of place
Art installation and colorful buildings across street create a visually complex scene inciting a sense of place.

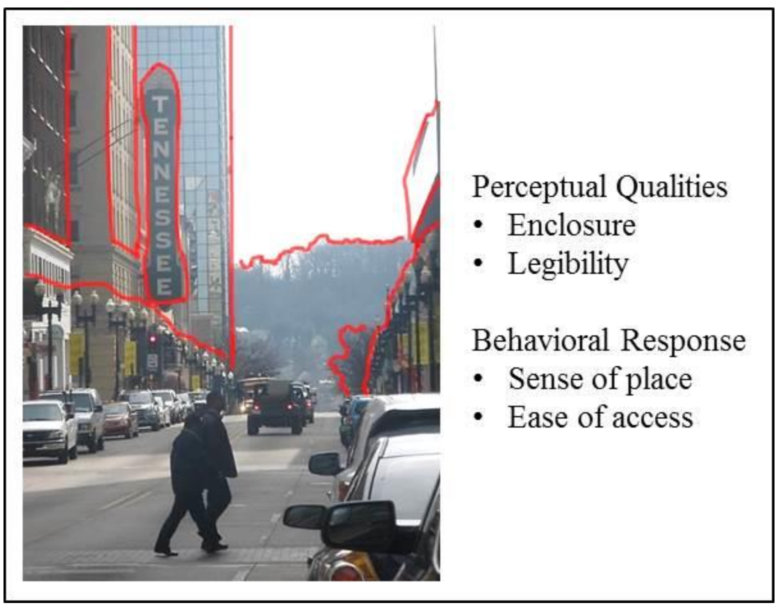


Figure D.51: (f) – Enclosure and Legibility / Sense of place and Ease of access
Street width is narrow in proportion to building height, South Knoxville tree line provide a visual termination point creating the perception of enclosure and providing place-based character.

Segment 14

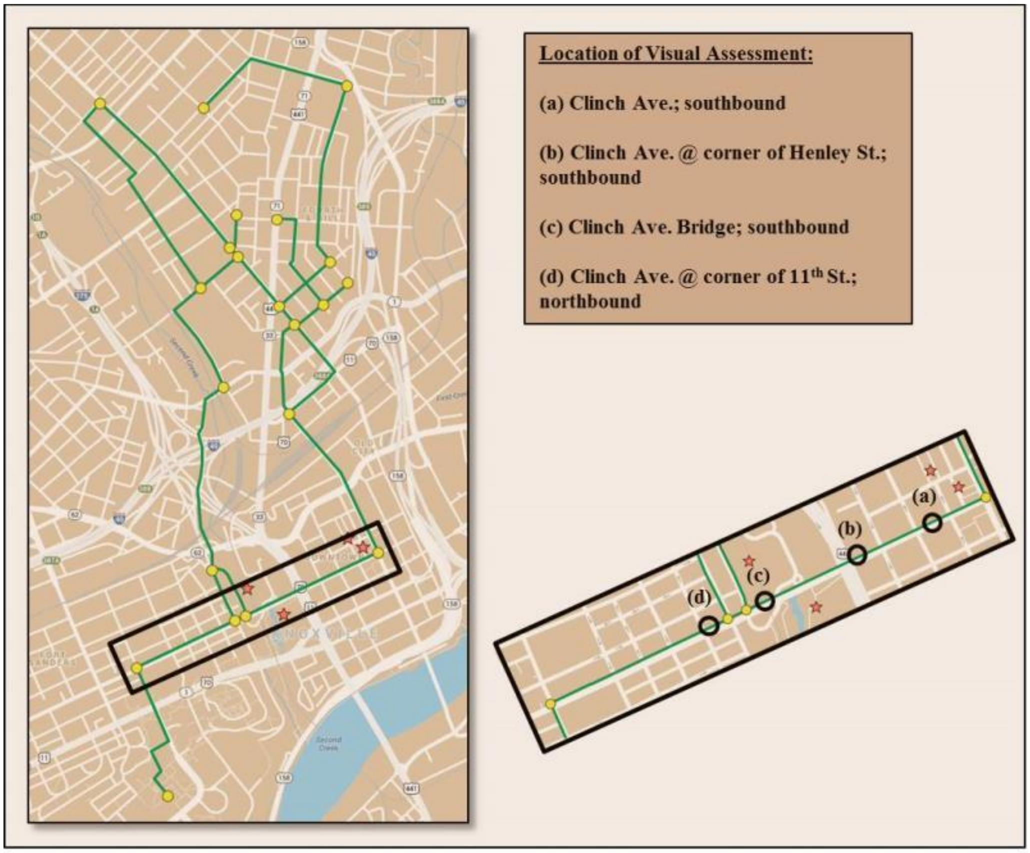


Figure D.52: Segment 14 – Clinch Ave.
Start cross-street, S. Gay St.; end cross-street, 16th Ave.

Figure D.53: (a) – Enclosure / Sense of place
Continuous, close-spaced trees with arching, low canopies line both sides of narrow road; pavement and trees are nicely kept, the combination of all produces a sense of place.

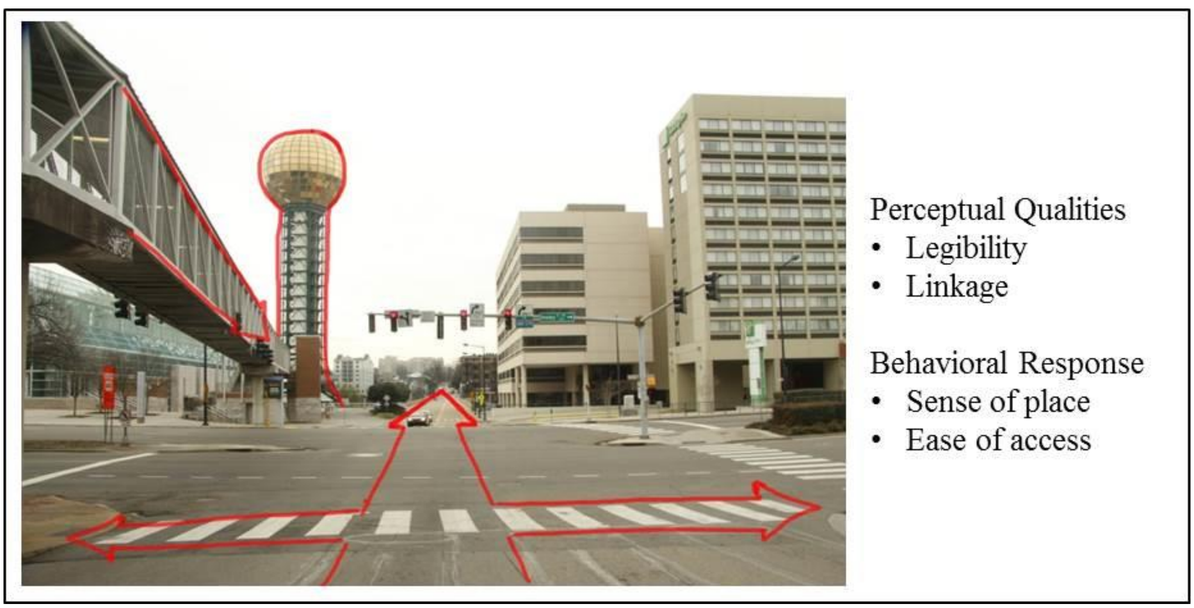


Figure D.54: (b) – Legibility and Linkage / Sense of place and Ease of access
The Sunsphere, a landmark to be used as a reference point, significantly influences the legibility of this area. This segment connects Downtown Knoxville to the Fort Sanders district, and is made possible with the bridge straight ahead and the pedestrian bridge overhead.

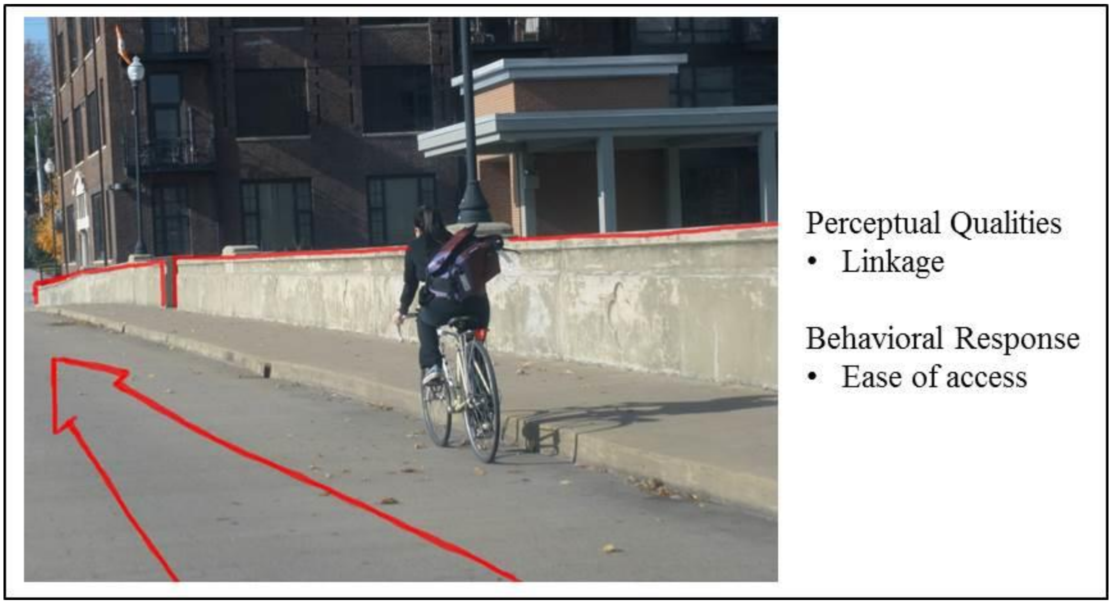


Figure D.55: (c) – Linkage / Ease of access
Clinch Ave. Bridge creates a connection between Downtown Knoxville and Fort Sanders and UT campus.

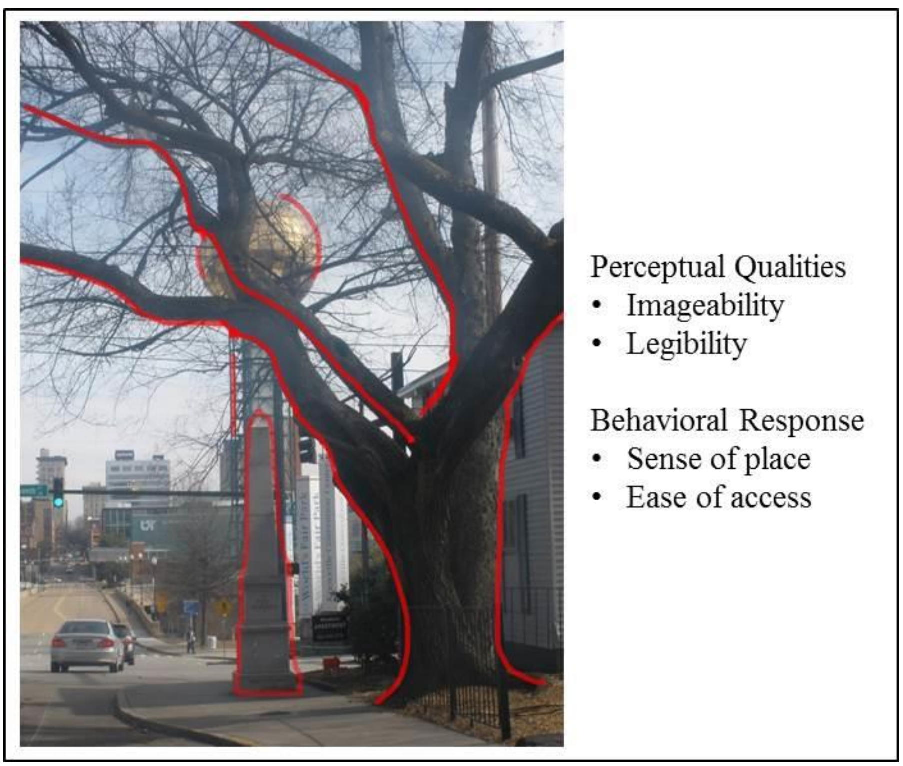


Figure D.56: (d) – Imageability and Legibility / Sense of place and Ease of access
Large tree standing at edge of Fort Sanders district, obelisk as signage next to tree, Sunsphere in the background; all can be used as reference points and incite a sense of place.

Segment 15

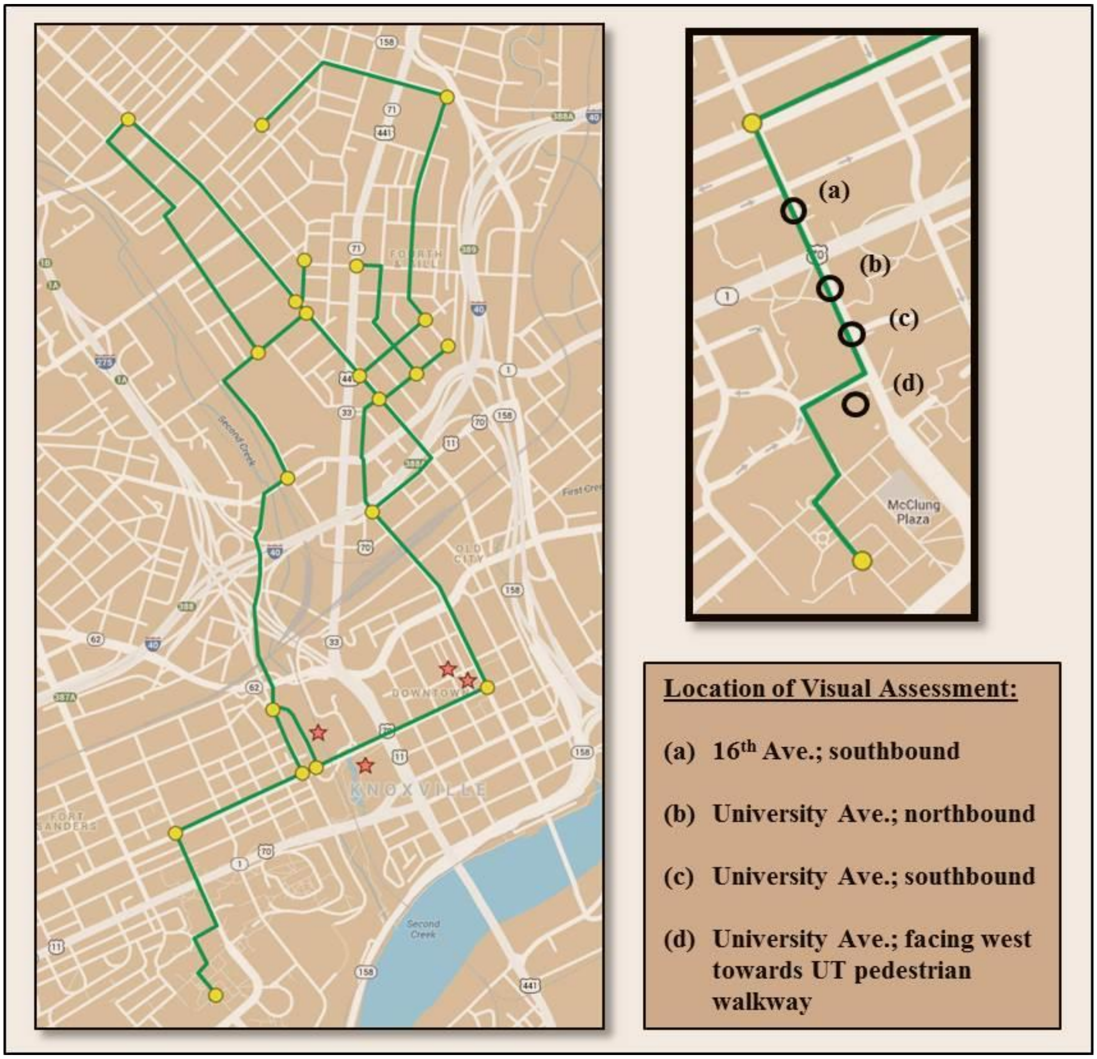


Figure D.57: Segment 15 – 16th Ave. and Volunteer Blvd.
Start cross-street, Clinch Ave.; end cross-street, Andy Holt Ave.

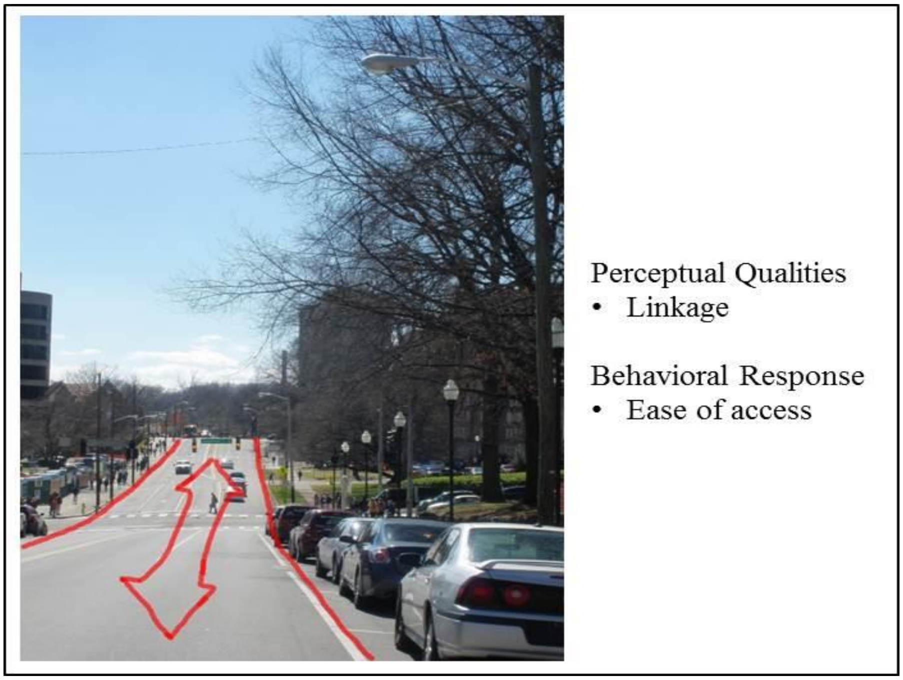


Figure D.58: (a) – Linkage / Ease of access
16th Ave. provides a linkage between Fort Sanders district and UT campus, creating easy access.

Figure D.59: (b) – Transparency, Complexity and Linkage / Sense of safety, Sense of place, and Ease of access
Open, long sight lines create a perception of transparency encouraging a sense of safety. Crowds and activity are visible, intereactions can be had all of which create a sense of place. Crosswalks create lateral linkages and increase sense of safety and connectedness.

Figure D.60: (c) – Transparency, Complexity and Linkage / Sense of safety, Sense of place, and Ease of access
Wide-streets, open sight lines create a perception of transparency. The ability to see and perceive human activity, encourages a sense of place. Sidewalks create longitudinal connectedness and an increased sense of safety.

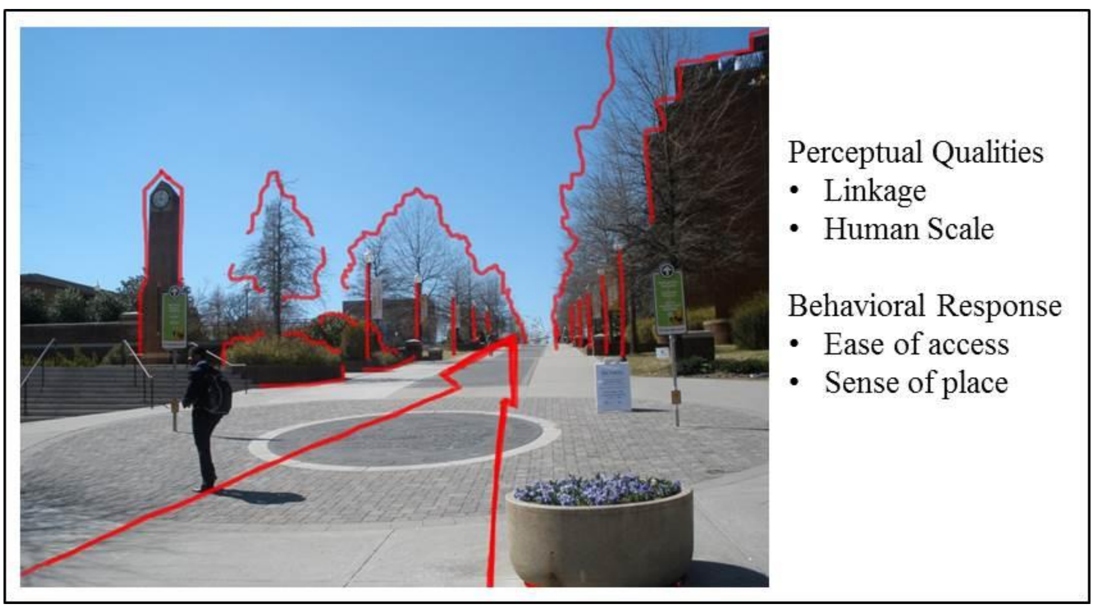


Figure D.61: (d) – Linkage and Human Scale / Ease of access and Sense of place
Pedestrian walkway connects several parts of campus without the vehicular component increasing ease of access. Tall, straight trees in continuous lines and landmark, Hodges Library, provide strong edges increasing the perception of connectedness. Clock tower, brickwork, planters all encourage enjoyment at a human proportion.

Segment 16

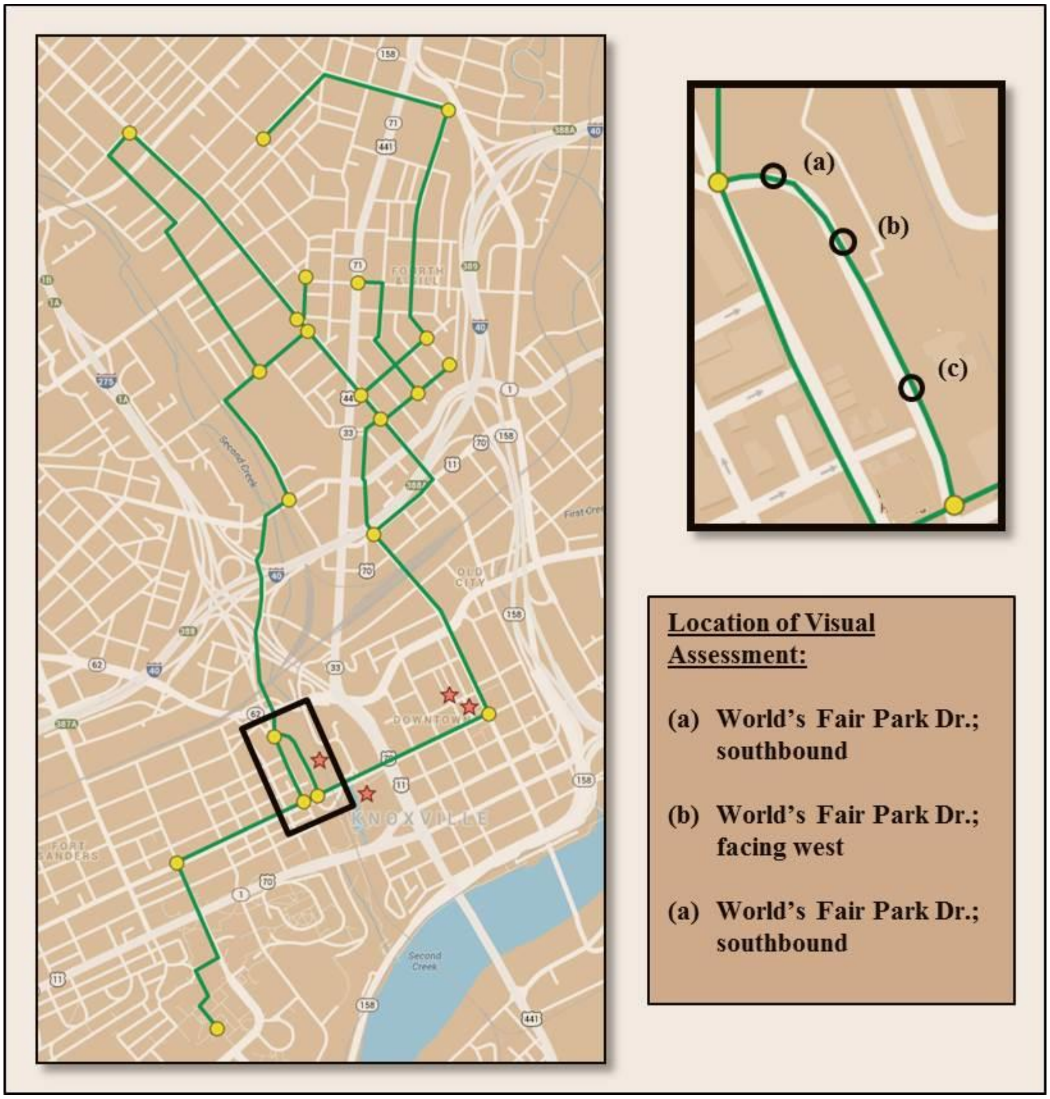


Figure D.62: Segment 16 – World's Fair Park Dr.
Start cross-street, Eleventh St.; end cross-street, Clinch Ave.

Figure D.63: (a) – Human Scale / Sense of place
Contrasting, bright colors of buildings and interesting structural design of playground on the hill are visually complex. Fort Kid provides opportunity to observe human activity.

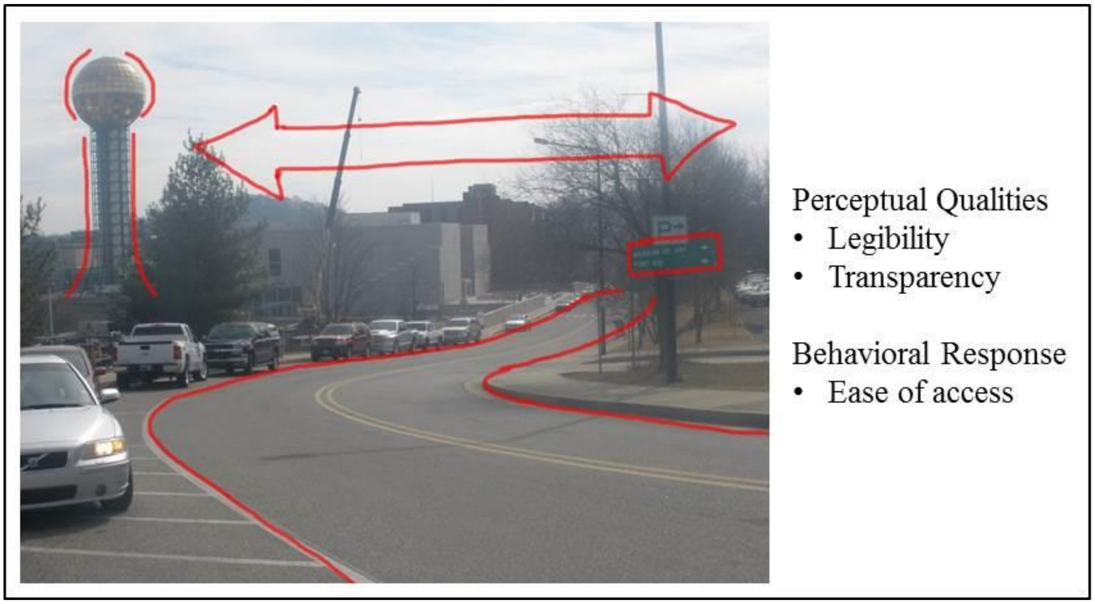


Figure D.64: (b) – Legibility and Transparency / Ease of access and Sense of place
Sunsphere and signage provide spatial orientation and direction, wide-open views of Knoxville Museum of Art and Downtown create the perception of transparency and sweeping curve of wide road create ease of access.

VITA

Beth Hawkins is pursuing a Master of Science in Landscape Architecture at the University of Tennessee, Knoxville. Prior to entering graduate school she received a Bachelor of Arts Degree in Cultural Anthropology at the University of Washington in Seattle, was as a Certified Dental Assistant for over a decade, was the founder of a Dental Assistant Training School, and mothered a child. Through her tenure as a graduate student she was a Graduate Assistant and interned as a Research Assistant at the Institute for a Secure and Sustainable Environment. Prior to graduation she became a full-time employee at Oak Ridge National Laboratory in the Environmental Sciences Division as a Research Associate where she is currently employed.