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GENERATING RECREATION, TRANSFORMING COMMUNITIES: UTILIZING TRANSMISSION POWER LINE CORRIDORS IN REGIONAL GREENWAY DESIGN

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GENERATING RECREATION, TRANSFORMING COMMUNITIES:
UTILIZING TRANSMISSION POWER LINE CORRIDORS IN REGIONAL GREENWAY DESIGN

A Thesis Project
Presented to
the Graduate School
at Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Landscape Architecture

by
John Christopher Pay
May 2013

Accepted by:
Dr. Matthew Powers, Committee Chairman
David Lycke, FASLA
Dr. Tom Schurch
Abstract

Utilizing existing transmission power line corridors and increasing their uses through the implementation of an infrastructural recreational element helps to preserve existing natural areas while increasing the recreation amenities in the areas. These corridors, often considered an eyesore to many, provide an opportunity to become beautiful public greenspaces which can act as recreational amenities, economic drivers, and providers of alternative transportation infrastructure. With the use of transmission lines being a necessity in supplying the energy needs of nearly all regions of the United States, the adaptability of this greenway system, model can be adapted by other communities throughout the country with similar corridor layouts. While these corridors have been utilized in many areas of the U.S. for single trails or as components of larger greenway systems, creating a comprehensive network primarily comprised of these corridors has yet to be done. This thesis project aims to uncover the issues and constraints which would be associated with a transmission corridor greenway and will attempt to offer design solutions and guidelines for these spaces which conform to the right-of-way regulations as imposed by the local power entity. The plan proposed in this document will attempt to unite the region while connecting the various sites, attractions, and recreational components of Upstate, South Carolina.
Dedication

This terminal project is dedicated to the memory of my grandfather:

Samuel C. Smith
March 1, 1924 – March 4, 2013

Electrical engineer and former
VP and Chief Engineer
Southwestern Electric Power Company,
Shreveport, LA
Acknowledgements

I would like to thank my committee members, Dr. Matthew Powers, Ph.D., ASLA and Dr. Tom Schurch, Ph.D., and David Lycke, FASLA for their time, guidance, and insight during this project.

I would like to thank the faculty of the Department of Landscape for the support and knowledge they have imparted to me during my time at Clemson University.

Special thanks to my parents, Linda and Tom Pay, for their continued love and support in all my endeavors. Thanks for always being there!
# Contents

1. **INTRODUCTION** .................................................................................................................................................. 1
   1.0 Introduction ...................................................................................................................................................... 1
   1.1 Project Purpose ............................................................................................................................................... 1
   1.2 Planning Process ............................................................................................................................................. 2
   1.3 Importance of Greenways ............................................................................................................................... 2
   1.4 Research Questions ........................................................................................................................................ 3
   1.5 Research Objectives/Vision & Goals .............................................................................................................. 3

2. **LITERATURE REVIEW** ...................................................................................................................................... 5
   2.0 Introduction .................................................................................................................................................... 5
   2.1 Greenways ...................................................................................................................................................... 5
   2.2 Transmission Power Line Corridors as Greenways ....................................................................................... 11

3. **METHODOLOGY** .................................................................................................................................................. 15
   3.0 Introduction ................................................................................................................................................... 15
   3.1 Case Studies ................................................................................................................................................... 15
   3.2 Summary of Existing Local and Regional Plans ............................................................................................ 19
   3.2 Design Considerations .................................................................................................................................. 22

4. **RESULTS** ........................................................................................................................................................ 27
   4.0 Introduction ................................................................................................................................................... 27
   4.1 Case Studies ................................................................................................................................................... 27
   4.2 Summary of Existing Local and Regional Plans ............................................................................................ 28
   4.3 Design Considerations .................................................................................................................................. 28

5. **INVENTORY & ANALYSIS** ............................................................................................................................... 29
   5.0 Introduction ................................................................................................................................................... 29
   5.1 Study Area ...................................................................................................................................................... 29
   5.2 Destinations ................................................................................................................................................... 31
   5.3 Existing Greenways and Trail Systems .......................................................................................................... 31
   5.4 Regional Transportation ............................................................................................................................... 33
   5.5 Transmission Corridor Inventory and Analysis ............................................................................................. 33
   5.6 Opportunities and Constraints ....................................................................................................................... 34
   5.7 Summary of Analysis .................................................................................................................................... 43
Contents (Continued)

6. PROPOSED NETWORK
   6.0 Introduction ......................................................................................................................... 44
   6.1 Concept Plan .......................................................................................................................... 44
   6.5 Photographic Simulations ...................................................................................................... 44
   6.6 Phasing .................................................................................................................................. 48

7. DESIGN GUIDELINES
   7.0 Introduction .......................................................................................................................... 49
   7.1 Wayfinding and Signage ......................................................................................................... 49
   7.2 Trail Details and Standards .................................................................................................... 50
   7.3 Road Crossings ...................................................................................................................... 51
   7.4 Trail facilities and Amenities .................................................................................................. 56

7.5 Planting Recommendations ......................................................................................................

8. CONCLUSIONS
   8.0 Conclusions .......................................................................................................................... 60
   8.1 Recommendations ................................................................................................................ 60

REFERENCES .................................................................................................................................... 61
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Example of a Transmission Line Corridor Located in Central, SC Near Hwy 93</td>
<td>4</td>
</tr>
<tr>
<td>2.1-2.5</td>
<td>Greenway Typologies.</td>
<td>6</td>
</tr>
<tr>
<td>2.6</td>
<td>Capital Area Greenway Trail Section</td>
<td>7</td>
</tr>
<tr>
<td>2.7</td>
<td>Greenways Provide Active Transportation</td>
<td>8</td>
</tr>
<tr>
<td>2.8</td>
<td>Bicycle Touring is a Popular Economic Booster for Communities</td>
<td>10</td>
</tr>
<tr>
<td>2.9</td>
<td>Greenways Provide an Increase in Value to Nearby Properties</td>
<td>10</td>
</tr>
<tr>
<td>2.10</td>
<td>Example of a Typical Transmission Line Right-of-Way</td>
<td>11</td>
</tr>
<tr>
<td>2.11</td>
<td>Existing U.S. Transmission Grid</td>
<td>12</td>
</tr>
<tr>
<td>2.12</td>
<td>Diagram of a Typical Right-of-Way Corridor</td>
<td>13</td>
</tr>
<tr>
<td>3.1</td>
<td>Signage Along the GHS Swamp Rabbit Trail</td>
<td>16</td>
</tr>
<tr>
<td>3.2</td>
<td>Section of the GHS Swamp Rabbit Trail</td>
<td>16</td>
</tr>
<tr>
<td>3.3</td>
<td>Section Along the Razorback Greenway</td>
<td>17</td>
</tr>
<tr>
<td>3.4</td>
<td>Trail Signage Along the Capital Area Greenway</td>
<td>18</td>
</tr>
<tr>
<td>3.5</td>
<td>Trail Section Along the Capital Area Greenway</td>
<td>18</td>
</tr>
<tr>
<td>3.6</td>
<td>Trail Section and Signage Along the Carolina Thread Trail</td>
<td>19</td>
</tr>
<tr>
<td>5.1</td>
<td>Map of Existing Conditions</td>
<td>30</td>
</tr>
<tr>
<td>5.2</td>
<td>Existing Local Greenway Networks</td>
<td>32</td>
</tr>
<tr>
<td>5.3</td>
<td>Map of Existing Upstate, S.C. Transmission Line Corridors</td>
<td>35</td>
</tr>
<tr>
<td>5.4</td>
<td>Visual Analysis Map of Upstate, S.C. Transmission Line Corridors</td>
<td>37</td>
</tr>
<tr>
<td>5.5-5.30</td>
<td>Images of Existing Upstate, S.C. Transmission Line Corridors</td>
<td>38</td>
</tr>
<tr>
<td>5.31</td>
<td>Map of Constraints Along Existing Transmission Line Corridors</td>
<td>41</td>
</tr>
<tr>
<td>5.32</td>
<td>Topographical Conditions of the Project Area</td>
<td>42</td>
</tr>
<tr>
<td>6.1</td>
<td>Proposed Plan</td>
<td>45</td>
</tr>
<tr>
<td>6.2</td>
<td>Photo Simulation of Proposed Corridor Design</td>
<td>46</td>
</tr>
<tr>
<td>6.3</td>
<td>Photo Simulation of Proposed Design Elements Including Shelter Placement</td>
<td>47</td>
</tr>
<tr>
<td>7.1</td>
<td>Example of Wayfinding Signage for Roadway Connections</td>
<td>50</td>
</tr>
<tr>
<td>7.2</td>
<td>Low Risk Roadway Crossing</td>
<td>52</td>
</tr>
<tr>
<td>7.3</td>
<td>Medium Risk Roadway Crossing</td>
<td>53</td>
</tr>
<tr>
<td>7.4</td>
<td>High Risk Roadway Crossing</td>
<td>54</td>
</tr>
<tr>
<td>7.5</td>
<td>Conflict Avoidance</td>
<td>55</td>
</tr>
<tr>
<td>7.6-7.29</td>
<td>Recommended ROW plantings for SC Corridors</td>
<td>59</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>57</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.1 - Recommended Right of Way Plantings for SC Corridors
("South Carolina Recommended" 2013)
1.0 Introduction:

Throughout the U.S., many cities and regions are realizing the potential that greenways can have in transforming their communities. Greenways have been well documented for their ability to improve recreation, health, tourism, environment, economics, as well as many other benefits. By implementing these trails into the fabric of their cities, they often see an immediate return on their investment in more than just monetary terms.

In his book, Greenways for America, Charles Little defines a greenway as:

“A linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, scenic road, or other route. It is any natural or landscaped course for pedestrian or bicycle passage. An open-space connector linking parks, nature reserves, cultural features, or historic sites with each other and with populated areas. Locally, certain strip or linear parks designated as parkway or greenbelt.” (Little, 1990, 1)

1.1 Project Purpose:

With the increase in popularity of greenways, many cities are planning and implementing their own greenways throughout the U.S. The case is no different in the upstate of South Carolina. Greenway plans have been adopted by cities such as Easley, Anderson, and Greenville, SC. Other cities in the Upstate region of S.C. have been the focus of graduate student thesis projects to examine their suitability for
the implementation of Greenways. The city of Clemson has referenced a 2002 thesis plan by Clemson University City and Regional Planning
graduate, Dana Marie Zaffuto, in its 2014 Comprehensive Plan and has mentioned implementing its design in the future. The purpose of this
plan is to develop an integrated system of multi-use trails which will connect the cities as well as recreational, cultural, and historic sites in the
Upstate of South Carolina. The plan aims to increase recreational and transportation options in the area while providing sustainable growth
options for the future. The Plan builds off of existing planning efforts and infrastructure in the region, creating a connection between the area’s
unlinked resources.

1.2 Planning Process:

The planning process began by examining existing regional transportation plans, comprehensive plans, as well as bikeway plans. This
was done in order to evaluate what plans were in place, plans for future development, and to examine where connections were lacking. A
case study evaluation of regional greenway systems was conducted to examine the successes and shortcomings of greenway systems that
have been in place long enough for post occupancy evaluation. A third method of data collection was used in the process. Consultation with
Duke Power allowed for the acquisition of beneficial data pertaining to existing right-of-way regulations.

1.3 Significance of Greenways:

Greenways provide an array of benefits to their surrounding communities. These trails provide immediate benefits as well as help
promote the sustainability of the communities in which they are implemented. Some of the benefits of greenways include:

- Providing sustainable, safe alternative modes of pedestrian and bicycle transportation
- Improving the economic activity along the trail and in the region
• Improving the health in the region through improved recreation amenities
• Providing environmental benefits such as flood zones and wildlife refuges.

These benefits will be discussed in more detail in chapter two of this document.

1.4 Research Questions:

The following questions were posed to present a basis and direction for the research to be investigated during this thesis project:

• What existing open space corridors and spaces could be used as part of a larger greenway master plan for the Upstate, SC region?
• How can green open spaces in the Upstate region of SC be used to connect the cultural, historic, and recreational amenities of the area?
• How can the health, sociological, cultural, and the economic benefits of a region be improved through improved walkability and bikeability?
• How do transmission power line corridors fit within larger green infrastructure plans?
• How can transmission power line corridors fit into a regional greenway system?
• What design standards must be addressed when designing a comprehensive transmission powerline greenways system?

1.5 Research Objectives/Visions & Goals:

The goal of this research project is to evaluate the feasibility of creating greenway systems utilizing transmission line corridors. These corridors are found throughout the United States and if it is determined that they are a viable trail building option, this greenway design model could be implemented in other areas of the country. This research plans to evaluate existing utility right-of-way (ROW) regulations and other
design standards to provide for an additional benefit in tandem with their primary function of transporting electrical power. The research will investigate the connections that will need to be addressed in areas of constraint such as road crossings and connections across bodies of water.

Chapter two will begin by giving an overview of the literature review performed for this project. Information provided gives an overview of the benefits of greenways as well as an overview of right-of-ways and suitability for use in trail design.

Figure 1.1 - Example of a transmission line corridor located in Central, SC near Hwy 93 (Photo credit: Chris Pay)
There are all sorts of opportunities to link separated [open] spaces together, and while plenty of money is needed to do it, ingenuity can accomplish a great deal. Our metropolitan areas are crisscrossed with connective strips. Many are no longer used, ...but they are there if we only look.”

-William Whyte, The Last Landscape, 1968

2.0 Introduction

This chapter aims to give a brief overview of greenways, detail the benefits associated with them, and begins explaining transmission line rights-of-ways and their potential use in regional greenway design. The information in this chapter has been researched and obtained from previously published materials and is intended to provide an introduction and basis for design guidelines in subsequent chapters.

2.1 Greenways

2.1.1 Overview and benefits

According to Charles Little in his book, Greenways for America, there are five main categories of greenways. These categories include:

- Urban riverside greenways, usually created during redevelopment plans along often neglected city waterfronts.
- Recreational greenways which feature various kinds of trails, usually of relatively long distances. These are often based on natural corridors as well as canals, abandoned railbeds, and public right of ways.
- Ecologically significant corridors, usually developed adjacent to streams or ridgelines in order to provide for wildlife migration,
nature study, and hiking

- **Scenic and historic routes**, usually along a road or highway with the intent to provide pedestrian access along the route.
- **Comprehensive Greenway Systems or networks**, usually based on natural landforms including valleys and ridges but sometimes an attempt to assemble greenways and open space of various kinds to create an alternative municipal or regional green infrastructure. (Little, 1990)

**Figures 2.1-2.5** exemplify each of the aforementioned typologies. The plan presented in chapter six of this document aims to combine the recreational greenway, scenic and historic routes, and comprehensive greenway system typologies to create an enjoyable and frequented greenway network for the upstate, SC region.

**Figure 2.1 - 2.5 - Greenway Typologies**

- Urban Riverside
- Recreational
- Ecologically Significant
- Scenic & Historic
- Systems or Networks

Photo credits:
http://www.americantrails.org
http://www.greenvillesc.gov/ParksRec/
http://josephtheur.files.wordpress.com
http://www.uniglobethetraveltimes.com/wordpress/
The modern greenway system is a relatively new idea but the idea and original greenway design can be attributed to Frederick Law Olmstead for the greenways he proposed in October of 1865. His vision was to create two greenways for the College of California in Berkeley (now University). As a part of his plans for the campus grounds he proposed creating public parkland with all the land in the whole valley of Strawberry Creek above the college grounds and to create pleasure drives and walks along it, terminating with a view atop a canyon. His second greenway plan was his first outside a park and involved linking the college with Oakland by way of a pleasure drive through the hills, designed first and foremost for carriages as well as the scenic experience. (Little, 1990) Olmstead went on to incorporate these greenways and parkways into his later designs which included Prospect Park, Riverside, Illinois, and his now famous Emerald Necklace in Boston.

Another notable greenway being implemented during this time was H.W.S. Cleveland’s Minneapolis-St. Paul metropolitan park system, finished in 1895. This is believed to be the first and finest open space network. (Little, 1990)

The earliest comprehensive greenway network in the country is considered to be the Capital Area Greenway located in Raleigh, NC. The plan was surprisingly not the work of a major landscape architectural or planning firm, but that of a graduate student at NC State University. The plan was conceived in 1970 by 25 year old Bill Flournoy, who needed a thesis project and wanted to ensure that the “natural environmental functions do not need to be displaced as cities expand.” His greenway plan and report is considered to be somewhat of a classic piece of literature amongst greenway designers today (Little, 1990). The report tackled such topics as floodplain zoning, acquiring easements, and provided politicians and the public a rationale for taking actions.

Figure 2.6 - Capital Area Greenway Trail Section
(Photo Credit: http://triangleexplorer.com/category/parks/)
2.1.2 Public Health

Increasing available recreational amenities within a community can have a great influence on improving the health of those living in the area. In the U.S., more than one-third (35.7%) of adults are obese. South Carolina Obesity rates are high, but are slightly lower than the national rate at 30.8% (Centers for Disease Control and Prevention August 23, 2012). According to the CDC, approximately 17% of U.S. children between the ages of two and nine are obese. Obesity prevalence among children has almost tripled since 1980 (“Data and Statistics” January 11, 2013). Improved recreation infrastructure such as greenways provides space for active recreation which can help control weight and high blood pressure, reduce the risk for Type 2 Diabetes, colon cancer, and heart attack, reduce the symptoms of anxiety and depression, reduce pain and disability, and can help prevent osteoporosis and falls (“Trails for Health: Increasing Opportunities for Physical Activity in the Community”). Walking and biking are two of the easiest ways to stay active. Greenway activities such as walking and bicycling provide low impact recreation which almost all members of the community from children to seniors can enjoy.

2.1.2.1 Transportation

Greenways can often serve an important function as an alternative form of transportation. Greenways provide access to local amenities through walking and cycling. This helps relieve traffic congestion on local roads, provides health benefits to the commuter, and helps the environment by preventing pollution and saving fossil fuels. Greenways provide a safe means of transportation, especially...
when separated from vehicular traffic. Regional greenways systems provide links between area towns that would otherwise need to be accessed by automobile.

2.1.2.2 Safety

Cycling and walking along busy city streets is often a deterrent for many people as they are often not comfortable recreating alongside fast moving vehicular traffic. In 2010, 4,280 pedestrians were killed and an estimated 70,000 were injured in traffic crashes in the U.S. In the same year, 618 cyclists were killed and an additional 52,000 were injured in motor vehicle crashes. In 2012, SC had a total of 90 pedestrian fatalities and 14 cyclist fatalities (“Traffic Safety Data Facts 2010: Pedestrians” August 2012). By creating greenway trails we are able to increase the separation of cyclists and pedestrians with vehicular traffic and thus provide a safer environment for trail users to recreate.

2.1.2.3 Environmental

Greenway trails help the environment in many different ways. Greenways provide an alternative means of transportation which helps decrease carbon emissions as well as the consumption of our nonrenewable fossil fuels. For every mile that is walked biked rather than driven, nearly one pound of CO$_2$ is saved (U.S. EPA, 2012). Greenways are also known for providing valuable habitat and corridors for wildlife. Greenways are also beneficial when serving as natural floodplains. The Federal Emergency Management Agency attributes over $1 billion in property damages annually to flooding. By restoring developed floodplains to their native state and constructing greenways in these floodplains, these natural systems can perform as they were intended, saving millions of dollars each year (CT Dept. of Energy and Environmental Protection 2012). Greenways constructed alongside bodies of water prevent contamination of these waterways while serving as a protective buffer. Greenways can also serve as education tools by serving as classrooms for hands-on, outdoor learning.
2.1.2.4 Tourism

Bicycle tourism has the potential to offer many benefits to a region. By connecting local cities, recreational amenities, and historic and cultural sites, a greenway has the ability to become a destination for bicycle and other tourists. By connecting these trails to state parks and campsites, the region will cater to a new type of tourist that the area may not have attracted, otherwise. These tourists can bring revenue into the region while patronizing local businesses. An example of the successes of bicycle tourism can be seen in the example of North Carolina’s Outer Banks. The area generates around $60 million in revenue through bicycle tourism. Their initial investment of $6.7 million sees an annual 9-1 return on their initial investment (Flusche, 2009).

2.1.2.5 Economic

As mentioned in the previous section, bicycle tourism can act as a revenue generator for regions containing greenways systems. Greenways also help stimulate the economy through local users. In Minnesota, bicycle trail users spend $481 million annually while recreating, creating 5,880 jobs and $40.6 million in state and local taxes (Venegas November 2009). Greenways and open space also provide an economic benefit in the real estate market. Homes located adjacent to or near greenway systems have seen increases in property values in many examples throughout the U.S. In a survey of recent homebuyers conducted by the National Association of Home Realtors and the National Association of Home builders, trails ranked second in importance in a list of 18

Figure 2.9 - Greenways Provide an Increase in Value to Nearby Properties (Photo Credit: http://www.greenways.com/)
community amenities ("Benefits of Greenways" 2007).

2.2 Transmission Power Line Corridors

As stated in Chapter one, Greenways are becoming increasingly popular among American cities looking to improve the connections between their parks and open spaces. Looking into the future, many counties and Metropolitan Planning Organizations (MPO’s) are looking to improve their regional transportation options by linking many of their local cities through the use of regional greenway systems. Regional greenways can sometimes be more difficult to plan or complete due to the increased amount of landholders and the difficulties associated with acquiring these lands for trail use. Finding ways to utilize lands with an existing land use can help expedite the process of planning and acquiring these lands.

When beginning this project a major goal of the research was to create a way to connect the region through greenways that could be replicated in other areas around the country. Throughout the U.S. there are around 6,600 operational power plants with a generation capacity of at least 1 MegaWatt (eia.gov). These power plants usually service a large area in the region surrounding the plant. Transmitting this energy requires the use of transmission lines to deliver the power to each developed area within the service area. The system which transfers the electrical power from the energy plant to homes is called the power distribution grid. When energy is produced at a power plant, it is then transferred by way of high voltage transmission lines to power substations. From the substations, the electricity is dispersed through the community by way of lower voltage power lines known as distribution lines. These
are normally the wooden poles you see as opposed to the large metal towers associated with transmission lines. With the implementation of Transmission lines comes the need to create right-of-ways (ROWs) to protect the poles and conductors. These ROW’s are basically a protective buffer around the power line in which vegetation and structures are restricted or prohibited in order to prevent their contact with conductors (wires) and their transmission of electrical energy. The transmission line ROW’s can be adapted to create trail connections between the areas being serviced and the greenway systems in these communities.

Figure 2.11 shows the existing transmission line corridors in the U.S. and the ability of this planning model to be used on national level. As of 2009 there were about 452,699 circuit miles of transmission line (>100kV) in North America. U.S. Transmission is predicted to grow from its 2009 number of 372,340 miles to 406,730 miles by 2019. (Silverstein April 20, 2011) With proper planning, greenway planning could take place in conjunction with the creation of these new right-of-ways.

2.2.1 Right of Ways

Transmission power line corridors are comprised of three main elements. These include the transmission tower, the conductors (electrical wires), and the cleared area surrounding the equipment known as the right of way. Right of ways (ROWs) are used in order to prevent damage to the utility company’s valuable equipment. By keeping this area clear, the utility company decreases the likelihood that a tree or other obstruction may cause damage to the conductors causing power outages. The following image (Figure 2.12) illustrates the elements associated with a transmission line right of way.
2.2.2 ROW Widths:

ROW's vary in width depending on the voltage of the conductors in the corridors. Generally, the widths of corridors are as follows, unless stated otherwise in a right of way agreement:

- 44,000-100,000-volt lines require a minimum 68’ corridor.
• 230,000-volt lines require a minimum 150’ corridor.
• 525,000-volt lines require a minimum 200’ corridor (Duke-Energy.com)

In some cases multiple lines are run parallel to each other, expanding the width of the corridors to 900’ or more.

2.2.3 Right of Way Ownership

Utility corridors are most often owned by private owners and not by the utility company owning the utility lines on the property. Utility companies secure easements in order to have their equipment on the landowners property. These are legal agreements that allow the utility company the right to access and use the property. These easements are usually placed in the property owners deed and are transferred to the new owner if the property is sold. Easements allow the utility company the right to enter or cross the right of way in order to install, operate, inspect, and maintain their equipment located on the landowners property.
3.0 Introduction

For this project the research methodology came from three main areas of focus. These included case studies of existing greenway plans, examination of existing local and regional comprehensive and transportation oriented plans, and a review of the existing design guidelines and right-of-way restrictions imposed by Duke Energy.

3.1 Case Studies

For the case study methodology, existing greenways were selected in order to evaluate the successes and flaws in existing greenways. All cases selected were regional in scale in order to better relate to the goals of this research project. Established greenways were selected over newer trails in order to gain more information from post occupancy evaluations while, a few newer trails were included in order to examine current trends in regional greenway design. The selected greenways include The GHS Swamp Rabbit Trail, The Razorback Regional Greenway, Capital Area Greenway, and the Carolina Thread Trail.

3.1.1 GHS Swamp Rabbit Trail

Greenways have had a proven track record of providing positive benefits in many of the areas in which they are implemented. One such example is the Swamp Rabbit Trail located in Greenville County, South Carolina. The trail makes use of the former Greenville and Northern Railroad Corridor, nicknamed the Old Swamp Rabbit Railroad, to connect the cities of Greenville, SC with Travelers Rest, SC.
The trail spans a distance of 17.5 miles with portions abutting the Reedy River in Greenville. The trail is currently surfaced in asphalt with portions paved with a rubberized running surface to provide less impact on joints. Trail width varies from 8 – 12 feet in width. Most non-motorized activities are encouraged and the trail is wheelchair accessible. Amenities along the trail include lighting, benches, water fountains, signage, public restrooms, and picnic areas (Swamp Rabbit Tram Trail, 2012).

While serving as a resource for recreation, the trail also serves as a connection between local area schools, parks, and businesses. Placed along the trail are multiple bus transit stops to allow citizens the option of commuting to work or area attractions without the use of a car. Plans for the trail include extending the existing trail to connect (GHS Swamp Rabbit Trail, 2012).

The implementation of the SWT was an effort by the Greenville County and City officials to prevent inactivity and obesity as well as to provide additional transportation options while promoting economic development and reduced emissions. In its first year the trail showed large user numbers. During a 16 day survey period, 15,751 users were counted on the SWT. Based on calculations factoring in seasonality, approximately 359,314 users were estimated to use the trail in its first year. Recreational users of the trail were reported to spend between 1-2 hours on the trail per visit. Approximately 6% of the SWT users reported using the trail as a method of transportation. This number is nearly twice the amount (2.7%) of Greenville County residents who reported “walking” or using “other means” to commute to and from work as noted in the 2009 American Community Survey (Reed, 2012).
As well as increasing alternative transportation usage and increasing recreation with in the community, the SWT trail has also shown to have a beneficial, economic impact on local businesses. In a survey of nine managers/retailers whose businesses sit within close proximity to the trail, most reported increases in sales ranging from 30% to as much as 85% (Reed, 2012).

### 3.1.2. Northwest Arkansas Razorback Greenway

The Razorback Regional Greenway is a newer project currently being developed and implemented in Northwest Arkansas. The trail greenway is envisioned as a 36 mile trail connecting Bentonville, AR to Fayetteville, AR and all towns in between. The trail links three major hospitals, 23 schools, the University of Arkansas, major entertainment venues, shopping areas, parks, historic sites, 3 major corporate headquarters, playgrounds, and residential communities. Approximately 14 miles are built with the remaining 22 miles currently being in the planning or design phase.

The trail was designed by the “Green Team,” an all star trail building cast including team members from Alta Planning and Design, Greenways, Inc, The Greenway Team, Thomas Woiwode, the League of American Bicyclists, and CEI Engineering. The team worked together with the community to create a plan linking Fayetteville, Johnson, Springdale, Lowell, Rogers and Bentonville, AR. The project is estimated to exceed $38 million. $15 million in federal funding was awarded through a TIGER II grant which includes funding for design, land acquisition, and construction costs. The Walton Family Foundation has agreed to match the $15 million grant 1:1 with addition funding to match additional federal funding. The local governments will be responsible for financing the remaining $8 million for lighting and site amenities (“Northwest Arkansas Razorback Greenway” 2013).
3.1.3. Capital Area Greenway

As mentioned in the history of greenways section in chapter 2, Capital Area Greenway is considered the first planned, comprehensive greenway network. The trail system is located in Raleigh, NC and the surrounding area. The multi-use trail, inaugurated in 1974, contains 117 miles of greenway trails. The trail system was built over a period of 15 years.

The trail was originally developed as a way to create environmental buffers for floodplain protection, wildlife buffers, recreation and connectivity of park spaces. Portions were designed along streams and creeks to prevent flooding of commercial and residential properties as well as to provide a buffer between these urban and riparian areas.

The trail surface is primarily 10’ wide and is mostly an asphalt surface with some areas unpaved and boardwalks in environmentally sensitive areas. The trail is mostly flat with the maximum grade being 8%. The trail offers such amenities as information kiosks, maps, and lighting in sections (Little 1994).

The trail is maintained by the county parks and recreation department. The trail also has a mobile device application which provides trail information while allowing users an opportunity to report damage or issues with the trail. The most recent version of the plan includes over 270 miles of stream slated for protection and greenway construction (Lebsock).
3.1.4. Carolina Thread Trail

The Carolina Thread Trail is a regional network extending throughout portions of both North and South Carolina. This multi-use trail consisted of 112 miles of trail as of 2012. The planning process, begun in 2005, consisted of over 40 local community and business leaders who gathered to discuss the region’s most important environmental needs. After two years of planning and design, the trail opened in 2007. The trail currently extends through 15 counties and reaches over 2.3 million people while linking universities, museums, natural features, gardens, and wildlife preserves.

The trail system is very well organized. Currently it has a 22 member governing body with members from around the region, an advisory board consisting of 17 members who provide input on projects, and a 20 member Leadership Council consisting of senior community or civic leaders who serve as ambassadors to the Carolina Thread Trail.

The trail is expected to extend to over 130 miles while continuing to link the region’s resources. The trail is planned to cost an average of about $200,000 per mile. A potential economic impact study of the trail predicted an increase in property values along the trail at $3,580 per household which would likely lead to around 17 million in tax revenue. The trail is also expected to generate 2,800 new jobs for the region (“Carolina Thread Trail “ 2013).

3.2 Summary of Existing Local and Regional Plans

In addition to Greenway case studies, an evaluation of existing local and regional comprehensive and transportation plans was...
conducted. The following plans were reviewed: City of Clemson Comprehensive Plan 2014, GPATS Long Range Transportation Plan, 2030 Pickens County Comprehensive Plan, Anderson County 20 Year Comprehensive Plan,

3.2.1. Pickens County Comprehensive Plan

The Pickens County plan expresses the desire to “encourage tourism development compatible with scenic and historic areas of the county.” Greenway systems that promote ecotourism can help with this vision (“Pickens County, SC Comprehensive Plan “ 2004).

3.2.2. Anderson County 20-Year Comprehensive Plan

The Anderson County Comprehensive Plan makes note of the adopted, 13-phase bikeway and pedestrian pathway project in the City of Anderson. The plan will create multiple connections to local schools as well as to sports and entertainment centers, and downtown areas and commercial districts. This is done in their support of the country’s current trend in increasing exercise while decreasing dependence on the automobile.

The plan lists as one of its goals for the future, “pursue development of alternatives to automobile transportation including walking, mass transit, and bicycling.”(Com. Fac. G 2, 04).

Community Facilities Goal 7 states, “Anderson County will update and implement a county parks and recreational plan that provides for future parks, trails and trails systems, and existing facility improvements that will enhance the quality of life and health of all citizens of the county.”

The Leisure and Recreation section of the Vision Plan states the counties desire to “increase green spaces, parks with themes, things to draw people to that place, trails to connect cities within the county, safe places for leisure” (“Anderson County 20-Year Comprehensive Plan “ 2004).
3.2.3. Oconee County Comprehensive Plan

The Oconee County Comprehensive Plan lists “Expanding bicycle and pedestrian routes to allow for greater use of alternative forms of transportation, and to promote ecotourism opportunities” as one of its objectives (“Oconee County Comprehensive Plan” November 2010).

3.2.4. Greenville-Pickens Area Transportation Study (GPATS): Long Range Transportation Study

GPATS is the Metropolitan Planning Organization which oversees the transportation planning of Greenville, S.C., Easley, Pickens, and Clemson, SC. This organization plans and prioritizes the federally funded transportation improvements the urbanized areas which it oversees.

The plan lists design guidelines for pedestrian and bicycle facilities within its jurisdiction. Some of these are as follows:

Conducts the use of pedestrian crosswalks and enhancements such as marked crosswalks, raised crosswalks, pedestrian refuge islands, and curb extensions

Multi-use paths should be a minimum of 10 feet wide. Their width may be reduced to 8’ depending on physical or right-of-way constraints. Extra width should be included for areas encountering steep terrain or high traffic volumes.

Designs must comply with MUTCD and AASHTO Bicycle Guide

Shade and rest areas with benches and water sources should be designed along multi-use paths. Vistas should be preserved when possible. Wayfinding signs should be included to express distances and destinations (“GPATS Long Range Transportation Plan “ November 2007).
3.3 Design Considerations
3.3.1 Existing Duke Power Right-of-Way Regulations

The following list provides the restrictions set forth by Duke Energy for property owner use in Duke Energy’s electric transmission ROW’s. Often times Duke Energy of other energy providers do not own the land their transmission wires travel through. They are often granted easements from the property owner to cross their property. Although Duke Energy does not necessarily own all they land their transmission lines and poles are housed on, they still reserve the right to maintain a safe and clear path for their lines to traverse through. Because of this, Duke has set forth a list of general restrictions on ROW’s for property owners. The following list details these restrictions, as provided by Duke-Energy.com:

- Structures, buildings, manufactured homes, mobile homes and trailers, satellite signal receiver systems, swimming pools (and any associated equipment and decking), graves, billboards, dumpsters, signs, wells, septic systems or storage tanks and systems (whether above or below ground), refuse of any type, flammable material, building material, wrecked or disabled vehicles and all objects (whether above or below ground) which may, in Duke Energy’s opinion, interfere with the electric transmission right of way, in any way, are not allowed within the rights-of-way limits. Transformers, telephone/cable pedestals (and associated equipment), and fire hydrants are not allowed. Manholes, water valves, water meters and backflow preventers are not permitted.

- Fences shall not be attached to poles or towers. Fences shall not exceed 10 feet in height and shall be installed greater than 25 feet from poles, towers and guy anchors. Fences shall not parallel the centerline within the rights of way but may cross from one side to the other at any angle not less than 30 degrees with the centerline. If a fence crosses the rights of way, a gate (16 foot wide gate at each crossing) shall be installed by the property owner, per Duke Energy’s specifications, to allow free access required by Duke
Energy equipment.

- Contact Duke Energy and obtain written approval before grading or filling on the rights of way. Grading (cuts or fill) shall be no closer than 25 feet from a pole or tower leg and the slope shall not exceed 4:1 on the rights of way. Grading or filling within the rights of way or near a structure, which will prevent free equipment/vehicle access, or creates ground to conductor clearance violations, will not be permitted. Sedimentation control, including re-vegetation, is required per state regulations.

- Streets, roads, driveways, sewer lines, water lines, and other utility lines, or any underground facilities shall not parallel the centerline within the rights of way, but may cross, from one side to the other, at any angle not less than 30 degrees with the centerline. No portion of such facility shall be located within 25 feet of Duke Energy’s supporting structures. Intersections of roads, driveways, or alleyways are not permitted within the rights of way.

- Any drainage feature that allows water to pond, causes erosion, directs storm water towards the rights of way, or limits access to or around a structure is prohibited.

- Contact Duke Energy prior to the construction of lakes, ponds or retention facilities, etc. within the rights-of-way limit.

- Duke Energy does not object to parking within the rights of way, provided that:
  - A barrier, sufficient to withstand a 15 mph vehicular impact, shall be erected by the party constructing the parking area to protect the pole, tower or guy anchor. The barrier shall be located in such a manner as to restrict parking to at least 5 feet from the structure.
  - Any access areas, entrances, or exits shall cross (from one side to the other) the rights of way at or near right angles to the centerline, and shall not pass within 25 feet of any structure. Parking lot entrances/exits cannot create an intersection within the right of way.
  - Lighting structures within the rights-of-way must be approved by Duke Energy before installing. Total height may not exceed 15 feet.
• Signs and other attachments to Duke Energy structures are prohibited.

• Duke Energy Carolinas will not object to certain vegetation plantings as long as:
  • It does not interfere with the access of existing structures or the safe and reliable operation and maintenance of the line.
  • With prior written approval, Duke Energy Carolinas does not object to plants, shrubs and trees that are of a species that will not exceed, at maturity, fifteen (15) feet in height.
  • Duke Energy Carolinas reserves the right to object to the planting of all plants, shrubs and trees within the right of way easement that may interfere with the proper operation and maintenance of the line.
  • Duke Energy Carolinas may exercise the right to cut “danger trees” outside the rights of way limits as authorized by the right of way agreement applicable to the subject property and as required to properly maintain and operate the transmission line (“Transmission Rights of Way Restrictions” 2013).

3.3.3.2. Existing Duke Energy Requirements for use of Trails in ROW's

Although Duke Energy lists general restrictions for ROW’s, the company does not give regulations for specific ROW applications such as multi-use trails on their website. In an August 2012 meeting with the Mecklenburg County, NC Park and Recreation, Duke Energy R/W Asset Protection Specialists, Ed Williams and Steven Pryor, met to discuss the current Duke Energy policies and their history and answered questions regarding the inclusion of trails in Duke Energy ROW’s.

Ed Williams described the restrictions in the online guidelines/restrictions as follows:

• All construction must remain 25’ or more from all electrical structures, including guy wires and their anchors.
• Pedestrian type light posts are limited to a 15’ height
• Grading is reviewed on a case-by-case basis, allowances vary by voltage of the lines
• Plants/trees under 15’ height at maturity are allowed, but rows of trees along the trail are discouraged
• Concrete and asphalt surfaces are allowed
• Boardwalk is not allowed. All structures must remain outside the ROW.
• Currently trails are limited to a 5’ width when traveling longitudinally in the ROW.
• Trails crossing the ROW must be at a 30 degree angle or greater with the ROW and are not limited in width.
• Vehicular access must be restricted through the use of such devices as collapsible bollards that are preferably steel.
• Bollards or barriers at electrical ROWs must allow passage of Duke vehicles, perhaps a double lock system. Collapsible bollards allow only one lock, so a “realtor box” with a shared key might be needed. Systems that allow multiple locks require swing gates. Greenways open 24/7 would not be able to use swing gates.
• Duke Energy recorded legal easements/rights-of-way language states that no parallel roads are allowed; therefore, trails/greenways must be distinguished in some way from a road/driveway.
• Duke Energy recorded legal easements/rights-of-way language states that no structures are allowed, therefore trail routes must be designed to avoid structures such as benches, trash cans, signage, walls, bridges, etc.
• In most cases Duke Energy does not own the land within the ROW. Pursuing an agreement with the underlying landowner would be the entity developing the trail.
• Encroachment agreements are required within the ROW. If the trail is crossing only, an approval letter is typically sufficient. If the trail
runs parallel to the ROW, a recorded encroachment agreement is required.

- Significant equipment is required for Duke Energy maintenance of towers and lines. Any trails in the R/W must be closed during maintenance of the lines.
- Many of the older duke Energy Transmission corridors were run through swamps. Again, boardwalks are not allowed.

Additional Information gathered through questions at the meeting:

- Dual/ shared use of maintenance access roads would need to be separated.
- Trails are allowed to meander, which allows for the opportunity to place needed structures and trail amenities outside the ROW
- Duke Energy will consider allowing a 10’ path to separate into 2-5’ paths for short runs with a median in between to avoid the path being considered a “road.”
- Maintenance such as mowing is allowed but Duke Energy reserves the right to shut down the trail at any time deemed necessary to make repairs (Williams, Ed 2012).

### 3.4 Conclusion

The information gained from these three methods will be used extensively to design the plan for this project. The information gathered from the sources above ensures that all factors are considered before design takes place in order to create a design that not only works functionally, but adheres to all local, regional, and utility company guidelines and regulations. Chapter four gives a brief overview of the results of these methods.
4.0 Introduction

Throughout the various research methods used, beneficial information was gathered to aid the proposed design included in this document. Each method provided unique information that proved valuable for one reason or another. The following sections provide an overview of the results of each method employed.

4.1 Case Studies

Case studies provided many important elements to consider while planning this design. When greenways are designed at a regional scale as opposed to a smaller scale local network, extra amenities must be included to facilitate enjoyed use of the trail. Most trails provided employed the use of needed signage and wayfinding along their often long stretches of trail. Information provided included distances to relevant sites and features as well as suggested travel times between routes. Also important to consider in regional design is the inclusion of shelter or water sources. With the expanse of the plan suggested in later chapters of this book, shelter from the sun and water filling stations will be necessary.

Another element to consider in regional greenway planning, as concluded from the case studies, is the importance of involving the local communities in the planning efforts. With so many stakeholders and property owners involved, it is important to assess the wants and needs of those who own the land or will be affected by those who use the trail on or near their property.

Case Studies provided important information on the phasing of plans as well. Greenways take time to plan and develop and are
often being constructed over a period of many years. This becomes important when deciding the best way to implement a proposed greenway network.

4.2 Summary of Existing Local and Regional Plans

The existing local and regional plans provided vital information in the research of this project. The plans outlined what greenways are in place or have been considered and any future plans for implementation. This information was later used to connect transmission line corridor trails to existing trail networks in order to create a wholistic network throughout the region. Most of the plans outlined the support of the community for the implementation of new greenways through the use of community feedback surveys.

4.3 Design Considerations

The information gathered from Duke Energy proved to be some of the most vital to the efforts of design of this regional greenway network. The plan clearly outlined what their current policies were towards use of their right-of-way lands. These guidelines were strictly adhered to in the design ahead. The guidelines put constraints on the design process which ended up making for an exciting planning process. The regulations such as policies on paths and structures prevented most commonly accepted guidelines for trail design but allowed for new design strategies to be implemented. These guidelines and how they were used will be further discussed in chapter seven.
5.0 Introduction

The following sections will give an overview of the area selected for this project design. An overview of existing conditions, the project location, and data collected about the physical and geographic features within the project region is provided. The information gathered will later be used in creating design suggestions and guidelines in subsequent chapters.

5.1 Study Area

The proposed area for this project takes place in the upstate of South Carolina. The project area encompasses the foothills north of Pickens, SC and extends to Anderson, SC in the South. The project region stretches across portions of Oconee, Pickens, Greenville, and Anderson Counties. Total population for all the aforementioned counties totaled 831,848 according to the 2010 Census. Major cities within the region include Greenville, Clemson, Seneca, Pickens, Easley, and Anderson. The region is ideally located between Charlotte and Atlanta with I-85 passing through the center of the project area. Figure 5.1 shows the scope of the project area.
Figure 5.1 - Map of Existing Conditions

PROJECT LOCATION:
UPSTATE SOUTH CAROLINA

SCALE: 1" = 1 MILE
5.2 Destinations

The area has a rich past and has many historical and cultural resources that offer residents and tourists an abundance of things to see and do. The area is home to Clemson, Furman and Southern Wesleyan Universities. The project area also includes many recreational opportunities within the Clemson experimental Forest, Sumpter National Forest, and multiple state and local parks. The region boasts two major lakes, Lake Hartwell and Lake Keowee. Other major attractions include the South Carolina Botanical Gardens, Duke Power World of Energy, and numerous historical homes and buildings. Other examples of potential destinations are included on the master plan in chapter six.

5.3 Existing Greenways and Trail Systems

The region is beginning to take part in the national trend of greenway design and implementation. Cities such as Greenville, Anderson, and Easley have all adopted greenway plans and some have even begun to implements these plans. The City of Clemson has also alluded to adopting a greenway plan in their 2014 Comprehensive Plan and reference a 2002 Thesis title “A Greenway Trails Plan for the City of Clemson” as a possible plan to begin implementing in the future. These plans will be utilized in the creation of this regional network system. These existing networks are shown in Figure 5.2.
Figure 5.2 - Existing Local Greenway Networks

[Map showing existing greenway networks in various cities, with labels for PIEDMONT, LIBERTY, GREENVILLE, PENDLETON, ANDERSON, BELTON, WILLIAMSTON, PICKENS, CENTRAL, SENECA, WALHALLA, WESTMINSTER, CLEMSON, EASLEY, CLEMSON UNIVERSITY, and connections to existing city greenway master plans.

KEY:
- Proposed Transmission Corridor Trail
- Existing City Greenway or Bikeway Trail
- Proposed City Greenway or Bikeway Trail
- Clemson University

CONNECTIONS TO EXISTING CITY GREENWAY MASTER PLANS

SCALE: 1" = 1 MILE
5.4 Regional Transportation

The region is well connected to the rest of the Southeast. As mentioned before, the I-85 corridor passes through the area and connects both Atlanta and Charlotte to the region. In addition to the interstate, both Clemson and Greenville have active Amtrak stations with daily service to the area. Air travel is also available through Greenville-Spartanburg Regional Airport. All these modes are potential means of bringing new trail users and eco-tourists into the area. Within the project area are two bus entities providing public transportation. The Greenlink services Greenville and its surrounding area. The Clemson Area Transit (CAT) Bus System provides a free service to members of the community. The CAT bus system has routes that connect Clemson, Central, Pendleton, Seneca, and Anderson. All buses have on board bike racks which can shuttle trail users back to their vehicles or point of origin after using the trails. As many of the proposed trails will be of medium to long distances, the bus system will expand the trail to all levels of trail users.

5.5 Transmission Corridor Inventory and Analysis

5.5.1 Duke Energy

Since its opening in 1973, Duke Energy’s Oconee Nuclear Station has been providing the upstate of South Carolina and surrounding areas with clean energy over 40 years. The plant, located about 8 miles north of Seneca, SC on Lake Keowee in Oconee County, has safely and reliably produced over 500 million megawatt-hours of electricity making it the first nuclear plant in the U.S. to reach this amount. It is also one of the country’s largest plants, with a generating capacity of around 2.6 million kilowatts, enough energy to power 1.9 million homes (duke-energy.com). As the plant generates high volumes of energy, it requires a great deal of transmission lines to disperse this voltage. These Transmission lines take the power from the nuclear plant and disperse it to substations throughout the region, where it is then
decreased in power and divided once again through local communities.

5.5.2 Transmission Line Right-of-Ways

In order to provide safe and reliable energy to its customers, power providers must create and maintain Right-of-Ways to distribute their power. Trees must be removed in order to prevent damage to the lines as well as fire and shock hazards. The widths of these right-of-ways (ROW's) vary depending on the amount of voltage being carried across the lines in the corridor. The greater the amount of power, the greater the distance must be from the transmission lines on each side of the conductors. In order to prevent future problems with their lines, power companies regularly maintain their ROW corridors through pruning, selective herbicide applications, and tree removal when needed. Because of the importance of maintaining safe and reliable corridors, energy providers usually have strict policies in place to regulate their corridors and specify the uses that can take place on these lands. This is no different for Duke Energy. Figure 5.3 Illustrates the existing regional transmission corridors in the project area.

5.6 Opportunities and Constraints

Although transmission Line corridors can provide direct routes between the cities within a region, there are many obstacles associated with them that must be overcome in order to make the system a success. Some of the major constraints to be addressed in transmission corridor planning are land acquisition, road crossings, riparian crossings, and terrain.

5.6.1 Land Acquisition

In most circumstances Duke Energy does not own the land their transmission lines are located on; they merely have an easement
with the landowners. In order to implement a trail system traversing these ROW corridors, an agreement would have to be made with each landowner by the trail developer. There are four main methods of acquiring private lands for greenways:

- Management agreements, leases, permits, and licenses
- Easements or partial rights to a specific piece of property
- Purchase or donation of the title or all the rights to a parcel of land from a willing seller or donor
- Land regulation that prohibits or encourages certain uses. (Flink 1993)

Each of these differs in the amount land control the owner gives up. Agreements such as joint-use easements are commonly used in situations where multiple uses exist on a single parcel of land. These are used for example when combining a recreation trail on an existing sewer easement. When creating a joint-use easement it is important to define stewardship to establish who will be in charge of maintenance of the trail. This method could be a solution for acquiring the use of lands within transmission line corridors.

Figure 5.4 Provides locations and sample images from existing corridors throughout the upstate of South Carolina and within the project area.
Figure 5.4 - Visual Analysis Map of Upstate, S.C. Transmission Line Corridors
Figures 5.5-5.20 - Images of Existing Upstate, S.C. Transmission Line Corridors (Photo Credits: Google Earth)
Figures 5.21 - 5.30 - Images of Existing Upstate, S.C. Transmission Line Corridors (Continued) (Photo Credits: Google Earth)
5.6.2 Road and Stream Crossings

Trails crossing high risk intersections may require the implementation of pedestrian bridges in order to safely transport pedestrians and cyclists across these busy roadways. These are often avoided in trail design because of the high costs associated with their construction. Although they are an expensive infrastructural element, if designed in a unique manner, they can be used as a marketing tool for the trail, acting as billboard for the many travelers passing under them on the roadways. Exciting and unique designs may entice travelers to want to come back and experience the trail and its unique structures first hand. Spending extra money on the design of these bridges will ensure continued excitement over the trail for years to come.

Due to Duke Energy’s prohibition of structures within ROWs, bridges within the ROW must be built of concrete at grade. These must also be built wide enough for Duke maintenance vehicles to cross. Current regulations prohibit the use of boardwalks with ROWs. Concrete bridges are allowed but may not be suitable for all riparian crossings. Major stream and lake crossings may need to be addressed just outside the ROW corridor. Figure 5.31 shows the existing constraints in the area, including all road crossings. Color coded dots rate the level on conflict at intersections based on vehicular traffic counts. These constraints will be addressed in subsequent chapters.

5.6.3 Designing around substations

Substations are the locations within the power grid that divide the incoming power supply into smaller voltage Units. The electrical current is then sent to different areas within the community from this central point. These sites are therefore the starting point of new corridors branching out from the Substation. Because of the concentration of trail heads in these areas, these may serve as trailhead locations and parking areas to service the Connected Greenways. Amenities such as maps and wayfinding information can be employed in these locations
as well as seating for trail users to prepare for their intended activity on the trail.

5.6.4 Terrain

The topography of the project varies greatly between the northern and southern points. The northern portion is engrossed in the foothills of the Appalachian Mountains while the southern end is for the most part a great deal flatter. In the areas of the southern portion of the plan South of Clemson, Minor grading may need to be implemented in order to address steep or drastic changes in grade. Duke Energy regulates the degree to which earthwork can be done and their evaluations is done on a case by case basis. The main topographical issue to face with the transmission line trail system will be addressing the grade changes where there trail intersects roadways. When these Roadways were built, often times a great deal of grading was done to care the road bed out of the existing landscape. In many cases this left steep grade changes on the sides of the road where the trail intersects. Most right-of-ways have maintenance roads in order to provide maintenance on the utility infrastructure as well as on the ROSs themselves. These roads have usually been graded to the paved roadways on one side of the ROW or the other in order to provide vehicular access to the corridor. Taking advantage of the grade adjacent to these maintenance roads will help address the problems with grade change along many roadways. The image below shows the problem with grade at some road crossing. The image below it shows how this problem can be addressed. Figure 5.32 illustrates the topographical conditions of the project region.

Figure 5.32 - Topographical Conditions of the Project Area (Photo Credit: https://is30.eporix.com/company_164/903162.jpg?qlt=80&cvt=jpeg)
5.7 Summary of Analysis

The project area offers a vast and differing landscape which will provide users with a varied changing view. The topographical changes will provide trail users challenges at times but will be rewarding on descents. The project area lends itself nicely to a design of this sort with its intricate and well laid out transmission line corridors.

Major constraints discovered with this inventory and analysis included the crossing of many roads throughout the upstate. Ways to cross and avoid these intersections will be addressed in Chapter seven. Additional information will be provided on the crossing of streams within these corridors.

Although there are many challenges associated with the design within these corridors, with proper planning these corridors can be sufficiently developed to provide an exciting network of trails to provide many generations of use for people in the upstate, S.C.
6.0 Introduction

The following chapter gives visual representation of the proposed “gridway” network. Images represent the guidelines followed in chapter seven to create a plan that was both enjoyable for users as well as one that conformed to Duke Energy policies and regulations.

6.1 Concept Plan

The adjacent plan illustrates the proposed transmission line greenway network. The most direct routes were chosen when possible. Routes with fewer roadway crossing were selected over those with more for safety and enjoyment of the trail. The transmission line trails connect with existing greenway routes in cities that have plans in place. The light green areas represent city boundaries while the dark green areas represent existing public parks. The plan provides connections between many state parks allowing bicycling tourists places to camp while traveling through and enjoying cities in the day.

6.2 Photo Simulations

Figures 6.2 and 6.3 illustrate what these trails could potentially look like. The second image illustrates how shelters and rest stops can be placed outside the corridor by way of a spur trail to provide amenities such as bike maintenance, seating, and water. This location conforms to Duke Energy’s restrictions on structures within the ROW.
Figure 6.1 - Proposed Plan
Figure 6.2 - Photo Simulation of Proposed Corridor Design
Figure 6.3 - Photo Simulation of Proposed Design Elements Including Shelter Placement
6.3 Phasing

This plan involves an extensive network of trails. In order to begin the process of implementation, the project should be divided into phases to allow for the best use of funding money as it is awarded. For this plan it is suggested that the process begin with land acquisition. As easements are acquired and connections are made, trail paths should be developed as simple dirt trails to allow community members to enjoy them as they are being further developed. Key areas between cities should be tackled first with the outer trails connecting state parks done following the community connectors. As more funding is acquired and the network has been attained, paving of trails can take place on these key trail sections first, followed by those on the outer edges. As paving is limited to 5’ wide within the Duke Energy corridors, the side of the trail should be prepped with gravel/soil to provide another 5’ or more of informal trail for use by equestrian or other users. This will allow for the expansion of the asphalt path in the future if Duke Energy policies change.
7.0 Introduction

Based on the results of the research methods, guidelines have been created to list beneficial design standards and practices that could facilitate the design of a successful greenway trail network in transmission line corridors. These are not the only methods of approaching or designing these corridors but provide an exemplary method that can be used to begin planning a successful “gridway.” The following sections list examples of how individual elements of gridway design could be handled.

7.1 Wayfinding and Signage

Providing adequate signage and wayfinding can prove to be a difficult task in corridors which have strict ROW guidelines such as those of Duke Energy. Signs are also included in Duke’s policy of no structures within the ROW. In order to provide adequate wayfinding, information must be periodically placed on or adjacent to the trail on a flat surface. Painting trail distances and directions on the trail surface can provide information to trail users. Adding incremental mile marker information to the trail surface can provide important location information to EMS responders in times of emergency. These should be checked often to ensure trail use is not reducing their legibility. Maps and more detailed information can be placed outside the ROW in the rest shelter areas. In addition, trail maps and information could be provided in an mobile application that smart phone users can access while on the trail. Scannable QR codes can be imbedded in the trail surface and provide easy access to this information.
7.2 Trail Details and Standards

Trail dimensions and design rely heavily on the utility company’s guidelines. Duke currently lists a maximum of 5’ trail to be acceptable for placement within their ROWs. The Greenville Pickens Area Transportation Study (GPATS) Metropolitan Planning organization lists a minimum 10’ width in their design guidelines with a preferred 12’ width. Because of this difference in widths, design must become somewhat unorthodox. In this project, a 5 foot wide asphalt path has been suggested with an adjacent gravel/dirt sidepath of an additional 5’. This allows for a smooth surface for wheeled users as well as helps to improve ADA accessibility. The informal gravel/dirt side path will allow users to briefly exit the path when the need for passage of users exists. The dirt/gravel path also allows for the trail to be used by horseback riders as long as the equestrian users refrain from traveling on and destroying the asphalt path surface. The informal side path also allows for a smooth and prepared surface for trail width expansion to a 10’ asphalt path in the future if existing guidelines become more lenient.
7.2.1 Bridge Design and Development

Bridges will play an important role in the implementation of this design. Within these corridors are many stream ditch crossings that will need to be addressed. Duke allows for the construction of bridges within the corridors but only if they are constructed of concrete and are wide enough for their maintenance vehicles to cross. Boardwalks are prohibited within the ROW. Other forms of bridges would need to be built outside the ROW in order to comply to Duke’s design regulations.

Pedestrian bridges across roadways may be necessary in areas of high risk roadways such as Interstate 85 or Highway 123. Pedestrian bridges are costly and should be avoided if necessary. With the trail system being a regional design, pedestrian bridges, if planned well, can serve as advertisements for the trail system. If these bridges are designed with a neat or artful appearance they can evoke interest in the trail system for all the vehicular traffic along the regions busiest roads.

7.3 Road Crossings

As stated in previous chapters, roadways act as a barrier along the trail in many locations. Traffic devices should be used to allow safe passage across these roadways. The map of constraints in the inventory and analysis chapter shows the various levels of risk associated with the many road crossings in the plan area. The following series of images addresses these roadways from the simple low risk crossings to the high risk crossings in the area.
The above image shows a low risk roadway crossing. These roads generally receive low levels of vehicular traffic but signage and traffic calming devices have been incorporated to make vehicles cognizant of pedestrians ahead.
The above image shows a medium risk roadway crossing. These roads generally receive moderate levels of vehicular traffic. The RRFB signals provide pedestrians an opportunity to press a button which enables flashing lights to alert vehicles of pedestrians needing to cross. The angled pedestrian refuge island forces pedestrians crossing the roadway to face and be aware of oncoming traffic.
The above image shows a high risk roadway crossing. These roads generally receive high levels of vehicular traffic. The HAWK signals provide pedestrians an opportunity to press a button which enables stop lights to activate, stopping oncoming traffic. The angled pedestrian refuge island forces crossing pedestrians to face and be aware of oncoming traffic.
The above image shows a high risk roadway crossing. The diagram shows how a high risk area could be avoided by diverting the trail under the roadway to utilize a railroad tunnel. Techniques such as this can help save money that might otherwise have to be spent on expensive pedestrian bridges.
7.4 Trail Facilities and Amenities

As these trails will cover great distances throughout many rural areas, adequate trail facilities and amenities become a greater necessity when compared to urban greenway trails. Because the transmission line trails will not be shaded by the canopy of trees, it is important to create places of refuge from the sun throughout the system of trails. To comply with the Duke Energy regulation prohibiting structures within the right-of-way, these structures will need to be places just on the outside of the ROW. The trail can veer to these structures or spur trails can be proposed to provide access to these while not forcing those not needing a break to pass by each shelter. When possible, potable drinking water shall also be provided to allow trail users to replenish their water bottles and maintain proper hydration.

In addition to water and shelter, it will be a great asset to trail users to provide workstations for bicycles periodically throughout the trail to allow for repairs to be made that they cyclist may not have packed prior to their trip. These can be simple, all inclusive pole structures that contain a pump, wrenches, tire levers, etc. to more extensive stations placed less frequently throughout the trail that are capable of making more intensive bike repairs.

Security call boxes may need to be located on the trail to allow for contact of emergency medical services for those without cell phones or for areas of limited cell service. Mileage markings should be painted on the trail surface at regular intervals, such as every 1/10th of a mile, to provide a finite location to give emergency medical responders when the need for medical assistance arises.

7.4 Planting Recommendations

Duke Energy Requires that all Planting within a right-of-way do not exceed 15’ in height at maturity. Although this restricts plant to selection to an extent, there are still many options available to enhance these corridors while complying with the utility company’s restriction.
Other plant materials such as native grasses or wildflowers can be used to present a different sense of place or ecosystem condition to users of the trail. These will also bring the benefit of providing additional habitat for various wildlife specimen. The following table (Table 1) lists suggested plants which will be highly adaptable to the conditions within the utility ROW’s. These plants were selected based on beneficial growth characteristics. All plants selected do not reach or exceed the regulated height set forth by Duke. They are also primarily

<table>
<thead>
<tr>
<th>#</th>
<th>Scientific</th>
<th>Common</th>
<th>Plant Type</th>
<th>Max. Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Achillea millefolium L.</td>
<td>Common yarrow</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>2.</td>
<td>Amsonia tabernaemontana Walt.</td>
<td>Eastern bluestar</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>3.</td>
<td>Arnica acaulis (Walt.) B.S.P.</td>
<td>Common leopardbane</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>4.</td>
<td>Asclepias tuberosa L.</td>
<td>Butterflyweed</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>5.</td>
<td>Callicarpa americana L.</td>
<td>American beautyberry</td>
<td>Herb</td>
<td>6’</td>
</tr>
<tr>
<td>6.</td>
<td>Conoclinium coelestinum (L.) DC.</td>
<td>Blue mistflower</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>7.</td>
<td>Coreopsis lanceolata L.</td>
<td>Lanceleaf coreopsis</td>
<td>Herb</td>
<td>1’</td>
</tr>
<tr>
<td>8.</td>
<td>Comptonia peregrina (L.) Coul.</td>
<td>Sweet fern</td>
<td>Shrub</td>
<td>6’</td>
</tr>
<tr>
<td>9.</td>
<td>Coreopsis verticillata L.</td>
<td>Threadleaf coreopsis</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>10.</td>
<td>Echinacea purpurea (L.) Moench</td>
<td>Eastern purple coneflower</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>11.</td>
<td>Erythrina herbacea L.</td>
<td>Coralbean</td>
<td>Shrub</td>
<td>6’</td>
</tr>
<tr>
<td>13.</td>
<td>Lindera benzoin (L.) Blume</td>
<td>Spicebush</td>
<td>Shrub</td>
<td>6’</td>
</tr>
<tr>
<td>14.</td>
<td>Liatris punctata Hook.</td>
<td>Dotted blazing star</td>
<td>Herb</td>
<td>6’</td>
</tr>
<tr>
<td>15.</td>
<td>Lobelia cardinalis L.</td>
<td>Cardinal Flower</td>
<td>Herb</td>
<td>6’</td>
</tr>
<tr>
<td>16.</td>
<td>Monarda punctata L.</td>
<td>Spotted beebalm</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>17.</td>
<td>Penstemon canescens (Britt.) Britt.</td>
<td>Eastern gray beardtongue</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>18.</td>
<td>Rhus glabra L.</td>
<td>Smooth sumac</td>
<td>Shrub</td>
<td>12’</td>
</tr>
<tr>
<td>19.</td>
<td>Robinia hispida L.</td>
<td>Bristly locust</td>
<td>Shrub</td>
<td>12’</td>
</tr>
<tr>
<td>20.</td>
<td>Rudbeckia hirta L.</td>
<td>Black eyed Susan</td>
<td>Herb</td>
<td>3’</td>
</tr>
<tr>
<td>21.</td>
<td>Rudbeckia laciniata L.</td>
<td>Cutleaf coneflower</td>
<td>Herb</td>
<td>6’</td>
</tr>
<tr>
<td>22.</td>
<td>Rudbeckia triloba L.</td>
<td>Browneyed Susan</td>
<td>Herb</td>
<td>6’</td>
</tr>
<tr>
<td>23.</td>
<td>Vaccinium stamineum L.</td>
<td>Deerberry</td>
<td>Shrub</td>
<td>12’</td>
</tr>
<tr>
<td>24.</td>
<td>Viburnum dentatum L.</td>
<td>Southern arrowwood</td>
<td>Shrub</td>
<td>12’</td>
</tr>
</tbody>
</table>
maintenance free. As the trail system is large in scale, this is important for saving on maintenance costs in the future. The plants suggested are primarily drought tolerant and prefer sunny conditions. With the ROW's being cleared for the transmission lines, no overstory plantings exist to provide shade for species that prefer shade or part shade. For this reason, selection of plants preferring full sun is important. Many of these plants are attractive to wildlife such as birds, bees, butterflies, and others. The images (Figures 7.6-7.29) show what these sample species look like visually.
Figures 7.6 - 7.29 - Recommended ROW plantings for SC Corridors (Photo credits: http://www.wildflower.org/)
8.0 Conclusions

Through the research in this project many conclusions have been made. Transmission Line Greenway Networks or “gridways” can be successfully implemented if all constraints are properly addressed. The main challenges faced with these trail systems appear to be the large amount of roadway crossings, large spans of trails across riparian areas, and securing easements for property. Also, securing government funding may be difficult in areas where the ROW guidelines prevent the meeting of funding entity requirements. An example of this would the trail width being too narrow. If all of these issues are addressed in the early stages of the project, the chances for success improve.

8.1 Recommendations

In order for “gridways” to be successful a few important recommendations should be considered. Holding community meetings in the planning stages of a greenway network will help attain the support and easements from community members and property owners. This will also provide valuable information including what are their wants and needs. Phasing these trails provides a method of gradually implementing the system and making sure quality remains consistent. Phasing will also allow portions of the trial to be in place while funding is secured for the remaining sections.

Fostering a strong relationship with the utility company, in possession of the ROWs, will help the process evolve from the beginning stages. Improved relationships with these individuals may also allow recommendations and future changes to policies that will benefit trail construction.
References


