6 open space connectivity system considerations

CHAPTER 6 > OPEN SPACE CONNECTIVITY SYSTEM CONSIDERATIONS

Bicycle and pedestrian connection projects are complicated, and the information contained in this section provides guidelines and suggestions for consideration at the planning, design, and construction phases of a project. Since no two projects are the same, all information may not apply and therefore pertinent ideas should be extrapolated from the text as applicable. The considerations contained herein are intended to assist the City of Concord's staff and consultants. The content as outlined does not preclude requirements of any city, state, or federal ordinance, as these considerations are intended to provide a direction for the development process.

PLANNING CONSIDERATIONS

Planning a pedestrian trail or bicycle facility project must first start with asking the critical questions.

- Who is the community that is being served by the project?
- What is the full scope of the project?
- What is the end goal?
- How will the project be funded?
- Who needs to be at the table in the early planning phases?
- What amenities will it provide?
- Who will be responsible for long term needs and maintenance?

To help answer some of these critical questions, it is recommended to have corridor and feasibility studies prepared. These studies will assess the practicality of the proposed project and guide decisions that shape project scope and budget.

A **corridor study** looks at the area as a whole. The goal is to identify major trip generators and terminations in a cohesive way that also has a long timeline for completion, i.e. 10-20 years. The purpose of a corridor study is to identify specific projects within a corridor that have logical beginnings and ends and that can be built with available funding sources. The study may include probable costs based on linear foot. However, the probable costs should only be used as a high level estimate, as base map data used to produce the estimate is only high level GIS data. While cost estimates from the corridor study may be used when applying for grant funding, they are very preliminary.

Corridor Studies typically include:

- 10-20 Mile Corridors
- Opportunities and Constraints Analysis
- Route Concept Maps
- Public Input
- Property Acquisition Strategy

A **feasibility study** is the next step upon completion of a corridor study but before engineering and design. A feasibility study takes a more detailed look at a specific project identified from the corridor study. The feasibility study is a relatively low expense to the City but produces a much more accurate picture of probable costs, especially regarding construction materials and rights-of-way needs. It also established an accurate schedule for design, permitting, and construction.

A typical feasibility study lays out a rough design that considers widths of trail and grades based on available GIS contours. Physical constraints such as sewer manholes, above ground utilities, and flood plains and flood ways are looked at in detail to route trail alignments. If there are alternative alignments, each will be looked at and weighed against each other and a preferred alignment will be recommended based on the available data. Grading limits can be estimated at the feasibility level which is the basis for starting right-of-way negotiations with property owners while having a more accurate idea of what will be needed for both permanent and temporary easements. From this information preliminary cost estimates can be produced that may be used to submit for grant funding for right-of-way, design and engineering services, as well as construction.

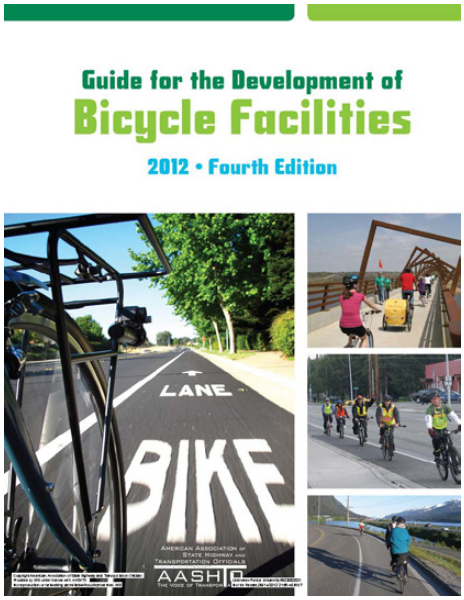
Feasibility Studies typically include:

- 1-5 Mile Corridors
- Definition of a Specific Project
- Detailed Route Analysis
- Public Input
- Cost Estimates
- Budgeting and Pursuit of Funding

DESIGN STANDARDS

AASHTO GUIDE FOR THE DEVELOPMENT OF BICYCLE FACILITIES, 4TH EDITION

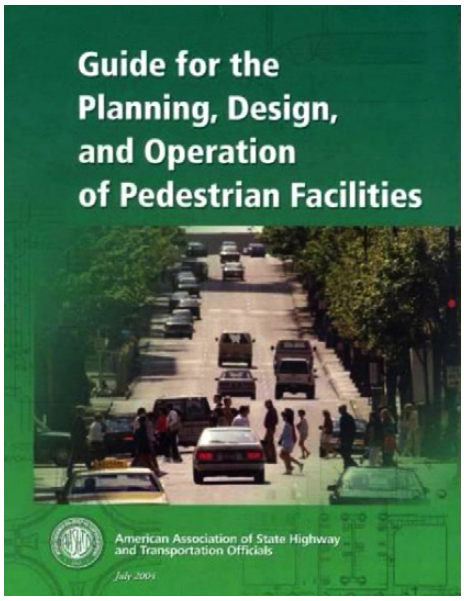
Published by the American Association of State Highway and Transportation Officials (AASHTO), this guide provides the basis for both planning and designing bicycle facilities. Information covered includes planning, bicycle operation and safety, on-road bicycle facility design, Shared-Use Path design, bicycle parking, and maintenance and operations. The purpose of the guide is to present sound planning and design guidelines by referencing a recommended range of design values and describing alternative design approaches. The guide also allows for the incorporation of pedestrians and motorists along with bicyclists for dynamic designs that are sensitive to local context.



(link: Guide for the Development of Bicycle Facilities, 4th Edition)

AASHTO GUIDE FOR THE PLANNING, DESIGN AND OPERATION OF PEDESTRIAN FACILITIES, 1ST EDITION

Much like the AASHTO's Guide for the Development of Bicycle Facilities, this guide provides instruction on planning, design and operation of pedestrian facilities along streets and highways, focusing on effective ways to accommodate pedestrians within public rights-of-way. Methods to accommodate pedestrian vary depending on the roadway and facility type, and those practices are described in this guide. It also addresses land use planning and site design, as these topics have a profound effect on pedestrian mobility.

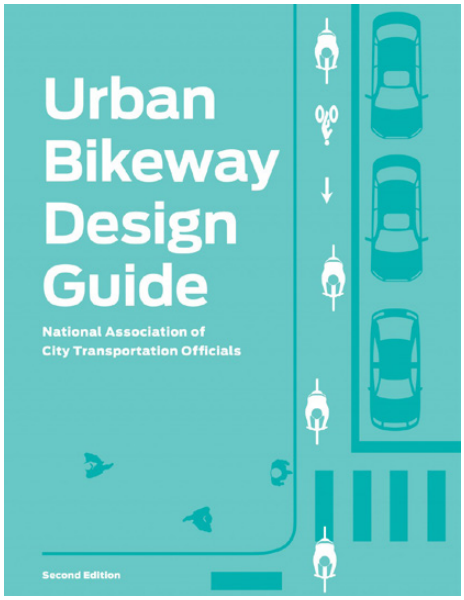


(link: Guide for the Planning, Design and Operation of Pedestrian Facilities, 1st Edition)

NACTO URBAN BIKEWAY DESIGN GUIDE

The NACTO Urban Bikeway Design Guide is based on experience and recommendations from prominent cycling cities from around the world. The target of this guide are cities seeking to improve bicycle transportation where unique challenges like high interaction with traffic, decreased right of way, and increased conflict points are present. These challenged demand innovative solutions and the NACTO guide showcases how other cities have conquered these challenges. The AASHTO Guide is not referenced in most of NACTO design solutions. However, virtually all treatments are permitted under the Manual on Uniform Traffic Control Devices (MUTCD).

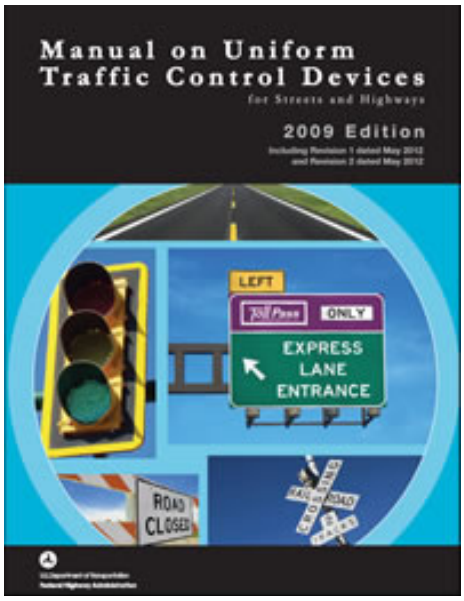
(link: NACTO Urban Bikeway Design Guide)



MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)

The Federal Highway Administration's MUTCD is the foremost source for guidance on lane striping requirements, signal warrants, recommended signage, and recommended pavement markings for greenway trails and roadway crossings. If desired design treatments are not covered in the MUTCD manual, they may be offered to FHWA for interpretation and official ruling. The FHWA provides an online database where past official rulings can be found (https://mutcd.fhwa.dot.gov/orsearch.asp) which may provide useful when progressing through the design process.

(link: Manual on Uniform Traffic Control Devices)



THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION COMPLETE STREETS PLANNING AND DESIGN GUIDELINES

This publication, released in 2012, includes detailed information on the processes, street types, and recommendations for designing complete streets in North Carolina. The guidelines are meant to help both NCDOT and municipalities with thinking through planning and designing new streets or improving existing infrastructure that all modes of transportation can use, be they pedestrians, bicyclists, or motor vehicles.

While all design standards referenced are valuable to planning and designing Concord's pedestrian and bicycle network, special attention should be paid to AASHTO, MUTCD, and ADA guidelines.

(link: NCDOT Complete Streets Planning and Design Guidelines)

AMERICAN WITH DISABILITIES ACT (ADA)

While elements such as curb ramps, slopes, and railings that are referenced in AASHTO or MUTCD guides, these guides do not explicitly reference compliance with ADA standards. There are several manuals listed below that provide standards for the construction of accessible facilities to comply with the American with Disabilities Act.

- 2010 ADA Standards for Accessible Design
- ABA Accessibility Guidelines for Outdoor Developed Areas
- Public Rights-of- Way Accessibility Guidelines (PROWAG)
- Proposed guidelines have been developed but are not yet adopted by the Department of Justice
- 2017 ICC/ ANSI A117.1 Accessible and Usable Buildings and Facilities
- US Forest Service Outdoor Recreation Accessibility Guidelines (FSORAG)

Meeting these requirements is important for any bicycle and pedestrian network to do such that the most users can participate.

OTHER VALUABLE RESOURCES

- U.S. Department of Transportation FHWA – Separated Bike Lane Planning and Design Guide
- 10 Techniques for Making Cities More Walkable
- Center for Disease Control and Prevention – Parks and Trails Health Impact Assessment Toolkit
- National Association of City Transportation Officials (NACTO) – Design Guide Archives
- Small Town and Rural Design Guide – Facilities for Walking and Biking
- American Trails
- Pedestrian and Bicycle Information Center
- Rails-to-Trails Conservancy
- America Walks – Learning Center
- International Mountain Biking Association
- FHWA Course on Bicycle and Pedestrian Transportation

ELEMENTS OF A MULTI-USE PATH NETWORK - TRAIL TYPES

Multi-use path networks are interconnected pedestrian and bicycle transportation facilities of various forms that allow people of all ages, abilities, and income levels to connect to desired destinations. These facilities must accommodate pedestrians and bicyclists and are intended for recreation and commuter uses. Facilities can run adjacent to roadways (like sidewalks, multi-use paths, or cycle track) or along independent alignments (like greenways trails) and can take different forms based on available land, intended usage, and the overall contribution to a greater connected system.

Many cities and towns have invested significant dollars in pedestrian and bicycle facilities, but few have a complete network that provides safe and convenient connections throughout the community. Access to primary destinations like schools, parks, retail and business centers along a safe and convenient route, while also minimizing exposure to vehicular traffic, is critical to implementing a successful system.

User comfort is also a vital facet of a multimodal network. Additional separation between vehicles and pedestrians/cyclists or reducing vehicle speeds for a safer walking and bicycling experience is important to create a more enjoyable network. Concord has great potential to serve both residents and visitors with a viable multi-modal transportation network.

GREENWAY TRAILS

As the most common type of trail, greenways can be defined as linear open space areas, often associated with wildlife corridors or valuable vegetative buffers. Most often located within a dedicated easement or public utility right-of-way, greenway trails usually include a developed (hard) surface to allow ease of usage for bicycles and other wheeled vehicles. Developed surfaces are most commonly asphalt, concrete or crushed stone. The width of the trail can vary from ten to fourteen feet, with ten feet being the most common. Communities around North Carolina including, Raleigh, Charlotte and Wilmington have recently updated their standard width to 12 feet due to the high usage seen on built greenways.

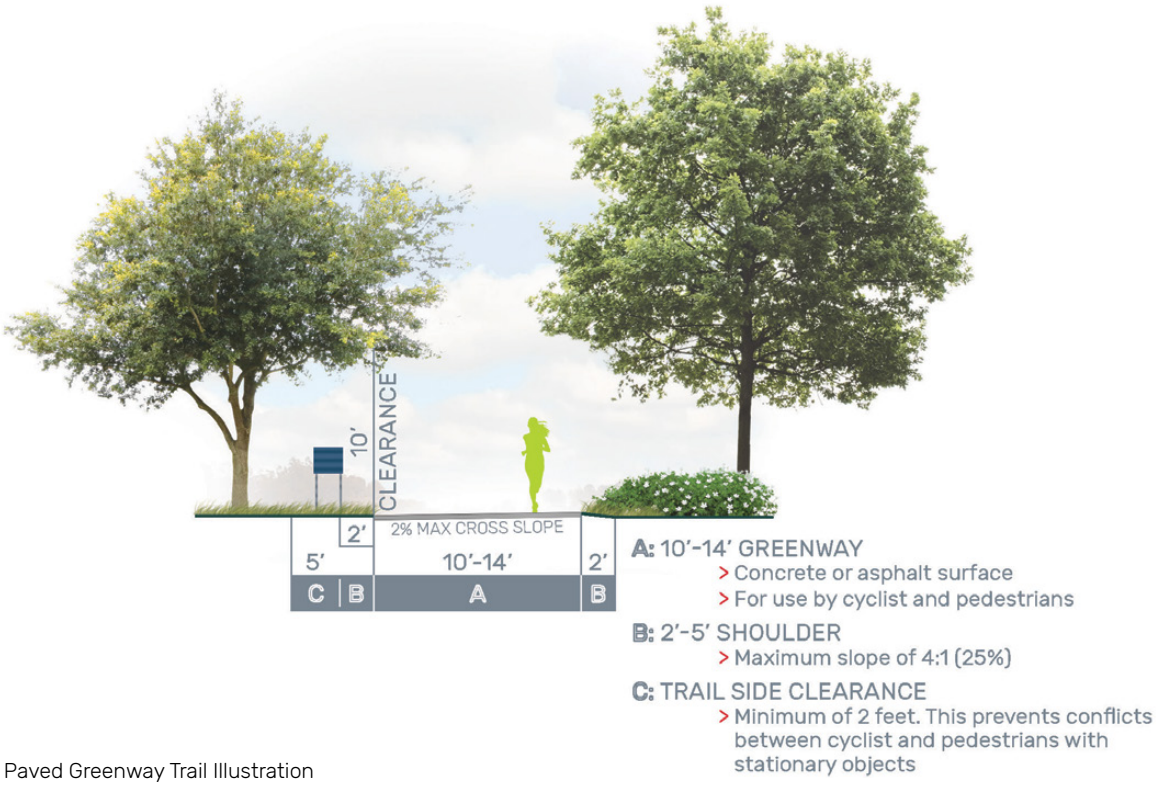


Figure 1 – Paved Greenway Trail Illustration

MULTI-USE PATHS

Usually located immediately adjacent and parallel to a roadway, shared multi-use paths are 10-14 feet in width for two-way traffic flow and are physically separated from vehicular travel through vegetated landscape strips, rumble strips or site furnishings (street lights, way finding signage or benches). Multi-use paths often share the right-of-way (ROW) with collector and highway roads with higher volumes and moderate-to-high speeds (15 – 55 MPH)[1]. As roadway speed increases so should the separation width between the vehicular path of travel and the shared multi-use path facility. Specific details regarding path width, separation width, landscape material, maintenance, crossing design or intersection with and connection to other multi-modal facilities should be considered during a detailed corridor study.

Multi-use paths should be located with consideration to a safe clear zone. Highway design manuals specify the distance from the edge of roadway to the multi-use path based on the posted speed of the road and average daily trips. This distance can be mitigated by installing curb and gutter or a vertical barrier to protect trail users from vehicles. The clear zone distance should be considered at the planning stage to determine the adequate right-of-way width required and possible increase in costs for the installation of curb and a closed drainage system. Multi-use paths can offer a more comfortable experience for cyclists as compared to on-road facilities such as bike lanes or wide outside shoulders located in heavy traffic environments and their inclusion within a network allows for reduced roadway crossing distances.

Multi-use paths are designed to be part of a transportation system, providing off-road routes for a variety of users. The primary users of multi-use paths are bicyclists and pedestrians, including pedestrians using mobility devices such as manual or motorized wheelchairs. While they may coincidently provide a recreational experience, multi-use paths differ from other types of trails with their transportation focus and serving as a supplement to on-road bike lanes, shared roadways, bike boulevards, and paved shoulders. They may extend or complement a roadway network. Multi-use path design is similar to roadway design but on a smaller scale and for lower speeds. Whether located within a highway right-of-way, provided along a riverbank, or established over natural terrain within an independent right-of-way, multi-use paths differ from sidewalks and trails in that they are primarily designed for bicyclists and others for transportation purposes such as commuting to work.[2]

For purpose of this plan, multi-use paths are paved facilities and are parallel to the road, connecting users from residential, civic, social, and employment areas to the greenway network.

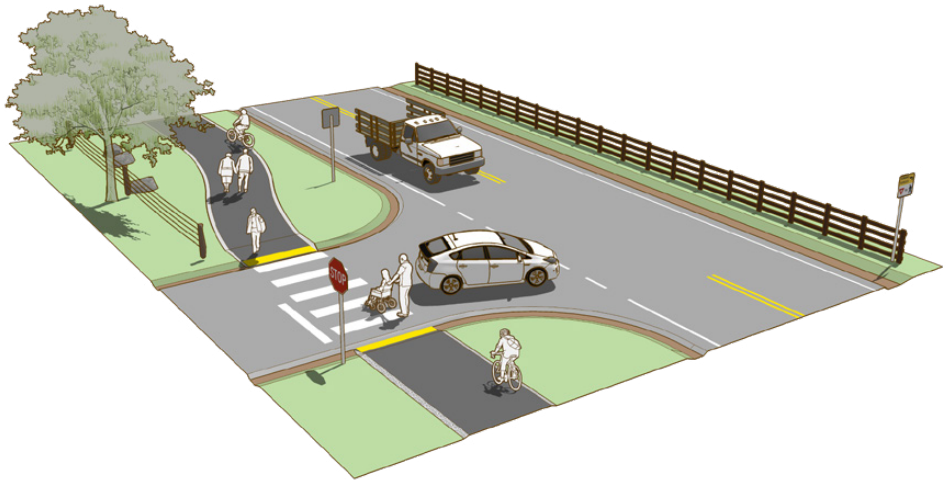


Figure 2 – Paved Greenway Trail Illustration

1 U.S. Department of Transportation, Federal Highway Administration. Small Town and Rural Multimodal Networks, 2016.

2 http://www.fhwa.dot.gov/environment/bikeped/framework.htm and https://www.fhwa.dot.gov/publications/research/safety/pedbike/05137/05137.pdf

SIDEWALKS

Sidewalks are dedicated to and designed for use by pedestrians. They should be safe, comfortable, and accessible to all. Sidewalks are physically separated from the roadway by a curb or unpaved buffer space and are paved. Like multi-use paths, sidewalks are typically parallel to a roadway but are designed for pedestrians only, not for bicycles or other recreational purposes.

Figure 3 – Paved Greenway Trail Illustration

STREAM CORRIDOR TRAILS

For purposes of this plan, stream corridor trails are defined as trails adjacent to stream or river corridors that are typically located within the floodway or floodplain.

This master plan suggests determining the surface of stream corridor trails during the detailed corridor analysis. While paved trails are best practice, the City may make more tangible progress in adding trail miles by considering natural surface trails in the short-term while planning to pave the trails when funding becomes available. While natural surface trails can present a higher degree of maintenance and are not accessible to all, they require less capital investment, engineering, and disturbance. Local interest groups and volunteers have been known to assist with both trail construction and maintenance, allowing the City to implement more miles of trails in the short-term.

It should be noted that there are challenges when including stream corridor trails into the transportation network. There is coordination with North Carolina Department of Transportation (NCDOT) in order to provide access under bridges where streams cross under state roads. There are also other permitting agencies like United States Army Corps of Engineers (USACE) and the Federal Emergency Management Agency (FEMA) that may be involved in obtaining approvals to construct.

In general, trails located along streams are typically asphalt or concrete to mitigate periodic flooding. Often, an undisturbed vegetated buffer is located between the stream bank and the trail to help stabilize streambanks, moderate stream flow, and filter pollutants. Located within the floodway, the materiality of trail cross sections should be carefully considered to provide an adequate foundation, stabilization, and non-slip surface depending on the frequency and velocity of flood events. Greenways adjacent to streams pose a variety of design challenges that should be considered during planning and project selection, including:

Urban Streams - Dense urban conditions restrict trails to the floodway and may require installation of railings, and/or retaining walls to stabilize stream banks.

Regular Flooding – Trail surface within the floodway that are regularly inundated should be carefully selected. Often concrete is the best solution for these areas. While there is a higher construction cost, maintenance savings for repairs quickly balance the initial investment.

Bench Modifications Beneath Bridges

These greenways stay at the stream elevation when crossing beneath vehicular bridges. Special design considerations and materials are recommended at these locations. Common materials include concrete trail surfaces, retaining walls (segmental block, cast-in place, pile and panel are often required to protect the trail from erosion) and safety rails. Connections up to the surface street network are desirable at most locations.

FEMA Regulated Streams - When working within the regulatory floodway, trail design (regardless of surface type) should minimize any change in ground elevation where possible. Any construction or increase in ground elevation within the floodway triggers detailed hydraulic modeling and required approvals through the Local Floodplain Administrator and possibly Federal Emergency Management Agency (FEMA).

Isolated Asphalt – Many stream corridors include areas of jurisdictional wetlands. Care should be taken to locate boardwalks that cross these wetlands with future maintenance in mind. Asphalt should be avoided if a trail section is located between boardwalks and cannot be accessed by paving equipment for resurfacing. Concrete is the best surface type in this condition as it provides a longer surface life and can be repaired in batches using the adjacent boardwalks.

BIKE FACILITIES

In North Carolina, the bicycle has the legal status of a vehicle. Cyclists have full rights and responsibilities when on the road and are subject to the same rules and regulations that govern the operation of a vehicle. When riding on the road, cyclists must ride on the right and in the same direction as traffic. All traffic signs and signals must be obeyed, and hand signals should be used to communicate intended movements. Bicycles must also be equipped for night riding with the appropriate front lamp and rear reflector. Thus, riding on the road and being treated with the same status as a vehicle can be intimidating for most recreational riders. As such, safer more comfortable provisions should be made with a multi-modal transportation system that caters to the bicycle.

There are various bike facilities that can be accommodated based on existing site conditions. Some are incorporated into a mixed traffic scenario, mixing with cars in the same space, while other facilities are visually or physically separated from traffic. The definitions and graphics as provided below were obtained from *"Small Town and Rural Design Guide – Facilities for Walking and Biking"* and *"NACTO Urban Bikeway Design Guide"*[3].

Bike Lanes

Bike lanes allocate an exclusive space for bicyclists with a designated 5-foot striped lane, pavement markings, and signage and enable bicyclists to ride at their chosen speed without interference from traffic. Conventional bike lanes are located directly adjacent to motor vehicle travel lanes and run curbside when no parking is present or adjacent to parked cars on the right side of the street. They typically follow the same direction as motor vehicle traffic and have no physical barriers (bollards, medians, raised curbs, etc.) that restrict vehicular encroachment into the bike lane.

Benefits of conventional bike lanes include:

- Increases use comfort and confidence on busy streets.
- Creates separation between bicyclists and automobiles.
- Increases predictability of bicyclist and motorist movement and interaction.
- Increases streets' carrying capacity.
- A visual reinforcement of the bicyclists' right to the street.

Bike lanes are most conducive on streets with:

- ≥ 3,000 motor vehicle average daily traffic.
- A posted speed ≥ 25 mph.
- High transit vehicle volume.

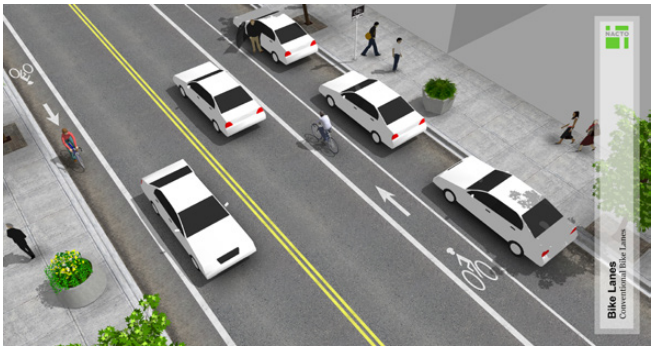


Figure 4 - Bike Lane Illustration

3 http://ruraldesignguide.com/ and https://nacto.org/publication/urban-bikeway-design-guide/

Buffered Bike Lanes

A Buffered Bike Lane is a conventional bike lane paired with additional buffer space to separate the motor vehicle traffic lane and/or parking lane from the bicyclists. Multiple pavement markings are typically used to delineate the edge of the travel way for both motor vehicles and bicyclists.

Benefits of buffered bike lanes include:

- Provides greater shy distance between vehicles and bicyclists.
- Provides space for bicyclists to pass other bicyclists without encroaching into adjacent vehicle traffic.
- Encourages bicyclists to ride outside of the door zone when buffer is located between parked cars and the bike lane.
- Provides a greater space for bicycling, but not so great that the bike lane is mistaken for a travel or parking lane.
- Appeals to a wider cross-section of bicycle users.
- Encourages bicycling by contributing to the perception of safety among bicycle network users.

Buffered bike lanes can be incorporated:

- Anywhere a standard bike lane is being considered.
- On streets with high travel speeds, high travel volumes, and/or high amounts of truck traffic.
- On streets with extra lanes or extra lane width.

Figure 5 – Buffered Bike Lane Illustration: Travel Side Buffer

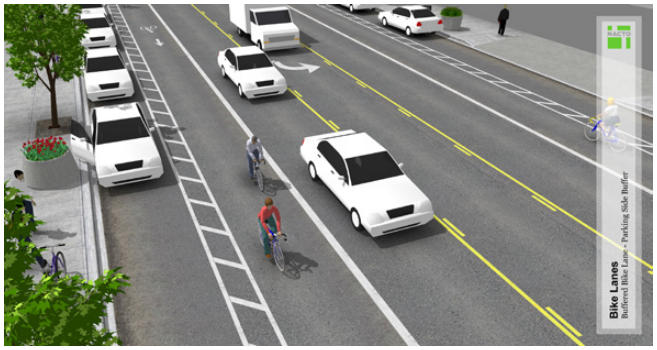


Figure 6 – Buffered Bike Lane Illustration: Parking Side Buffer

Contra-Flow Bike Lane

Contra-flow bicycle lanes are designed to allow bicyclists to ride in the opposite direction of motor vehicle traffic by converting a one-way street into a two-way street. One direction is for vehicles and bikes while the other direction is for bikes only. Contra-flow lanes are separated with yellow center lane striping. While the contra-flow bike lane works best on low-speed and low volume streets, it does introduce new challenges and additional conflict points as motorists may not expect on-coming bicycle traffic.

Benefits of contra-flow bike lanes include:

- Provides connectivity and access to bicyclists traveling in both directions.
- Reduces dangerous wrong-way riding.
- Decreases sidewalk riding.
- Influences motorist choice of routes without limiting bicycle traffic.
- Decreases trip distance, the number of intersections encountered, and travel times for bicyclists by eliminating out-of-direction travel.
- Allows bicyclists to use safer, less trafficked streets

Contra-flow bike lanes can be incorporated:

- On streets where large numbers of bicyclists are already riding the wrong way.
- On corridors where alternate routes require excessive out-of-direction travel.
- On corridors where alternate routes include unsafe or uncomfortable streets with high traffic volumes and/or no bicycle facilities.
- Where two-way connections between bicycle facilities are needed along one-way streets.

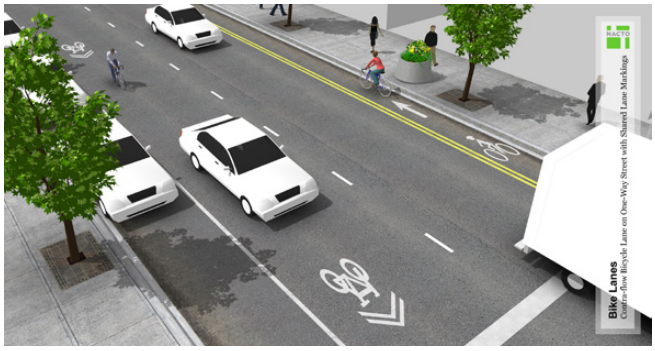


Figure 7 – Contra-Flow Bike Lane Illustration

Left-Side Bike Lane

Left-side bike lanes are conventional bike lanes located on the left side of one-way or two-way median divided streets. Left-side bike lanes offer advantages along streets with heavy delivery or transit use or frequent parking turnover on the right side.

Benefits of left-side bike lanes include:

- Avoids potential right-side bike lane conflicts.
- Improves motorists' visibility of bicyclists by having the bike lane on the driver's side.
- Provides consistent facility configuration in locations where right-side travel lanes are subject to rush hour parking restrictions and other flexible uses.
- Minimizes door zone conflicts next to parking as there are fewer door openings on vehicles' passenger side.
- Fewer bus and truck conflicts as most bus stops and loading zones are on the right-side of the street.

Left-side bike lanes can be incorporated:

- On one-way streets or median divided streets with frequent bus stops or truck loading zones on the right- side of the street.
- On streets with high parking turnover.
- On streets with rush hour parking restrictions.
- On streets with high volumes of right turn movements by motor vehicles.
- On streets with a significant number of left-turning bicyclists.
- On streets where traffic enters into a merge lane on the right-hand side, as from a freeway off-ramp.
- For favorable alignment to connect to a multi-use path, two-way cycle track, or other bicycle facility.

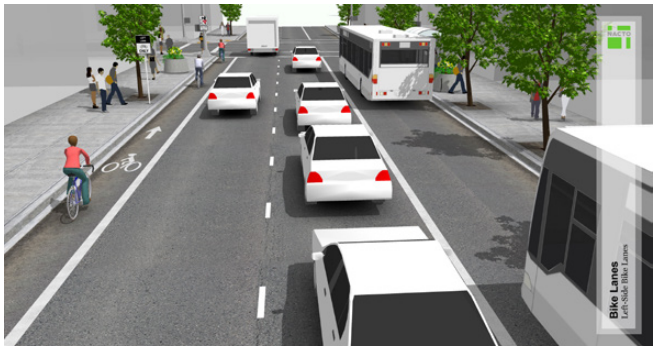


Figure 8 – Left-Side Bike Lane Illustration

Shared Bike Lane

Shared bike lanes use shared lane markings, or "sharrows," to indicate a shared lane environment for bicycles and automobiles. Shared bike lanes reinforce the legitimacy of bicycle traffic on the street, recommend proper bicyclist positioning, and may be configured to offer directional and wayfinding guidance.

However, utilizing shared lane markings should not be considered a substitute for bike lanes, cycle tracks, or other separation treatments when these types of bicycle facilities are warranted and/or where space permits. Shared lane markings can be used as a standard element in the development of bicycle boulevards to identify streets as bikeways and to provide wayfinding along the route. Shared bike lanes are typically not appropriate on streets with a speed limit above 35 mph.

Benefits of shared bike lanes include:

- Encourages bicyclists to safely position themselves in lanes too narrow for a motor vehicle and a bicycle to comfortably travel side by side within the same traffic lane.
- Alerts motor vehicle drivers to the potential presence of bicyclists.
- Indicates a bicycle path through difficult or potentially hazardous situations (e.g. railroad tracks).
- Advertises the presence of bikeway routes to all users.
- Provides a wayfinding element along bike routes.
- Keeps bicyclists out of the "door zone."
- Encourages safe passing by motorists.
- Requires no additional street space.
- Reduces the incidence of sidewalk riding.
- Reduces the incidence of wrong-way bicycling.

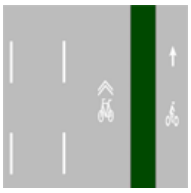
Desirable shared bike lane marking applications:

- When the speed differential between bicyclist and motorist travel speeds is very low, such as:
  - On bicycle boulevards.
  - On low volume, traffic calmed, shared streets with a designed speed of < 25 mph.
  - On downhill segments, preferably paired with an uphill bike lane.
  - On streets where the traffic signals are timed for a bicycling travel speed of 12 to 15 miles per hour.
- As a reasonable alternative to a bike lane in limited circumstances, such as:
  - Where street width can only accommodate a bicycle lane in one direction.
  - Within single or multi-lane roundabouts.
  - Along front-in angled parking where a bike lane is undesirable.

- To strengthen connections in a bikeway network, such as:
  - To fill a gap in an otherwise continuous bike path or bike lane, generally for a short distance.
  - To transition bicyclists across traffic lanes or from conventional bike lanes or cycle tracks to a shared lane environment.
  - To direct bicyclists along circuitous routes.
- To clarify bicyclist movement and positioning in challenging environments such as:
  - Through intersections.
  - Through a combined bike lane/turn lane.

  - In the presence of a double turn lanes. Double turn lanes are undesirable for bicyclists.

  - In the street alongside separated bikeway facilities such as cycle tracks, to permit continued use of the street by bicyclists who prefer to ride in the street.



Cycle Track

A cycle track is an exclusive bike facility, physically separated from motor traffic and distinct from the sidewalk, that combines the experience of a separated path with the on-street infrastructure of a conventional bike lane. Cycle tracks have several different forms, but all provide space that is primarily used for bicycles and are separated from motor vehicle travel lanes, parking lanes, and sidewalks. In contrast to bike lanes, where on-street parking exists, cycle tracks are located on the curb-side of the parking lane.

Cycle tracks can be one-way or two-way and can be at street level, sidewalk level, or an intermediate level. When located at street level, cycle tracks can be separated from motor traffic by raised medians, on-street parking, or bollards. When a cycle track is located at sidewalk level, a curb or median separates it from motor traffic, while pavement markings such as color/texture separates the cycle track from the sidewalk. Separating cyclists from motor traffic offers a higher level of safety than other bike lane facilities and are attractive to a wider array of users.

One-Way Protected Cycle Track

One-way protected cycle tracks are bikeways at street level and use a variety of methods for physical separation from the motor vehicle travel lane such as a raised curb, planters, or a parking buffer.

Benefits of one-way protected cycle tracks include:

- Dedicates and protects space for bicyclists in order to improve perceived comfort and safety.
- Eliminates risk and fear of collisions with vehicles.
- Reduces risk of 'dooring' compared to a bike lane
- Eliminates the risk of a doored bicyclist being run over by a motor vehicle.
- Prevents double-parking, unlike a bike lane.
- Low implementation cost by making use of existing pavement and drainage and by using the parking lane as a barrier.
- More attractive for bicyclists of all levels and ages.

One-way protected cycle tracks can be incorporated:

- On streets with parking lanes.
- On streets where conventional bike lanes would be stressful to bicyclists due to multiple lanes, high traffic volumes, high speed traffic, high demand for double parking, and high parking turnover. While there are no US standards for bicyclist and motor vehicle volumes that warrant the implementation of cycle tracks, several international documents provide basic guidance (refer to the *NACTO website* for such references).
- On streets where intersection conflicts can be effectively alleviated using parking lane setbacks, bicycle markings through the intersection, and other signalized intersection treatments.
- Along streets with high bicycle volumes.
- Along streets with high motor vehicle volumes and/or speeds.

Figure 9 – One-Way Protected Cycle Track Illustration: Raised Curb and Parking Buffer

Figure 10 – One-Way Protected Cycle Track Illustration: Planter and Parking Buffer

Figure 11 – One-Way Protected Cycle Track Illustration: Parking Buffer

Raised Cycle Track

Raised cycle tracks are vertically separated from motor vehicle traffic and many are paired with a furnishing zone between the cycle track and the vehicle travel lane and/or pedestrian area.

Raised cycle tracks may be one-way or two-way and at either the level of the adjacent sidewalk or set at an intermediate level between the roadway and sidewalk. The latter is used to segregate the cycle track from the pedestrian area. A raised cycle track may also be combined with a parking lane or other barrier between the cycle track and the vehicle travel lane. At intersections, the raised cycle track can either be dropped to street level, merging with vehicle traffic or at sidewalk level, where bicyclists cross with pedestrians.

When placed adjacent to a travel lane, one-way raised cycle tracks may be configured with a mountable curb to allow entry and exit from the bicycle lane for passing other bicyclists or to access vehicular turn lanes. This configuration has also been known as a 'raised bike lane.'

Benefits of Raised Cycle Tracks include:

- Dedication and protection of space for bicyclists in order to improve perceived comfort and safety.
- More attractive biking environment to a wider range of bicyclists at all levels and ages.
- Keeping motorists from easily entering the bicyclists space.
- Encouraging bicyclists to ride in the bikeway rather than on the sidewalk.
- Visual reduction of the width of the street when provided adjacent to a travel lane.
- Minimizing maintenance costs due to limited motor vehicle wear.
- Cost reduction on new roadway construction; a raised cycle track can be less expensive to construct than a wide or buffered bicycle lane.

Raised cycle tracks can be considered:

- Wherever a bicycle lane would be the standard recommendation.
- Along higher speed streets with few driveways and cross streets.
- Along streets where bike lanes would cause many bicyclists to feel stress due to factors such as multiple lanes, high traffic volumes, high speed traffic, high demand for double parking, and high parking turnover.
- On streets where intersection conflicts can be effectively alleviated using parking lane setbacks, bicycle markings through the intersection, and other signalized intersection treatments.
- On streets with numerous curves where vehicle encroachment into bike lanes is a concern.
- Along streets with high bicycle volumes.

Figure 12 – Raised Cycle Track Illustration

Two-Way Cycle Track

Two-way cycle tracks are also known as "protected bike lanes," "separated bikeways," and "on-street bike paths." They are physically separated bicycle facilities that allow bicycle movement in both directions on one side of the road. Two-way cycle tracks share some of the same design characteristics as one-way tracks but may require additional considerations at driveway and side-street crossings.

A two-way cycle track may be configured as a protected cycle track—at street level with a parking lane or other barrier between the cycle track and the motor vehicle travel lane—and/or as a raised cycle track to provide vertical separation from the adjacent motor vehicle lane.

Benefits of two-way cycle tracks include:

- Dedication and protection of space for bicyclists in order to improve perceived comfort and safety.
- Reducing the risk of 'dooring' compared to a bike lane.
- Eliminating the risk of a doored bicyclist being run over by a motor vehicle.
- Reduction of out of direction travel by providing contra-flow movement on one-way streets.
- Low implementation cost when making use of existing pavement and drainage and using parking lane or other barrier for protection from traffic.
- More attractive biking environment to a wider range of bicyclists at all levels and ages.

Two-way cycle tracks can be considered:

- On streets with few conflicts, such as driveways or cross-streets, on one side of the street.
- On one-way streets where contra-flow bicycle travel is desired.
- On streets where more destinations are on one side of the street, thereby reducing the need to cross.
- On streets with extra right-of-way on one side.
- To connect with another bicycle facility, such as a second cycle track on one side of the street.
- Along streets on which bike lanes would cause many bicyclists to feel stress because of factors such as multiple lanes, high traffic volumes, high speed traffic, high incidence of double parking, and high parking turnover.
- On streets where intersection conflicts can be effectively alleviated using parking lane setbacks, bicycle markings through the intersection, and other signalized intersection treatments.
- Along streets with high bicycle volumes.
- Along streets with high motor vehicle volumes and/or speeds.

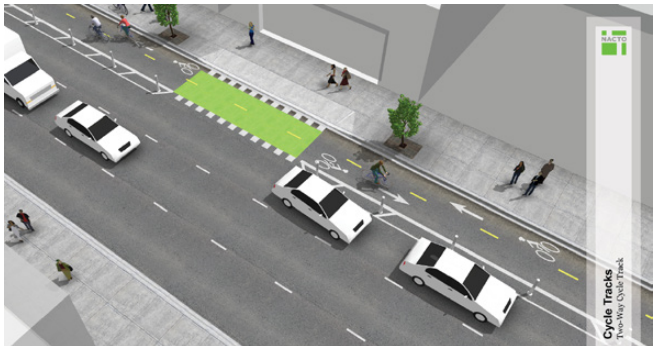


Figure 12 – Two-Way Cycle Track Illustration

Bicycle Boulevard

A bicycle boulevard is a low-stress, shared roadway bicycle facility designed to give bicycles travel priority within a roadway shared with low volume and low speed motor vehicle traffic. Bicycle boulevards use signs, pavement markings, and volume and speed management techniques to create safe and convenient bicycle facilities. The basic components of a safe bicycling environment are often found on existing local streets that have low speeds and volume.

Establishing bicycle boulevards on existing streets can materialize by enhancing these streets with design treatments tailored to existing conditions and desired outcomes. Providing bicycle boulevards not only benefit cyclists, but also creates peaceful streets, benefiting residents and improving safety for all road users.

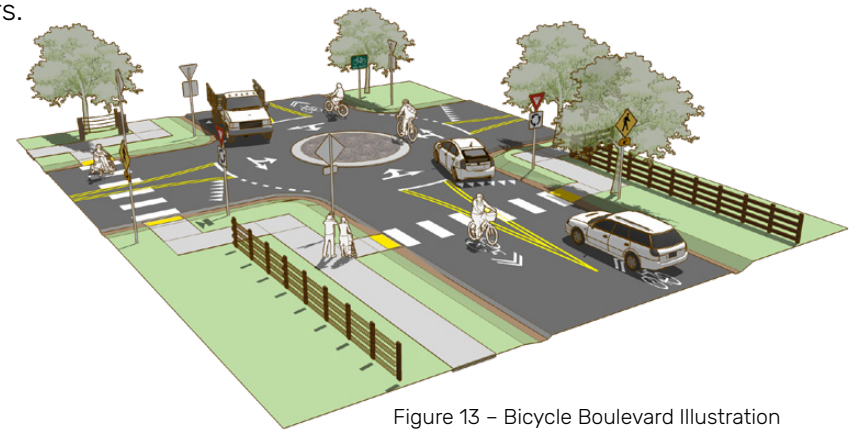


Figure 13 – Bicycle Boulevard Illustration

Paved Shoulder

Paved shoulders on the edge of roadways can be enhanced to serve as a functional space for bicyclists and pedestrians to travel in the absence of other facilities with more separation. Paved shoulders are only recommended for rural roads with lower motor vehicle volumes.

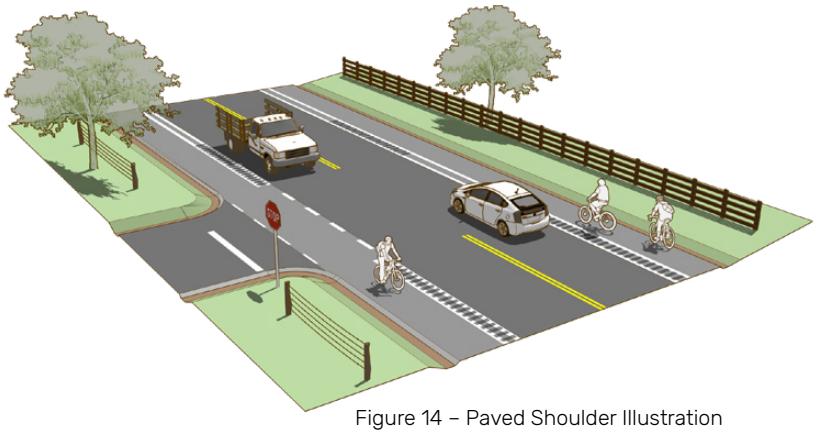


Figure 14 – Paved Shoulder Illustration

DESIGN + CONSTRUCTION CONSIDERATIONS

For the connectivity system to succeed and thrive, certain design and construction considerations should be evaluated and incorporated where applicable. In this section, you will find the following considerations:

1. User Needs
2. Considerations for Environmental Protection
3. Considerations for Greenway Trail Physical Components
4. Considerations for Riparian Greenway Trails
5. Considerations for Greenway Trails in Utility Corridors
6. Considerations for Greenway Trails in Roadway Corridors
7. Typical Cross Sections
8. Control Measures
9. Intersections / Crossings
10. Comfort Facilities + Furnishings + Artwork
11. Branding + Wayfinding
12. Permitting
13. Construction Administration

1. USER NEEDS

Pedestrian users have a variety of needs, abilities, and potential impairments, of which are most often determined by a user's age. Age can be a contributing factor in a pedestrian's walking speed and the perception of their surrounding environment. Children walk more slowly than adults and have different environmental perceptions as they cognitively develop. Older adults may also walk slowly and may require the assistance of physical devises to walk, hear, or see. While a user's mobility will vary significantly across all users, the pedestrian connectivity system should accommodate all users to the greatest possible extent.

Dog walkers make up a large contingent of users on greenway trails. Design dimensions should take into dog size, leash length, walking style, all of which vary greatly. Thus, there is a wide range of possible facility dimensions that can accommodate dog walkers. However, greenway trails that have been designed to accommodate wheelchair users will likely provide the necessary space for the typical dog walker. Dog waste stations at trailheads or periodically along the trail improve the experience for these users.

Runners and joggers are frequently found on greenway trails, many of which prefer softer surfaces like rubber, bare earth or crushed rock. Trail surface is the primary design consideration when taking runners into account. If softer surface options cannot be accommodated, asphalt is preferred over concrete.

Strollers are often used on greenway trails. The size, design, and capacity of strollers vary greatly and the greenway's design considerations when accommodating strollers should examine stroller size and the ability and speed of the adult pushing the stroller. Also, a stroller's small pivoting front wheels that aid in maneuverability may limit their use on unpaved or rough surfaces. Curb ramps are especially useful to these users as lateral overturning is a safety concern.

As populations age, **mobility assistance device users** grow. These devises are typically manual or powered wheelchairs and maneuvering them, particularly around a turn, requires additional space. Providing space for proper turning radii movements at appropriate locations is part of accessible design and shall be considered when designing greenway trail systems.

Bicyclists come in a variety of ages and abilities. Variations of cyclists typically occur with the type of equipment being used (e.g. a conventional bicycle, mountain bike, road bike, recumbent bicycle or tricycle), and the cyclist's skill and comfort level riding on the provided bicycle facility. The design of a connected bicycle system should consider multiple bicycle types, using dimensions that are appropriate to accommodate the broad range of styles and abilities. Proper bicycle facilities require clear, open space without visual obstruction and with a preferred five feet or larger width within which a bicyclist can safely operate.

Electric scooters now are in frequently use on paths and roadways in cities across North Carolina and the country. Per North Carolina legislation, a scooter is not classified as an electric personal assistive mobility device (EPAMD) but rather a vehicle.[4] As such, the City should consider how these devices will be monitored and their proper use enforced or whether local ordinances will be enacted to regulate the time, place, and manner for operating the scooters.

4 https://nccriminallaw.sog.unc.edu/its-a-bird-its-a-scooter-its-an-overnight-sensation-but-is-it-legal/

2. CONSIDERATIONS FOR ENVIRONMENTAL PROTECTION

One of the many positive benefits of greenway trails is that they link transportation, recreation, and conservation. As such, the network must be planned, designed, constructed, and maintained to preserve the area's natural resources. Some recommendations to consider for developing and maintaining greenway trails to reap the benefits of natural resource conservation may include the following.

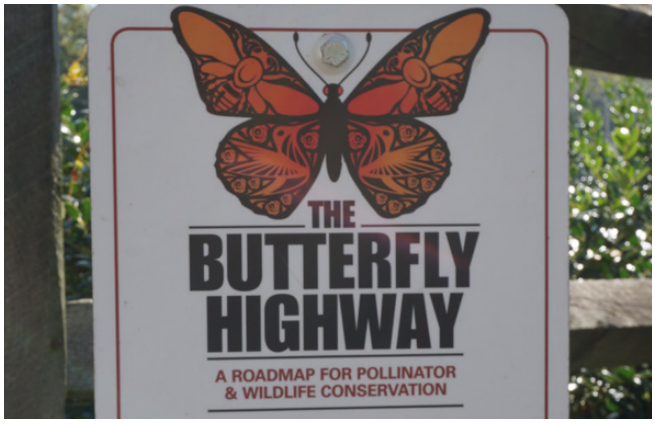
Protecting ecologically sensitive areas should be part of trail development prioritization. Environmental impacts need to be weighed against land availability, costs, accessibility, access, and aesthetics. When possible, it is wise to prohibit greenway trail development that negatively impacts:

- Wetlands, creeks, streams, rivers, and lakes
- Habitat for rare and endangered species
- Steep slopes and poor soils not capable of supporting trail or road development
- Sensitive forests
- Public water supplies
- Unique geologic features

Providing and maintaining buffers that protect sensitive natural areas adjacent to greenway trails is critical to ensure that these natural areas sustain ecological quality and value. Regardless of how sensitively a greenway trail is designed and constructed, they inevitably impact the environments through which they travel. Due to impacts like soil compaction, increased runoff and erosion, and habitat fragmentation, the implementation of vegetative buffers is imperative when planning and designing greenway trails. However, not all buffers will be the same.

Their recommended widths will vary to respond to specific conditions, such as:

- Sensitivity of the natural area being impacted
- Type of greenway trail
- Grade and soil types
- Desired user experience



Using best practices for stormwater management along the greenway trail is critical to avoid standing water on the trail. Using natural infiltration systems like vegetated swales are more ecologically and hydrologically advantageous than engineered stormwater solutions like storm drains and catch basins.

Using low impact methods when planning, designing, constructing, and maintaining greenway trails that touch environmentally sensitive areas is preferred. In Concord, most greenway trails occur within riparian systems. As such, low impact methods will lessen the impacts to these sensitive areas, aiding in the preservation of existing vegetation, wildlife, water resources, and soils. By employing low impact methods, a greenway trail system becomes a durable facility that serves the public and provides a quality experience.

Clearing & Demolition - While tree preservation and environmental protection is critical for preserving and/or improving ecological, hydrological, and recreational value throughout the pedestrian and bicycle network, it may be necessary to clear vegetation along the length of a new multi-use path or greenway trail. When clearing and demolishing existing vegetation to create greenway facilities, the following guidelines should be considered:

- Prior to any clearing or demolition activities, set and inspect tree protection fence and limits of disturbance.
- Protect existing, natural, and man-made cultural assets. These may include historic sites, cultural landmarks, and significant views.
- Comply with all environmental protection regulations from governing agencies; regulations that apply to erosion control, water quality, NCDENR requirements, and others depending on location.
- Preserve all riparian buffers.
- All debris, garbage, dumped items, hazardous material, creek obstructions, and extraneous or abandoned structures shall be removed from greenway property.
- Prune vegetation in accordance with the National Arborist Association and ANSI A300 standards.
- Remove invasive species where possible and avoid planting species known to have invasive and aggressive growth habits along the greenway.

Drainage and erosion control are necessary environmental controls to maintain a stable and low maintenance facility. Water flowing along the trail edge or across the path with enough volume and velocity to remove soil results in undesirable erosion conditions. The resulting degraded greenway trail then has the capability to impact adjacent or downstream water resources. Dispersed infiltration stormwater features such as vegetated swales, are recommended along the network to minimize erosion for reduced maintenance and improved aesthetic. Following contours also helps reduce erosion issues, minimizes maintenance, and increases user experience.

Drainage measures are dependent on the trail surface material. Paved surfaces should consider the following guidelines:

- A 2% cross slope will combat most drainage issues and is recommended to be used for both the main path and shoulders. A maximum 1:6 slope may be used for the shoulders, but 2% is preferred.
- In cut conditions where uphill water is collected and directed to a catch basin, water should be captured and directed under the greenway in a suitably sized drainage pipe.
- To help prevent erosion along shoulders, install low groundcover up to the edge of the greenway.

Natural Surface trails should consider the following guidelines.

- Designing natural surface trails with rolling grades is preferred. "Rolling grade" describes the series of dips, crests, climbs, and drainage crossings that form a sustainable trail that responds to existing contours.
- Contour trails should be outsloped 5% from the ridge face so that water sheets water off the trail during rain events. This design guideline disperses and sheds water off the trail in a non-erosive manner.
- Natural surface trails should be designed so that water sheets across, rather than down its tread.
- Avoid fall line greenway trails when possible. A fall line trail generally follows the most direct line downhill.
- Erosion can be controlled through frequent grade reversals, dividing the trail into smaller watersheds. Breaking up the drainage area this way allows the drainage attributes from one section to not affect another section. It is recommended to incorporate a grade reversal every 20 to 50 linear feet.

Grading & Earthwork - Ideally, grading and earthwork will be kept to a minimum, with grading activities occurring only as necessary to build the trails, connections, and associated amenities. Filling the floodplain or wetlands will not be permitted unless doing so provides the best greenway alignment in terms of safety, water quality, and/or stream bank restoration. If doing so, placing fill in the floodplain shall be conducted in strict compliance with local and state regulations and their respective policies. All grading activities shall follow all jurisdictional permitting requirements.

3. CONSIDERATIONS FOR GREENWAY TRAIL PHYSICAL COMPONENTS

Surfacing

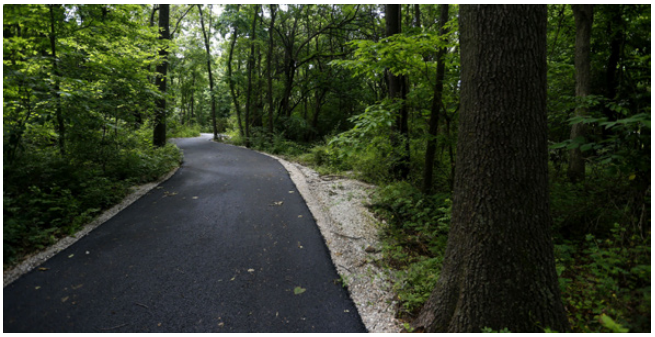
Greenway trail **surfacing** should be selected to accommodate the intended use and intensity along the trail. Surfacing should also account for flooding frequency, drainage, topography, available construction budget, and maintenance levels.

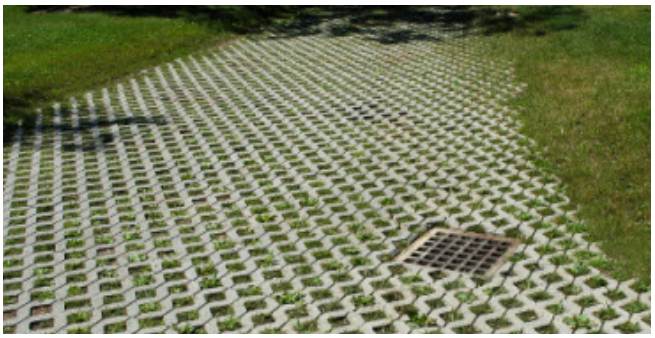
To be compliant with American Disabilities Act (ADA) Accessibility Guidelines, a greenway trail must be constructed with a paved surface (asphalt or concrete). Where there is little to no topography, compacted gravel fines can be used as an ADA compliant surface. However, these surfaces require more maintenance and cost over time, but does provide a softer, tactile pavement option.

Asphalt is popular with trail users for its smooth, continuous, and joint-forgiving attributes. It also boasts lower material and installation costs but does require more maintenance than concrete. It has a life span of about 10-15 years if constructed properly on suitable sub-grade, which is about half that of concrete. Asphalt is typically used for Concord trails, as it offers durability and the cost of installation and maintenance is not cumbersome.

Concrete, however, can last 25 years or more when properly constructed and maintained. As one of the most expensive surfaces, the cost of concrete is often a limiting factor when selecting surface materials. However, concrete should be considered in areas that frequently flood or in urban conditions due to its durability over asphalt and lower maintenance needs. It should be noted, however, that concrete is not the preferred surface by runners, as its hardness is not easy on the joints. And control joints should be saw cut vs. troweled.

Permeable paving is another surface option, but being twice the cost of asphalt to install, it should only be used under special circumstances. When using permeable paving, the area must have proper drainage; permeable paving is not suitable in floodplain conditions or in areas where ponding and sedimentation occurs. Maintenance protocol for permeable paving must be established, as this material needs to be vacuumed to remove debris after storm events in order to maintain its permeable properties.





Natural surface greenway trails are typically located in environmentally-sensitive corridors that exhibit conditions that can support bare earth, wood chip, or crushed stone trails. Natural surfaces offer a low-impact solution, typically found in less developed areas, where a trail is being laid out for future hard surface paving or where a more natural experience is preferred. The most common use of natural surface trails is for mountain biking. Additional guidance on design and construction of mountain biking facilities can be found at the International Mountain Biking Association's (IMBA) website – www.imba.com

Some options for natural surfaces include:

- Bare earth
- Rock
- Mulch, wood chip, or other native materials
- Crushed stone or screenings (not to be used in flood-prone or environmentally sensitive areas or on steep slopes)

Regardless of surface material, positive drainage must be provided. Trails that are bench cut should be done so with minimal removal of existing vegetation and grade reversals shall encourage sheet flow across the trail.

Stormwater features are recommended to be located along the network at small scales to minimize erosion. Longitudinal slope should not exceed 5% with the cross slope not exceeding of 2%.

Boardwalks are used when crossing sensitive or inundated areas, small creeks and wetlands in order to limit environmental impacts. Boardwalks can be constructed with timber, modular concrete systems or cast in palace concrete decks. Recycled material has durability advantages but come with structural limitations and can only be used in limited applications. Modular concrete boardwalk systems provide low-impact installation solutions and durability and are gaining popularity. Permatrak™ is one such system being used in Charlotte and by the National Park Service. Cast in place concrete decks are also being used in Mecklenburg County and are in service. This is a non-proprietary design that uses wood for sub-structure and cast in place concrete decks to greatly extend boardwalk life.

Maintenance can also be reduced by replacing wooden pickets that are traditionally used. Municipal maintenance departments have shared that replacing individual pickets is time consuming, costly and labor intensive. By replacing pickets with vinyl coated, chain link fence many municipalities around the state have removed this maintenance challenge. The fence panel is tensioned into place and readily available.

A few considerations to keep in mind when analyzing the desire to implement boardwalks:

- Boardwalks should have a 10' minimum clear span if railing are not used. If railings are used or on sections with higher use expectations, a 12' width is preferred.
- A 6-inch curb rail is recommended for all boardwalks. However, a 42-inch guardrail will be required if there is a 30-inch or greater grade change between the boardwalk surface elevation and the ground elevation below.
- A structural engineer should be consulted for foundation post sizing and footing design. Foundation posts are typically marine-grade timber or auger piers with screw anchors. Structural evaluation and design of footings should include uplift as well as loading considerations for flood events.
- Minimize slippery timber decking surfaces following rain events. A topcoat of non-skid sealer can be used to increase slip resistance.
- Local, state, and federal permits will be required when constructing a boardwalk is within jurisdictional wetlands.

Regardless of the selected surface material, proper foundation design and installation will maximize the greenway trail's longevity. And all surfaces have their advantages and disadvantages, and each must be examined to ascertain which surface is most appropriate in any given location.

Toby Creek Greenway, Mecklenburg County - Cast in Place Concrete Decks

Width

- Eight feet is the minimum width recommended for a low volume, shared use greenway trail. Any trails receiving federal funding must be a 10' minimum per AASHTO requirements.
- Ten feet is recommended for most moderate to heavy use situations.
- Twelve feet (and in very heavy use areas, 14-feet) is appropriate for trail sections with high concentrations of multiple user types. Where space permits, a separate lane of 5-feet minimum may be provided for pedestrian only use.

Lateral Clearance

- Provide 2-foot minimum shoulder on both sides of the greenway trail.
- Provide an additional 5-feet of clearance (7-feet total) when signage or other site furnishings are provided.
- Provide 5-feet shoulders in fill sections
- Provide 5-feet shoulders in cut sections.

Overhead Clearance

- Provide 10-feet recommended, 8-feet minimum clearance from overhead obstructions.
- Provide convex mirrors at blind corners and underpass approaches with poor sight lines.

Striping

Stripe greenway trails with expected heavy use or high concentrations of multiple users.

Surface Grade

- Comply with ADAAG standards when possible.
- Provide a 2% cross slope from crown in both directions to positively drain off the trail.
- Provide a 48-inch height safety rail within 6-feet of pavement edge when:
    - Slope is greater than or equal to 3:1 and drop of 6-feet
    - Slope is greater than or equal to 2:1 and drop of 4-feet
    - Slope is greater than or equal to 1:1 and drop of 1-foot

Accessible Greenway Trails

Constructing **accessible greenway trails** that meet the American with Disabilities Act Accessibility Guidelines (ADAAG) may prove difficult and sometimes prohibitive. It is necessary to comply with these requirements where possible. However, there are certain circumstances where a facility may be exempt from compliance. These exceptions are made when compliance would:

- Harm significant cultural or natural resources,
- If compliance would significantly change the intended purpose of the greenway trail,
- Construction method requirements necessary to become complaint are against federal, state, or local regulations, or
- Terrain prevents compliance.

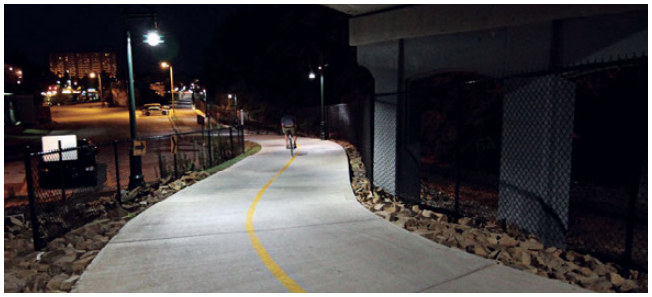
More information regarding accessible recreation facility requirements can be found at the United States Access Board's website.

Crime Prevention Through Environmental Design (CPTED)

Both actual and perceived personal safety sways one's decision to use a greenway facility. The inherent safety (or lack thereof) also determines whether a community will welcome and support the system. Both actual threats (criminal acts or infrastructure failure) and perceived concerns (fear of crime or fear of injury) must be addressed and can be done so through Crime Prevention Through Environmental Design (CPTED). CPTED is "…a multi-disciplinary approach for reducing crime through urban and environmental design and the management and use of built environments. CPTED strategies aim to reduce victimization, deter offender decisions that precede criminal acts, and build a sense of community among inhabitants so they can gain territorial control of areas and reduce opportunities for crime and fear of crime."[5]

As such, it is recommended to apply CPTED guidelines throughout the network when appropriate, some of which are listed below.

- Fencing along greenway trails should not obstruct the view of trail users.
- Where long stretches of greenway are fenced, provide intermittent openings to allow trail users to enter and exit the corridor.
- Good visibility from all access points is needed for all trail users and its neighbors.
- Signage should include contact numbers to report suspicious behavior, graffiti, and maintenance issues.
- All understory vegetation along greenway trails should not exceed 3-feet height.
- Vertical clearance under trees, over the trail, should be 8-feet minimum.
- Hostile plant material (e.g. native vegetation with thorns) can be strategically used to discourage access to/use of an area.
- Add anti-graffiti application to surfaces where appropriate.
- Where lighting is installed, illumination should:
- Be sufficient for a face to be identified up to 20-yards away.
- Provide uniform coverage that eliminates dark spots.
- Provide good color rendition – recommend using LED or metal halide lamps.
- Not be obstructed by tree canopies.
- Lighting should respond to site conditions and meet the minimum safety standards set forth by the Illuminating Engineering Society of North America (IESNA). Remember too, that light quality is as important as light quantity. Whether too bright or not bright enough, poor lighting, can curtail safety.



5 http://www.cpted.net/

4. CONSIDERATIONS FOR RIPARIAN GREENWAY TRAILS

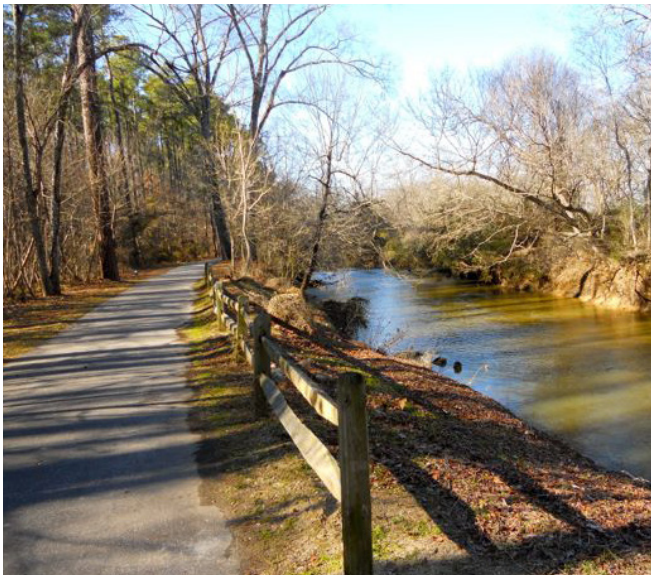
As mentioned, most greenway trail development in Concord occurs in riparian corridors. These corridors include rivers, streams, creeks, and wetlands. And depending on the size of the floodplain area, riparian corridors can offer both recreational and open space preservation opportunities. All greenway trails constructed within riparian corridors should be examined for stormwater, wildlife habitat, and floodplain development impacts.

Routing and Alignment

- Greenway trails should follow the natural contours when possible.
- Avoid construction along erosion prone fall lines – these areas generally cannot be maintained.
- Choose the narrowest point to cross wetlands.
- Avoid construction immediately adjacent to streambanks. Construct all trails at the maximum distance from streams as possible. While Concord does not require a minimum distance trails need to be from the stream, the City has designated River/Stream Overlay Districts as described in Concord's Development Ordinance, Article 4, Environmental/Land-Disturbing Activities, that require an undisturbed buffer and a vegetated setback along Class 1 and Class 2 streams. Both Article 4 and Article 1, Section 1.5.3 of Concord's Stormwater Technical Standards Manual call out specific development and land disturbing activities that are exempt or allowed within a designated stream buffer. Those exempt and allowed activities that most directly correlate with the development of an open space connectivity network include:
    - Bridges (allowed)
    - Greenway/hiking trails (allowed)
    - Stream restoration (exempt)
    - Streambank stabilization (allowed)
    - Planting vegetation to enhance the stream buffer (exempt)
    - Removal of understory nuisance vegetation, e.g. invasives (exempt)
    - Wetland restoration (exempt)
- Consider stream restoration opportunities where feasible. Stream restoration projects frequently reshape the floodplain to allow the stream to access its floodplain.
- Design logical access points and points of interest to avoid informal "cow paths" that trample floodplain vegetation or infringe into sensitive areas.

Materials and Management

- Concrete, due to its durability and lower maintenance requirements, is the recommended surface for greenway trails that will see regular flooding. Concrete should always be used on the approaches and beneath vehicular bridges as these areas are regularly inundated with standing water.
- It is not advisable to use permeable paving in riparian corridors (or in other areas with poor drainage). Sediment transport through sheet flow clogs the permeable system and requires vacuuming and extra maintenance after all storm events.
- Do not use gravel or crushed fines in riparian corridors that are prone to flooding. These materials erode easily and can contribute to sediment build up in streams.
- When traversing wetlands, use elevated systems like boardwalks to preserve the wetland ecosystem.
- Stormwater should be managed using natural infiltration systems such as vegetated swales.
- Avoid concentrated channels which may lead to larger pipes and high velocity of stormwater run-off causing uneven greenway surfaces.



5. CONSIDERATIONS FOR GREENWAY TRAILS IN UTILITY CORRIDORS

- Corridors that house underground utilities such as water, sewer, natural gas, or buried electric as well as above-ground utilities such as telephone, cable, or overhead electric can serve the needs of greenway trail users. A few things to consider when utilizing a utility corridor for greenway trail use.
- All greenway trails utilizing a utility corridor will require procurement of a trail easement from the land owner.
- Review and plan for each utility's policies regarding specifications for construction, repair, maintenance, access requirements.
- Most utility companies require that specific design guidelines be followed. These include but are not limited to, routing and alignment, width limitations, landscaping requirements, and restrictions on structures.
- Ten-feet width must be provided if motor vehicles will be accessing the trail for utility maintenance.
- In sanitary sewer easements, the greenway trail edge should be 10-feet minimum, where possible, from manhole rims.
- For Duke Electric utility corridors, a minimum separation of 25-feet is required between the greenway trail and any associated electrical equipment (such as guy wires, power poles, and towers; based on Duke Energy ROW requirements for greenway trails).

6. CONSIDERATIONS FOR MULTI-USE PATHS

Trails located within the road right-of-way (ROW) provide wider, more comfortable widths than sidewalks and can accommodate multiple users when properly designed. Paths within ROWs work best along roads that have few driveway crossings along its length and with services primarily located on one side. Multi-use paths can be used on one or both sides of a roadway. In determining the appropriate cross-section planners should evaluate the following:

- Roadway cross-section: How will cyclists access destinations on both sides of the road? If the roadway does not offer safe comfortable travel for cyclists, then MUPs on both sides may be appropriate. Low volume, low speed roads may not require separated cycling on both sides, while high volume, high speeds roads may.
- Adjacent land-use: Are there schools, libraries, parks, retail areas or other destinations on both sides of the roadway that users would likely access? Again, focus on the cycling movement to determine if access is supported.
- Distance to crossings: How far would a cyclist have to ride on the roadway to access the multi-use path? Is there a safe crossing to access the MUP?

Multi-use paths are also advantageous when a road travels along a riverfront or other natural feature.

- Multi-use paths are 10-feet minimum; necessary for bicyclists to pass other users safely.
- A 5-foot minimum vegetated buffer between the multi-use path and the road edge should be provided. NCDOT will conditionally allow a 3-foot buffer when right-of-way dimensions are constrained.
- Provide appropriate regulatory and wayfinding signage and crossing treatments at driveway entrances crossings.
- All greenway trails constructed within NCDOT ROW require an encroachment permit.
- Follow NCDOT standards and specifications when providing multi-use paths along NCDOT roadways.

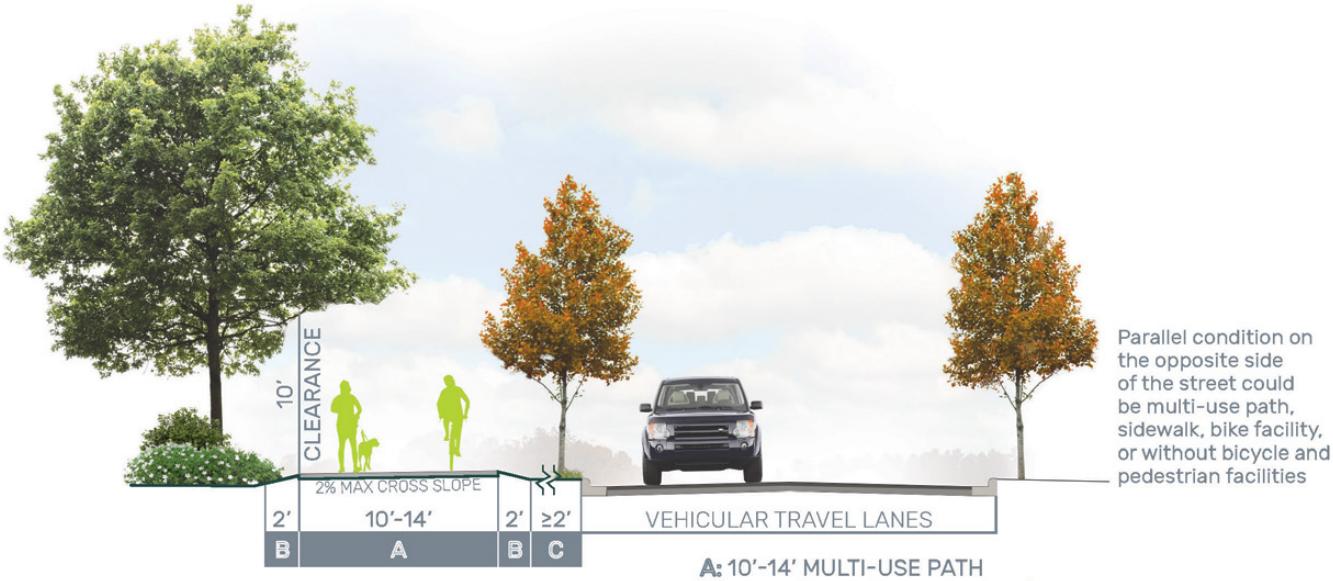
7. TYPICAL CROSS SECTIONS

A: 10'-14' GREENWAY
> Concrete or asphalt surface
> For use by cyclist and pedestrians

B: 2'-5' SHOULDER
> Maximum slope of 4:1 (25%)

C: TRAIL SIDE CLEARANCE
> Minimum of 2 feet. This prevents conflicts between cyclist and pedestrians with stationary objects

Figure 15 – Typical Paved Greenway Cross Section



A: 10'-14' MULTI-USE PATH
> Concrete or asphalt surface
> For use by cyclist and pedestrians

B: 2' SHOULDER
> Maximum slope of 4:1 (25%)

C: TRAIL SIDE ZONE
> Minimum of 2 feet. Width determined by traffic volume and speed, and pavement edge treatment
> Minimum of 5 feet when considering street tree planting

Figure 16 – Typical Natural Surface Greenway Cross Section

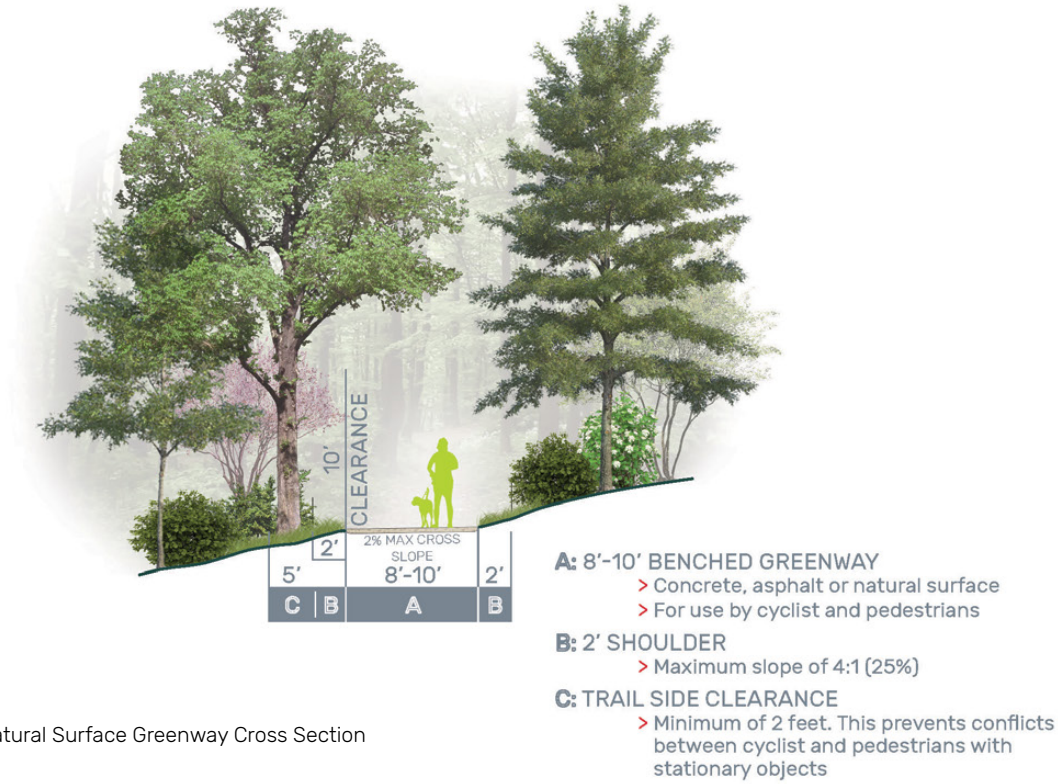


Figure 17 – Typical Natural Surface Greenway Cross Section

8. CONTROL MEASURES

Most greenway trails require some level of control and management to enhance user experience, provide security, or to expand the life of the greenway trail. Features such as trailheads, bollards, or vegetative screening help control greenway access. Bridges allow for environmental control and features such as fences and railing help to control greenway safety.

Access Control

As the City of Concord's greenway system expands, it is essential to provide access to a wide range of users and way finding amenities throughout the system. This can be achieved through establishing trailheads at popular greenway access points. Ideally, trailheads will consist of a paved parking area, signage, restrooms, and a drinking fountain. But ultimately, the size of and amenities provided at the trailhead is contingent upon its location, the size of the parcel of land, and the popularity of the trail being accessed. Trailheads serve several purposes, providing:

- Wayfinding for individual elements as well as larger system;
- A central, public location to disseminate greenway rules, programs, and other information; and
- Convenient parking and entry for greenway users.

Trailheads are an essential element of a successful and active greenway system and when determining when and where to develop trailheads, consideration needs to be given to locations where:

- prominent greenways intersect,
- multiple greenways and other community trails intersect, and
- a wide range of greenway users can effectively be served.

Trailheads are designated public access points to the greenway trail system, connecting roadways and/or activity centers to the greenway system and may include amenities such as:

- Vehicle and bicycle parking
- restrooms
- seating areas/benches
- shelters and picnic areas
- drinking fountains
- trash and recycle receptacles
- bike share stations
- pet waste stations
- bicycle repair stations
- public art
- lighting
- wayfinding and informational signage

Consider locating trailheads in conjunction with other public facilities or through a shared use agreement with owners of adjacent parking areas. Trailheads could be classified into major and minor categories.

Major trailheads should be established near high population and high use areas such as large residential and commercial developments, transportation nodes, or popular parks. Such siting makes the trailhead accessible to a larger number of users and provides greater access to the greenway trail system.

- Major trailheads can have a large paved parking lot with emergency and maintenance vehicle access and turnaround. ADA accessible parking spaces must be provided near the site's accessible route, at a rate of one accessible space per 25 standard spaces.
- Consider one-way vehicle circulation within parking areas to minimize road width.
- Provide user access from local streets when major trailheads are located near neighborhoods.


Example of kiosk typical of a major trailhead

Minor trailheads have minimal infrastructure and can occur at smaller parks, residential developments, or other trail/roadway intersections. Some may include a small parking lot, drinking fountains, benches, trash and recycling receptacles, an information kiosk, and informational signage. Consider negotiating shared parking with adjacent development to capitalize on available land for development of the trailhead. Careful consideration should be given in residential neighborhood connections to discourage public parking, congregating on neighborhood streets, signage, landscaping, and lighting.

A **defined trail edge** provides visual separation, delineating the public trail space from private property, separating users from dangerous conditions like a steep grade change, or to discourage "cow paths" from forming into and out of the trail system. Various physical elements can define a trail's edge: vegetation, fencing, railings, topography, or walls. Consider trail user safety and wildlife movement when determining applicable edge treatments. Other things to consider are detailed below.

- Fencing is often viewed as a safety measure to prevent unwanted access. When incorporating fence along the greenway to prevent access, a semi-transparent fence four feet tall or less typically provides a sufficient edge to deter most. But fencing that completely blocks visual access to the greenway will restrict casual trail surveillance, thereby resulting in a real or perceived safety issue.
- When fencing is used to denote property boundaries, there must be a balance between the residents' desire for privacy and casual surveillance of the greenway trail. Opaque structures can obscure views and create and uneasy feeling of being enclosed, both of which negatively impacts a user's experience.
- For physical separation to protect against hazardous slopes, semi-transparent fencing or railings, hostile vegetation, or topography, may be appropriate solutions.


Fence creating a defined edge along a path

Vegetative buffers can be used to create privacy screens, provide wildlife habitat, and stabilize precarious soils. When providing vegetative buffers along a greenway corridor, the following should be considered.

- When possible protect, preserve, and maintain existing native vegetation when constructing greenway trails through riparian corridors. Existing vegetation is the first choice for providing separation between the trail and adjacent properties.
- Remove all competing invasive vegetation.
- When trees and shrubs are planted, native species are recommended, as they are the most ecologically sustainable option. Native species typically require less maintenance and often provide a necessary food source and habitat for wildlife, thus offering the most effective method to create wildlife habitat.
- Groundcover and shrub height should be 24-inches maximum to maintain an open sight line.
- Plant the right plant in the right place; responding to topography, sun/shade exposure, and soil moisture.
- Tree canopies shall not obstruct trail illumination from overhead lighting.
- Select and locate plant material to provide seasonal comfort: shade during warmer months and sunlight in the winter.
- Select native, hostile plant material (e.g. vegetation with thorns) to deter greenway users entering unauthorized areas.
- Consider Crime Prevention Through Environmental Design (CPTED) recommendations.
- Mulch regularly to conserve water.
- Trim trees adjacent to the greenway trail to provide an 8-foot minimum vertical clearance.
- Fertilize native plant material only when necessary if soil conditions need repair.

The presence or absence of vegetation and the type of plant material present in a corridor influences the greenway's quality and performance as a wildlife corridor, its ecological sustainability, and the experience for the trail user.

Bollards are physical barriers designed to restrict access by vehicles. Bollards are effective in preventing unauthorized vehicles from accessing the greenway and should be employed at all primary access points and major trail heads.

- Bollards should be 40-inches minimum height and 4-inches minimum diameter.
- Set bollards back from the edge of road by 20-feet minimum.
- If more than one bollard is installed, it is preferable to use an odd number and space bollard 6 feet apart.
- Bollards should have reflectors for night time visibility.
- "No Motor Vehicles" signage (MUTCD R5-3) and/or vertical curb cuts may be used to reinforce vehicular access rules.

It should also be considered that physical barriers may occasionally be ineffective at preventing access and alternately create obstacles to rightful trail users. Other design strategies to accomplish access control utilize signage, landscaping, and curb cut designs to reduce vehicular access.

Environmental Control

Greenway trail bridges are used to cross streams, rivers or other natural features where installing a culvert is not an option. Bridge type and size will vary according to specific site constraints and type of greenway trail, often taking the form of a suspension or a prefabricated clear span bridge. It is also critical to consider emergency and maintenance vehicle access when developing a bridge design for greenway trails.

- Poorly designed trails traversing through water features can impact wetlands and streams and become conduits for sediment, nutrient, and pathogen delivery throughout the watershed. Poor design and construction can also contribute to bank and streambed erosion. As such, it is best to utilize the following guidelines when considering implementation of a trail bridge.
- Bridge deck grade should be flush with adjacent greenway surface elevation to provide a smooth transition. If a gap exists between bridge deck and trail, said gap should be covered with a steel plate.
- Length and height of the bridge cords are dictated by floodway width and anticipated impacts to a stream's base flood elevation.
- The bridge's clear span should include 2-feet additional feet on both ends of the approach to accommodate the shoulder.
- Railings, where warranted, shall maintain a 42-inch minimum height and 48-inches where hazardous conditions exist. If utilizing a picket style rail, maximum opening between pickets is 4-inches.
- A 10-feet minimum overhead clearance is desirable for emergency vehicle access.
- A 10-foot-wide greenway trail bridge should support 10 tons. If wider than 10-feet, the bridge should support 20 tons to accommodate emergency vehicle access.
- When crossing creeks or streams, align the crossing as far upstream as possible and in the narrowest channel section to minimize the impact.
- Trail stormwater features should be implemented before the trail crosses the watercourse.
- All abutments and foundations should be designed and sealed by a professional structural engineer licensed in the State of North Carolina.
- Construction and/or installation of greenway trail bridges will require local building permits, stormwater and land disturbance permits, and FEMA approval.

Safety Control

Railing and fences are necessary features on some bridges, boardwalks, or in areas where a hazardous grade change or incompatible adjacent land use is present. Below are a few guidelines to consider when planning for fencing and railings.

- If grade change requires, railings shall be 42-inches above finished grade and up to 48-inches where more hazardous conditions exist (e.g. a bridge over a highway).
- Picket style fencing presents a safety hazard for bicyclists and may want to be avoided.
- Use durable materials for reduced maintenance.
- Consult local, state, and/or federal regulations and building codes to determine when railing installation is appropriate thus complying with current standards.

9. INTERSECTIONS / CROSSINGS

Roadway Crossings

Pedestrian traffic signals and signage are critical at trail and roadway intersections, particularly at mid-block crossings. Where possible at roadway crossings, the user shall have the opportunity to pass under the street, connect to other sidewalks along the street, or cross at street level with one of these crossings conforming to ADA requirements.

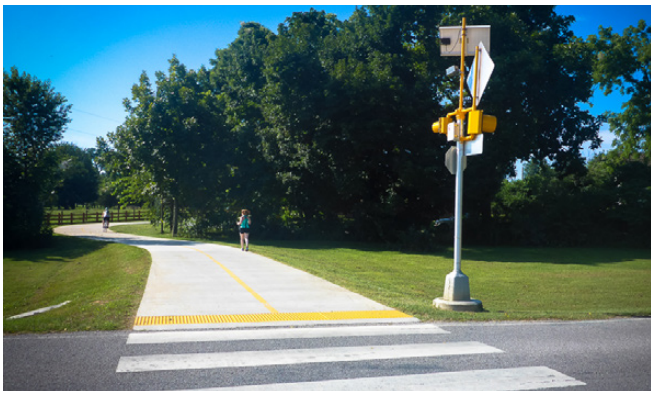
At grade crossings of the road by the trail are the most efficient use of construction and right of way funds that serve several opportunities for a trail. However, at grade crossings also have drawbacks with the potential to create conflicts between greenway trail users and motorists. However, well-designed crossings can mitigate many of these conflicts and provide a high level of safety and comfort for users.

Opportunities for having an at grade crossing is creating visibility of the trail to the community, informing residents and visitors alike that a trail is present and open. The identification of the trail through signage and branding help to establish place and trip origination for trail users. The access is also good for safety as first responders and emergency vehicles have direct access to the trail system from the roadway.

Safety is a concern for at grade crossings and measures must be taken to protect the vulnerable users. Basic two-lane roads typically have the least potential for conflict between crossing trail users and motor vehicles. As roads become bigger with additional lanes and increased speed and volume of motor vehicles, the potential for conflicts with trail users subsequently increases.

Special consideration must be given when delineating at grade crossings. Warning sign types, pavement markings, and other strategies will vary based on the type of roadway the trail crosses. Below are several considerations to evaluate when preparing to design or construct an at grade crossing.

- The increased possibility for conflict between trail users and motor vehicles must be mitigated to provide a comfortable and safe experience for all. Provide adequate sight distance for trail users and motorists with siting, clearing, and other strategies.
- Proper signage and pavement markings alerting trail users and motorists of at grade crossings is critical.
- Warn motorists of approaching trail crossings with pedestrian crossing signage.
- Warn pedestrians and bicyclist of approaching road crossing with appropriate warning signage.
- Install marked/painted pedestrian crossing or a speed table where possible.
- However, care must be taken not to place too many signs at crossings as they may lose their visual impact.
- Minimize length of crossing as much as possible.
- Avoid locating crossings where steep side slopes are created, making them prone to erosion.
- Where curb to curb distance is greater than 75-feet, provide median refuge areas.
- Clearly indicate through signage who has priority within the right-of-way.



When to Use Signals for at grade crossings - A warrant is a condition that an intersection must meet to justify a signal installation. The Manual on Uniform Traffic Control Devices (MUTCD) specifies eight "traffic control signal needs studies", known as warrants. However, "The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal." (MUTCD, 4C.01) The final decision is made based upon the traffic engineer's judgment.

Process to determine if a signal is warranted The traffic engineer analyzes vehicle traffic volume, pedestrian activity, intersection crash history, and the physical environment in order to determine whether the intersection warrants a traffic control signal. Engineers examining the intersection may review the following:

- Number of vehicles entering the intersection from all directions during 4-hour and 8-hour periods
- Vehicular volumes during peak hours, classified by vehicle type for traffic movement in all directions
- Pedestrian and cyclist volume on each crosswalk in all directions, including children, the elderly, and/or persons with disabilities, during each hour of the day
- How the crossing fits into the larger bicycle and pedestrian network bot planned and existing.
- Requests from participants attending nearby facilities and activity centers that serve the young, elderly, and/or persons with disabilities
- Posted speed limit
- Physical layout
- Crash experience/history

Different warrants require detailed analysis of different aspects of the above information.

Roadway Intersection Crossings – At locations where a trail crosses at an existing street intersection, City of Concord and NCDOT signals provide necessary pedestrian signage, pavement markings or signals. The advantage of a crossing at an existing intersection is that there are already measures in place for controlling traffic that can be modified to accommodate trail users. Signalized crossings at intersections provide the most protection for users. Desired crossings that are within +/- 400 feet of an existing signalized intersection should be diverted to the existing intersection. Doing so avoids traffic operation issues that arise when two crossings are in close proximity.

Additional features that may be implemented at an existing intersection may include:

- Bike signals
- Green paint (Must obtain experimental letter from FHWA)
- Limiting turning movements of motor vehicles, I.E. "No Turn on Red"
- Reducing crossing lengths
    - Pedestrian refuges in median and when space allows
    - Reducing radii and creating curb bulb outs
    - Moving stop bars back from the middle of intersection

Mid-block Trail Crossings

A mid-block at grade crossing can serve as a convenient point of access for the trail when an existing intersection is not present or when it becomes impossible to route the trail to an intersection. Because no existing traffic control features are likely present, steps need to be taken to ensure the safety of trail users and mitigate potential conflicts with motor vehicles. Even though North Carolina Law gives pedestrians in the crosswalk the right of way, good design encourages compliance and improves safety. Designing mid-block crossings is evaluated on elements such as vehicular traffic, greenway trail traffic, line of sight, vehicle speed, road type and width, and other factors like proximity to major attractions.

The trail crossing types described below are for mid-block crossing situations. Mid-block crossings are those that occur solely for the purpose of a greenway trail crossing a surface street. Descriptions of the trail crossing types are as follows:

Midblock Trail Crossing, 2- and 3-Lane Roads

- Warning and stop signs at locations where the trail meets the road
- Reduce road width or create curb and gutter bulb outs at the crossing to reduce the length of the crossing
- Change of pavement surface on the approach of the crossing
- 10-foot wide longitudinal crosswalk, across road with curb ramps at each end
    - Curb ramp width should match the width of the of the trail.
- Fluorescent yellow-green warning signs along road at approaches to trail crossing
    - Recommended 35 mph or less / Required over 35 mph
- Distinctive markers at approach to trail – boulders, plantings, etc.
- Alternative pavement surface
- Rumble strips (in non residential areas), speed tables (in residential areas) or pavement markings at approaches
- Raised crosswalk
- Pedestrian-activated rectangular rapid flashing beacons (all)
- Raised pedestrian refuge in place of center lane
- Planted median in place of center lane; +/- 200 ft. long (each side of trail crossing)
- Trail crossing – striped or imprinted asphalt; flush through median
- Angle crosswalk in the median to orient pedestrian toward on-coming traffic
- Pedestrian-activated High-Intensity Activated crossWalK (HAWK) signal
- Rectangular Rapid Flash Beacon (RRFB)
- Two signal types that my be utilized are the High-Intensity Activated CrossWalk

(HAWK) beacon and the Rectangular Rapid Flash Beacon (RRFB).

Rectangular Rapid Flash Beacon (RRFB)

Midblock Trail Crossing, 4- and 5-Lane Roads (45 mph or Less)

- Warning and stop signs at trail approaches to road
- 10-foot wide longitudinal crosswalk, across road with curb ramps at each end
    - Curb ramp width should match the width of the of the trail.
- Fluorescent yellow-green warning signs along road at approaches to trail crossing
- Distinctive markers at approach to trail – boulders, plantings, etc.
- Alternative pavement surface
- Rumble strips (in non-residential areas) or pavement markings at approaches
- Pedestrian-activated rectangular rapid flashing beacons (all)
- Raised pedestrian refuge in place of center lane
- Planted median in place of center lane; +/- 200 ft. long (each side of trail crossing)
- Trail crossing – striped or imprinted asphalt; flush through median
- Angle crosswalk in median to orient pedestrian toward on-coming traffic
- Pedestrian-activated High-Intensity Activated crossWalK beacon or HAWK signal
- Pedestrian Hybrid Beacon (PHB)

Grade Separated Crossings – Grade separated crossing removes the potential conflict points between trail users and motor vehicles. Sometimes these crossing can be achieved by an existing overpass or bridge where the trail can pass underneath the existing roadway. When existing structures are not present or cannot be suited to fit a trail, new structures often have to be built. While expensive, these structures offer a level of safety and comfort that is unmatched with an at grade crossing.

Pedestrian tunnels and bridges are the most common types of grade separated structures. A structure will be required when crossing any NCDOT controlled access such as an interstate. A structure is also recommended for high volume roadways or if the projected number of users of the trail are expected to be high. Additional warrants for a structure for a grade separated crossing include:

- Crossing of any facility with a design speed higher than 45 miles per hour.
- Crossing four lanes or more.
- Crossing a road with poor horizontal or vertical sight distances.

Pedestrian Tunnels or greenway trail underpasses provide critical connections between areas separated by barriers like railroads or high speed/volume roadway corridors. Safety is a major concern with underpasses as users may be temporarily out of sight from the public or may experience poor visibility. Design criteria for pedestrian tunnels include:

- Vertical clearance: 10-foot minimum
- Width: 12-feet required
- Provide positive drainage with a 2% minimum longitudinal slope to avoid pooling of stormwater. Where appropriate, incorporate trench drains at the tunnel entrance to intercept water before it enters the tunnel. Pedestrian tunnels may also be designed to flood periodically if necessary.
- Pedestrian tunnels should have a 10 foot-candles minimum daytime illuminance. This can be achieved through artificial and/or natural light. Night time illuminance levels should reach 4 foot-candles.
- Design to allow for wildlife crossing if located in a natural area
- Roadway Bridge spanning trail is most desirable solution
- Requires NCDOT encroachment agreement (if crossing state maintained road)
- Existing box culverts may sometimes be retrofitted but may require additional hydraulic analysis.
- It is recommended to post warning signage in advance of the pedestrian tunnel on both approaches that indicate necessary warnings regarding visibility or other safety concerns.
- Consider providing convex mirrors at blind corners and at tunnel approaches with poor sight lines.
- Pedestrian tunnels are most appealing when they are open, accessible, and exhibit a sense of safety.

Pedestrian Bridges or greenway trail overpasses are often built over large man-made features like highways. Greenway trail bridges are exceptionally expensive and should only be used in locations with an extraordinary need. Site specific design and construction specifications will vary per bridge location, but safety should be the primary design consideration. Design criteria for pedestrian bridges include:

- Clear Width: 10-feet required, 12-feet preferred
- 54-inch guard rail on both sides
- H5 (10,000LBS) Loading requirement minimum, for light maintenance and emergency vehicles.
- Fenced cover where trail crosses highways/ busy streets
- Requires NCDOT encroachment agreement (if crossing stataintained road)
- Shall meet governmental safety requirements and be structurally engineered to support proposed use
- Always engage a structural engineer in new bridge designs or before making alterations or additions to an existing bridge.
- While more expensive, a decorative, artistic bridge will draw attention to the trail network and could serve as a landmark.

Routing Trail Beneath Roadway Alongside Existing Streams Crossing

- Vertical Clearance: 8-foot minimum, 10-feet desired
- May require additional hydraulic analysis
- Requires NCDOT encroachment agreement (if crossing state-maintained road)
- Modification to bench must not impact structure
- Concrete surface recommended to extend life of trail in regularly flooded location.

Bike lane connections to and from greenway trails should have smooth transitions. Detectable pavement warnings and signage shall be placed at approaching connection points and avoid, when possible, locating bike lane connections at the bottom of steep slopes. Doing so aids in user safety and helps prevent stopping hazards.

At the **intersection with other greenway trails,** users need to be informed that an intersection is approaching and of the potential to encounter different user types from multiple directions. This notification can be provided through signage and/or unobstructed sight lines. Other design criteria include:

- Trails should intersect at 90 degrees when possible with clear sight lines.
- Include wayfinding signage at intersections.
- A roundabout may be a viable intersection design option to slow user speeds and maintain efficient circulation.
    - Consider using low growing (no more than 24-inches high), native landscape that require minimal maintenance and provide clear sight lines.
    - Other material, like boulders and public art, can be used in the center of roundabouts to discourage shortcut paths across the central island. However, clear sight lines under 36-inches should be maintained.

Median refuge islands provide a stopping place between vehicular travel lanes such that trail users can navigate crossing one direction of traffic at a time. These islands improve user safety by minimizing exposure with vehicular conflicts as it breaks the crossing distance into more manageable sections. A few things to consider regarding median refuge islands:

- They are appropriate at both signalized and unsignalized crosswalks.
- The refuge island must be accessible, preferably via and at grade passage through the space rather than ramps and landings.
- Refuge islands can be landscaped. However, the landscape shall not compromise trail users' visibility across the crosswalk. Consider low growing, native shrubs and ground cover that require minimal maintenance and do not reach heights greater than 18-inches.
- Road debris may collect at refuge islands. Therefore, they do require frequent maintenance efforts.
- The approach nose to the island must be highly visible with appropriate regulatory signage.

10. COMFORT FACILITIES + FURNISHINGS + ARTWORK

When designing a functional and inviting greenway trail system, comfort facilities, furnishings, lighting, artwork, and other unique amenities must work together to enhance the overall experience for all trail users. Including furnishings along the route provides the opportunity to rest from exercising or to contemplate as a break from causally traversing the trail. Placing seating strategically along the path, especially in communities with an aging population will encourage these users to enjoy the trails to their fullest potential.

When utilities are available, safety furnishings should be included. These features allow users to maintain a sense of comfort and safety. Water fountains and water-bottle filling stations allow users to stay hydrated and adequate lighting provides visibility when natural light is no longer available.

Other amenities commonly available to users include restrooms, overlooks and viewing areas, bike racks, bike maintenance stations, public art, and landscape. Consider grouping these amenities together, providing a centralized rest stop or comfort station. Throughout this section, guidelines for each of the previously mentioned amenities are provided for consideration.

Public restrooms

Public restrooms are one of the most critical amenities. They must be responsive to a wide range of needs and careful consideration must be given to multiple factors before locating them. Available land, size of trailhead, distribution of existing restroom facilities within system, utility availability, and user's needs are some of the factors that need to be explored.

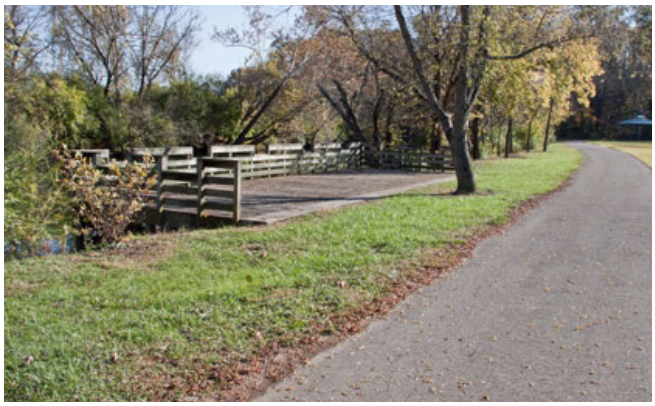
Prior to undertaking any restroom building design, Concord should consult with design professionals who can guide the City through building codes, health and safety codes, ADAAG standards, and local development codes. It is worth noting that restrooms demand substantial maintenance and service. Access to these amenities should be a primary factor when planning for restroom building construction. Other considerations include:

- Prioritization of locating restrooms at trailheads in existing parks, outside the floodplain, and with access to water and sewer.
- Reviewing the overall system to identify gaps where restrooms could be placed.
- Locating restroom structures adjacent to vehicular access to accommodate security measures and maintenance activities.
- Taking advantage of natural light and ventilation to the greatest extent possible.
- Placing and appropriate quantity of bicycle parking close to restrooms to discourage informal parking and impeding trail users.
- Providing durable and vandal resistant finishes.

Overlooks + Viewing Areas

Overlooks and viewing areas may be provided to take advantage of pristine views or cultural features along a corridor. A space separate from but adjacent to the primary circulation path allows users to rest, observe, contemplate, and enjoy their surroundings; natural features like a beautiful grove of trees, an interesting rock outcropping, a winding wetland system, or other areas that have natural or historic significance.

Observation areas should accommodate pedestrians and cyclists, with adequate space to circulate and to keep the observer from interfering with primary trail traffic, seating and/or leaning rails, and bike racks. If the structure is 30-inches above ground elevation, railings must be included, which can provide the perfect mounting structure for interpretive and educational signage.



Trash + Recycle Receptacles

Trash and recycle receptacles assist in the necessary maintenance and overall appearance of the system. Signage should be provided in conjunction with the receptacles indicating the bin for trash and the bin for recycling, and which recyclables are accepted. Other guidelines to consider include:

- Locating receptacles at every trailhead and each seating area.
    - Placement of other receptacles will depend upon the location of other facilities and areas of group activities are programmed.
- Consider using solar powered, compacting receptacles in areas with adequate sunlight.
- Receptacles should be set back 3-feet from the edge of the trail, but still accessible to maintenance personnel and trail users.
- Receptacle size and style should be selected with the following criteria in mind:
- Expected trash/recycling amount
- Maintenance and collection program limitations
- Durability
- Animal and weather proof features

Drinking Fountains

Drinking fountains allow trail users to hydrate and potentially prolong their experience on the trail. Ideally, drinking fountains should be located near restrooms, at trailheads, within parks and other public gathering places along the greenway trail. Additional considerations and guidelines include:

- Availability to the City's water service.
- Drinking fountains should be located at least 5-feet from the edge of the trail.
- Standard and ADA compliant fountains shall be installed to accommodate all users.
- Drinking fountains should be placed on a well-drained surface, typically a concrete slab at 2% slope.
- Consider using durable and vandal-resistant materials.

Seating

Seating throughout the trail network provides a place for users to rest, meet, or contemplate. Benches can be merely utilitarian or designed to create whimsy and identity along specific trails. Picnic tables are also an option to incorporate into the trail system. They provide places for users to congregate for meals, meeting, or to relax. Factors to consider when selecting and locating seating include:

- Locate benches where appropriate and where there is a demand by users along the greenway, ideally in one-mile increments. Seating within 1/2 mile of trailheads is recommended.
- Locating benches and other site furniture 3-feet minimum from the edge of the trail.
- Benches should be 4-feet from restrooms and drinking fountains and 2-feet from trash and recycling receptacles, light poles, and sign posts.
- Provide benches and picnic tables in areas that offer interesting views, are close to an interpretive element, and offer shade or shelter from seasonal conditions.
- Wheelchair access shall be available at picnic tables and alongside benches; provide access with a hardened surface like concrete or asphalt.
- Provide positive drainage away from the bench and the greenway trail.
- Seating should be securely mounted to the ground.
- Heat absorption should be considered when selecting bench material and color.
- Seating does not only have to be manufactured furnishings, but can take the form of seat walls, retaining or planter walls, boulders, or even tree stumps.

Bicycle Parking

Bicycle parking should be as convenient and abundant as automobile parking and should be easily accessible to cyclists while minimizing any conflict with trail user circulation patterns. Bicycle parking should be located on a hardened surface adjacent to, but not blocking other greenway amenities. Bike racks should be in highly visible locations, parallel to the greenway approach and no more than 25-feet from ingress/egress of the trail. It is also recommended that bike parking be installed at least 5-feet from the edge of the trail to avoid greenway traffic conflicts. Consideration should also be given to avoid conflicts with emergency ingress/egress routes, service access, and authorized vehicular areas. Other bicycle parking guidelines include:

- Locating bicycle racks at restrooms, trailheads, points of interest, and overlooks and viewing areas.
- Bicycle racks should support the bike in at least two places.
- Bicycle racks should allow locking the frame and one or both wheels with a U-lock.
- Ensure the rack is securely anchored via in-ground mounting or surface mounting mechanisms.
- Consider bicycle racks that are durable; resisting scratches, rusting, heat absorption, and bending.

Bicycle Repair Stations

Bicycle repair stations are small work stands that offer a complete set of tools necessary for routine bicycle maintenance and repair. Preferred locations for the repair stations include major and minor trailheads and rest stops throughout the trail network. Consider grouping repair stations with other amenities like seating, bicycle parking, and drinking fountains.

While bicycle repair station tools are secured by durable, high security cables, they will still be an enticing target for theft and vandalism. Locating stations in areas of high activity and visibility is one strategy to thwart potential negative behavior.

Public Art

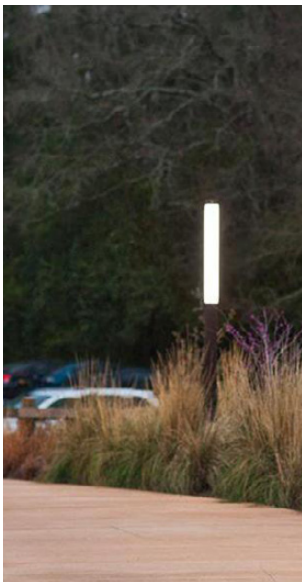
Public art engages the community, ignites imaginations, and creates a memorable experience for greenway users. Art and sculpture can strengthen a greenway's identity and heighten the emotional attachment between Concord's Bicycle and Pedestrian System and its users. Public art can be aesthetic and/or functional, serve as a public attraction or double as seating, shelter, or gathering areas. Art installations throughout the network become landmarks and act as both useful wayfinding mechanisms and a means by which to tell fascinating stories about Concord's culture and history.

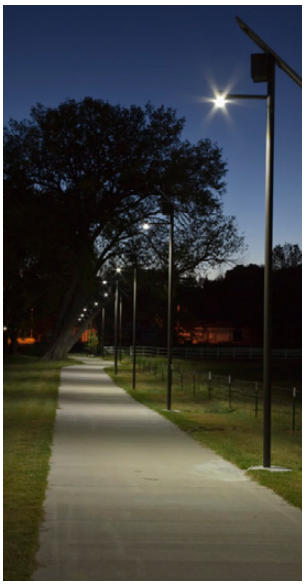
- When incorporating art along the greenways, it is recommended to consider the following.
- Artists may be commissioned to create works at a single location or on multiple sites throughout the network.
- Art on greenway trails provide the most public benefit when located on trails with the greatest expectation of exposure to trail users.
- Artists should engage the public when developing their concept to obtain the flavor and passion of the local community.
- If an artist(s) has been selected prior to planning and design services, it may be beneficial for them to engage in the project process.
- Artists should be encouraged to produce artwork in a variety of materials for sites along the corridor.
- Site furnishings and amenities may also act as art installations. Key intersections or areas where there is a distinct change in the ecology may be worth showcasing and enhancing through the inclusion of public art.
- If multiple artists are displayed throughout the network, consider how to balance the design continuity with the artists' unique vision.
- Community produced art and/or temporary installations should also be considered.

Lighting

Lighting can improve visibility and safety, both real and perceived. Lighting is especially beneficial along commuter corridors, particularly during the winter, as darkness lingers in the morning and comes early in the evening. Lighting may also be necessary in pedestrian tunnels to illuminate the passage during day-time use. Additional thoughts to consider are listed below.

- Lighting is best used at the following locations:
  - Trailheads and parking areas
  - Restroom facilities
  - Major trail intersections to assist with navigating through the network
  - Bridge entrances and exits and in pedestrian tunnels
  - Pedestrian street crossings
- Light emitting diodes (LED) are low cost fixtures offering a range of styles, light levels, optics, and colors. Using LED fixtures for new installations and retrofitting existing fixtures to accept LED lamps can reduce long term utility costs.
- Solar powered fixtures are an option where the connection to the electrical utility line would be difficult or cost prohibitive, or where using an alternate energy source is preferred.
- Trail lighting should be pedestrian scale and the lighting design for each corridor where illumination is desired should be analyzed to determine appropriate light levels for that specific location.
- Light fixtures placed at eye level could impair one's vision. Avoid eye level installations.
- Direct glare or illumination beyond the greenway property or easement onto adjacent properties, streets, or sidewalks is not permitted. Fixtures can be provided with full cut-off/shielding and luminaires can be designed with specific optics to direct light only where needed.

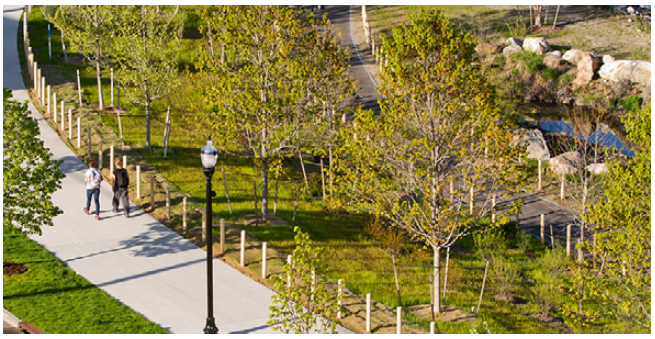




Landscape

Landscape is often used to aesthetically enhance, screen, or define spaces along a greenway. Landscape can also improve degraded riparian corridors, providing bank stabilization and shade for waterways to boost water quality and improve stream habitats. Other uses and considerations regarding landscape can be found below.

- Plant material shall be suitable for site specific conditions and either native or adaptive species that thrive in our region.
- Plant material should be low maintenance and support the character of the greenway.
- Plant material scale/size shall range from groundcover to large canopy trees based on their location and purpose and shall meet sight clearance requirements as required.
- Use landscape to define and enhance edge conditions with adjacent developments, neighborhoods, and open spaces.
- Remove invasive species when developing a new greenway corridor and institute an invasive species management program to eradicate and control invasives along established greenways and riparian corridors.
- Preserve existing vegetation where possible to emphasize the conservation of natural habitat.
- Use landscape to frame stunning and/or culturally significant views.



11. BRANDING + WAYFINDING

Concord's Parks and Recreation Department has an amazing brand that includes consistent, monumental sign standards and a whimsical greenway icon that brings attention to and guides users through the greenway system. When bolstering the signage and wayfinding amenities throughout the system, the existing design should be followed to remain true to the aesthetic and clarity of the system.

Additional elements of the signage and wayfinding system should also be incorporated into the greenway network. Trailhead markers help trail users and drivers on adjacent roadways identify trail locations, making navigation through the network safer. Other safety signs should be designed and located per MUTCD regulations. A cohesive signage standard contributes to the safety and ease of which a new (or even experienced) user navigates through the network.

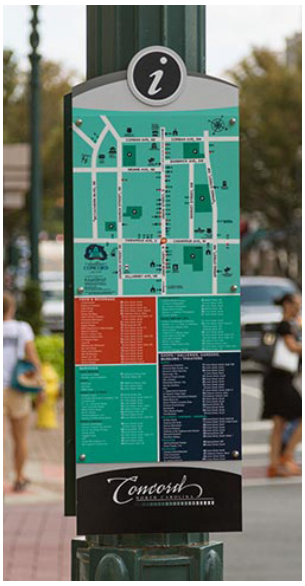
A successful signage network will provide a sense of identity and utility for the greenway trail network. The program adheres to a consistent, selective, and strategic manner so as not to clutter or dominate the visual character of the greenway trails. Signage types throughout the network may include directional, regulatory, etiquette, interpretive, and informational. More information about for each sign type is included in this section with guidelines and suggestions to consider.

Destination / Directional Signs

Wayfinding is the ability to navigate through your surroundings, using visual cues like signage, landmarks, or natural features. Within a bicycle and pedestrian network, wayfinding or directional signage is typically situated at locations that lead to greenway access, along greenway trail routes, and at the intersection of multiple trails. Signs throughout the network should communicate direction of travel options, location of popular destinations, and location of access points where users can enter or exit the network. Wayfinding signs also visually signal motorists that they are traveling near a greenway trail corridor and should proceed with caution.

Directional signage increase users' comfort level with the trail network, providing them with an increased level of safety and security as they successfully navigate the system. Wayfinding signage can serve many additional functions as well; functions such as:

- Encouraging new patrons to use the greenway trail system by identifying access points
- Helping users determine the best route to desired destinations.
- Assisting emergency responders and patrons by identifying locations, in case of emergency on the trails.



Regulatory / Safety Signs

Regulatory signs indicate rules or laws that must be obeyed and typically apply to intersection control (e.g. stop or yield), speed, vehicular circulation pattern, and parking. Other signs may simply call out hazardous conditions, like slippery when wet or tight turning radius, both of which showcase conditions where caution should be used to maintain user safety.

Figure 17 – MUTCD- Regulatory Signs and Plaques for Bicycle Facilites

Etiquette Signage

Etiquette signs inform trail users of desirable or acceptable behavior along the trail system. Such guidance is a common when multiple user types are anticipated within the same corridor. For example, yielding the right-of-way to pedestrians may be considered a courtesy, but is a necessary component of a safe trail experience. Trail etiquette messages must be easily understood and should be posted at access points and regularly along the trail.

Interpretive Signage

Interpretive signage displays information about the surrounding context; notable environmental, wildlife, and vegetative features or the significance of historical or cultural elements. Interpretive displays may be combined with public art or have interactive, technological components, and typically are geared to provide educational opportunities to users. The character of each greenway and surrounding environment must be considered when designing these signs. Other considerations include:

- Working with experts in the field within which you are developing information for each sign such as historians, ecologists, or horticulturists.
- Separating interpretive signage from the main circulation path so that patrons can stop to engage without impeding regular greenway traffic, ideally at rest or gathering areas.
- Signage panels must be ADA accessible so that they can be enjoyed universally by all users.

Information Kiosks

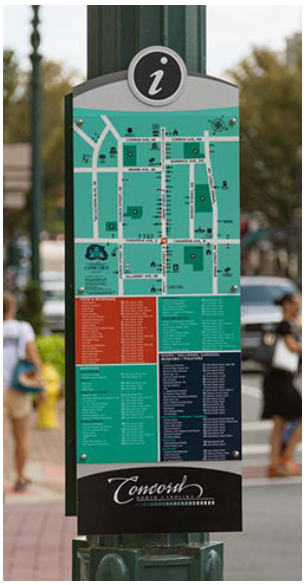
Information Kiosks relay pertinent information to patrons so that they may orient themselves within the trail network, familiarize themselves with rules and regulations of the greenway system, identify potential areas of interest, and be notified of upcoming program opportunities. When providing information kiosks, Concord should consider:

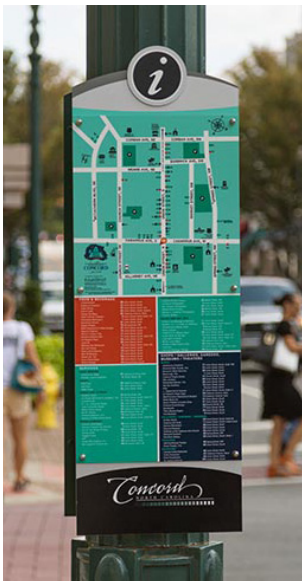
- Installing kiosks at each trailhead, designed using ADA access guidelines as applicable.
- Setting kiosks away from traffic when locating adjacent to parking facilities and incorporating appropriate barriers to protect the structure.
- Posting at a minimum, a map of the full bike/pedestrian network and rules and regulations at each kiosk.
- Evaluating the incorporation of modern technology in the kiosk design to assist in the communication of up-to-date greenway information and messages.

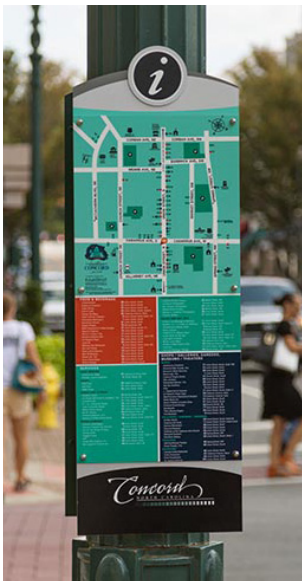
Pavement Markings

Pavement markings are typically used to reinforce posted greenway signage. However, pavement markings should not replace signage. While center line striping is the most common type, warning, regulatory, and directional markings may be incorporated. To direct as much attention as possible to these pavement marking notices, they should be used sparingly. Other guidelines are listed below.

- White or yellow high visibility thermoplastic material is the most durable and visible.
- Safety pavement markings to consider include “Stop,” “Yield,” and “Slow” or road name identification at road crossings.
- Pavement messages should be placed at access points, near intersections with other trails, or prior to roadway intersections and bridges.
- When centerline striping is utilized, use a yellow, 4-inch dashed centerline stripe and a white, 4-inch solid line at trail edges. Solid centerlines should be used at tight or blind corners and on the approaches to road crossings.
- Always use non-slip or nonskid pavement marking materials.







12. PERMITTING

Building any greenway trail will require obtaining construction permits. Depending on the location and amenities proposed, obtaining permits will require coordination with various agencies at the local, state and/or federal levels. Potential required permits for greenway trail construction may include:

- City of Concord Zoning Clearance/Stormwater Installation /Grading Permit
- Cabarrus County Building Permit (for structures)
- North Carolina Department of Transportation Encroachment Permit
- Other public agency encroachment agreements / permits may be required as well
- North Carolina Department of Environmental Quality Erosion and Sediment Control Certificate of Approval
- FEMA Conditional Letter of Map Revision (CLOMR)/FEMA Letter of Map Revision (LOMR)
- U.S. Army Corps of Engineers Section 401/404 Permit, Pre-Construction Notification (PCN) Permit

13. CONSTRUCTION ADMINISTRATION

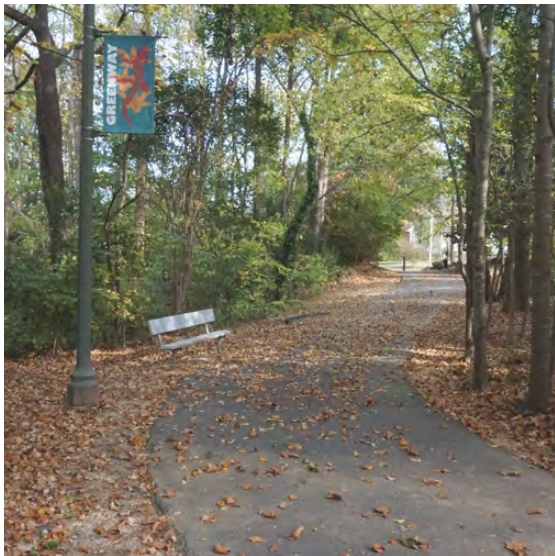
Each construction project must have a certain level of construction administration and inspection services to ensure that the project is being delivered per the approved drawings and specifications. The City may opt to perform construction administration services, utilize the design team to carry out these services, or they can employ a third party. Regardless, the decision should be made up front regarding the preferred direction. It should be noted that if federal or state money is being used as part of the construction budget for a facility, construction administration is required to be performed by an outside, third party. Federal and State projects also require Construction, Engineering, and Inspection (CEI) services be performed by a third-party firm.

Maintenance Considerations

Greenway trail maintenance should be discussed at the feasibility stage of each project to determine the type, interval, and cost of annual trail maintenance. Design consultants should also reduce the maintenance burden through appropriate design decisions. Often there is a tradeoff between higher construction costs and lower maintenance costs and vice versa. As a benchmark, The Ohio River Greenway Development Commission has developed best practices in trail maintenance. For reference, this document is attached in the Appendix. The factors that impact maintenance include:

- Trail Surface - Fully stabilized surfaces like concrete and asphalt have very low annual maintenance requirements. Repaving of asphalt surfaces should be budgeted every 15 years.
- Materials - Likewise bridges and boardwalks with concrete decks have a lower life cycle cost than southern yellow pine decking, which must be replaced every 7-9 years. Other materials choices have lower maintenance costs including; handrails, kick boards, top rails, pickets and signage.
- Location - The location of trails also impacts the County's maintenance burden. Trails of any surface type will require higher a maintenance commitment when they are located within a floodplain that sees regular inundation of water.
- User Type – Different users impact the life of trails. Natural surface trails dedicated to walking and running require substantially less maintenance than mountain biking.

7 recommendations



CHAPTER 7 > RECOMMENDATIONS

The proposed open space connectivity network traverses through differing development densities and connects various destinations City-wide through a series of linked greenway trails, multi-use paths, and expanded bike and sidewalk facilities strategically located to connect residential neighborhoods, commercial centers, schools, transit stops, existing parks, and future recreation amenities.

The overall connectivity network is focused on meaningful connections and opportunities to provide more mobility and access to users, to improve their health and wellbeing, and to enhance economic impact and environmental protection. This plan prioritizes connectivity improvements for five, ten, and fifteen-year planning horizons by identifying corridors that consider:

- Minimal land / easement acquisition
- Strong support from the community
- The ability to improve access to priority destinations, especially public parks and schools
- Potential for acquisition of land in danger of more immediate development
- Proximity to population growth centers
- Connection to or traversing across isolated, low-income areas
- Facilitation of regional connections

METHODOLOGY

The Design Team's mythology to arrive at the recommendations contained herein included data collection through desktop map analysis, on-site field visits, and public input. Existing bicycling and pedestrian facilities (e.g. sidewalks, bike lanes, multi-use paths, and greenways) and proposed facilities from previous planning efforts were mapped to determine where gaps currently exist and to identify which previously planned corridors have yet to be integrated into Concord's transportation system. This exercise also helped inform the design team about which corridors have been the subject of previous focus and planning efforts and are therefore significant to advancement of the network.

Not only does Concord desire to be a connected community internally, but they want to provide opportunities to link to and become a significant contributor to a regional trail system. The design team explored possible connections to planned or existing trails in the surrounding jurisdictions of Kannapolis, Harrisburg, Cabarrus County, and Charlotte/Mecklenburg County and incorporated connections where feasible.

From these key steps, recommendations were developed in concert with Concord Staff, across City departments, and with the needs and desires of Concord residents at the forefront.

THE CITYWIDE OPEN SPACE CONNECTIVITY NETWORK

The Concord open space connectivity network intends to:

- Provide easily accessible connections to destinations.
- Provide facilities that safely accommodate multiple user types, abilities, and ages.
- Provide access to the greenway trail system from the street network.

In the following Network Recommendations section, the open space connectivity network will be presented through maps at various scales and levels of detail. These include:

- The Overall Network
- Small Plan Study Areas
- Detailed Greenway Corridor Studies

NETWORK RECOMMENDATIONS

THE OVERALL NETWORK

The largest scale of analysis is presented in a series of maps that layer existing and proposed bicycle and pedestrian facilities to build a connected network.

During the design process, it became evident that the existing greenway trails, sidewalks, and bicycle facilities are important to the City's transportation system and that the public desired to expand upon the existing network with additional bicycle/pedestrian facilities throughout the City.

To respond to this unmet need, the overall connectivity network builds upon existing facilities with proposed greenway corridors, multi-use path corridors, and sidewalks as well as identifying prominent intersections in need of improvement to accommodate bicycle and pedestrian movement.

Proposed Greenway Corridors

The network plan recommends greenways along Rocky River, Coddle Creek, Irish Buffalo Creek, Three Mile Branch Creek, and Academy Branch as previously identified in the City's planned greenway system. In addition, greenway corridors are recommended along Clarke Creek, Stricker Branch, Cold Water Creek, Reedy Creek, Wolf Meadow Branch, tributaries of both Rocky River and Coddle Creek, the North Carolina/Bootsmead Rail Spur, and the Great Philadelphia Wagon Road.

Within the proposed greenway corridors, several were examined more closely to develop specific recommendations for segments of the Hector Henry Greenway (Rocky River), Clarke Creek Greenway, Coddle Creek Greenway, and Irish Buffalo Greek Greenway. Recommendations from that analysis can be found within this section under "Detailed Greenway Corridor Studies."

Proposed Multi-Use Path Corridors

Given the significant overland mileage to connect people to destinations east to west through the City, it is recommended that Concord coordinate closely with the North Carolina Department of Transportation (NCDOT) to implement multi-use paths and/or greenway segments along state highways. For example, Concord has requested a multi-use path on the south side of Poplar Tent as part of NCDOT's widening project - STIP Project #U-3415A.

On the following maps, it should be noted that the multi-use corridor lines that are located on a specific side of a road (like Poplar Tent Road) denotes a specific recommendation or predetermined location. If the multi-use corridor line is located along the centerline of the road, a specific location(s) shall be determined upon more detailed analysis of the corridor during subsequent phases of corridor and feasibility studies. The City must evaluate these corridors on a case-by-case basis to determine the appropriate treatment based on citizen input, road type/speed limit, number of travel lanes,

volume of vehicular traffic, etc. Multi-use paths are recommended along:

- Davidson Highway (NC-73) widening – STIP Project #R-5706B
  - Requested multi-use paths - both north and south side
- Poplar Tent widening from Woodhaven Place/ Gable Oaks Lane roundabout to George Liles Parkway – STIP Project #U-3415A
  - Requested multi-use path - south side
- Union Cemetery Road Realignment with Rock Hill Church Road – STIP #U-5956
  - Requested sidewalks and bike lanes on both east and west side
- Derita Road widening – STIP #U-4910
  - Requested sidewalks and bike lanes on both east and west side
- George Liles Extension future widening from Concord Parkway (NC-29) to NC-49
  - from Roberta Rd south to NC-49 – STIP Project number to be assigned when the TIP is adopted in Summer, 2019
  - Requested multi-use paths - both north and south side

It is recommended that Concord utilize multi-use paths in lieu of sidewalks + on-road bicycle facilities where feasible, as multi-use paths attract the widest range of users, appealing to the "8 to 80" demographic.

Proposed Sidewalk and Bicycle Enhancements

However, due to limited ROW within Historic Downtown and other densely developed areas, it is recommended to widen and/or repair sidewalks where necessary and feasible, filling in the gaps between existing facilities. Where existing conditions permit, accommodate on-street bike facilities like buffered bike lanes, cycle tracks, conventional bike lanes, or shared bike lanes ("sharrows").

Funded Projects

You will also notice in the following maps, identification of several corridors that are funded. These projects have advanced beyond the planning stage and are moving forward with design and construction. Projects that are funded include:

Greenways

- Hector Henry: Riverwalk Phase
- Hector Henry: Airport Phase (Derita Road to Weddington Road)
- McEachern: Hospital Phase (Lake Concord to Burrage Road)

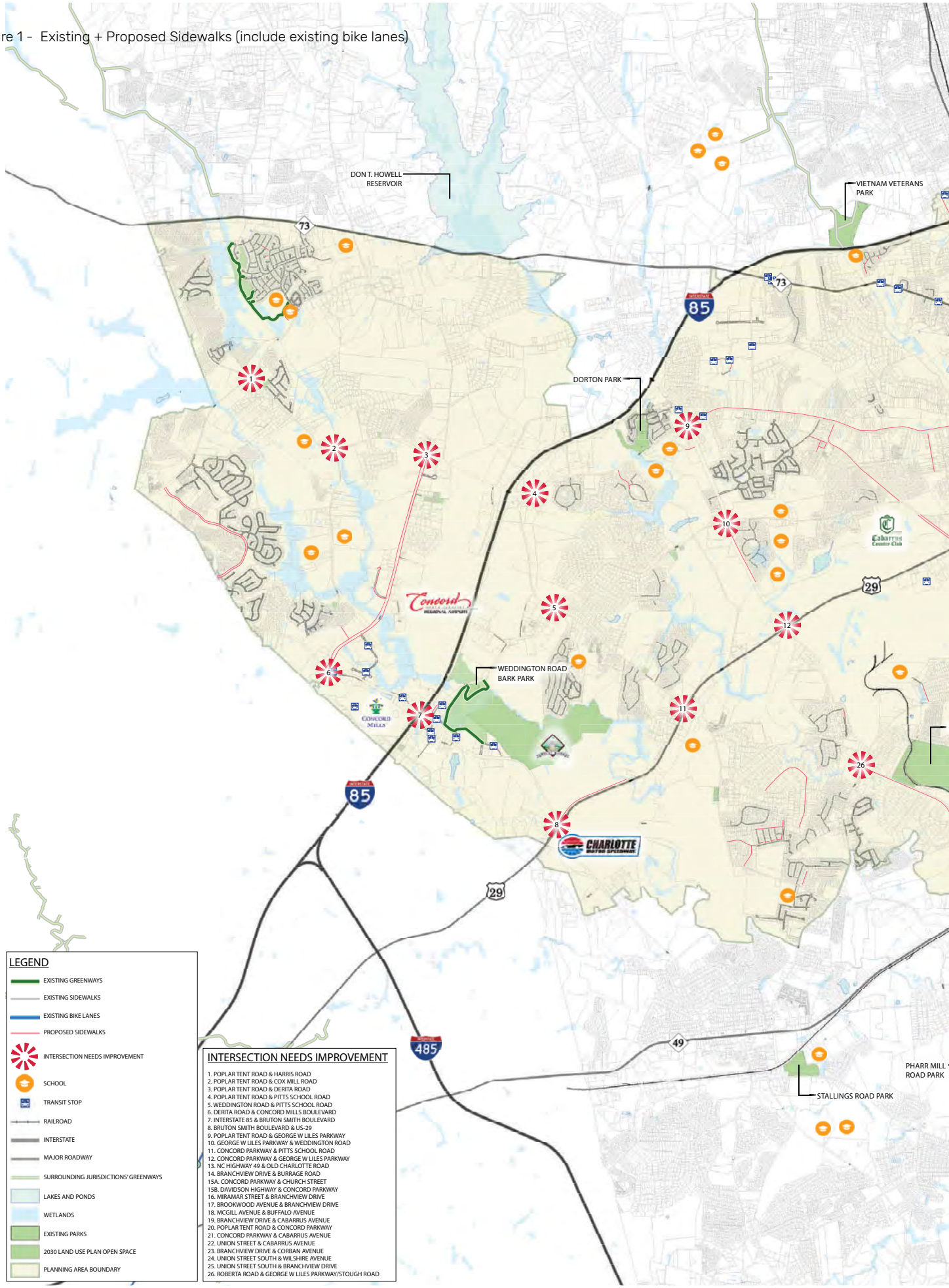
NCDOT – STIP Projects

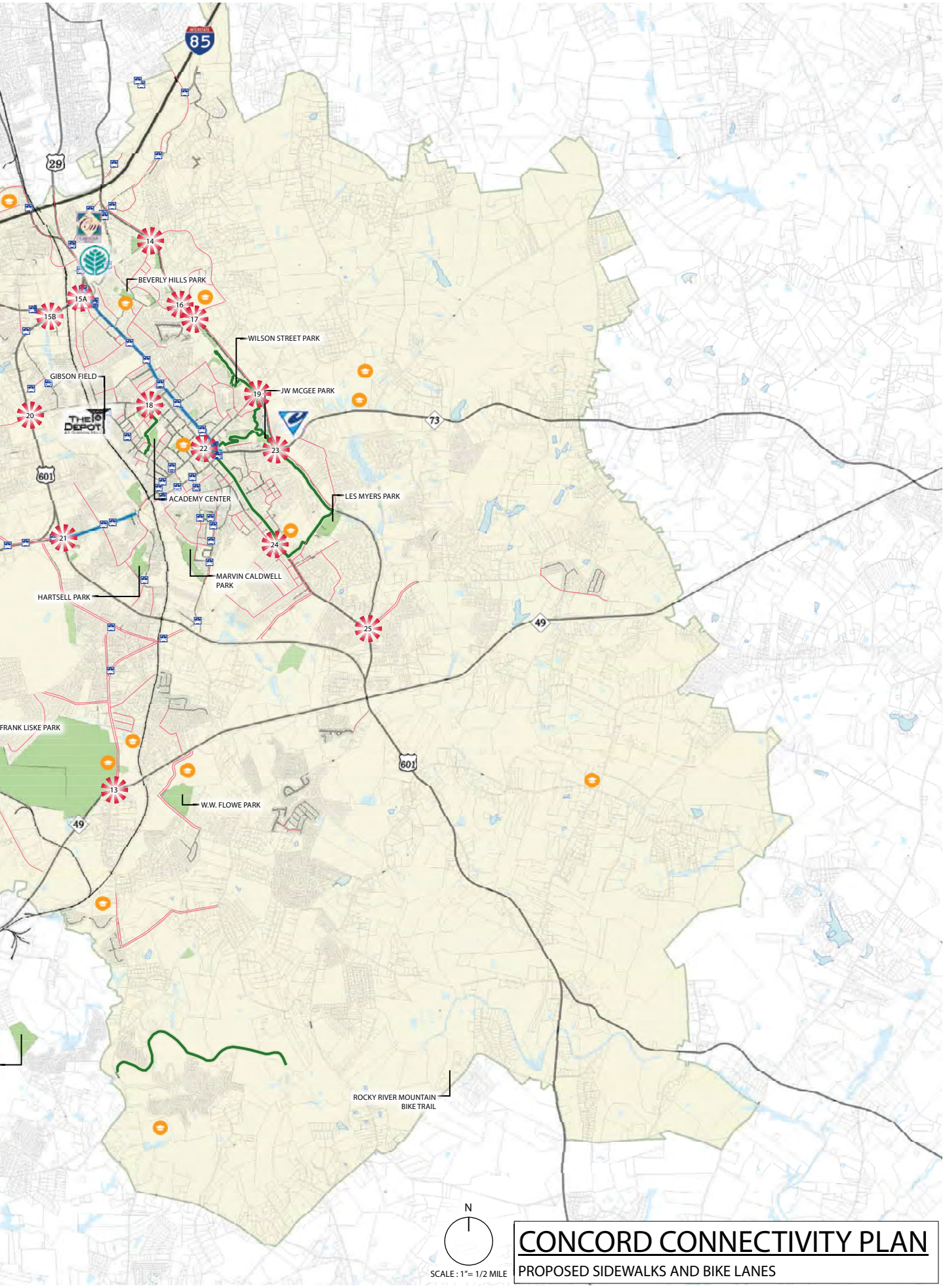
- Davidson Highway (NC-73) widening – STIP Project #R-5706B
  - Requested multi-use paths - both north and south side
- Poplar Tent widening from Woodhaven Place/ Gable Oaks Lane roundabout to George Liles Parkway – STIP Project #U-3415A
  - Requested multi-use path - south side
- Union Cemetery Road Realignment with Rock Hill Church Road – STIP #U-5956
  - Requested bike lanes and sidewalks on both north and south side
- Derita Road widening – STIP #U-4910
  - Requested sidewalks and bike lanes on both east and west side
- George Liles Extension future widening from Concord Parkway (NC-29) to NC-49
  - from Roberta Rd south to NC-49 – STIP Project number to be assigned when the TIP is adopted in Summer, 2019
  - from Roberta Rd north to Concord Parkway (NC-29) – STIP Project number to be assigned when the TIP is adopted Summer, 2019

Multi-Use Paths

- Bruton Smith Blvd from Gateway Lane to Concord Parkway (NC-29)
- Multi-Use Path on north side

Figure 1 - Existing + Proposed Sidewalks (include existing bike lanes)

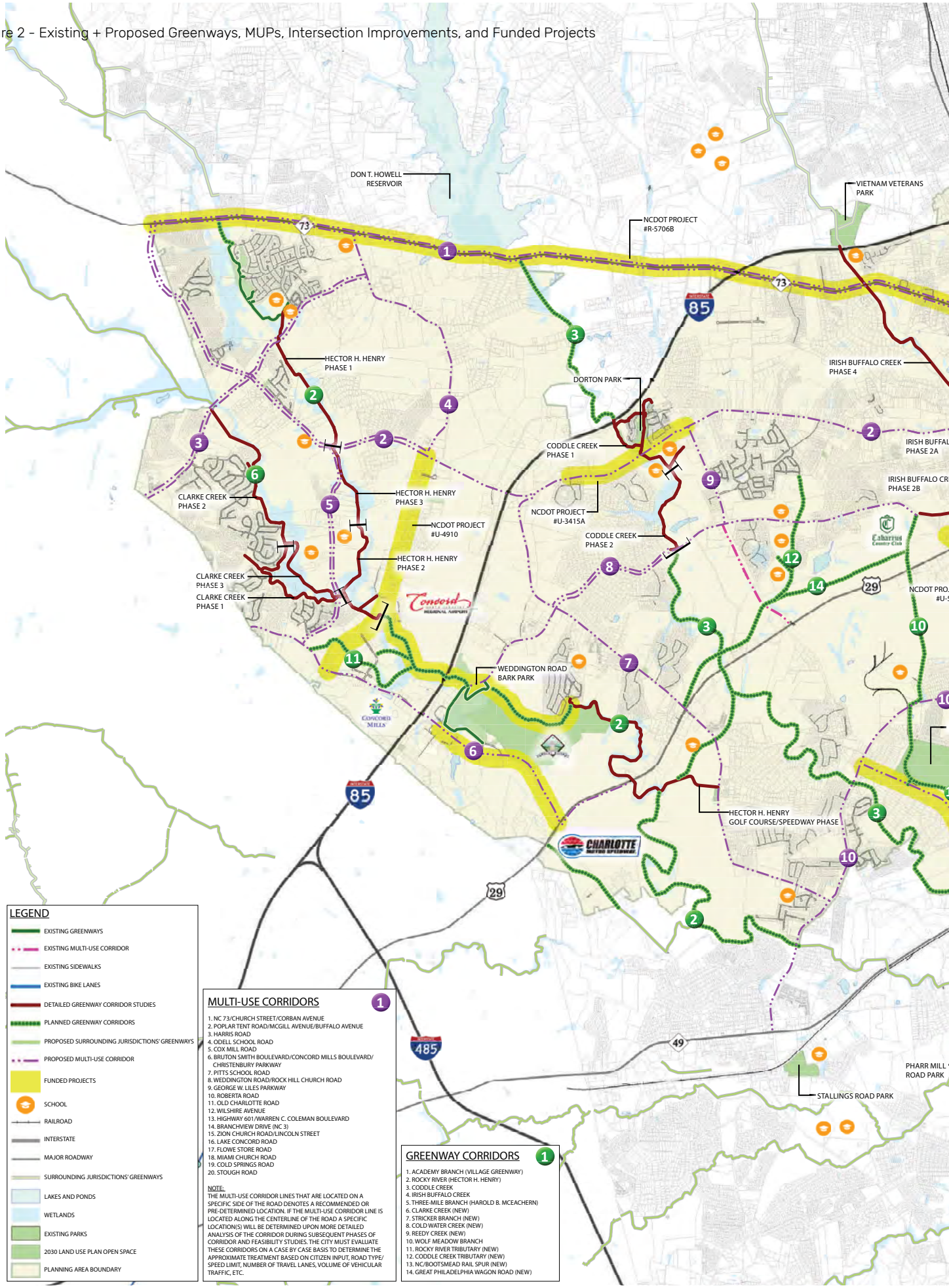


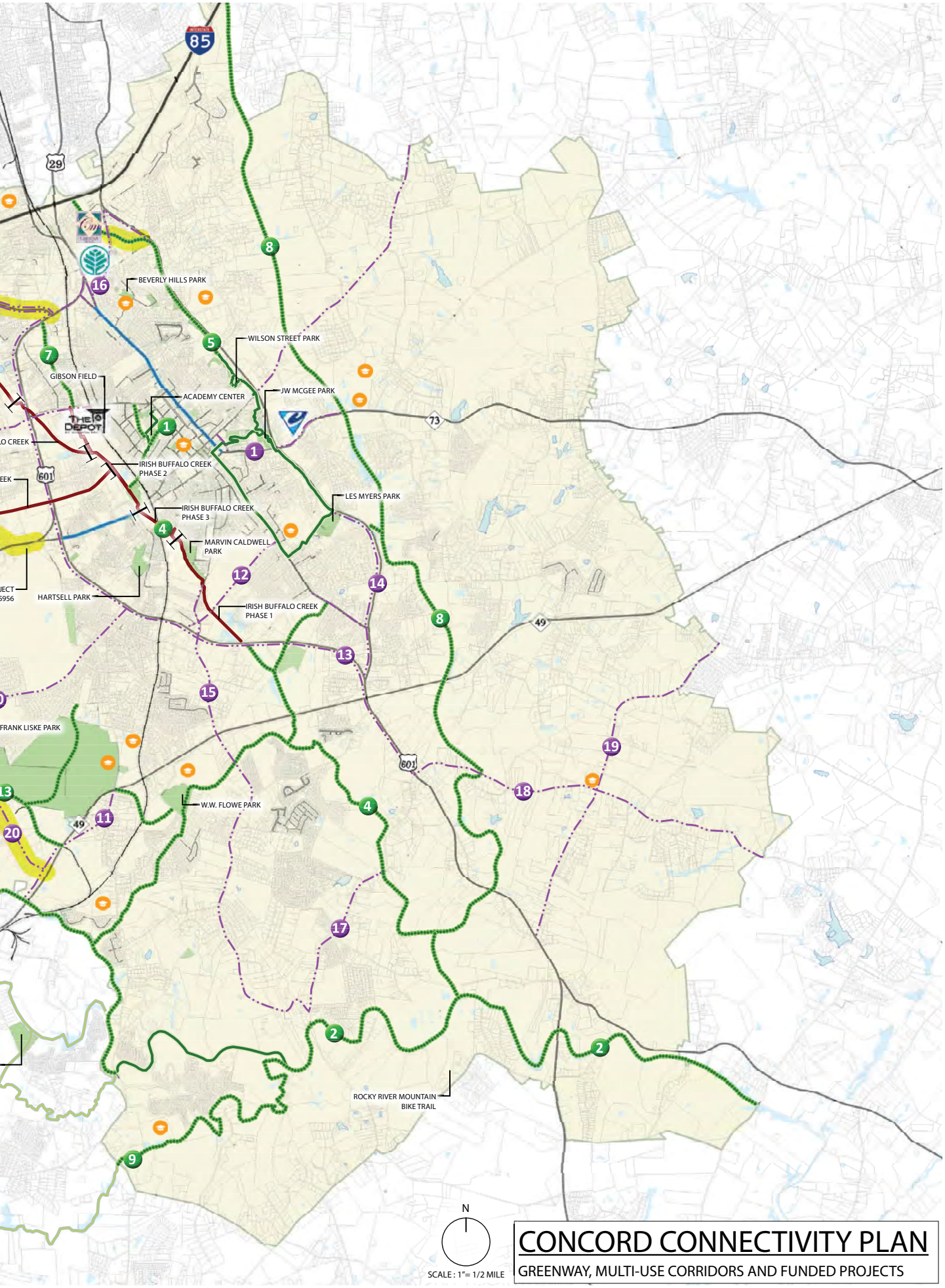


CONCORD CONNECTIVITY PLAN

PROPOSED SIDEWALKS AND BIKE LANES

Figure 2 - Existing + Proposed Greenways, MUPs, Intersection Improvements, and Funded Projects



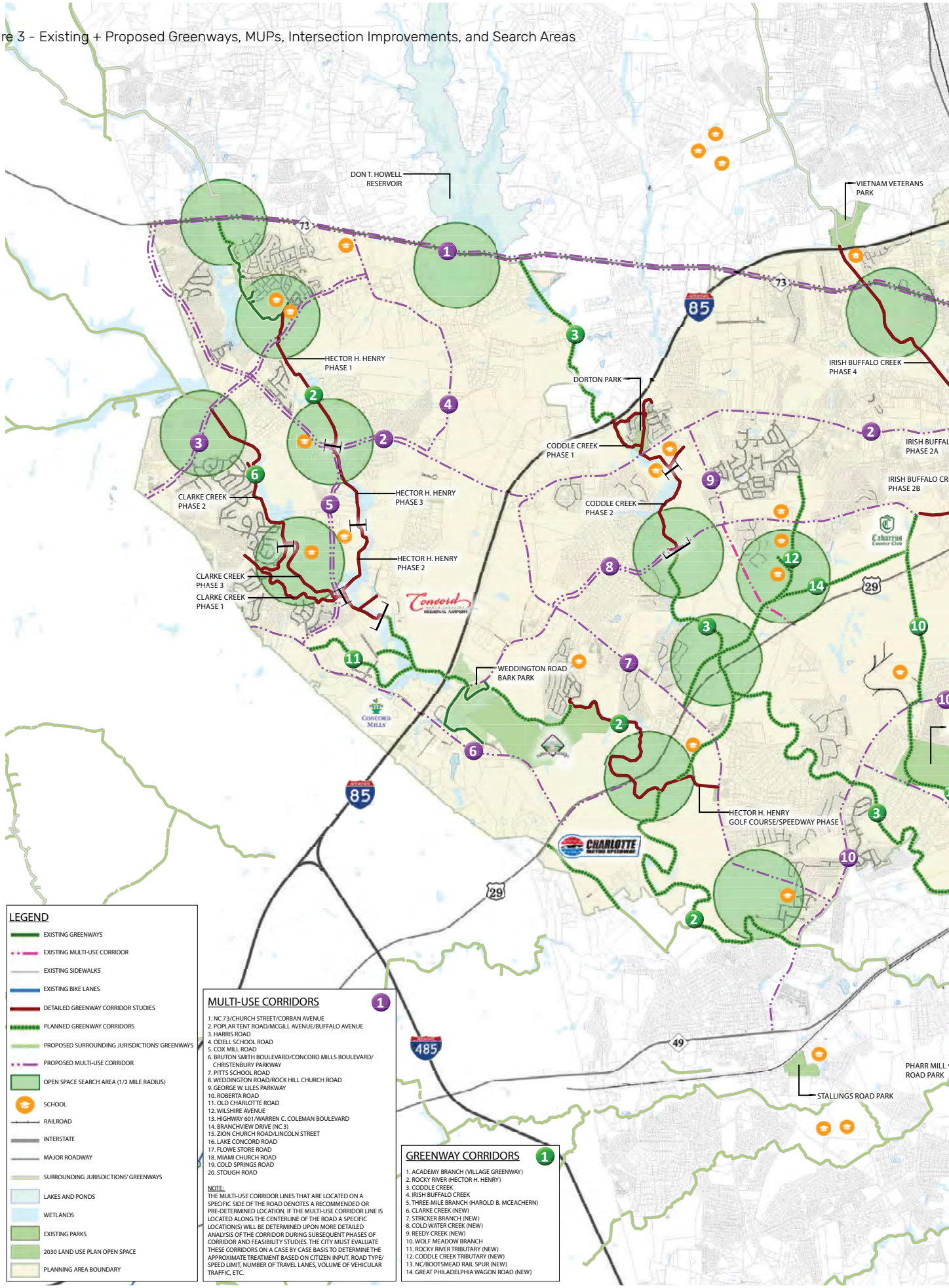


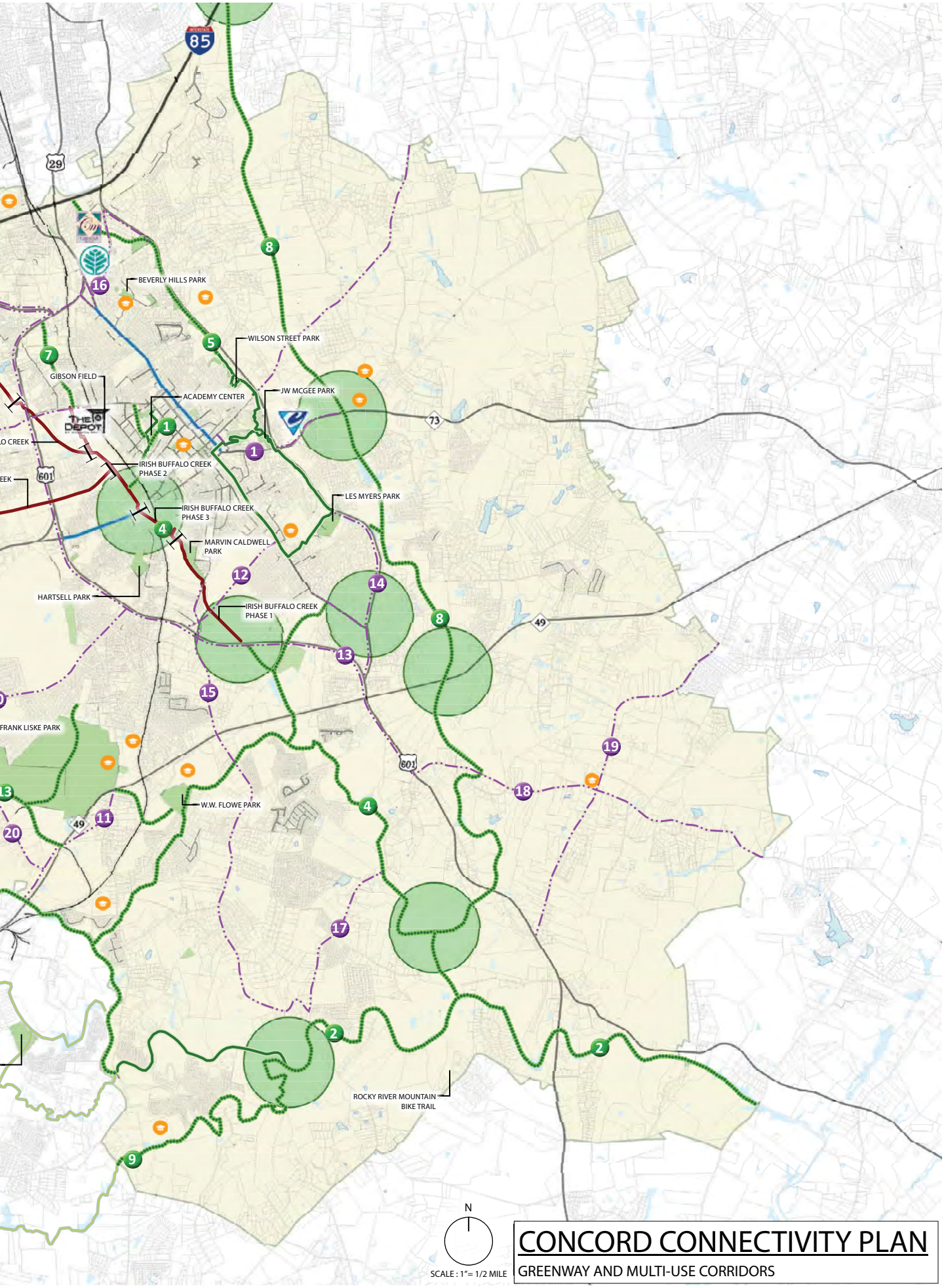
CONCORD CONNECTIVITY PLAN

GREENWAY, MULTI-USE CORRIDORS AND FUNDED PROJECTS

RECOMMENDATIONS

Figure 3 - Existing + Proposed Greenways, MUPs, Intersection Improvements, and Search Areas

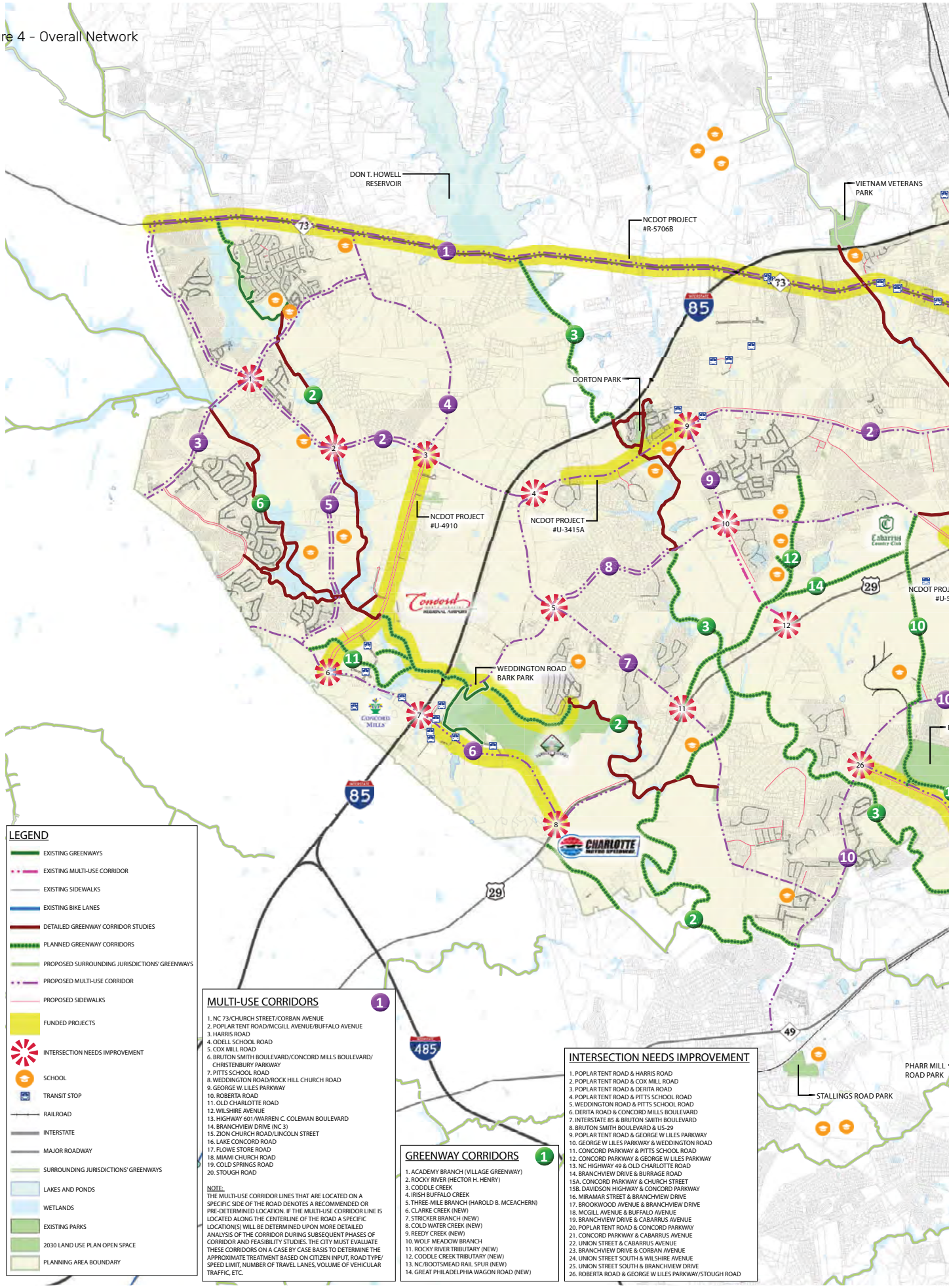


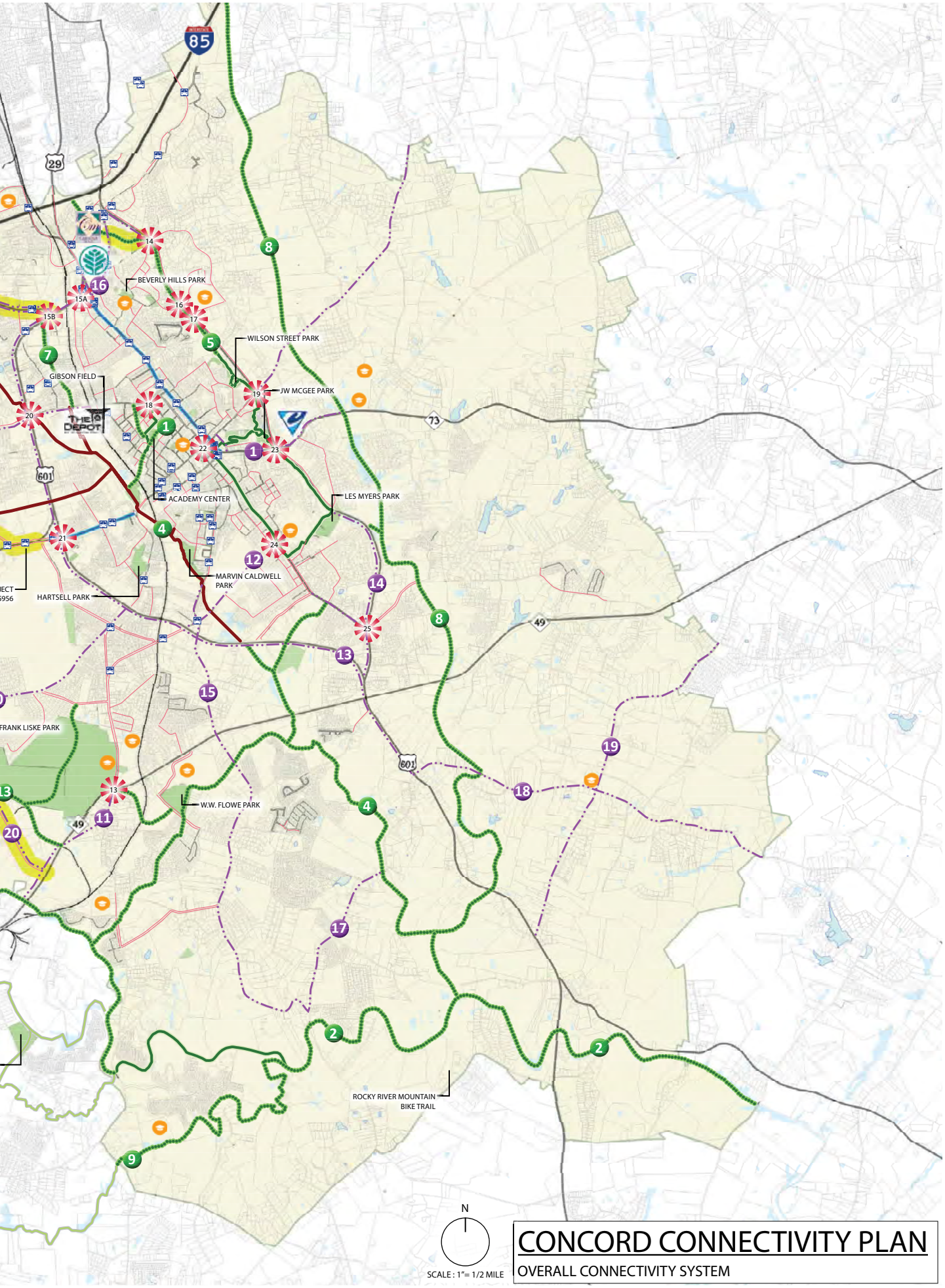


CONCORD CONNECTIVITY PLAN

GREENWAY AND MULTI-USE CORRIDORS

Figure 4 - Overall Network

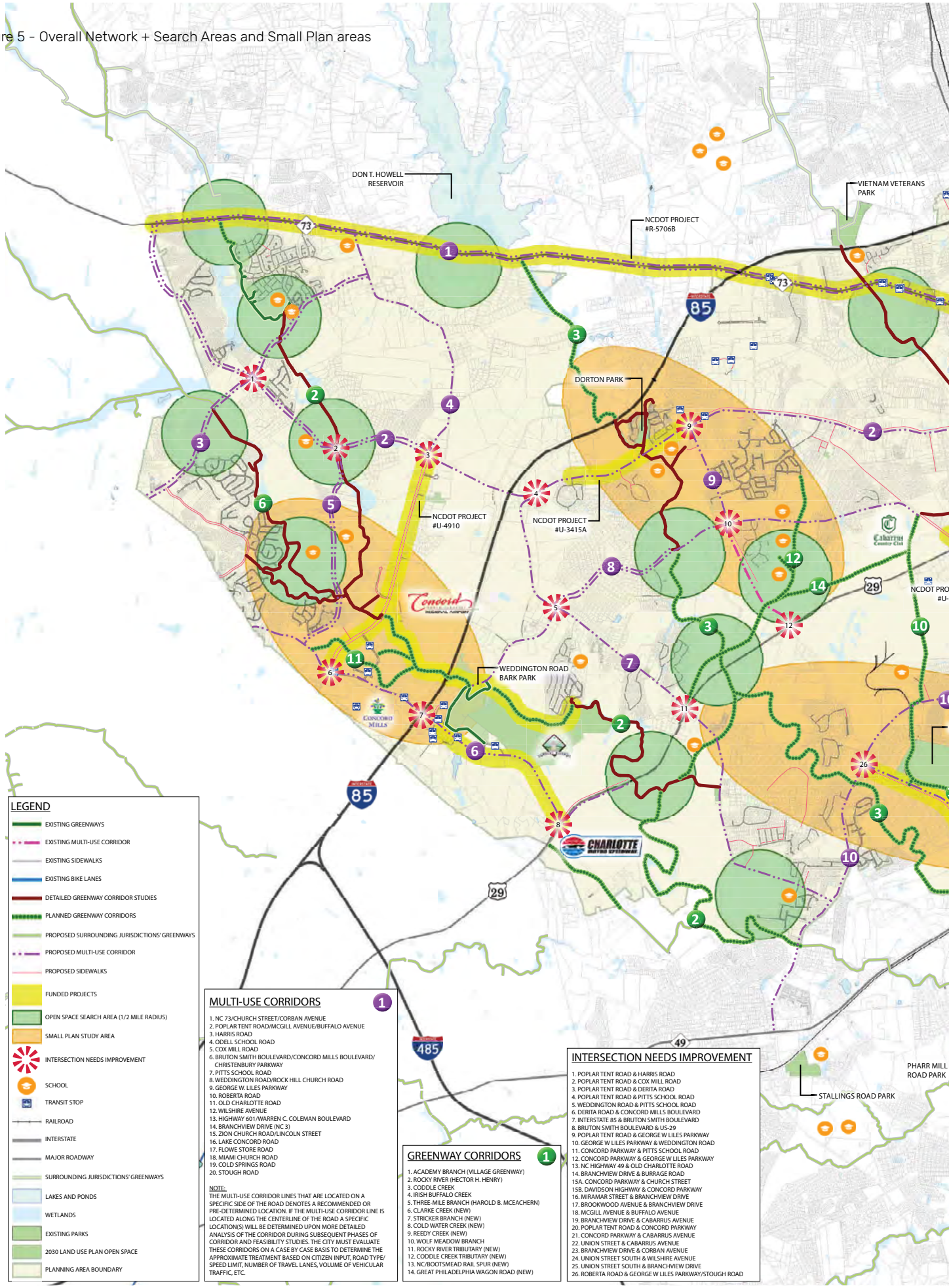


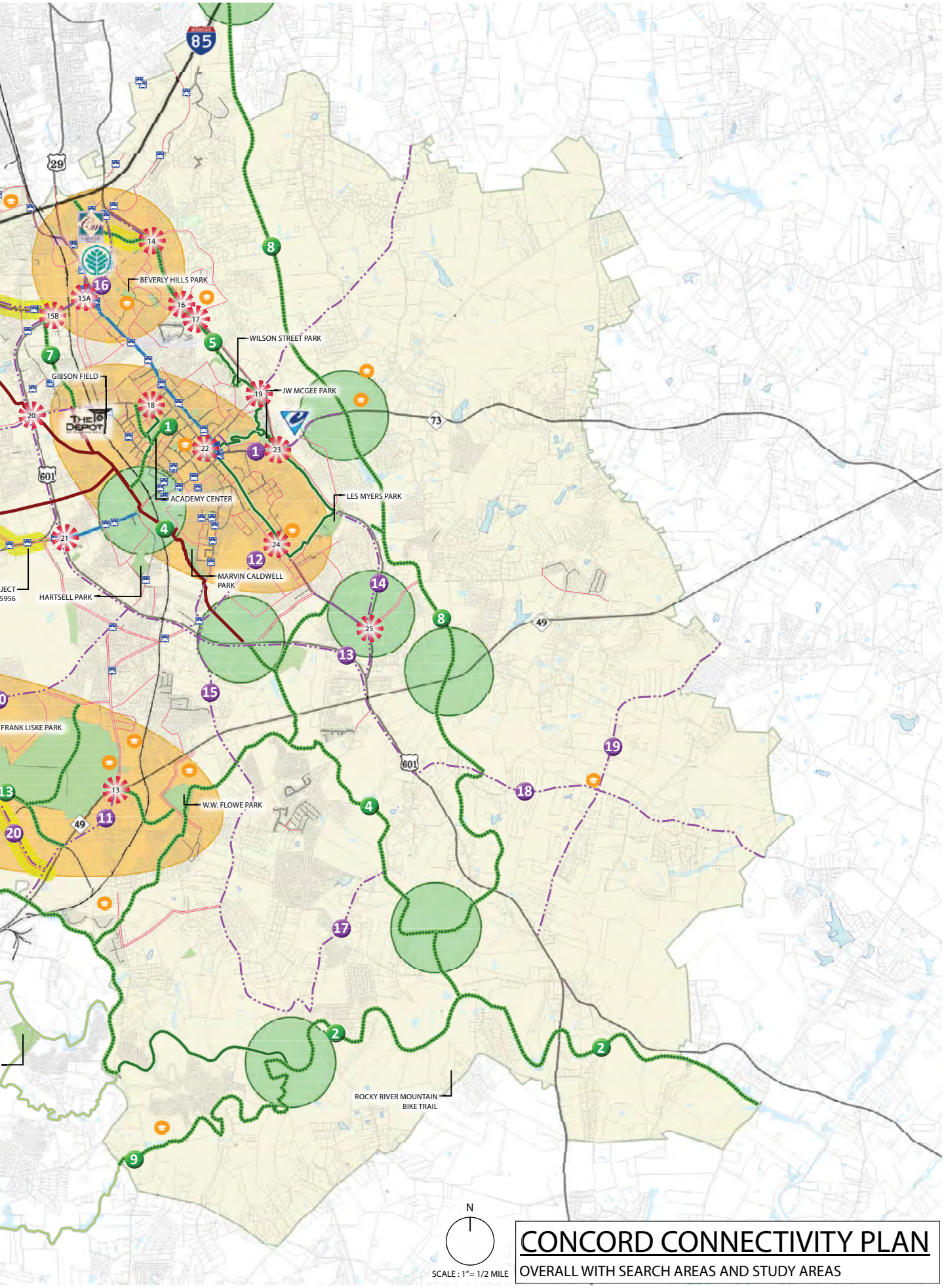


CONCORD CONNECTIVITY PLAN

OVERALL CONNECTIVITY SYSTEM

Figure 5 - Overall Network + Search Areas and Small Plan areas





CONCORD CONNECTIVITY PLAN

OVERALL WITH SEARCH AREAS AND STUDY AREAS

SMALL PLAN STUDY AREAS

The second level of study are known as small plan study areas that explore a finer grained planning analysis of a more focused area, highlighting key destinations and activity hubs to clearly show connectivity through the system. During the process, it was determined that diving into smaller scaled planning areas would offer a greater understanding and projection of proposed connections between existing/proposed pedestrian and bicycle facilities and to existing/proposed destinations (e.g. schools, parks, commercial centers, etc.). The small plan study areas also identify opportunities for key open spaces along trail corridors. These small plan study areas were derived from zones with the greatest concentration of desired destinations as provided by citizens and Staff during the public input process. Five areas were selected and include the following.

- Western Edge Boundary
- Central City Boundary
- South Central City Boundary
- Downtown Boundary
- Hospital Boundary

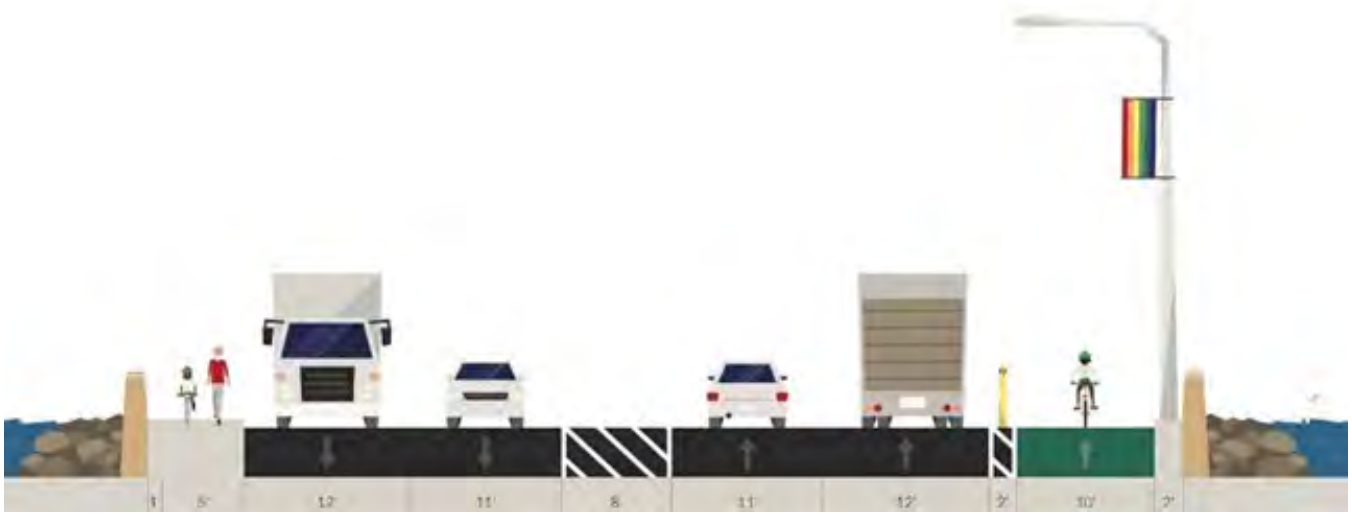


Figure 6 - Cross Section: Weddington Rd. at Hector Henry Greenway (Rocky River) Bridge (Western Edge Boundary)

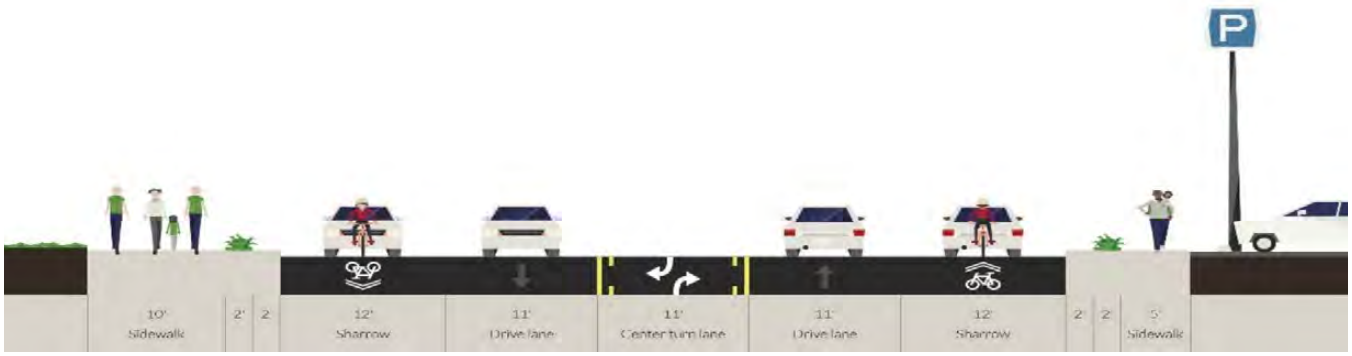


Figure 7 - Cross Section: Poplar Tent Rd. – George Liles Pkwy. to Concord Pkwy. (Central City Boundary)

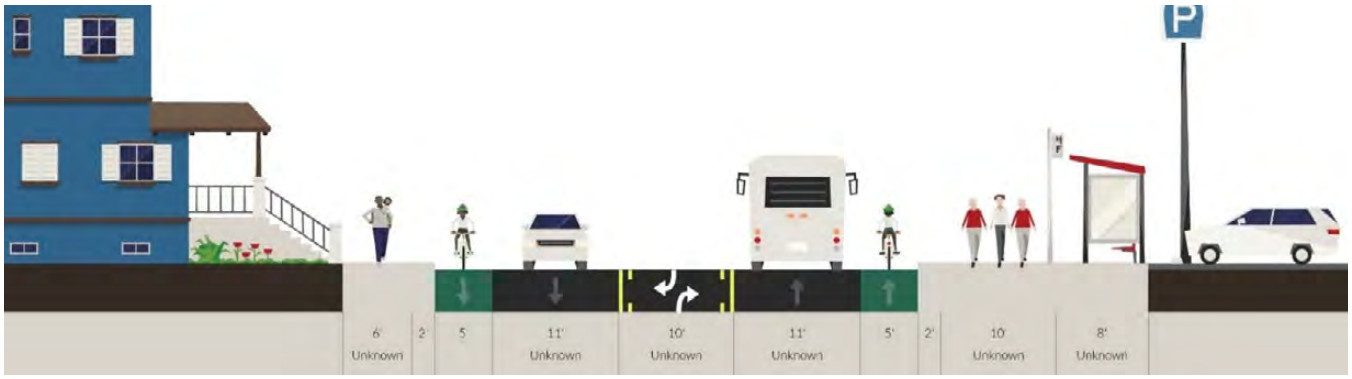


Figure 8 - Cross Section: McGill Ave. – Irish Buffalo Creek to Rail Road (Downtown Boundary)

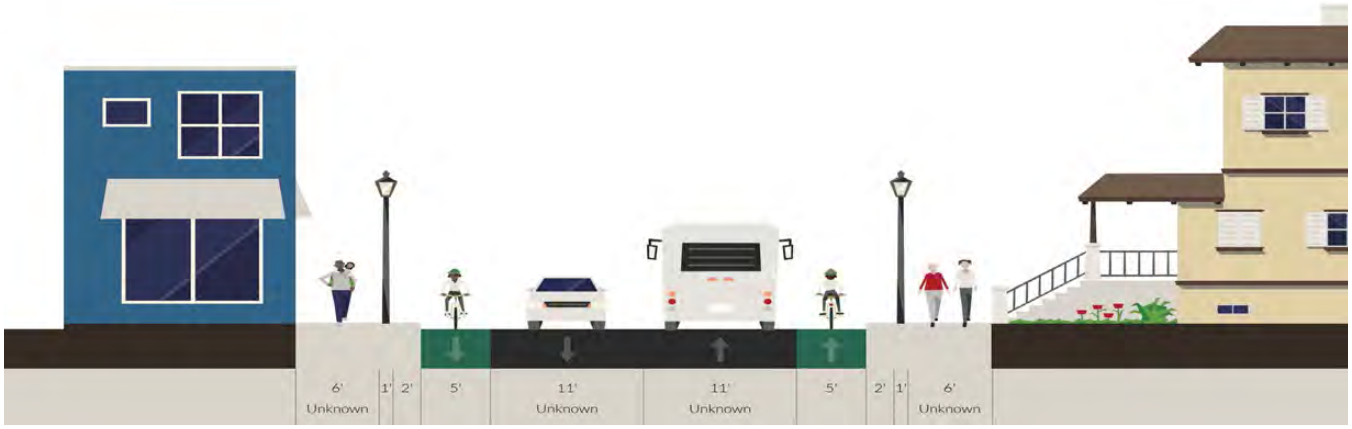


Figure 9 - Cross Section: McGill Ave. – Railroad Dr. to Kerr St. (Downtown Boundary)

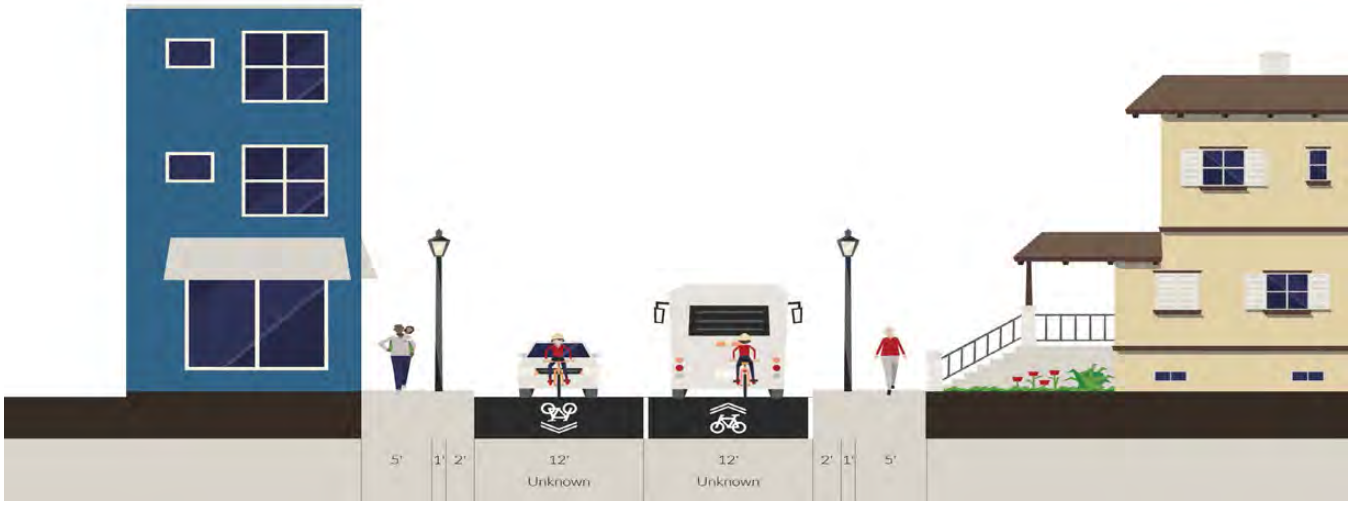


Figure 10 - Cross Section: McGill/Buffalo Ave. – Kerr St. to Church St. (Downtown Boundary)

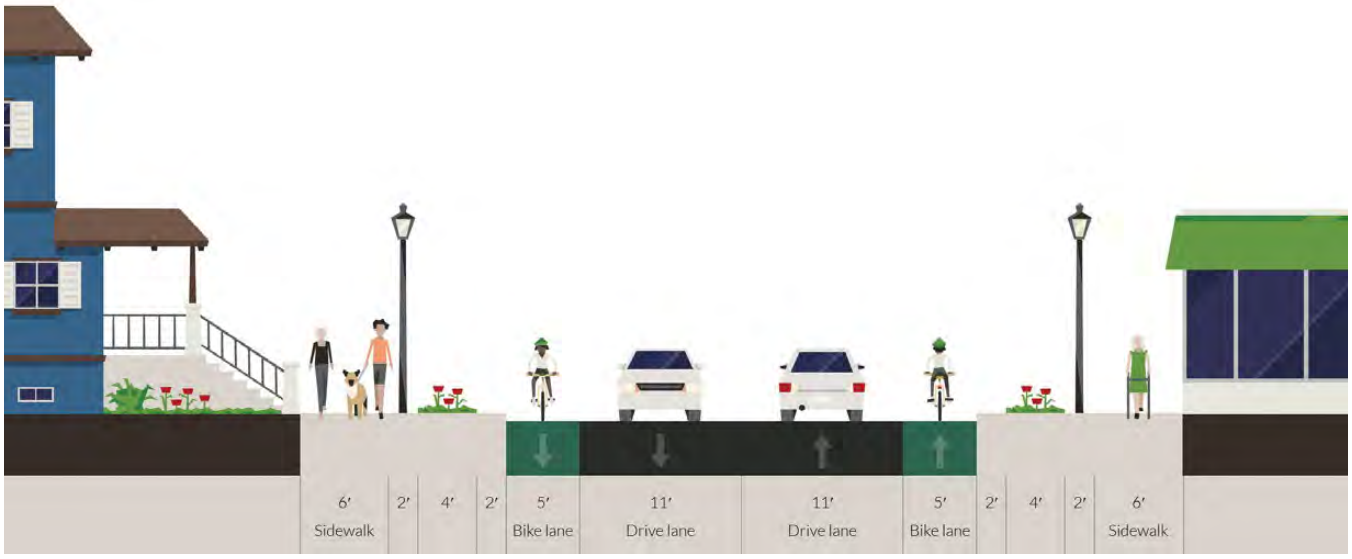


Figure 11 - Cross Section: Cabarrus Ave.
*Note: 60' Right-of-way. At major intersections where turn lanes are necessary, bikers will share the travel lane.

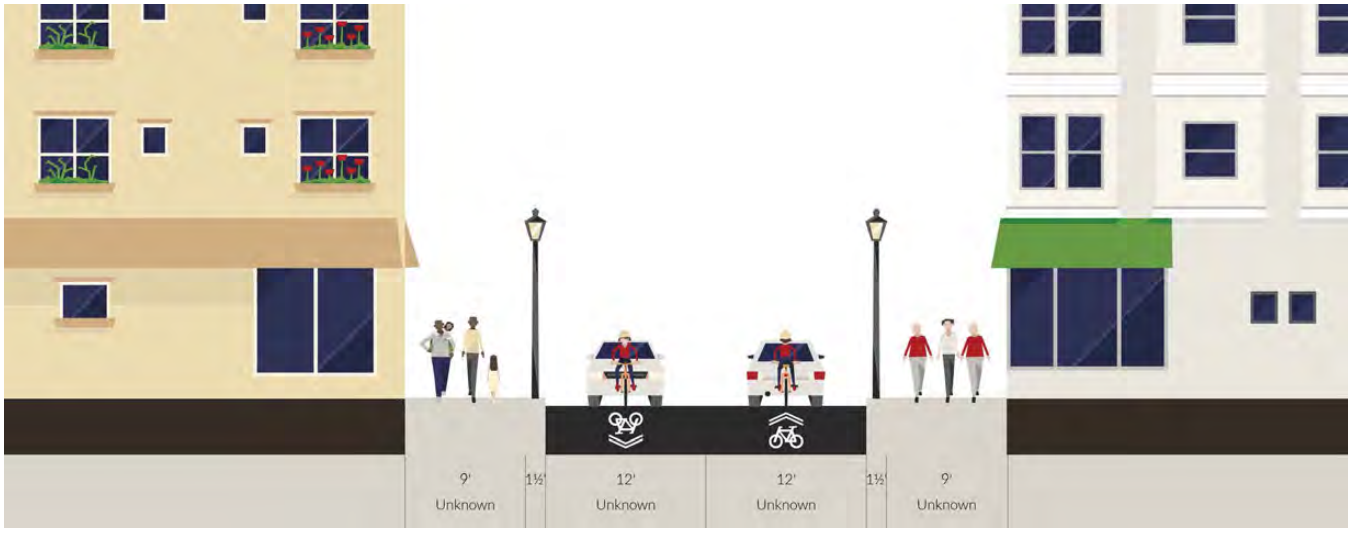


Figure 12 - Cross Section: Cabarrus Ave. – Spring St. to Church St. (Downtown Boundary)

Figure 13 - Cross Section: Kerr St. (Downtown Boundary)

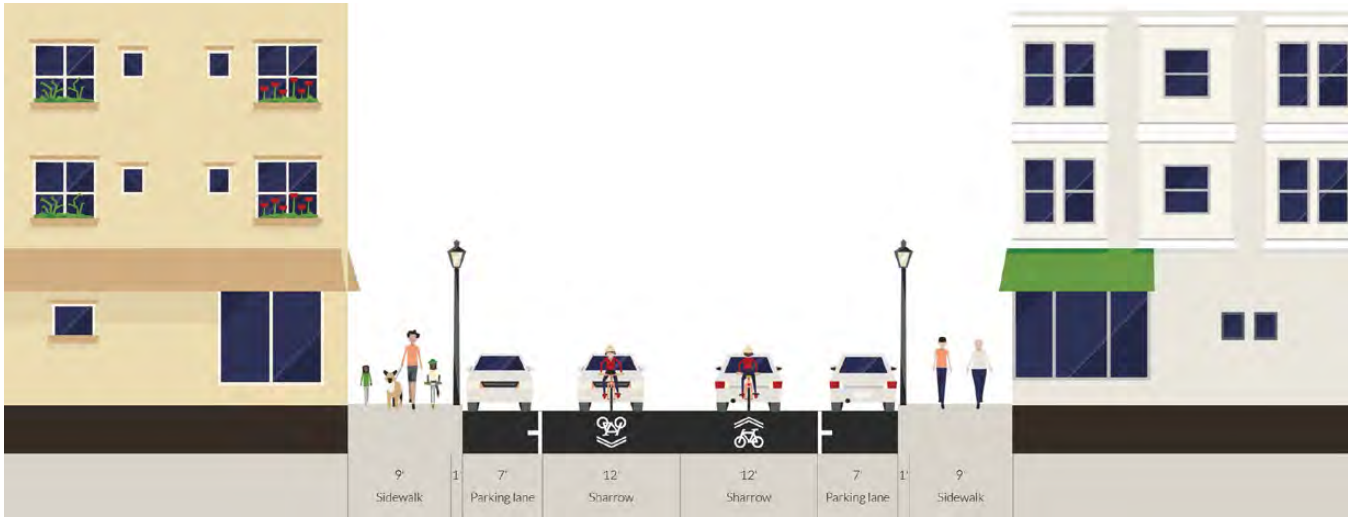


Figure 14 - Cross Section: Union St. (Downtown Boundary)

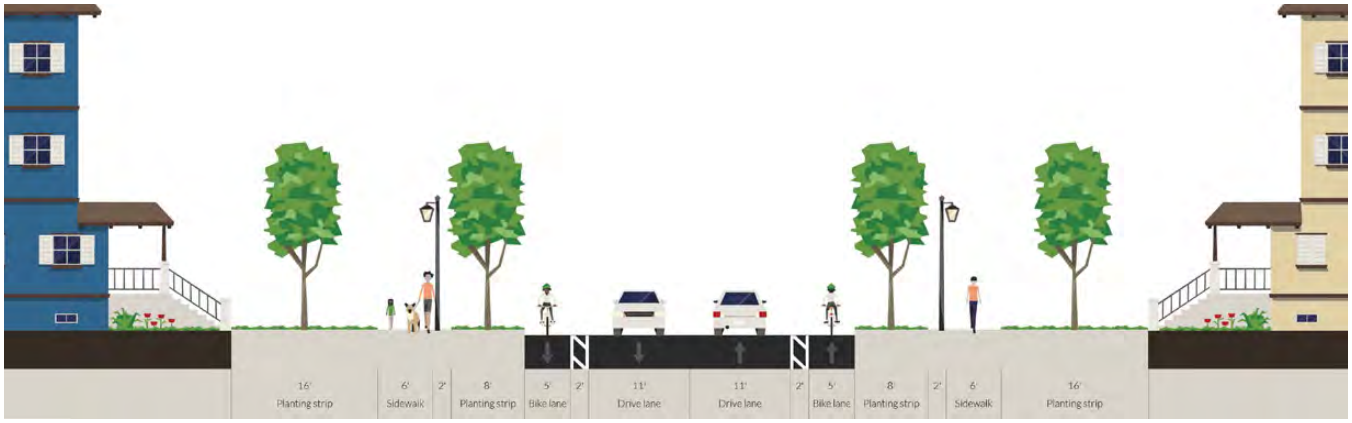


Figure 15 - Cross Section: Union Street South

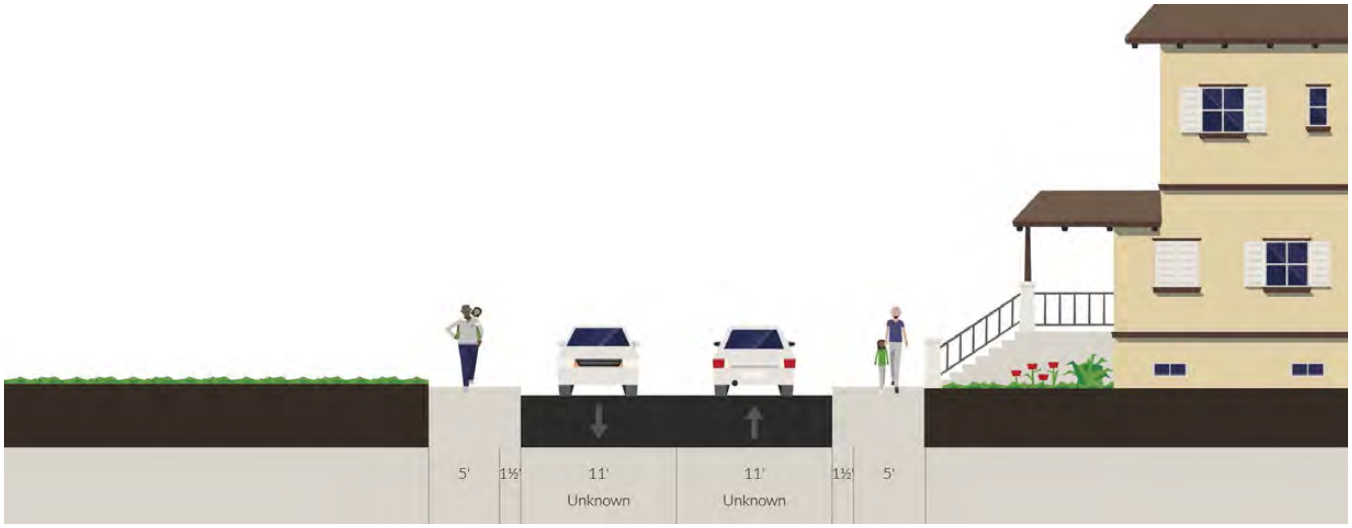


Figure 16 - Cross Section: Georgia St. – Booker Dr. to Caldwell Park (Downtown Boundary)

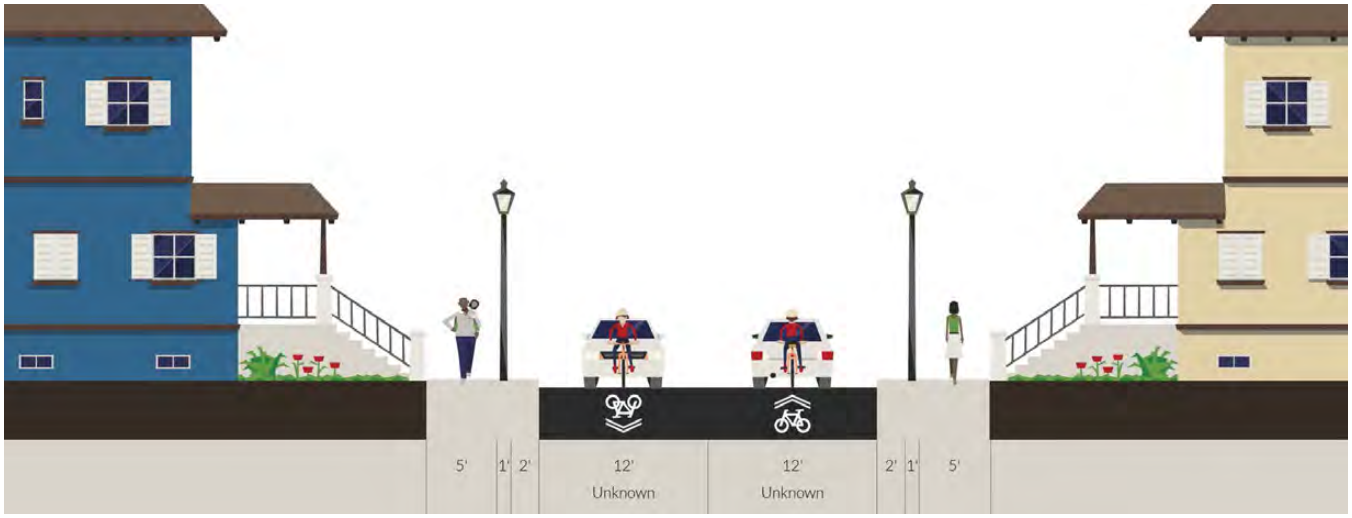


Figure 17 - Cross Section: Lincoln St. – Rone Ave. to Caldwell Park (Downtown Boundary)

Figure 18 - Cross Section: Wilshire Ave. (Downtown Boundary)

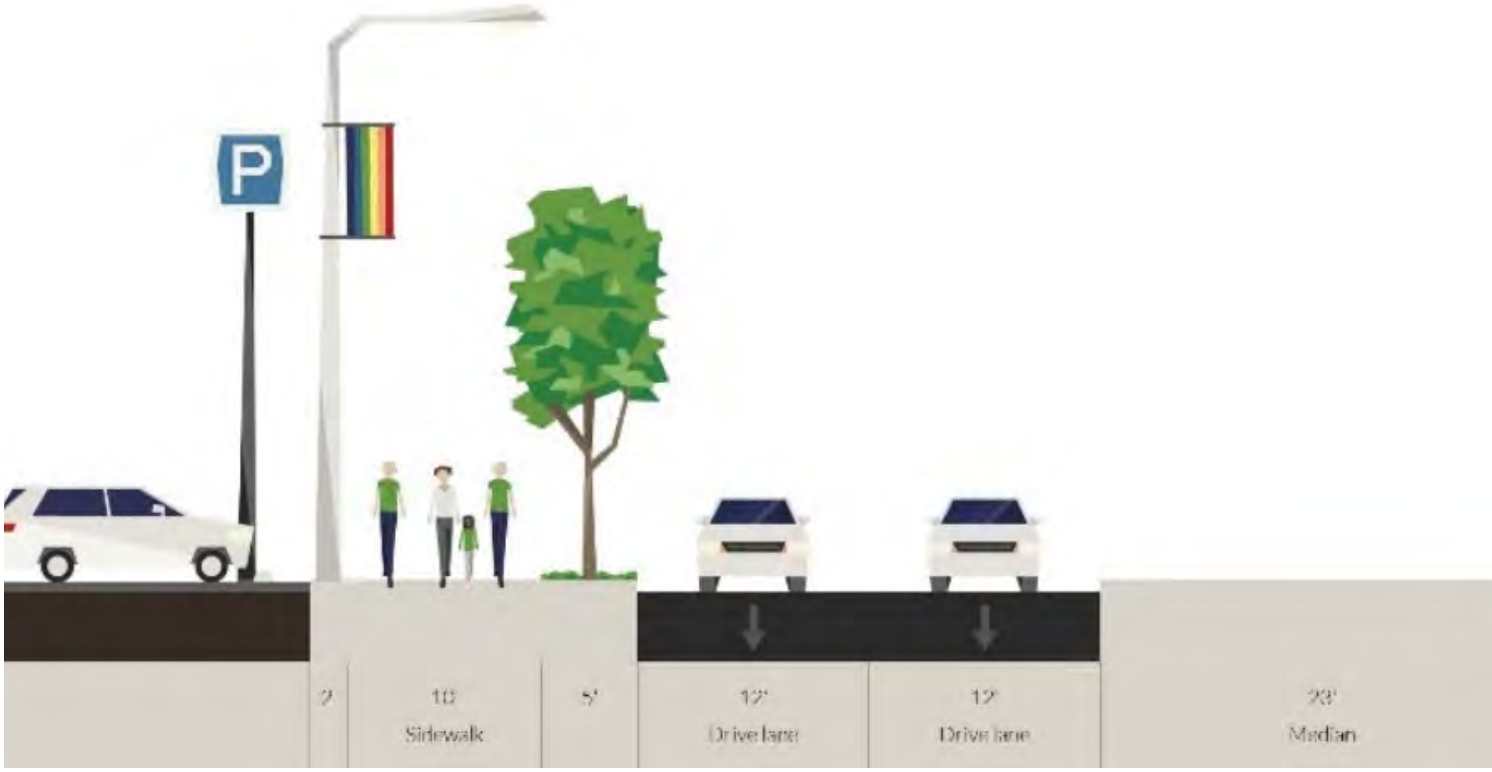


Figure 19 - Cross Section: Branchview Dr. – Lake Concord Rd. to Bradley St. (Hospital Boundary)

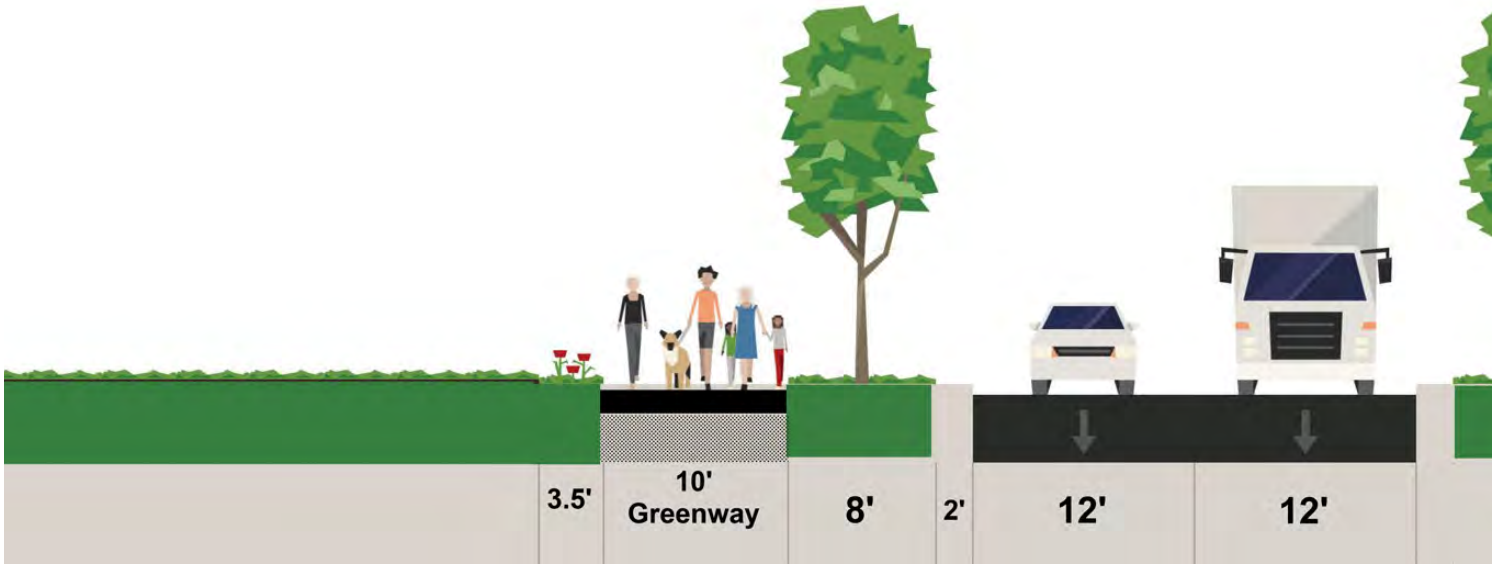
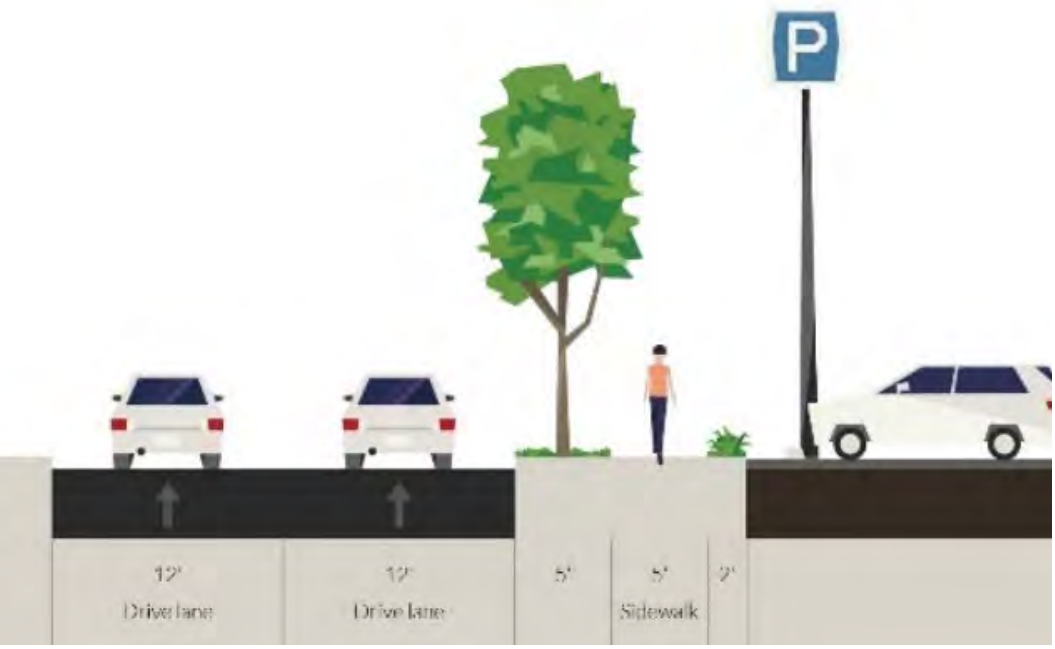


Figure 20 - Cross Section: Branchview Dr. –Lawndale Ave to Union Street
*Note: Right-of-way minimum: 110' (Modified 4-C)


P
12'
Drive lane
12'
Drive lane
5'
5'
Sidewalk
2'

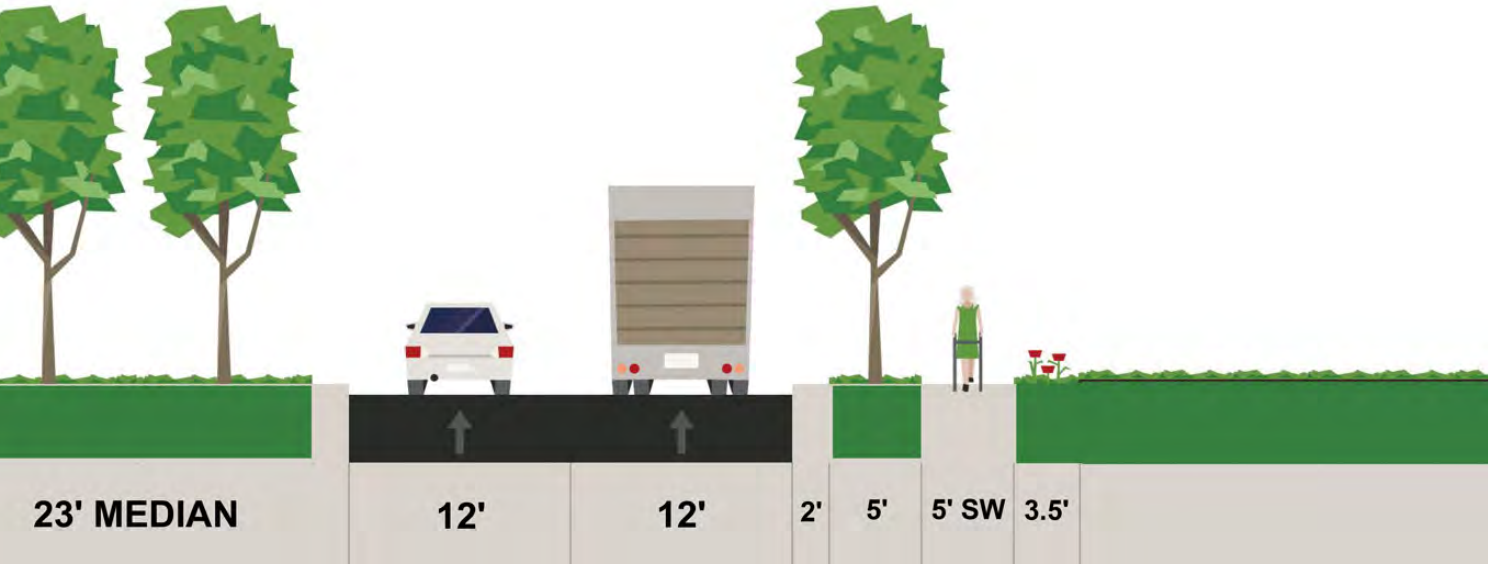
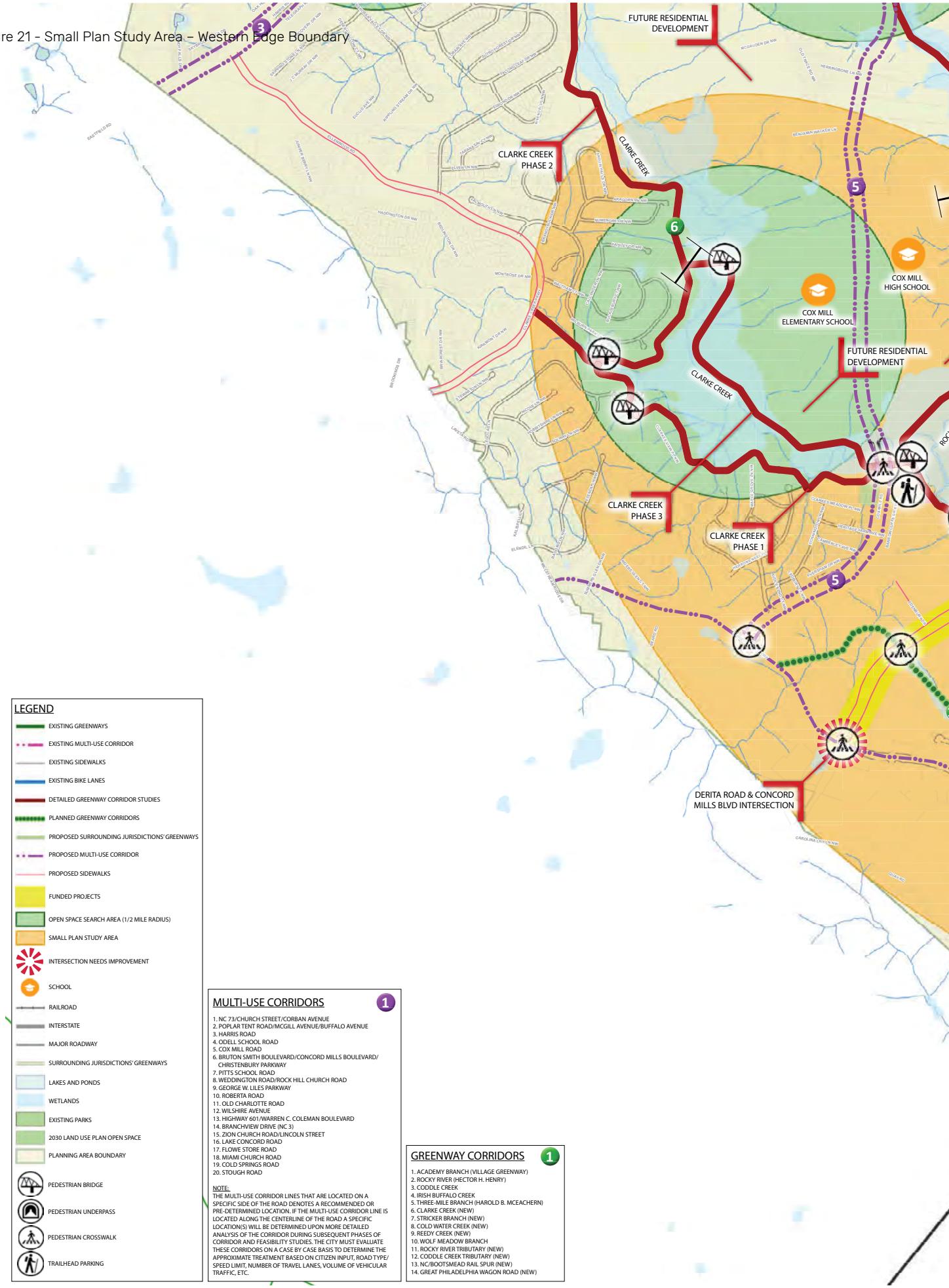
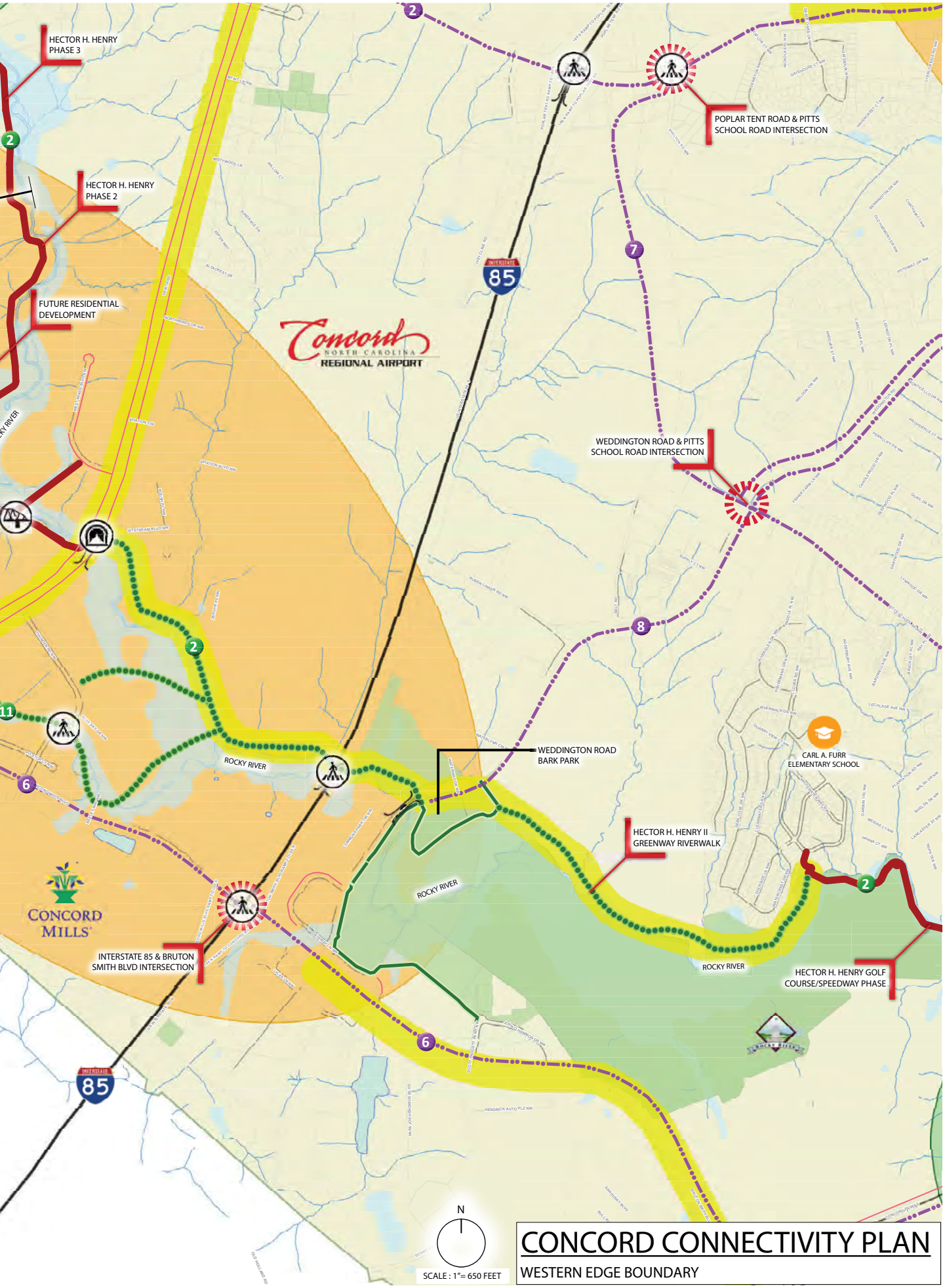

23' MEDIAN
12'
12'
2'
5'
5' SW
3.5'

Figure 21 - Small Plan Study Area – Western Edge Boundary

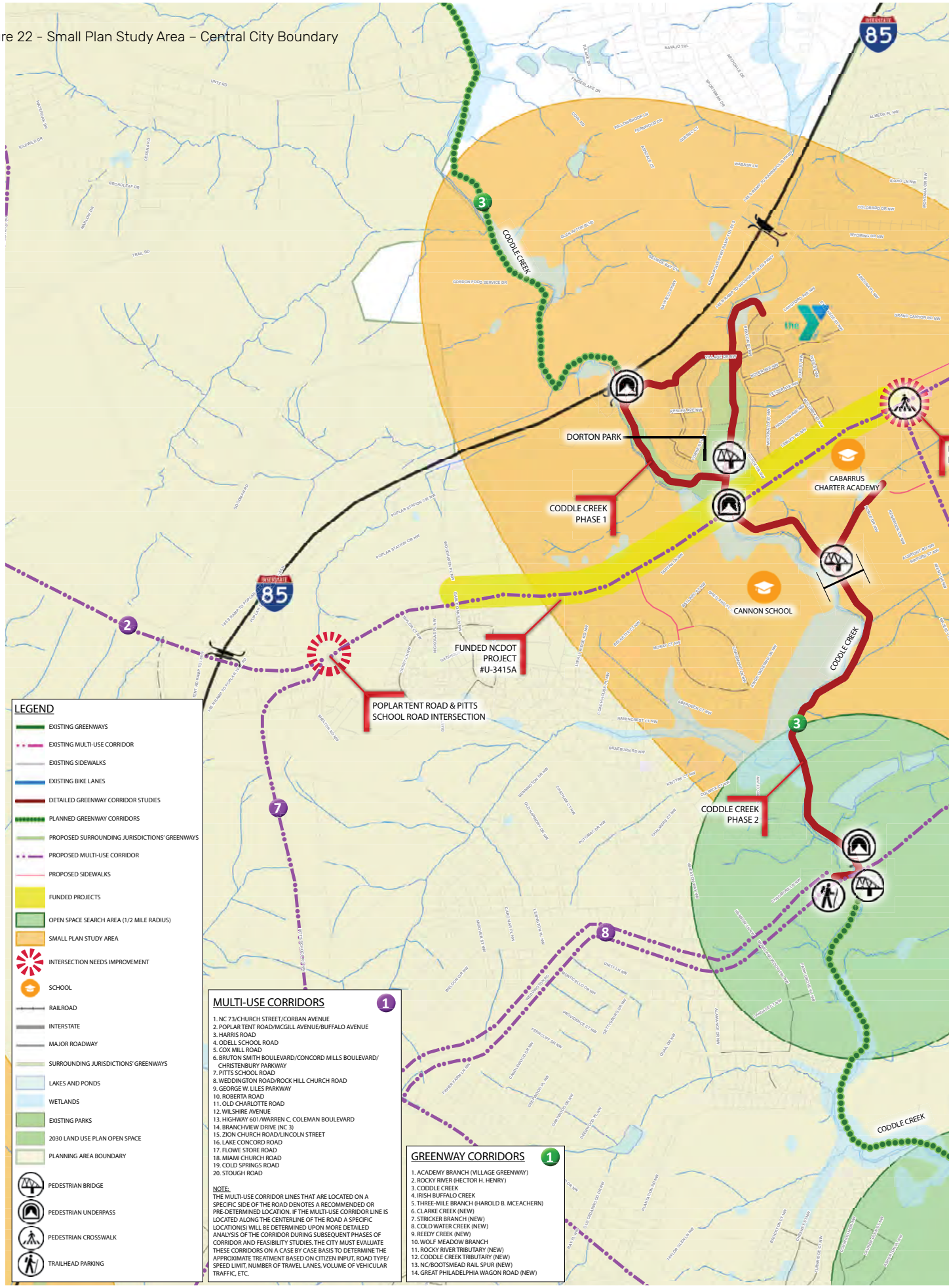


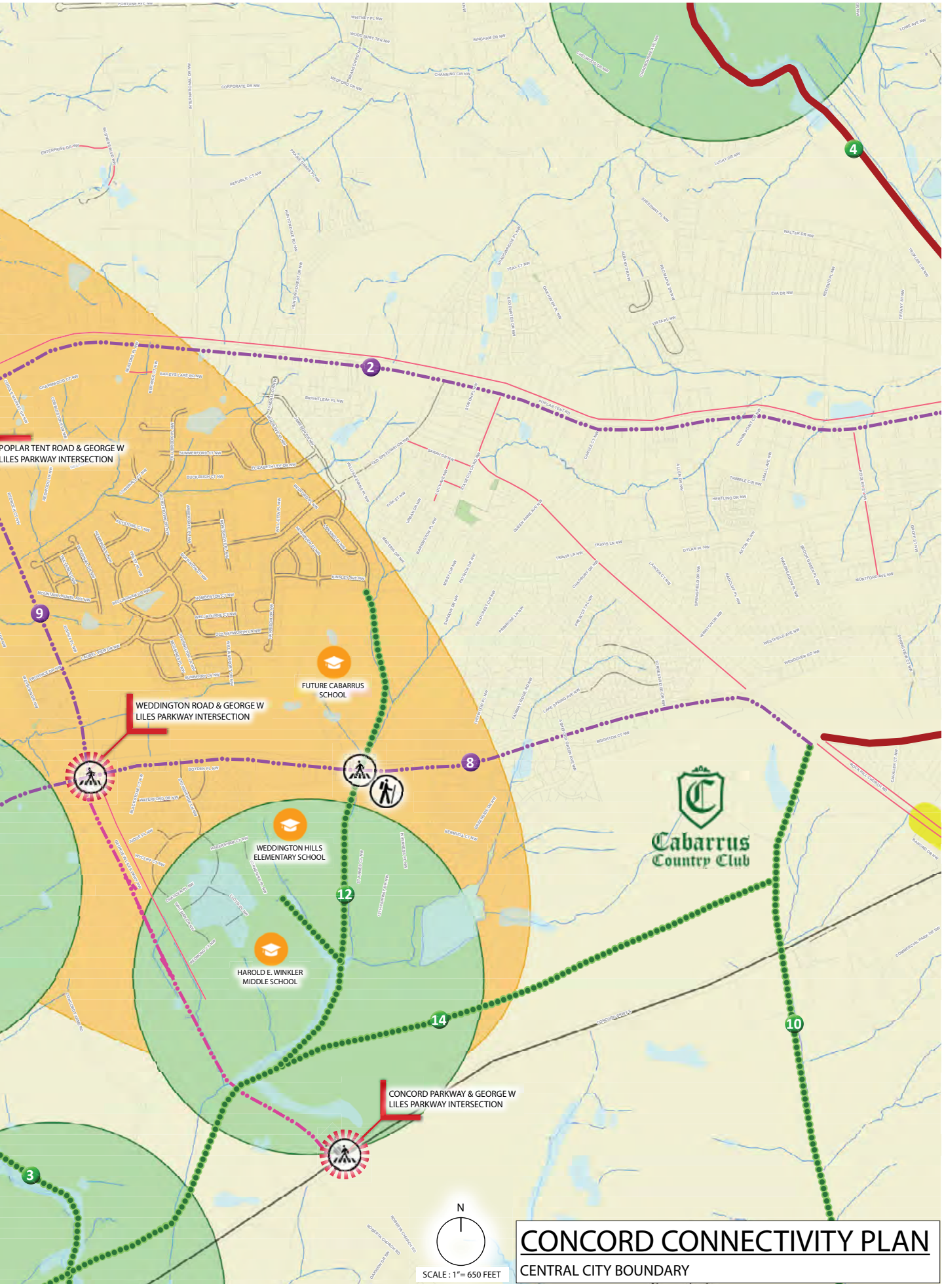


CONCORD CONNECTIVITY PLAN

WESTERN EDGE BOUNDARY

Figure 22 - Small Plan Study Area – Central City Boundary

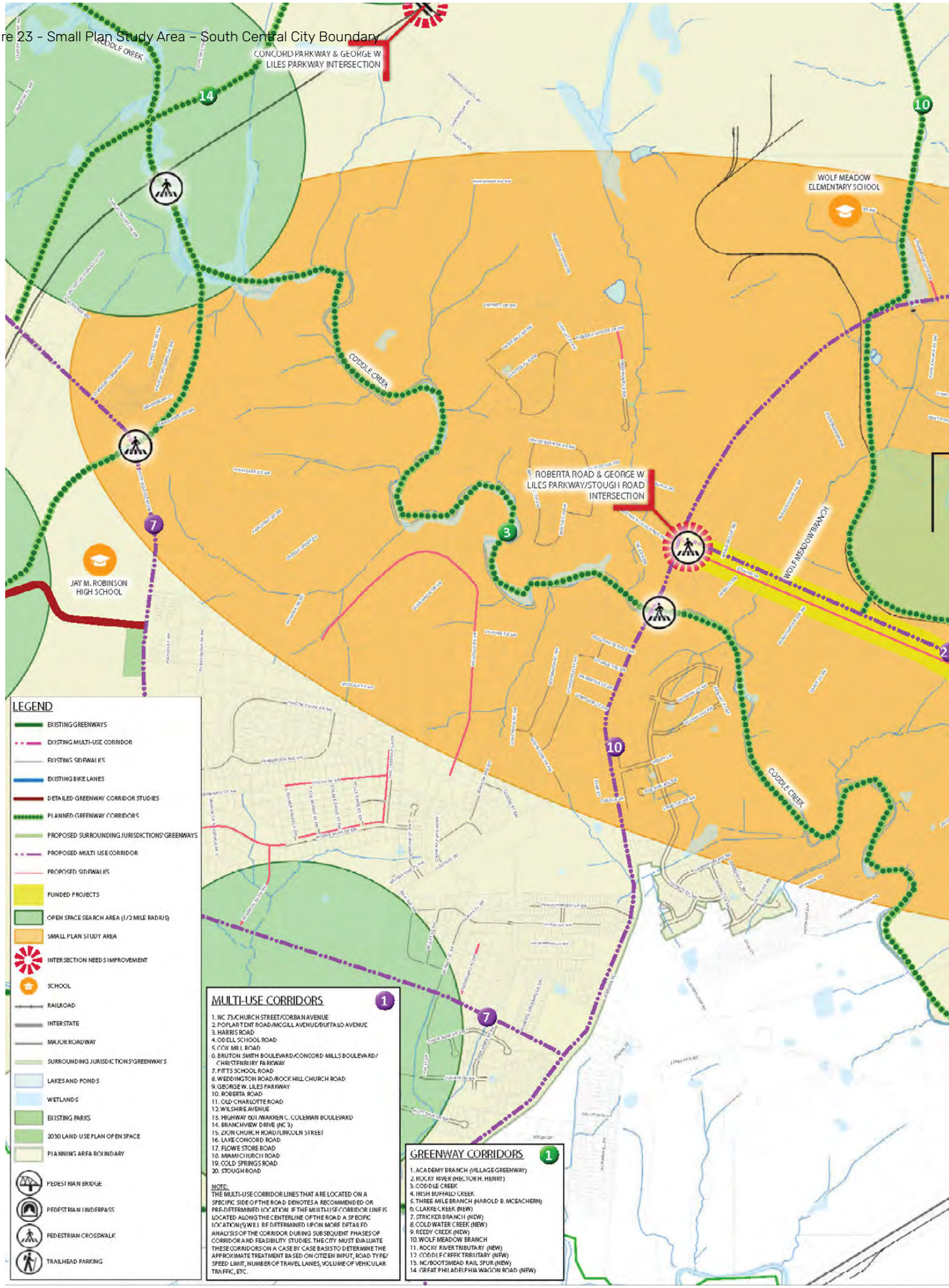




CONCORD CONNECTIVITY PLAN

CENTRAL CITY BOUNDARY

Figure 23 - Small Plan Study Area – South Central City Boundary



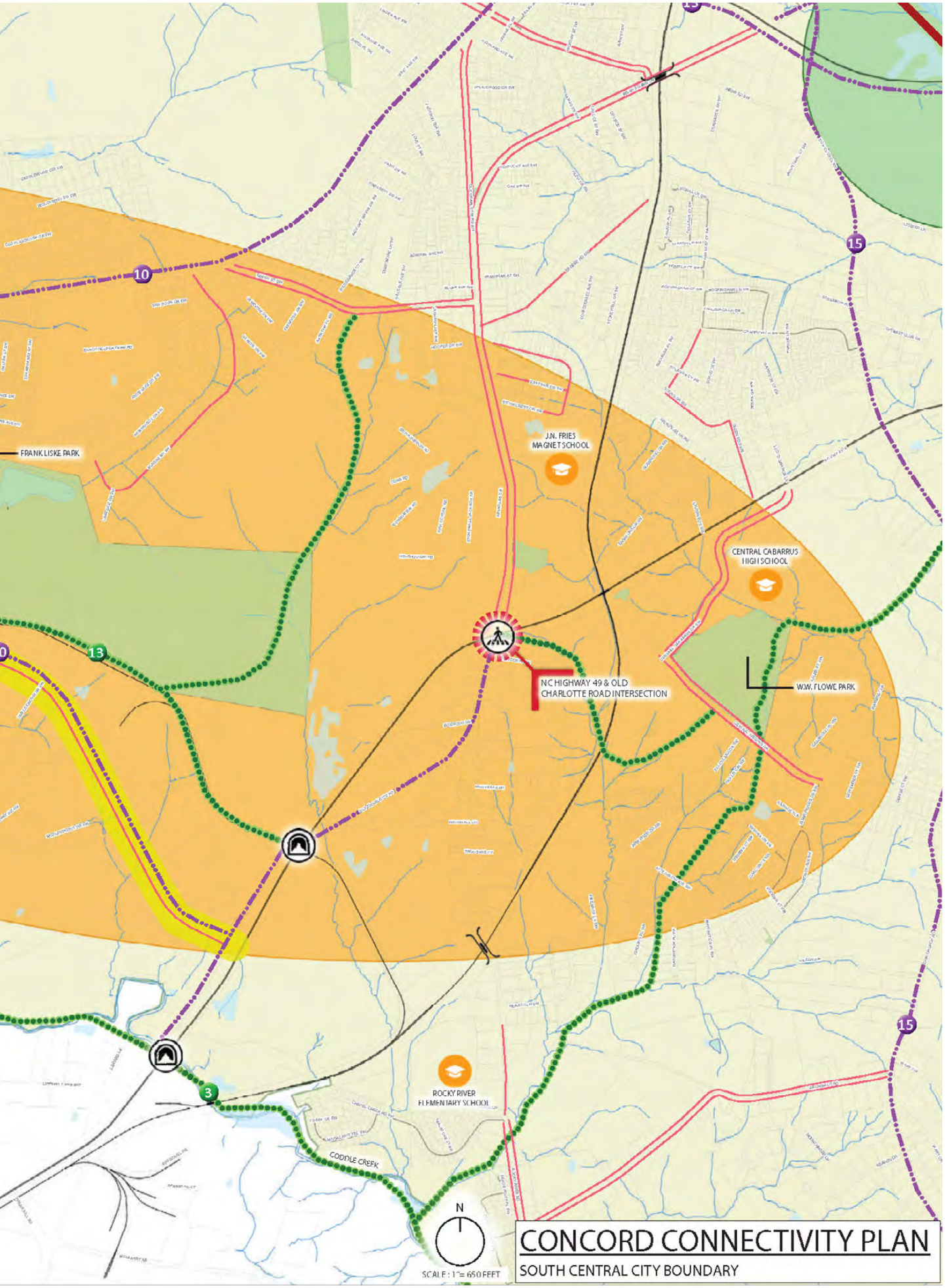
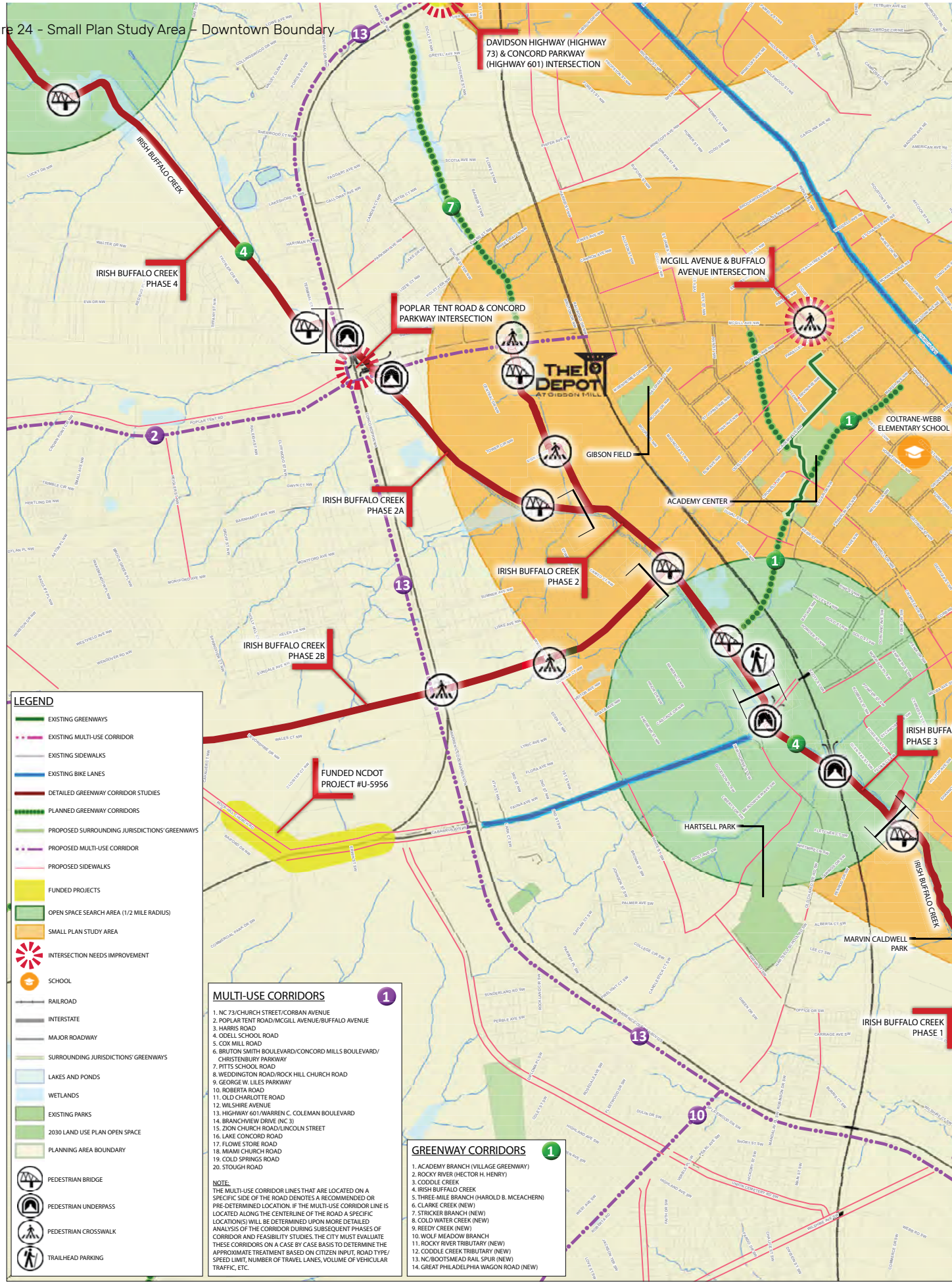
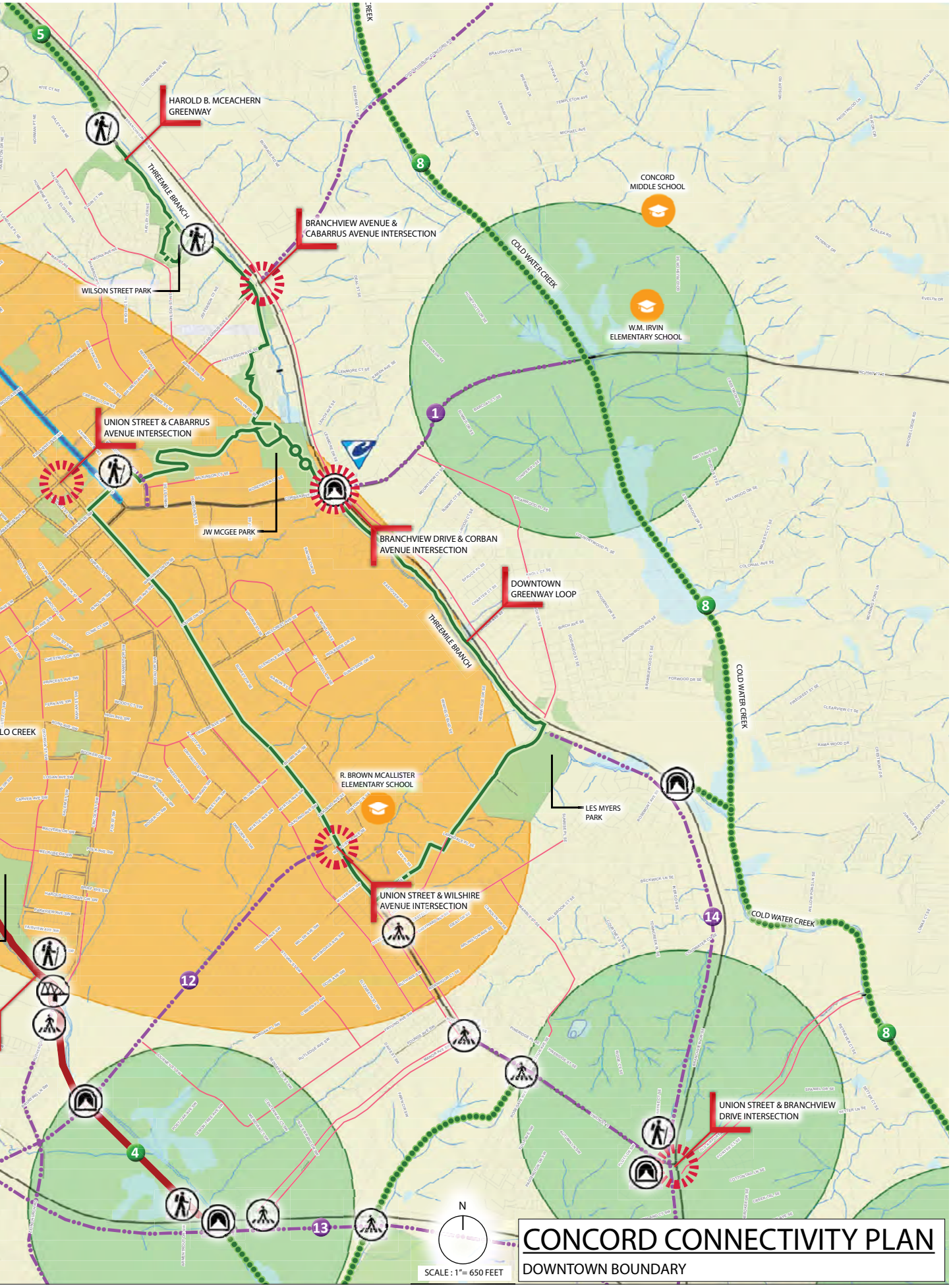

FRANK LISKE PARK
J.N. FRIES MAGNET SCHOOL
CENTRAL CABARRUS HIGH SCHOOL
NC HIGHWAY 49 & OLD CHARLOTTE ROAD INTERSECTION
W.W. FLOWE PARK
ROCKY RIVER ELEMENTARY SCHOOL
CODDLE CREEK
10
13
15
3
N
SCALE: 1"= 650 FEET
CONCORD CONNECTIVITY PLAN
SOUTH CENTRAL CITY BOUNDARY

Figure 24 - Small Plan Study Area – Downtown Boundary

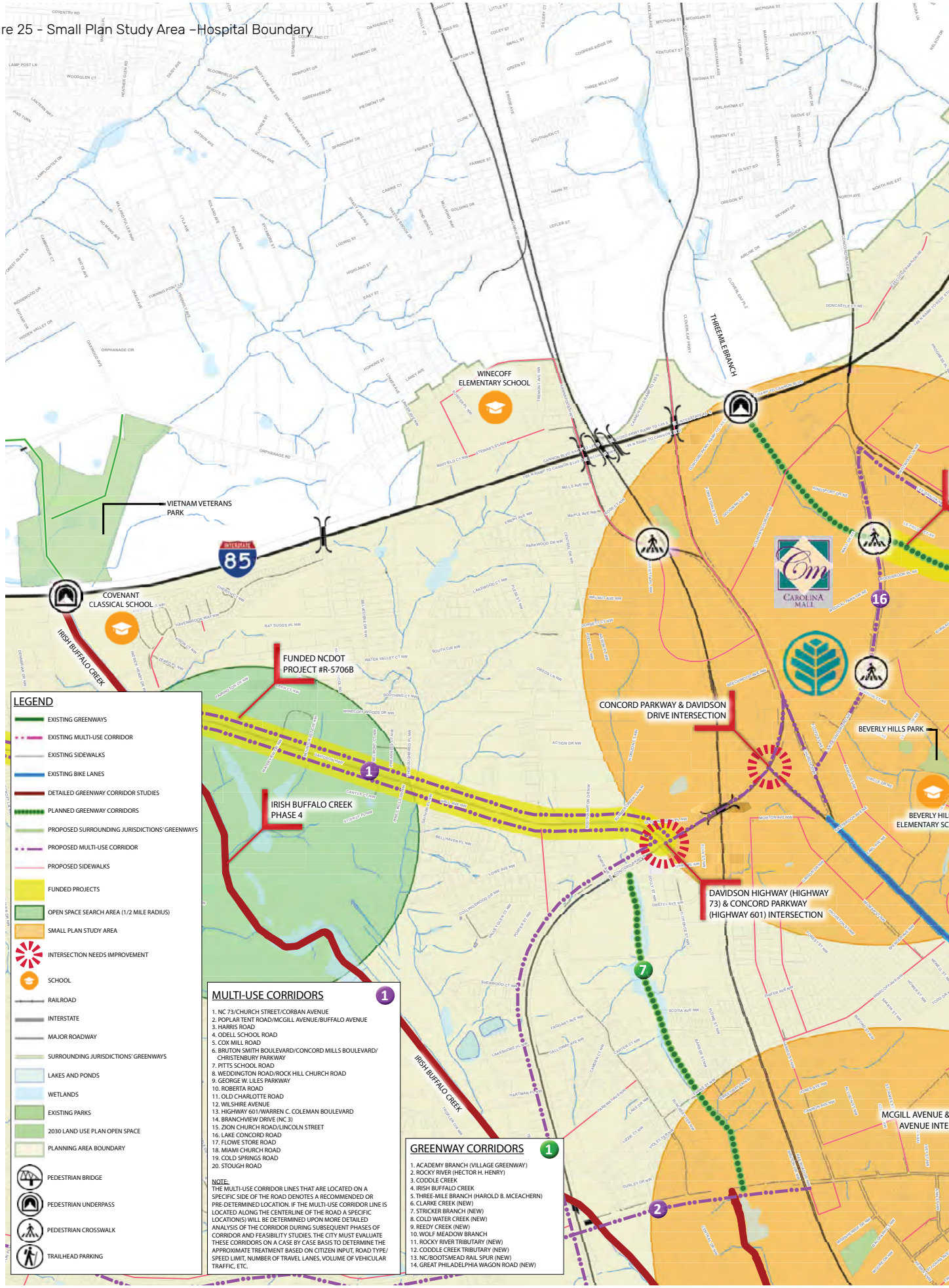


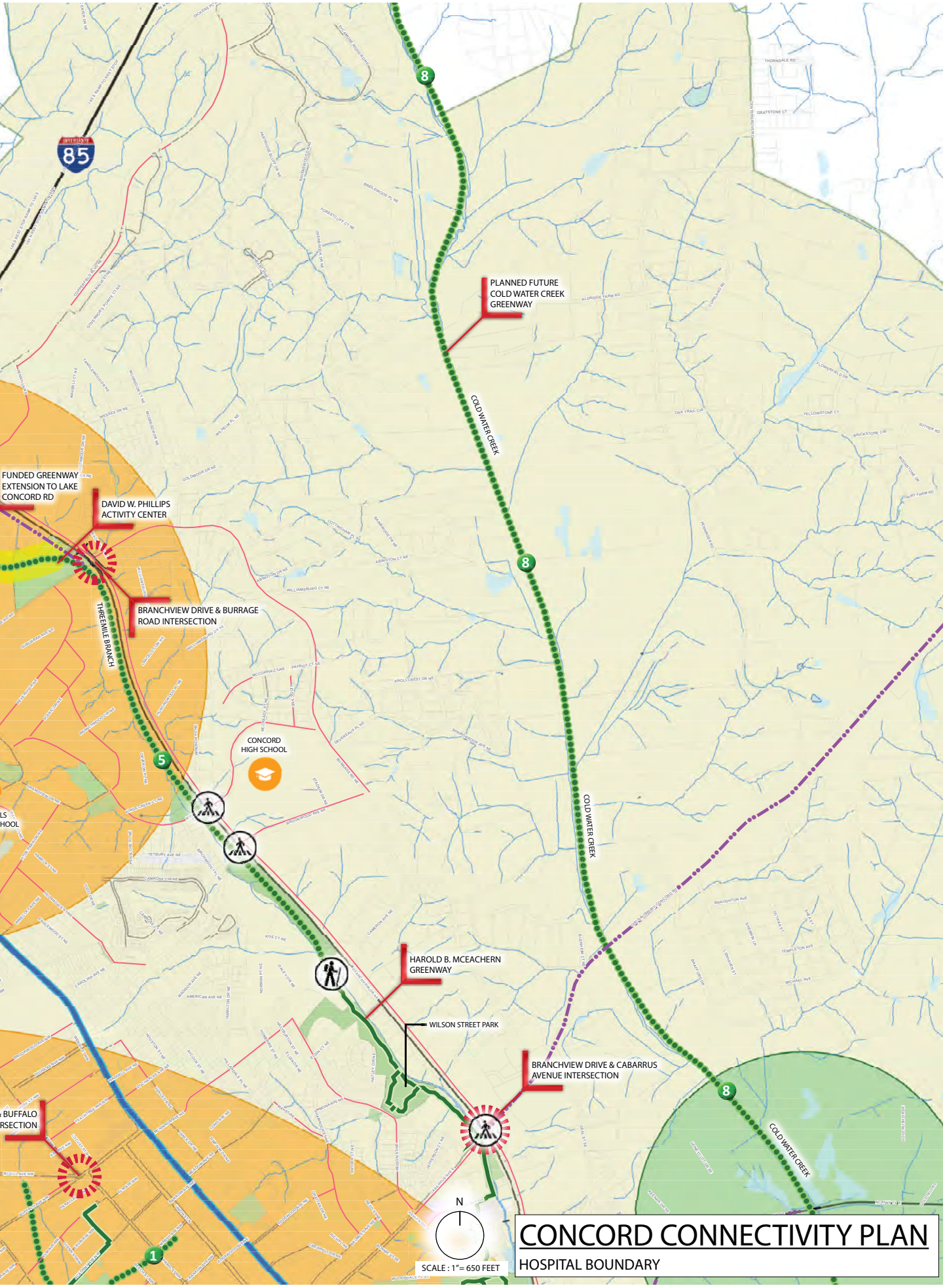


CONCORD CONNECTIVITY PLAN

DOWNTOWN BOUNDARY

Figure 25 - Small Plan Study Area –Hospital Boundary





CONCORD CONNECTIVITY PLAN

HOSPITAL BOUNDARY

DETAILED GREENWAY CORRIDOR STUDIES

The most detailed investigation is presented in the detailed greenway corridor studies where cut sheets are provided to set up priority greenway corridors for future implementation. The detailed greenway corridors were selected based on public input priority corridors and Staff recommendations. Information contained in each cut sheet includes:

- Detailed segment map which identifies streams and wetlands, roads, neighborhoods, schools, parks, and existing pedestrian / bicycle facilities as well as adjacent greenway projects (some of which are detailed in subsequent cut sheets)
- Recommendations
  - Proposed alignment (note: where streams, creeks, or wetlands were inaccessible, assumptions were made to reach an alignment solution)
  - Pedestrian bridge and underpass locations
  - Pedestrian crosswalk locations
  - Trailhead/parking locations
- Routing challenges and opportunities addressing items including but not limited to:
  - Topography
  - Stream crossings
  - Floodplain impacts
  - Observed wetlands
  - Road crossings
- Project Snapshot including:
  - Project Location
  - Project Type
  - Length of Project
  - Estimated Construction Year
  - Trail Trip Generators (i.e. key destinations and activity hubs)
- Previous Planning Efforts
- Potential Right-of-Way Needs
  - Total estimated area needed
  - Number of impacted parcels that are privately owned (not City or County)
  - Number of impacted property owners
- Potential Permitting Needs
- Estimated Project Cost (description on how to use the estimated costs is provided below)
  - 2019 Estimated Construction Costs
  - Escalated Construction Costs (adjusted to reflect the project's estimated construction year)
  - 10% Contingency
  - Estimated Right of Way Costs
  - Estimated Design Services
  - Estimated Construction Engineering and Inspection (CEI) services
- Potential Funding Sources

How to Use Estimated Costs

When reviewing the estimated project costs contained in the subsequent cut sheets, please consider the following:

These are only estimates; all values are rounded up to the nearest one thousand dollars.

The estimated costs are indicative of a planning-level of analysis. No survey, subsurface investigation, or precise measurements were taken to produce base maps.

Elements of the project are priced by using a linear foot (LF) or mile (MI) unit cost from the US dollar value in 2019. Each item is inclusive of all costs associated with their construction. However, these costs should not be taken as a final estimate and should only be used for planning purposes.

Detailed construction cost estimates should be completed during the design phase of each project.

The estimated subtotal of construction costs is escalated out to the fiscal year that each segment is expected to be constructed (see below for how this was calculated by the design team).

Typical elements for each estimate include but are not limited to:

- Cost per linear foot (LF) of 10-foot asphalt trail - $178.87/LF. This price includes grading, base materials, basic drainage, and asphalt.
- Cost per linear foot (LF) of boardwalk - $1,136.29/LF. This price includes piles for foundation, boardwalk substructure, decking, and handrails.
- Cost per linear foot (LF) of bridge - $3,341.36/LF. This price includes bridge foundations, end bents and caps, prefabricated bridge, and bridge erection.
- Cost per linear foot (LF) of erosion control: $21.78/LF. This price includes silt fence and outlets, temporary crossings, construction entrances, etc.
- Cost per mile (MI) of temporary traffic control for construction: $9,894.35/MI. This price includes signs, traffic cones/barrels, temporary concrete barriers, flagmen, etc.

Each estimate was projected to a fiscal year (FY) of probable construction. For example, the fiscal year 2022 is identified as "FY2022". As more detailed information becomes available during the design process, costs will evolve. Costs are listed in the base year of 2019 and should be escalated at a rate of 3.5% (current industry standard) each year thereafter. The formula used is a linear compound interest formula, $A = P(1 + r)^t$

- Where "P" is the original cost in 2019 dollars,
- "r" is the rate of 3.5% escalation, and
- "t" is difference in years from 2019 to construction year (i.e. the "t" value for a project constructed in 2022 would be: t = (2022-2019) = 3.

Each estimate includes a 10% contingency line for unforeseen or unknown costs that may arise during design and construction of projects. Unforeseen or unknown costs may include any flood study permit fees, such as CLOMR/LOMR, any additional construction material costs that may vary over time like steel, utility relocation, etc. Cost estimates for land acquisition/right-of-way needs are based on the City of Concord's assessed property values and are an approximation. The method for attaining costs are based on the current tax value of each property (broken down per square foot) and multiplied by the easement needed for greenway and construction of the greenway. The easement needed is based on the proposed alignments.

Engineering and Planning Services (design costs) can range between 8-14% of construction costs. The cost of design has not been escalated in the estimates with the assumption that design may occur several years before construction and that design fees are somewhat more stable than construction costs. Survey and wetland delineation are included in the design costs as well as whether a FEMA study is needed. Please note that the estimated design costs will be higher on projects that encounter:

- The inclusion of structures such as bridges and boardwalks
- Impacts to FEMA regulated floodways; will require detailed flood modeling and permitting
- Where federal funding is utilized – this requires a high level of regulatory compliance
- If the project is smaller in size/scope

Construction Engineering and Inspection (CEI) services account for a third party CEI firm providing to the City documentation of the construction, reviews submittals, approval of pay applications, and coordination with NCDOT on federally and state funded projects. Fees for CEI services range between 8% and 12% of the construction costs. Since the CEI occurs at the same time as the construction, the estimate is based on the escalated construction costs to the calculation of the CEI fee. The City may also provide CEI services in-house for non-state or non-federal funded projects as a cost savings option.

Estimated Budget Recommendation Quick Key

2019 Construction Estimate (Basis for Calculations):	(Basic elements of the project) x (linear feet x unit cost)
Escalated Construction Cost Estimate (Design Year):	Basis compounded at 3.5% annually to the Design Year
10% Contingency:	10% of escalated construction estimate
Estimated Right of Way Costs:	(Estimated easement area) x (current tax value)
Estimated Design Services ±3%	11% of 2019 Basis cost +/-3% adjusted per project
Estimated CEI Services ±2%	10% of escalated cost +/-2% adjusted per project
TOTAL ESTIMATED BUDGET RECOMMENDATION:	**TOTAL**

SEGMENT	LENGTH (MILE)	ESTIMATED CONSTRUCTION YEAR	ROAD CROSSINGS # OF PED. CROSSWALKS	ROAD CROSSINGS # OF PED. UNDERPASS	# OF STREAM CROSSINGS	# OF IMPACTED PARCELS (NOT CITY OR COUNTY OWNED)	TOTAL COST ($)
HECTOR HENRY- PHASE 1	1.64	2021	1	1	3	10	**5,086,000.00**
HECTOR HENRY- PHASE 2	1.35	2023	0	1	2	5	**4,600,000.00**
HECTOR HENRY- PHASE 3	0.88	2034	0	1	0	7	**3,999,000.00**
HECTOR HENRY GOLF COURSE/ SPEEDWAY PHASE	3.10	2024	0	1	2	11	**9,947,000.00**
CLARKE CREEK- PHASE 1	1.81	2023	1	0	2	10	**4,103,000.00**
CLARKE CREEK- PHASE 2	2.04	2022	0	0	0	14	**5,991,000.00**
CLARKE CREEK- PHASE 3	1.05	2023	0	0	2	5	**2,909,000.00**
CODDLE CREEK- PHASE 1	2.2	2022	0	2	2	13	**4,100,000.00**
CODDLE CREEK- PHASE 2	1.09	2022	0	1	2	3	**5,126,000.00**
IRISH BUFFALO CREEK- PHASE 1	1.37	2020	1	1	1	10	**2,776,000.00**
IRISH BUFFALO CREEK- PHASE 2	1.29	2022	1	0	1	5	**2,661,000.00**
IRISH BUFFALO CREEK- PHASE 2A	0.95	2029	0	2	1	8	**2,885,000.00**
IRISH BUFFALO CREEK- PHASE 2B	1.58	2029	2	0	1	12	**4,470,000.00**
IRISH BUFFALO CREEK- PHASE 3	0.60	2023	0	2	2	6	**2,763,000.00**
IRISH BUFFALO CREEK- PHASE 4	2.25	2024	0	2	2	24	**6,336,000.00**

ACTION PLAN

The action plan outlines project priorities in a 5-10-15-year implementation plan. The action plan as provided is a guide and is meant to be flexible as needs change or as funding becomes available.

0-5YR PLAN (THROUGH FISCAL YEAR 2024)

1. Irish Buffalo Creek Greenway Phase 1
2. Hector Henry Greenway Phase 1
3. Irish Buffalo Creek Greenway Phase 2
4. Gibson Mill Loop – Develop a second loop trail system connecting Irish Buffalo Creek Greenway Phase 2, McGill Avenue, Kerr Street, and Cabarrus Avenue
5. Coddle Creek Greenway Phase 1
6. Coddle Creek Greenway Phase 2
7. Davidson Hwy (NC-73) – partner with NCDOT to construct multi-use path(s) as part of the NC-3 widening project
8. Clark Creek Greenway Phase 2
9. Harris Road multi-use corridor
10. Hector Henry Greenway Phase 2
11. Clarke Creek Greenway Phase 1
12. Clarke Creek Greenway Phase 3
13. Irish Buffalo Phase 3
14. Poplar Tent multi-use corridor
15. Bruton Smith Boulevard/Concord Mills Boulevard/Christenbury Parkway multi-use corridor
16. Irish Buffalo Phase 4
17. Hector Henry Greenway Golf Course/Speedway Phase

5-10YR PLAN (THROUGH FISCAL YEAR 2029)

1. Branchview Drive (NC-3) – partner with NCDOT to construct greenway and multi-use path as part of the NC-3 widening project
   - Harold B. McEachern Greenway – connect existing greenway north to Lake Concord Road
   - Multi-use path – connect existing greenway south from trailhead at Lawndale to Union Street
2. Lake Concord Road multi-use corridor
3. Cox Mill Road multi-use corridor
4. Church Street restriping to accommodate bicycle facilities
   - Coordinate with NCDOT
5. Downtown Greenway Loop Bicycle Improvements on:
   - Lawndale Ave.
   - Patton Ct.
   - Union St. South
   - Means Ave.
6. Wilshire Avenue – bicycle and pedestrian improvements from Rutherford to Union St.
7. Weddington Road/Rock Hill Church Road multi-use path
   - PH1: Coddle Creek bridge to Concord Pkwy (NC-29)
   - PH2: Bark Park to Coddle Creek
8. George W. Liles Parkway/Roberta Church Road/Stough Road multi-use corridor
9. Irish Buffalo Phase 2A
10. Irish Buffalo Phase 2B

10-15YR PLAN (THROUGH FISCAL YEAR 2034)

1. Pitts School Road multi-use corridor
2. Warren C. Coleman Boulevard (NC-601) multi-use corridor
3. Old Charlotte Road multi-use corridor
4. Roberta Road multi-use corridor
5. Zion Church Road/Lincoln Street multi-use corridor
6. Flowe Store Road multi-use corridor
7. Miami Church Road multi-use corridor
8. Cold Springs Road multi-use corridor
9. Hector Henry Greenway Phase 3

ADDITIONAL SYSTEM RECOMMENDATIONS

This plan recommends that Concord partner and coordinate with NCDOT to implement multi-use corridors along state roads (e.g. Poplar Tent Road, Davidson Highway (NC-73), and Weddington Road) to provide linkages throughout the City and providing opportunities to accommodate pedestrians and cyclists, further advancing the City's multi-modal transportation network. Continue to seek incorporation of bicycle/pedestrian/Complete Streets elements as part of NCDOT projects.

Concord must keep open the lines of communication with surrounding jurisdictions and their respective Metropolitan Planning Organizations (MPO), including them in conversations as bicycle/pedestrian projects arise with the opportunity to connect across the City borders.

City Departments should continue coordination efforts, especially on unified street cross sections and ordinance amendments to avoid redundancy, confusion, and inefficiency.

To help answer critical planning questions, it is recommended to have corridor and feasibility studies as described in Chapter 6 prepared for priority corridors. These studies will assess the practicality of the proposed project and guide decisions that shape project scope and budget. Recommended corridor and feasibility studies may include:

- Irish Buffalo Creek to Concord Parkway (NC-601)
- Stricker Branch
- Hospital to Davidson Highway (NC-73)
- Clark Creek Parkway

When possible, dovetail the construction of bicycle and pedestrian facilities into identified future projects such as the development of new parks and school facilities as well as renovations and improvements to existing parks or schools.

Develop an ADA Transition Plan to address non-compliant issues, pinpointing facilities, programs, and services that must be modified to comply with ADA requirements.

With all the proposed development of new greenways, Concord must continue to maintain and enhance existing greenways. Some additional amenities that should be incorporated into existing greenways include:

- Bike share stations at trailheads
- Wayfinding signage, maps, and distance markers on the trails to help orient patrons and direct them to popular destinations within the greenway network
- Public art (either temporary or permanent) by both local and nationally recognized artists
- Emergency communication system and location markers to connect with security or emergency responders

In addition to paved bike trails, the City should look for opportunities to develop mountain bike trails. There is a demand for these facilities based on input received at the public workshops and in stakeholder interviews. Currently there are no public mountain bike trails in Concord, but there is a privately held mountain biking trail off Parks Laferty Road (west of NC-601) known as Rocky River Trail. There is also discussion of donating a parcel on the east side of Warren C. Coleman Blvd to the City for development of a mountain biking trail.