RBTN FACILITY GUIDELINES & MEASURES STUDY

Phase I TECHNICAL MEMORANDUM

Development of Measures for Evaluating Proposed Changes to the RBTN

METROPOLITAN COUNCIL

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TOOLE DESIGN

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I. Introduction

The Regional Bicycle Transportation Network (RBTN) emerged from the Metropolitan Council's Regional Bicycle System Study in 2013–2014, conducted in partnership with Toole Design. Eleven Guiding Principles were developed through the assistance of the project's Technical Advisory Working Group (TAWG), made up of agency partners in transportation planning, to shape the network and its role in regional planning and policy. The RBTN's inception was also grounded in careful methodology and stakeholder involvement. The RBTN and its Guiding Principles are documented in Chapter 7 of the *Transportation Policy Plan*. [1]

Since the RBTN and its Guiding Principles were established in the region's Transportation Policy Plan (TPP), the Metropolitan Council (Council) has applied these principles qualitatively in its evaluations of agency-proposed changes to the regional network. As the Twin Cities metropolitan area grows, the Council seeks more objective ways to perform these evaluations via new measures that will maintain or enhance the RBTN's capacity to encourage cities to plan and implement bikeways that are consistent with regional goals. In addition, new measures developed in this study will allow Met Council to consider more significant changes to the RBTN on a regular basis (i.e., biannually). The RBTN was identified for its performance on and compatibility with eleven Guiding Principles; therefore, proposed additions and changes need to be evaluated for how well they maintain or improve upon them.

This technical memorandum represents the culmination of work carried out under Phase 1 of the RBTN Guidelines and Measures Study. It presents a collection of measures linked to these Guiding Principles that the Council will use to evaluate future proposals by agencies to extend, shift or add new RBTN corridors and alignments. These methods for evaluating spacing, directness, and other measures will help the RBTN evolve organically in tandem with regional growth and communities' transportation needs, with the Guiding Principles shaping its evolution and ensuring that the RBTN continues to serve its regional purpose and goals. The measures presented here are grounded in research and evidence but implemented in a way that is efficient and straightforward for both Council staff and constituent communities to apply and interpret. Phase 2 of this study will focus on developing guidelines for selecting facility treatment types for RBTN alignments.

II. Background

A. Goals and Guiding Principles

The Regional Bicycle Transportation Network (RBTN) was established in the 2014 update to the Transportation Policy Plan as the official regional bikeway network that sets the region's priority vision for planning and investment. The network was based on a Regional Bicycle System Study

Guiding Principles

1. Overcome physical barriers and eliminate critical system gaps,
2. Facilitate safe and continuous trips to regional destinations,
3. Function as arteries to connect regional destinations and the transit system year-round,
4. Accommodate a broad range of cyclist abilities and preferences to attract a wide variety of users,
5. Integrate and/or supplement existing and planned infrastructure,
6. Provide improved opportunities to increase the share of trips made by bicycle,
7. Connect to local, state, and national bikeway networks,
8. Consider opportunities to enhance economic development,
9. Be equitably distributed throughout the region,
10. Follow spacing guidelines that reflect established development and transportation patterns, and
11. Consider priorities reflected in adopted plans.

[1] https://metrocouncil.org/Transportation/Planning-2/Key-Transportation-Planning-Documents/Transportation-

analysis and prioritization of potential bikeway corridors based on five primary factors:

- bicycle trip demand
- network connectivity
- social equity
- population and employment density
- connections to transit

The purpose of the RBTN is shaped by three goals:

- Establish an integrated and seamless network of on-street bikeways and off-road trails,
- Provide the vision for a “backbone” arterial network to accommodate daily bicycle trips by connecting regional destinations and local bicycle networks, and
- Encourage cities, counties, parks agencies, and the state to plan and implement future bikeways in support of the network vision.

The RBTN is planned to facilitate bicycling for transportation, which includes commute trips to work and school, shopping trips, trips to entertainment venues, and trips to visit family/friends. Planning for cyclist bikeability and convenience across a range of experience levels and abilities is an important focus area.

The RBTN Guiding Principles were closely considered to inform the development of the measures. These Guiding Principles were used to define the original RBTN to include regional corridors that would accomplish the following:

1. **Overcome physical barriers and eliminate critical system gaps**. Specifically addressing gaps and barriers in the regional system will improve convenience and continuity for bicyclists.
2. **Facilitate safe and continuous trips to regional destinations**. Developing and upgrading bicycle facilities along the RBTN will improve the convenience and safety of bicycling along these facilities.
3. **Function as arteries to connect regional destinations and the transit system year-round**. Designating alignments within RBTN corridors and implementing bikeways on the RBTN will provide the needed connections to regional destinations and the regional transit system.
4. **Accommodate a broad range of cyclist abilities and preferences to attract a wide variety of users**. Bicyclists have varying levels of comfort to ride based on facility type (on-street facility vs. off-road trail), roadway characteristics, and personal levels of experience and ability. In some urban, high demand corridors it may be appropriate to develop both an on-street facility and an off-road trail to accommodate the full range of cyclist preferences.
5. **Integrate and/or supplement existing and planned infrastructure**. When developing the RBTN, existing and planned infrastructure should be used when possible to reduce the need to purchase new right-of-way and to minimize the growing financial burden of preserving and maintaining existing facilities.
6. **Provide improved opportunities to increase the share of trips made by bicycle**. Implementing a complete RBTN that provides convenient connections to key regional destinations and the regional transit system will increase the likelihood of choosing bicycling for transportation over other travel modes.
7. **Connect to local, state, and national bikeway networks**. Connecting to other established bicycle networks will expand the reach and effectiveness of the regional network.
8. **Consider opportunities to enhance economic development**. New bicycling investments can be an effective tool for creating local economic development opportunities and to foster the Twin Cities' image as a highly livable region with many bike-friendly destinations.
9. **Be equitably distributed throughout the region**. Social equity and regional geographic balance were emphasized in identifying the RBTN. By focusing on population and employment

concentrations, the network will be able to attract the greatest number of riders. By also applying the Metropolitan Council's identified Areas of Concentrated Poverty (where at least 50% of the residents are people of color), the network will offer equitable access to bicycling and the economic opportunities and health benefits afforded by bicycle infrastructure.

10. **Follow spacing guidelines that reflect established development and transportation patterns**. The RBTN corridors were developed in a way that applied spacing concepts based on urban and suburban development patterns and plans. The resulting network is denser and has greater accessibility compared to regional bikeway corridors found in other metropolitan regions.
11. **Consider priorities reflected in adopted plans**. The RBTN was developed to reflect local bicycle plans and policies that inform regional priorities.

B. Technical Reviews

This RBTN Study was conducted with regular reviews and input from the Bicycle-Pedestrian Peer Discussion Group (BPPDG). Since 2016 this informal discussion group has advised Council staff on previous bicycle-related studies and planning issues and provided substantive reviews for this study's work scope; it consists of key staff from the region's seven Counties, a sample of small and large cities, MnDOT, Metro Transit, and regional parks implementing agencies who are regularly engaged in bicycle system and facility planning/design.

III. Measures Overview

In total, eight measures (several of which are multi-pronged) were developed to enable the Council to effectively assess RBTN change requests. Two of these measures address route directness, one measure addresses corridor spacing, and the remaining measures are other measures that provide information about the proposed route's utility and relate to several of the RBTN Guiding Principles.

These eight measures will be used to assess proposed changes and additions to the RBTN, which are categorized by the request type, the route type, and the Thrive 2040 community designation group. In many cases, the application of measures will vary based on the categorization of the request. These categories are detailed below:

- Request Type

Addition: a proposal for an entirely new alignment or corridor that does not currently exist on the RBTN.

Shift: an alignment or corridor moved or adjusted from its existing location.

Extension: adding to an existing alignment or corridor beyond its current extent.

- RBTN Route Type

Each request will pertain to either an alignment or a corridor, which are described in the 2040 Transportation Policy Plan as follows:

  - Corridors reflect where alignments have not yet been identified; the presence of corridors allow for local planning processes to determine the most appropriate alignment that follows the orientation of the corridor and combines on-street bikeways with off-road trails, where appropriate.

- Alignments are defined where there are existing or planned bikeways, or in the absence of these, a consensus of which road or roadways would most efficiently meet the regional corridor's intent.

- Thrive community designation type

Guidance and applicable thresholds vary by the Thrive 2040 community designation type the route falls within. Community designations are grouped as follows:

  - Urban Center
  - Urban
  - Suburban: includes Suburban, Suburban Edge, Emerging Suburban Edge
  - Rural: includes Diversified Rural, Rural Residential, Agricultural

- Measure Test Application Approach

Quantitative measures presented in this memo have been applied to a collection of test cases throughout the region. These test cases were selected for their geographic representation of different Thrive community designation groupings and underlying conditions that made them well suited to illustrate the measurement concepts. Figure 1 shows a map overview for all Test Case Examples in the Metropolitan Council Area. They are not intended to represent any actual proposed changes to the RBTN.

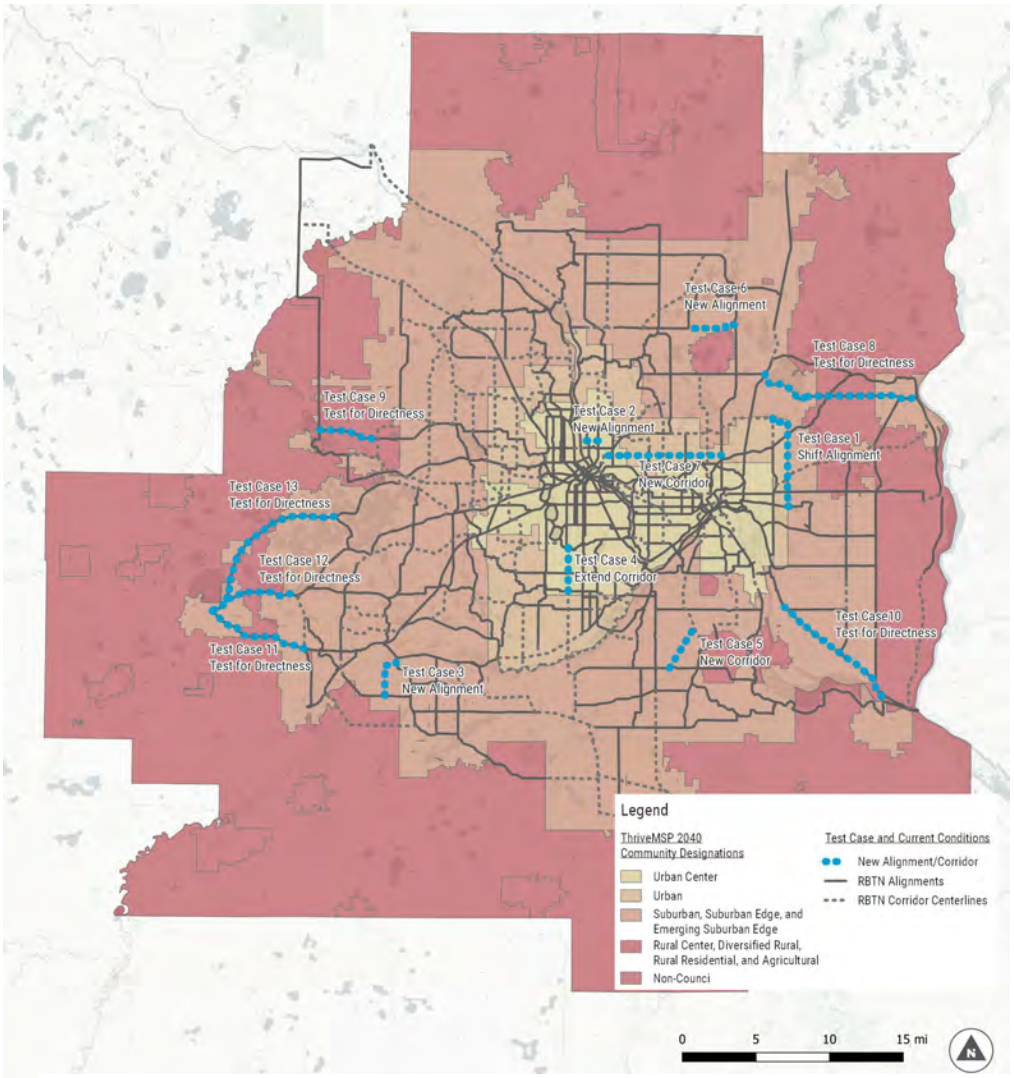


Figure 1. Test case examples used for various measures in this study

IV. Development of Spacing Measures

Network spacing measures provide an understanding of whether the bicycle network provides enough travel and connectivity options for people bicycling. Prior research efforts have been conducted to review spacing guidelines currently used by local municipalities, regional roadway spacing guidance, and peer region bikeway corridor spacing. The preferred maximum spacing between barrier crossing criteria has been developed as part of the Regional Bicycle Barriers Study. This measure builds on these prior research efforts to provide an understanding of how the proposed change is consistent with regional spacing guidelines. This proposed guidance varies according to the regional Thrive Planning sub-areas. In addition, a methodological approach is presented to quantify and measure the network along with directions for practitioners. This can be used to assess requests for new or extended corridors or alignments.

To measure how a proposed change meets the intent of Guiding Principle 10, which relates to spacing guidelines that are reflective of established development and transportation patterns, and Guiding Principle 1, which relates to overcoming barriers and system gaps, a **Buffer Method** is recommended. This method compares the buffers of both the existing and proposed facilities to provide an understanding of the extent to which the new route overlaps with buffers of existing parallel routes as well how the gaps between buffers are impacted. Buffers are based on the preferred minimum spacing distance between RBTN alignments and/or corridor centerlines that vary with Met Council community type designations.

Spacing of alignments and corridors is less relevant in rural areas, where the roadway spacing may already be sparser than the minimum spacing guidelines. Spacing will also need to be flexible where alignments and corridors come together to serve regional destinations such as in dense urban downtown districts, large university districts, and suburban development centers.

A. Background

A variety of approaches to measuring spacing were considered, informed by a review of relevant existing research about minimum spacing, trip length, and detouring, included below. The spacing measures recommended were selected based on their ease of application and suitability for this purpose. Discussions with the BPPDG helped to define the best method as well as the appropriate minimum spacing criteria.

1. Existing Metropolitan Council Research and Guidance on Bikeway Spacing

The Regional Bicycle System Study investigated spacing with two requirements in mind; the regional network should:

- Function as arteries to connect regional destinations and the transit system year-round, and
- Facilitate safe and continuous bicycle travel to and between regional destinations.

At the time of the Regional Bicycle System Study, the original RBTN had denser spacing than the peer regions of Atlanta, Denver, and Nashville – approximately 2.3 to 2.5 miles closer together than the peer region average for the area within 15 miles of the Central Business District (Table 1).

Additionally, the study reviewed local plans and roadway spacing for guidance on optimal regional bikeway spacing. The 2011 Minneapolis Bicycle Master Plan, which has since been replaced by the city's Transportation Action Plan, recommended that arterial bikeways should be spaced 1- and 2-miles apart for minor and major arterials, respectively. The Saint Paul Transportation Plan recommended that bikeways should be no greater than a half-mile apart, and arterial bike lanes or off-street paths should be no more than 1-mile apart. An analysis of spacing of collectors and arterials in the region offered guidance based on land use context, with spacing ranging from as close as ¼ mile apart (metro centers and regional business concentrations) to 2 miles apart (developing areas of the region) or as needed (rural areas).

Table 1. Analysis of Peer Region Bikeway Corridor Spacing [2]

Region	Distance from Center of Primary Business District		
	5 miles	**10 miles**	**15 miles**
Atlanta	3.4 mi	3.1 mi	6.6 mi
Denver	4.2 mi	4.7 mi	5.0 mi
Nashville	2.6 mi	4.3 mi	3.9 mi
Peer average	**3.4 mi**	**4.0 mi**	**5.2 mi**
RBTN	**1.1 mi**	**1.7 mi**	**2.7 mi**
Difference	-2.3 mi	-2.3 mi	-2.5 mi

The Council considered spacing again in 2018 as part of the Regional Bicycle Barriers Study. In that study, the Council examined crossing opportunities along the region's major physical barriers (freeways and expressways, rail corridors, and streams) throughout the seven-county region. With input from the project management team and the BPPDG and based on Thrive MSP 2040 community designations, the spacing guidance for regional bicycle barrier crossings shown in Table 2 was established in the 2018 update to the Transportation Policy Plan.

Table 2. Preferred Maximum Spacing of Regional Bicycle Barrier Crossing Opportunities by Thrive MSP 2040 Community Designation [3]

Thrive Community Designation	**Preferred Maximum Spacing between Regional Bicycle Barrier Crossings**	**Example Cities**
Urban Center	½-mile	Minneapolis, Saint Paul, Richfield, Hopkins, South St. Paul
Urban	¾-mile	Golden Valley, Roseville, Maplewood, Crystal, Edina
Suburban, Suburban Edge, Emerging Suburban Edge	1 mile	Blaine, Woodbury, Maple Grove, Eagan, Lakeville
Diversified Rural, Rural Residential, Agricultural	2 miles	Grant, Afton, Ham Lake, Lake Elmo, Independence

[2] Reproduced from Regional Bicycle System Study, Table 2, and Table 3
[3] Reproduced from Transportation Policy Plan, 2018 Update

The existing RBTN guidance states that regional bikeways should "Follow spacing guidelines that reflect established development and transportation patterns." This guidance lends itself to an approach that is sensitive to land use context, which in this case is broadly differentiated by Thrive community designations.

2. Other Existing Research Findings on Bikeway Spacing

This section describes existing research related to minimum spacing guidance.

a. Literature Scan

A brief literature scan was conducted to identify any existing guidance that sets forth minimum spacing requirements, however literature that specifically identifies minimum spacing guidance is limited.

- Proposed Update of the AASHTO *Guide for the Development of Bicycle Facilities:* Guidance on spacing or density of bikeways recommends that "A bicycle network should be planned for maximum use and comfort, and thus should provide an appropriate density relative to local conditions. Some bicycle network plans have a goal to provide a bikeway **within one-quarter mile of every resident**." Examples of such goals include Seattle, San Jose, and Hennepin County.
- Atlanta Regional Commission 2014 Bicycle and Pedestrian Plan: Connectivity guidance supports a connected network serving key destinations with bikeways **spaced a half-mile apart.** This guidance relates to all community, state, and regional bikeways.
- Portland Metro Regional Active Transportation Plan: This plan includes a regional bicycle network concept that includes guidance that varies based on the functional hierarchy of the bicycle network. Regional bike routes, classified as bicycle parkways, are spaced approximately **every two miles to form the network's spine**.
- Saint Paul Bicycle Plan (Adopted 2015, updated 2017): This plan aims to establish a maximum of **½ mile overall spacing for bikeways** throughout the City of Saint Paul, including a maximum **1-mile spacing of arterial bike lanes or off-street trails.**

These examples provide helpful context, although none of the examples provide explicit minimum spacing values that vary based on development and transportation patterns.

b. Trip Length and Detouring

A related concept is how far bicyclists will detour to reach their destination, in order to use a dedicated bicycle facility that provides a safer or more comfortable ride. When combined with typical bicycle trip distances in the region, willingness to detour can inform spacing guidance by implying the maximum possible spacing that would still support typical bicycle travel. Studies have found bicyclists are willing to detour anywhere between 10 and 20% of their route length in order to use bicycle facilities. [4] [5] The 2019 Travel Behavior Inventory of the Twin Cities region indicated a median bicycle trip length was 2.1 miles (Table 3. Regional Average Trip Distance/Duration by Mode). For the median bike trip of 2.1 miles, research would indicate bicyclists would be willing to detour up to 0.42 miles. For the average bike trip of 3.4 miles, research would indicate bicyclists would be willing to detour up to 0.68 miles. Minimum spacing distances sparser than this range (0.42 - 0.68 miles) may preclude some bike trips. At this time, information on how the typical trip distances vary by regional sub-area is not available, but the regional average trip distances still provide helpful context to consider in relation to spacing guidelines.

[4] Boisjoly, G. and El-Geneidy, A. (2016) Are We Connected? Assessing Bicycle Network Performance Through Directness and Connectivity Measures, a Montreal, Canada Case Study. *Paper to be presented at the 95th Annual Meeting of the Transportation Research Board*, Washington, D.C.

[5] Broach, J., Dill, J., and Gliebe, J. (2012). Where do Cyclists Ride? A Route Choice Model Developed with Revealed Preference GPS Data. *Transportation Research Part A*, 46, 1730-1740. http://dx.doi.org/10.1016/j.tra.2012.07.005

Table 3. Regional Average Trip Distance/Duration by Mode [6]

Trip Mode	Trip Distance		Trip Duration	
	Average (miles)	Median (miles)	Average (minutes)	Median (minutes)
Walk	0.8	0.4	21.3	14.6
Bike	3.4	2.1	31.3	24.2
Drive	7.9	4.1	31.3	22.7

B. Approaches Considered

The study team considered several approaches to measuring spacing, with varying levels of technical difficulty and relevance of the measure outputs. Three of the main ones evaluated are listed in Table 4.

C. BPPDG Feedback

BPPDG members weighed in on both the approach to measuring spacing and the guidelines to accompany it. BPPDG members preferred the buffer overlap approach described above for its clean simplicity. While it does not produce numeric results like other approaches, it does provide an easy visual indication of whether a proposed route is closer than or farther than the recommended minimum spacing guidelines for nearby parallel facilities.

Some members expressed concern about edge cases, where some overlap in the buffers would be present but the full proposal may still be properly spaced. The study team discussed approaches to mitigate this. The guidance written for spacing includes an acknowledgement that small areas of overlap are not cause for concern, and the test case depicted in APPENDIX B – Test Case Examples (pg. 32) provides an example of this.

Members also expressed some interest in having the minimum spacing guidance being set as a range instead of a fixed value. While the guidance ultimately ended up being a set of distinct values tailored to each Thrive community designation, the values chosen can be interpreted as a range with each threshold as the bottom value. Practitioners should keep in mind that the values described below (see Table 4) will not be applied as absolute thresholds as local context will always need to be considered and examples of where flexibility should be applied are included under “E. Application Guidelines.” Also relevant to this discussion is to recall the RBTN goal to “provide the vision for a “backbone” arterial network to accommodate daily bicycle trips.” The RBTN is developed with the expectation that local bikeway networks are planned and developed to complete the overall bikeways system with locally appropriate spacing of facilities that complements the wider spacing of RBTN routes.

[6] Reproduced from 2020 Transportation System Performance Evaluation, Table 6-5

Table 4. Approaches considered for spacing measure

Approach	Process	Pros/Cons
Point-sampling average spacing	• Create evenly spaced points along the route • At each point, measure the distance to the next nearest parallel route in either direction • Average these distances across all points to produce the average spacing distance	• Measures actual distance between parallel or semi-parallel facilities with accuracy, even if facilities converge or diverge in places • Procedurally complex • Depending on how many points are created, may be time consuming • Requires identifying the nearest parallel facilities
Transect-sampling average spacing	• Draw a line at least 3-4 times as long as the recommended minimum spacing perpendicular through the middle of the route (transect) • Count the number of parallel or semi-parallel facilities that cross this line • Divide the distance of the transect by the number of facilities (including the new proposed one) crossing it to produce the average spacing distance	• Measures *average* (mean) distance between semi-parallel facilities in an area • Does not measure *actual* distance between proposed route and the nearest adjacent ones • Only measures distance where transects are drawn • Process can be repeated at multiple points along the line if desired, though this increases the work and time needed for application • Procedurally simpler than the point-sampling method
Buffer overlap	• Generate buffers around the route and nearby parallel (or all) facilities, with a buffer radius equal to one-half the recommended minimum spacing threshold • Visually examine whether and to what extent the route's buffer overlaps with buffers of parallel routes	• Does not measure distance between routes, but does indicate whether they are closer together or farther apart than the recommended minimum • Very simple to apply and interpret • Outcome is easy to visualize • Requires subjective evaluation around how much overlap is acceptable and under what conditions (e.g., where facilities converge in a downtown area)

D. Recommended Measure

Based on feedback from the BPPDG, computational simplicity, ease of interpretation, and alignment with spacing guidance and literature, **this study recommends Spacing Buffer Overlap as the preferred spacing measurement method.**

The proposed spacing minimum distance thresholds (below) are directly informed by the 2018 Regional Bicycle Barriers Study and use the same thresholds as the *maximum* spacing criteria for barrier crossing opportunities. The Bicycle Barriers Study considered how spacing can help achieve direct and well-connected bicycle networks—considering the maximum distance between barrier crossings as an appropriate spacing for well-connected bicycle networks and applying it as a minimum spacing criterion will ensure that the regional network is spaced in a way that best facilitates regional connectivity while maintaining suitable spacing in order to balance needs and resource distribution throughout the region. A review of test case applications confirmed the suitability of this method.

E. Application Guidelines

Table 5 provides the minimum spacing criteria for RBTN routes according to Thrive Community Designation as well as the related buffer distance to use for the spacing test. In addition, relevant context was considered, including the preferred maximum distance between barrier crossings and the existing network average spacing. It is important to note that in all cases, the preferred minimum spacing of RBTN routes is less than the average route spacing of the existing network across all Thrive Community designation groups. This indicates that there should be ample room to fill-in the regional network with new corridors or alignments throughout the RBTN coverage area.

Spacing should be measured by buffering agency-proposed routes and existing, parallel RBTN corridors and alignments by one half of the preferred minimum spacing distance shown in Table 5. The resulting buffers are reviewed to determine whether the route has significant overlaps with buffers of existing parallel routes. The spacing measure is intended to be interpreted in context with other measures. The full procedure for measuring spacing is outlined in APPENDIX C – Measurement Procedures / Steps for calculating Spacing (pg. 52).

Table 5. Recommended RBTN Route Minimum Spacing Distance

Thrive Community Designation	Preferred Maximum Distance between Barrier Crossings	Existing network average spacing	Preferred Minimum Distance between RBTN Routes	Implementation: Buffer distance for spacing test (1/2 of minimum spacing)
Urban Center	½-mile	North-South: 0.98 mi East-West: 0.98 mi	½-mile	¼-mile
Urban	¾-mile	North-South: 0.94 mi East-West: 1.94 mi	¾-mile	3/8-mile
Suburban, Suburban Edge, Emerging Suburban Edge	1 mile	North-South: 2.3 mi East-West: 2.42 mi	1 mile	½-mile
Diversified Rural, Rural Residential, Agricultural	2 miles	Varies with many locations > 2 miles	2 miles	1 mile

1. RBTN Alignment/Corridor Shifts

In order to meet this spacing criterion, alignment and corridor shifts should: (1) reduce or not change overall gaps in network coverage (i.e., network buffered by minimum spacing criteria), while (2) not resulting in significant overlap with parallel facilities (spacing redundancy). When assessing (2), Council staff should consider routing irregularities and converging/diverging routes. In some cases, irregular or converging/diverging routes may result in a small overlap that may not reflect significant redundancy. Staff should assess the length of overlap relative to the total length of the new or adjusted route to determine if the overlap is significant and reflective of the overall shift, or is minor and reflects more of a nuance over a relatively short segment of the route. More flexibility is suggested when evaluating corridor shifts as a future designated alignment could be strategically placed to minimize or even remove the potential overlap.

2. RBTN Alignment/Corridor Additions and Extensions

In order to meet this spacing criterion, additions and extensions should not result in significant overlap (spacing redundancy). When assessing this, Council staff should consider routing irregularities and the

presence of converging/diverging routes. In some cases, irregular or converging/diverging routes will result in a small overlap that may not reflect significant redundancy. Staff should assess the length of overlap relative to the total length of the new or adjusted route to determine if the overlap is significant and reflective of the overall shift, or is minor and reflects more of a nuance over a relatively short segment of the route. Note that there are edge cases where spacing criteria will not be applicable, such as new extensions beyond the current RBTN coverage area or through rural areas. In these areas, the road network spacing may already be sparser than the recommended minimum spacing guidance. Other measures are more tailored toward the unique characteristics of the region's rural areas.

3. Test Case Examples

An illustration of spacing buffers is shown in Figure 2. Seven cases were tested for the spacing buffer method, including one shift. For this method, spacing buffers were generated for the entire existing RBTN. Test cases 1, 2, and 7 are briefly reviewed in APPENDIX B – Test Case Examples (pg. 32), with both a map of the output and narrative interpretation.

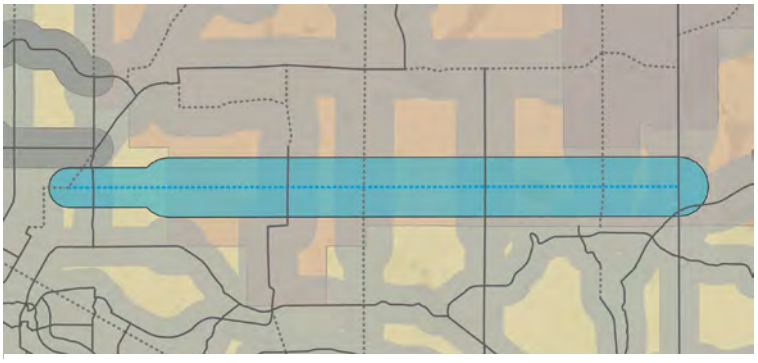


Figure 2. Example of spacing buffer around an east—west test case example, with no significant overlap of parallel route buffers.

V. Development of Directness Measures

High quality bicycle networks minimize the number of detours users need to take to ride on a bicycle facility. Route directness is an important criterion that can assess how far users need to travel out of their way to find a facility they can use. Route directness is related to, but not interchangeable with, corridor spacing, which is discussed above. Route directness can complement corridor spacing by factoring in land use changes as well as how the network's connectivity actually connects users to important destinations and connections. Route directness measures help provide an understanding of how proposed shifts or additions to the RBTN change typical travel distances to key destinations.

Directness has also been analyzed as pedestrian route directness or diversion. [7, 8] In her 2004 study, Jennifer Dill noted that pedestrian route directness is a strong measure for network connectivity because it reflects the distance travelled; however, she notes it is complex to calculate and selection of destinations may be subjective. [9] To mitigate this potential weakness, it is critical that clear and concrete guidance on destination selection is provided in order to minimize potential subjectivity down the road.

A. Background

A variety of approaches to measuring directness were considered. Relevant literature was reviewed, and informed recommendations made. Because pedestrian and bicyclist route directness can become very complex to calculate, the directness measures recommended were selected based on their ease of application, potential to minimize excessive subjectivity, and suitability for this purpose.

[7] Hess, P. M. (1997) Measures of Connectivity. Places, 11, 58-65.
[8] Boisjoly, G., Lachapelle, U., & El-Geneidy, A. (In press). Are we connected? Assessing bicycle network performance through directness and connectivity measures, a Montreal, Canada case study. International Journal of Sustainable Transportation.
[9] Dill, J. (2004) Measuring Network Connectivity for Bicycling and Walking, TRB 2004 Annual Meeting

1. Origins and Destinations for Evaluating Directness

The RBTN was originally developed with a primary goal of connecting regional destinations and major transit hubs. The approaches to measuring directness described here retain that focus on efficient connections to regionally significant destinations and the regional transit system.

For this methodology, destinations include the following:

- RBTN regional destinations
- Existing and planned light rail transit stations
- Existing and planned bus rapid transit stations
- Bus transit centers
- Major park-and-ride lots
- Bike-and-ride centers

A full and more detailed list of destination types is included under “Application Guidelines” (pg.15).

Additional destination types were considered throughout the study; however, the final list retains consistency with the original RBTN’s emphasis on regional-scale and regional-purpose destinations.

B. Approaches Considered

Individuals make trips from specific origins to destinations. Someone planning a trip might calculate a route connecting their home to a regional job center, or from their work to an LRT or BRT station. Translating this into a universal measure of directness, where we can evaluate how efficiently a section of the network connects to destinations for any given possible trip, is challenging and complex. One approach that is common in academic literature but less practical for application and evaluation is measuring destination accessibility on a network repeatedly across the region to evaluate changes in access in response to changes in the network. This is computationally burdensome and, while useful for examining regional patterns and trends, not applicable to the type of corridor- or alignment-level evaluations for which these measures were being developed. Setting aside this type of measure, the study team identified three plausible approaches to measuring directness and ultimately created measures for two of them, shown in Table 6 (next page).

C. BPPDG Feedback

On the destination proximity measure, BPPDG members weighed in that for alignments, only destinations on or quite close to the RBTN corridor centerline or alignment should count. Based on BPPDG feedback, the initial proposed buffer to assess destination proximity for alignments was reduced. The buffer distances for corridors were not reduced since, without a known alignment, it is impossible to determine whether a destination is actually on the alignment.

The out-of-direction ratio measures a very specific element that applies only under very specific circumstances. For people making longer distance trips on the network, where part of their trip may use the new RBTN corridor, out-of-direction ratio can indicate whether the new corridor may make that trip more or less efficient. While out-of-direction ratio was well received, BPPDG members found an initial version including multiple trips to be too time consuming to calculate. The simple, single trip version ultimately recommended does not capture as large of a variety of hypothetical trips on the network, but it does provide clear indication if an addition or extension is providing a shortcut on the network, or if a shift may result in people having to detour substantially.

Per discussion with BPPDG, the threshold on an acceptable out-of-direction ratio is preferred to be relatively generous and should be interpreted in context with all the other measures. A high out-of-direction ratio may be acceptable if it also is connecting to more destinations.

Table 6. Approaches considered for directness measures

Approach	Process	Pros/Cons
Destination Proximity	• Overlay the proposed route with regional destinations • Identify how many destinations are being newly connected to the RBTN • For shifts: identify whether any destinations are losing access to the RBTN	• Measures whether the RBTN is providing direct access or direct connections to regional destinations • Does not consider the full extent of a person's trip, only the destination • Recommend pairing with out-of-direction ratio – single trip version (below)
Out-of-direction Ratio [10] – multi trip version	• Create 2-3 points on the RBTN at either end of the proposed corridor, representing approaches to the corridor from any direction • For each possible pair of points from either end (i.e., one point from one end of the corridor paired with one point from the other end), draw two routes between them: once using the new proposed corridor, and once using the best existing RBTN connection • For each pair of points: measure the length of the two routes created and calculate the ratio <new length> / <old length> • Calculate the average (mean) of the ratios across all pairs of points	• Measures an average out-of-direction ratio for travel along the new corridor for multiple different trip trajectories • Does not consider access to destinations, only intra-network efficiency • Reflects how the new facility may make long trips on the network more or less efficient • Fully capturing all possible approaches to the corridor may require drawing 18 or more distinct routes on the network and calculating their distances
Out-of-direction Ratio – single trip version	• Create one point at either end of where the new corridor starts and ends • Draw two routes between these two points: once using the new proposed corridor, and once using the best existing RBTN connection • Measure the length of the two routes and calculate the ratio <new length> / <old length>	• Measures an out-of-direction ratio for travel along the new corridor for a single assumed trajectory • Does not consider access to destinations, only intra-network efficiency • Reflects how the new corridor may make long trips on the network more or less efficient • Clearly identifies whether a corridor may provide an intra-network shortcut, but does not necessarily reflect efficiency for trips coming from different approaches • Much simpler to calculate than multi trip version above • Recommend pairing with destination proximity (above)

[10] Other versions of this ratio, such as dividing by a straight line "as the crow flies" distance instead of a route length using an existing alignment or corridor centerline, were also evaluated, and rejected.

D. Recommended Measures

Based on feedback from the BPPDG, computational simplicity, ease of interpretation, and alignment with spacing guidance and literature, **this study recommends using both (1) Destination Proximity and (2) Out-of-Direction Ratio (single trip version) to measure directness**.

1. Destination Proximity

This measure indicates the extent to which the proposed change affects route directness or efficiency for accessing regional destinations and was selected due to its computational simplicity in combination with its usefulness to assessing whether the change supports direct access to regional destinations, which is a critical function of directness. A review of test case applications confirmed the suitability of this method. When paired with the out-of-direction ratio for a single trip, these two measures together provide a more comprehensive perspective on network directness than either alone.

2. Out-of-Direction Ratio

This measure creates an out-of-direction ratio for travel along the proposed change, for a single assumed trajectory. This measure was selected as a simpler alternative to an out-of-direction ratio that assesses multiple trips based on BPPDG feedback and concern for computing a multi trip version of the ratio. This measure was determined to be an appropriate indicator of whether a proposed change results in shortcuts that improve directness. A review of test case applications confirmed the suitability of this method. When paired with the proximity to regional destinations measure, these two measures together provide a more comprehensive perspective on network directness than either alone.

E. Application Guidelines

Two measures are used to evaluate directness comprehensively: a destination proximity measure and a routing measure. While the first measure looks only at proximity of regional destinations and major transit centers to the RBTN, the second uses routing calculations between a sample of various points along the RBTN to see whether travel within the RBTN increases or decreases in efficiency. Both measures are likely appropriate under different circumstances. Destination proximity is valuable in cases where the proposed change either brings RBTN connectivity to new destinations or disconnects destinations from the RBTN. A routing-based approach may help clarify situations where there are no destinations being added or removed from the network, or where the proximity measure produces mixed results, such as a neutral score resulting from new connectivity offset by a disconnection from an existing destination.

For both measures, proposers may describe additional factors to consider. For example, a narrative response could include additional destinations that meet or may be just shy of a regional destination threshold (e.g., asking for consideration of a high school with slightly less than the threshold of 2,000 students).

1. Destination Proximity

This method uses buffers to visually determine whether there are major regional destinations that are being newly connected to or disconnected from the RBTN. Proximity is measured using a 1/10-mile buffer for alignments and using ¼-mile buffer for corridors in the Urban Core and ½-mile buffer for corridors in all other Thrive Designations (this reflects ½ of the corridor bandwidths). For a destination to be considered proximate, there should not be a barrier that severs the destination from the corridor centerline or alignment. The full procedure for measuring spacing is outlined in APPENDIX C – Measurement Procedures / Steps for calculating Directness – Destination Proximity (pg.53).

a. Eligible Regional Destinations

Eligible destinations considered for the Destination Proximity Measure are comprised of the RBTN destinations, as follows:

- Metropolitan job centers (>50,000 jobs)
- Regional job centers (15,000 to 50,000 jobs)
- Subregional job centers (7,000 to 15,000 jobs)
- Colleges & universities (≥2,000 students)
- Large high schools (≥ 2,000 students)

- Major sport and entertainment centers
- Regional Parks (≥400,000 annual visits)
- Existing/planned Light Rail Transit stations
- Existing/planned Bus Rapid Transit stations
- Bus transit centers [11]
- Park-and-ride lots (≥ 200 spaces)[11]
- Bike-and-ride centers[11]

These regional destinations will be considered during evaluation of proposed changes using the destination proximity measure.

b. Measure Criteria

- Alignments: Regional destinations are considered to be proximate if they are within approximately 1/10 of a mile of the proposed alignment
- Corridors: Regional destinations are considered to be proximate if they are within the corridor bandwidth. For Urban Center cities, this means within ¼ mile of the corridor centerline. For all other locations, this means within ½ mile of the corridor centerline.

c. Measure Thresholds

Shifts (alignments and corridors)
This criterion has multiple tiers, with each tier categorized according to its overall impact to destination connectivity. Tiers include high impact, medium impact, adverse impact, and no impact. Adverse impact reflects a net reduction in access to destinations that does not satisfy the directness criteria for this metric. No impact reflects for shifts that do not result in a net change in destination proximity, reflecting a neutral result which would not positively or negatively affect the scoring of the proposed change.

The thresholds for each level are as follows:

- ***High Impact:*** A substantial positive net increase of 2 or more new regional destinations are connected by the proposed change. The net change reflects subtraction of any existing destinations that are disconnected by the proposed change.
- ***Medium Impact:*** A positive net increase of 1 new regional destination is connected by the proposed change. The net change reflects subtraction of any existing destinations that are disconnected by the proposed change.
- ***Adverse Impact:*** The number of existing destinations that are disconnected by the proposed change exceeds the number of new destinations connected by the proposed change.
- ***No impact:*** There is no net change in destinations accessed by the proposed change compared to the original alignment.

Council staff judgment may be necessary to distinguish between high and medium impact destination connections. Although quantitative guidelines recommend simply counting destinations (e.g., two or more destinations counting as “high impact”), in some cases, a high impact score may be appropriate for a net increase of only one destination if it is deemed to have elevated regional significance. The as-written criterion for tier evaluation should consider destinations as equally weighted (e.g., treat proposed changes with a equally importance). In addition, applicants should have the opportunity to justify certain destinations as having more importance than others. This may support a higher level threshold than outlined above if the disconnected existing destinations are deemed less critical to connect to the RBTN compared to connections made to new destinations. Proposers should be alloted

[11] For this study, these elements were added as regional destinations to the official RBTN-included regional destinations above

space in the application to describe other potentially relevant factors to consider (e.g., newly constructed regionally-significant destinations).

Extensions and Additions (alignments and corridors)
The criterion for alignment extensions and additions are similar to alignment shifts, except that a net change in destinations is not applicable given disconnections from existing destinations will not be applicable. Because of that, there is no adverse impact category. Proposers may wish to provide narrative text identifying relevant factors, such as new or planned regional destinations that may be missing from Council databases.

- ***High Impact:*** Two or more new regional destinations are connected by the proposed change.
- ***Medium Impact:*** One new regional destination is connected by the proposed change.
- ***No impact:*** There are no new destinations accessed by the proposed change compared to the original alignment.

d. Test Case Examples

Figure 4 shows a simple example of counting destinations within a corridor buffer. Four test case examples of the destination proximity measure are included in APPENDIX B – Test Case Examples (pg. 36), with both a map of the output and narrative interpretation.

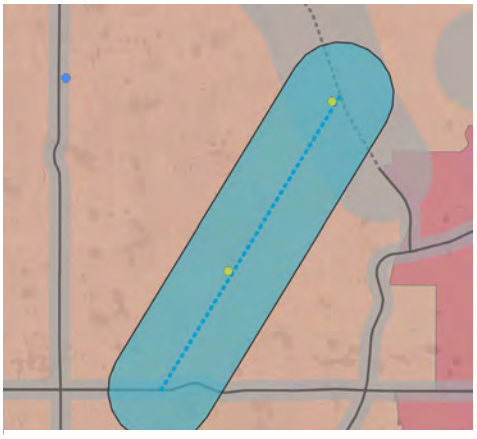


Figure 3. Example of destination proximity buffer around a corridor example, with two destinations inside the buffer.

2. Out-of-Direction Ratio

This measure indicates whether the proposed addition, extension, or shift provides a new and more direct connection between two or more RBTN facilities (i.e., does the proposed route provide a new short-cut along an RBTN route?). It provides for an evaluation of whether a proposed shift or addition might increase the efficiency of intra-network travel.

The out-of-direction ratio measures two network distances relative to each other to indicate comparative efficiency of two routes. The out-of-direction ratio is calculated for the corridor start and end points for both the proposed corridor and the existing corridor or alignment. The new corridor's route's length is then divided by the existing corridor's route's length. For shifts, the existing corridor route should use the corridor or alignment's original location, and the new corridor route should use the shifted or proposed location. This measure is applicable for additions and shifts, but not for extensions. The routing calculations can be completed using an online mapping tool like Google Maps or Bing Maps, or manually in GIS software.

a. Measure Thresholds

This measure has three thresholds that correspond to three levels of impact based on the out-of-direction ratio. The levels include positive impact, adverse impact, and no impact and are categorized by the thresholds as follows:

- ***Positive Impact:*** The distance between the new corridor route's length divided by the existing corridor route's length is less than 1.
- ***Adverse Impact:*** The distance between the new corridor route's length divided by the existing corridor route's length is greater than 1.
- ***No impact:*** The distance between the new corridor route's length divided by the existing corridor route's length is approximately 1.

While there is no hard threshold above which a proposal would "fail" on this measure, high values greater than 1 indicate significant possible detour for the hypothetical trips represented by the measure.

For example, an out-of-direction ratio greater than 2 indicates more than doubling the travel distance. For a change application with a high out-of-direction ratio (greater than 2) to be successful, there would need to be some other significant benefit or plausible justification for how the measure did not account for the full benefit of the change.

b. Test Case Examples

Figure 5 shows how the out-of-direction ratio routes are drawn. Three examples of the out-of-direction ratio measure are included in APPENDIX B – Test Case Examples (pg.40), with both a map of the output and narrative interpretation.

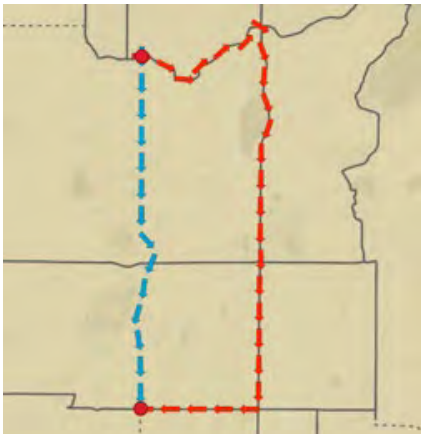


Figure 4. Example of out-of-direction ratio routes, with new facility shown in blue and the detour required without the new facility shown in red.

VI. Development of Additional Measures

In addition to spacing and directness, the project team reviewed academic literature, federal guidance, and the eleven Guiding Principles to develop additional measures to apply to proposed RBTN changes. The study team evaluated an initial collection of over fifty measures documented in federal guidance and worked with Council staff to develop measures specifically tailored to the Guiding Principles. Each one was evaluated for its relevance to Guiding Principles, feasibility of application given available data and resources, and relevance to the stage of planning at which these evaluations occur (e.g., measures that are applicable even if the specific design elements are not yet known). Candidate measures were shared with BPPDG members and further refined based on their feedback. The recommended measures, as well as background, BPPDG feedback, and application guidelines, are presented in the next sections.

A. Recommendation

Based on feedback from the BPPDG, computational simplicity, ease of interpretation, data availability, and alignment with existing guidance and literature, **this study recommends the following set of eight additional measures in** Table 7**. These are described in detail in subsequent sections to evaluate proposed changes to the RBTN.**

Table 7. Additional Recommended Measures

Category	Measure
1. Barrier Connectivity	1. Net Number of Direct Connections to Regional Bicycle Barrier Crossings
2. Inter-Jurisdictional Connectivity	2. Continuity/Connectivity Between Adjacent City and County Bikeway Networks
3. Inter-Network Connectivity	3A. Number of Connection Points with Local Bikeway Networks 3B. Number of Connection Points with State or Regional Trails
4. Equity	4A. Net Change in BIPOC Individuals and People in Poverty with Access to RBTN 4B. Qualitative Agency Self-Assessment of Benefits to Disadvantaged or Vulnerable Populations
5. Population and Jobs	5A. Proximity to Projected Population and Jobs 5B. Activity per Mile Ratio

Note that the numbers of these recommended measures in the outline above are used throughout the rest of this section and in the Appendix.

B. Barrier Connectivity

1. Background

Net Number of Direct Connections to Regional Bicycle Barrier Crossings (Measure 1) was developed to address RBTN Guiding Principle number 1, which relates to regional goals to promote connections to existing and planned regional barrier crossings. The purpose of the measure is to evaluate the extent to which a proposed RBTN change would improve connections to regional barrier crossings, thereby overcoming physical barriers and eliminating critical system gaps. Specifically, addressing gaps and barriers in the regional system will improve convenience and continuity for bicyclists.

2. BPPDG Feedback

BPPDG members weighed in throughout the development of this measure, including elevating the priority of Guiding Principle 1 and regional barrier crossings.

3. Application Guidelines

Net Number of Direct Connections to Regional Bicycle Barrier Crossings can be applied to all alignment and corridor proposal types and RBTN route types.

The measure is calculated by counting the net numbers of existing and planned direct connections that overlap with the proposed RBTN change. The procedure itself is very simple: overlay the proposed route change with a map of regional barrier crossing points and count the number that the proposed route touches. For additions and extensions, this raw count is the net number of new connections. For shifts, also count the number of regional barrier crossing points that would no longer connect to the RBTN (e.g., if the proposed shift relocates an RBTN alignment or corridor centerline away from a barrier crossing point). For shifts, subtract the number of crossing points disconnected from the number connected to find the *net* number of new connections.

When evaluating proposals on this measure, the proposed alignment/corridor **preferably should not reduce the net number of direct connections.** However, this method should be interpreted in context with other measures. For instance, while connecting to barrier crossings is advantageous, not every proposal alignment/corridor will connect to a regional barrier crossing and this should not disqualify a proposal.

a. Test Case Examples

Figure 6 shows regional barrier crossing points overlaid with the proposed route. This test case example of calculating the net number of direct connections to regional barrier crossings (existing and planned) is included in APPENDIX B – Test Case Examples (pg.43), with both a map of the output and narrative interpretation.

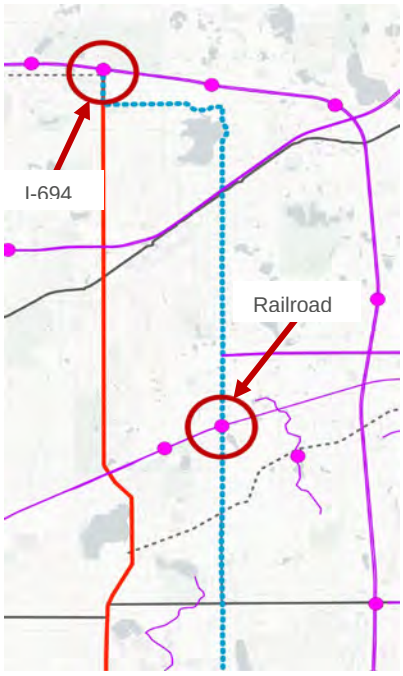


Figure 5. Example of counting barrier crossings along a proposed route.

C. Inter-Jurisdictional Connectivity

1. Background

Guiding Principles 2 and 7 both speak to a need for facilitating continuous travel to regional destinations and RBTN integration with local, county, and state bikeway networks. **Continuity/Connectivity Between Adjacent City and County Bikeway Networks** (Measure 2) speaks to these two Guiding Principles. Additionally, this measure was designed to encourage inter-agency collaboration for bikeways that cross jurisdictional boundaries and provide regionally connected linkages. The intent of this measure is to increase the continuity of future RBTN alignments/corridors across jurisdictional lines.

2. BPPDG Feedback

BPPDG members weighed in throughout the development of this measure, including elevating the priority of connectivity-related Guiding Principles.

3. Application Guidelines

Continuity/Connectivity Between Adjacent City and County Bikeway Networks, can be applied to all corridor or alignment proposal types and RBTN route types.

The measure provides a count of the number of adjacent cities and counties with bikeway networks that are newly connected as a result of the proposed RBTN change. Notably, for a connection to be counted, the proposed RBTN alignment or corridor centerline must directly connect to bikeway networks within the cities and counties being tabulated; it is not enough for the RBTN route to merely pass through with no local connections. The test case example provided in APPENDIX B – Test Case Examples (pg.44) illustrates how this is operationalized.

The proposed RBTN changes should be viewed favorably when any additional jurisdictions are connected by the route. Additionally, the proposed alignment/corridor **preferably should not reduce the number of continuously connected cities and counties.**

a. Test Case Examples

Figure 7 demonstrates connections to local bikeway networks across multiple cities and counties. The full mapped example for Measure 2 as well as the next two measures (3A/3B) are included in APPENDIX B – Test Case Examples (pp.44), with both a map of the output and narrative interpretation.

Figure 6. Example of counting both connectivity between adjacent cities and access points to local bikeway networks.

D. Inter-Network Connectivity

1. Background

Guiding Principles 2 and 7 both speak to a need for facilitating continuous travel to regional destinations and RBTN integration with local, county, and state bikeway networks. This pair of measures, **Number of Connection Points with State or Regional Trails** (Measure 3A) and **Number of Connection Points with Local Bikeway Networks** (Measure 3B), speak to these two Guiding Principles. The intent of these measures is to increase connection points to local, regional, or state bikeway networks.

2. BPPDG Feedback

BPPDG members weighed in throughout the development of this measure, including elevating the priority of connectivity-related Guiding Principles.

3. Application Guidelines

Both of these measures can be applied to all proposal types and RBTN route types.

Number of Connection Points with State or Regional Trails (Measure 3A) provides a count of the number of state or regional trail access points/intersections (net change in number of networks accessed is considered for shifts). This measure does not include regional trails that are already designated as part of the RBTN. This measure aims to increase the number of access points/intersections of future RBTN alignments/corridors with the existing State and Regional trails. Additionally, the proposed alignment/corridor **preferably should not reduce the number of access points/intersections with**

regional or state trails. The net change in state/regional trail access points is considered for alignment/corridor shifts.

Number of Connection Points with Local Bikeway Networks (Measure 3B) is distinct from Measure 3A in that it counts *all* connections to or intersections with local bikeway networks, regardless of how many jurisdictions the proposed RBTN alignment or corridor centerline passes through. Measure 3B provides a count of the number of local bikeway network access points/intersections. Similar to Measure 3A, this measure aims to increase the number of access points/intersections of future RBTN alignments/corridors with the existing local bikeway network. The proposed alignment/corridor **preferably should not reduce the number of access points/intersections with local bikeway networks. The net change in local network access points is considered for alignment/corridor shifts.**

a. Test Case Examples

One example of connectivity (measures 2, 3A, and 3B) is included in APPENDIX B – Test Case Examples (pg.44), with both a map of the output and narrative interpretation.

E. Equity

1. Net Change in BIPOC Individuals and People in Poverty with Access to RBTN [12]

Net Change in BIPOC Individuals and People in Poverty with Access to RBTN (Measure 4A) will be applied only for proposed RBTN alignment/corridor shifts (i.e., RBTN route additions and extensions will be excluded from this measure). The sums of these populations within 1 mile of the alignment or corridor in question will be compared for the existing and proposed RBTN routes to establish the net change in Black, Indigenous, and People of Color (BIPOC) and people in poverty with access to the RBTN. The proposed alignment/corridor should not decrease overall access to the RBTN among BIPOC individuals or people in poverty. Details of how to calculate this measure are shown in APPENDIX C – Measurement Procedures (pg. 54). In cases where a regional bicycle barrier (as defined in Chapter 7 of the regional Transportation Policy Plan) separates a BIPOC or impoverished population from the proposed alignment/corridor, average distances via existing regional barrier crossings may need to be calculated manually.

2. Qualitative Agency Self-Assessment of Benefits to Disadvantaged or Vulnerable Populations12

This measure, **Qualitative Agency Self-Assessment of Benefits to Disadvantaged or Vulnerable Populations** (Measure 4B), will give agencies the opportunity to highlight ways in which the proposed new or moved RBTN corridor or alignment will benefit disadvantaged populations or individuals. For the purpose of this measure, disadvantaged populations and individuals include:

- BIPOC populations or individuals
- Individuals or households for whom poverty status is defined based on the region's poverty definition of those with incomes falling below 185% of the federal poverty line
- Immigrant communities
- Individuals with physical disabilities
- Senior citizens (age 65-plus)
- Youth (ages 5 to 15)

A survey form will be produced by Met Council staff to query agencies proposing RBTN changes; the survey should contain questions including but not necessarily limited to the following items:

- List of disadvantaged groups likely to be affected by proposed RBTN change

[12] Note that this equity measure was developed with and recommended by Met Council staff working to implement regional policies relating to social and economic equity

- Location of disadvantaged community or group within jurisdiction in relation to proposed RBTN facility and to existing RBTN facility for alignment or corridor shifts
- Detailed description of benefits likely to result from implementing RBTN facility according to proposed addition or change
- 'Level of confidence' that the benefit or benefits will be realized
- Evidence from research studies and/or experience from other similar jurisdictions in support of 'level of confidence' stated.
- Description of the potential unintended consequences to disadvantaged groups that could result from projects implemented according to the proposed RBTN addition or change and what steps agency can take to minimize or offset such impacts.
- Results of measures 4A and 4B will be interpreted in context with the other measures. Proposed RBTN additions or changes that significantly improve access to the RBTN for BIPOC individuals or people in poverty will be viewed favorably and may be interpreted to offset deficiencies in some other measures. RBTN access for BIPOC individuals or people in poverty should not be reduced.

F. Population and Jobs

1. Background

The RBTN Guiding Principle number 10 focuses on spacing guidelines that are reflective of established development and transportation patterns. In addition to the spacing measure outlined earlier (IV. Development of Spacing Measures), an additional two-part measure is included to assess how the proposed change relates to development patterns. Measure 5A is **Proximity to Projected Population and Jobs** (measured for urban center, urban, suburban, suburban edge, and emerging suburban edge only). Measure 5B is **Activity per Mile Ratio** (measured for areas beyond emerging suburban edge only).

These two method components are tailored to meet the planning and development needs of urban and suburban areas (5A) and rural areas (5B). The key distinction between them is that the rural version (5B) is a measure of activity per linear mile of proposed RBTN alignment or corridor centerline, while the urban and suburban version (5A) is a measure of activity density per square mile. The linear denominator in 5B scales more slowly than density (5A) and lends itself to rural-specific threshold recommendations.

The purpose of these measures is:

- To understand to what extent the proposed route provides access to existing and planned development density, and
- For RBTN shifts, to understand the extent to which the proposed route increases or decreases access to development nodes compared to the existing RBTN alignment/corridor centerline.

2. BPPDG Feedback

BPPDG members weighed in throughout the development of these measures, including elevating the needs of rural-specific proposals.

3. Application Guidelines for Proximity to Projected Population and Jobs (Measure 5A)

Proximity to Projected Population and Jobs (Measure 5A) can be used in all RBTN proposal types in the urban and suburban Thrive designated communities.

Proposed changes in rural areas will be assessed separately with the activity per mile ratio (measure 5B). This measure is calculated by the sum of the weighted averages of forecasted people and jobs within a 1/2-mile buffer of the proposed RBTN alignment/corridor centerline. The formula is as follows:

- $AD = \frac{\sum p+j}{a}$
- Where:
  - AD = Activity density
  - p = Forecast population measured within a one-half mile buffer around the proposed RBTN route

- j = Forecast jobs measured within a one-half mile buffer around the proposed RBTN route
- a = Area (in square miles) of a one-half mile buffer around the proposed RBTN route

This measure looks at the density context to evaluate the feasibility of the proposed RBTN alignment/corridor. Density is critical for the proposed alignments/corridors because it concentrates trip origins or destinations so that usage becomes practical as well as economical. A diversity of land uses at destinations means that the proposed route can serve multiple purposes (employment, shopping, and recreation), increasing the system's efficiency and convenience for users. Details of how to calculate this measure are shown in APPENDIX C – Measurement Procedures.

The study team tested this measure on thirteen test cases throughout the region and aggregated the results by Thrive community designations. This application used existing population and jobs, whereas the recommended measure uses forecasted population and jobs, which in most cases will be higher than existing. The study team recommends using generously rounded initial targets based on observed values from these test cases. Table 8 provides results of population and jobs per mile and its 75 percent used to calculate the initial target threshold for urban, urban center and suburban community designations. Over time it may be useful to adjust these up or down, based on future trends. For example, when new regional population and employment forecasts are released, averages based on the entire region, rather than a subset of test cases, could be used to modify these thresholds. Since proposals will be evaluated comprehensively, initial flexibility should be exercised in the application of this threshold.

Table 8. Population and employment density

Thrive Community Designation	*Population + Jobs [13] per square mile*	*75% of Population + Jobs per square mile*	*Rounded initial target threshold*
Urban Center	6,804	5,103	5,000
Urban	4,393	3,294	3,000
Suburban, Suburban Edge, Emerging Suburban Edge	1,965	1,474	1,300
Regional Average	*2,953*	*2,215*	

a. Test Case Examples

One example of proximity to projected population and jobs is included in APPENDIX B – Test Case Examples (pg.46), with both a map of the output and narrative interpretation.

4. Application Guidelines for **Activity per Mile Ratio** (Measure 5B)

For proposed extensions and additions connecting suburban communities and/or rural centers through rural areas, a measure of **Activity per Mile Ratio** (Measure 5B) is used. This measure fills a need where the spacing buffer method is not as relevant in rural areas due to the greater spacing of existing road networks and limited RBTN coverage. The process to develop this measure is similar to 5A, with the key distinction being that 5B is measured using linear miles as the denominator (as opposed to 5A, which used square miles as the denominator).

[13] These calculations were done using existing population and jobs. As applied, these measures should use forecasted population and jobs. The regional average was computed using an area-weighted average that corresponded to overlapping Thrive community types within the buffers around each test case alignment.

The activity ratio method sums jobs and people within 1 mile of the corridor bandwidth measure for both corridors and alignments and divided by the sum by the length of the route. The formula is as follows:

- $AR = \frac{\sum p+j}{l}$
- Where:
  - AR=Activity per mile ratio
  - p=Projected population measured within a one-half mile buffer around the proposed RBTN route
  - j=Forecast jobs measured within a one-half mile buffer around the proposed RBTN route
  - l=Length (in miles) of the proposed RBTN route

Like Measure 5A, the study team derived thresholds from applying the measure to a set of test cases in largely rural areas. Table 9 indicates the activity per mile ratio for existing and non-existing test case used to calculate the initial target threshold.

Table 9. Activity per Mile Ratio for rural test cases

Test Case	*Population + Jobs* [14]	*Miles*	*People + Jobs / Mile*	*75% of People + Jobs per mile*	*Rounded initial target threshold*
8. Stillwater	30,174	11.22	2,689		
9. Medina [15]	1,119	4.05	277		
11. Waconia	4,549	7.18	634		
12. Waconia	3,080	6.11	504		
13. Waconia	19,578	10.8	1,813		
Test Case Average			*1,183*	*887*	*800*

This criterion, which is applicable to alignment and corridor extensions and additions through rural areas, is evaluated in relation to this rounded initial target threshold of 800 people and jobs per mile.

Note, this initial threshold should be applied with some flexibility and evaluated within the context of local development plans and initiatives and in context with other measures. The threshold should be monitored and assessed for consistency and fairness as RBTN proposals are evaluated. As noted for 5A, the threshold may be adjusted up or down based on future regional forecasts.

a. Test Case Examples

Five examples of activity per mile ratio are included in APPENDIX B – Test Case Examples (pg.47), with both a map of the output and narrative interpretation.

[14] These calculations were done using existing population and jobs. As applied, these measures should use forecasted population and jobs.

[15] This route is not currently part of the RBTN

VII. APPENDIX A – RBTN Measure Summary and Details

The table below provides a high-level overview of each measure, including applicable Guiding Principles, request type, and thrive communities.

Table 10. RBTN Facility Measures Summary

DIRECTNESS			
Guiding Principle(s) Addressed	**Description**	**Guidelines**	**Applicability**
GPs #1 and #3	**Destination Proximity** Measures net change in proximity to regional destinations. Proximity is measured using a 1/10-mile buffer for alignments and includes points within the corridor bandwidth (½-mile bandwidth for core cities, 1-mile outside core) for corridors. For a destination to be considered proximate, there should not be a barrier that severs the destination from the corridor centerline or alignment.	**Applicable Destinations:** • Metropolitan Job Centers • Regional Job Centers • Subregional Job Centers • Colleges & Universities (2000+ enrolled) • Large High Schools (2000+ enrolled) • Major Sport & Entertainment Centers • High-visit Regional Parks (> 400k/yr) • Existing Transitway Stations • Planned Transitway Stations • Park & Rides (> 200 spaces) and Transit Centers • Bike & ride centers Measured based on overall impact to regional destination connectivity, ranging from adverse impact to high impact. *Interpret in context with other measures.*	 *All Locations*
	Out-of-Direction Ratio Measures two network distances relative to each other to indicate comparative efficiency of two routes. The out-of-direction ratio is calculated and averaged for several starting and end points for both the proposed corridor and the existing facility.	**Maximum recommended ratio:** Initial flexible target guidance based on a combination of empirically derived values, Council/BPPDG input, and literature about bicyclist willingness to detour. Ratio 2.0 *Interpret in context with other measures.*	 *Locations: Case by Case*

SPACING			
Guiding Principle(s) Addressed	**Description**	**Guidelines**	**Applicability**
GPs #1 and #10	**Spacing Buffer Overlap** Compares the buffers of both the existing and proposed facilities to provide an understanding of the extent to which the route overlaps with buffers of existing parallel routes as well how the gaps between buffers are impacted. Buffers based on the preferred minimum spacing distance between RBTN alignments and/or corridor centerlines that vary with Met Council community type designations.	**Minimum Spacing:** Urban Center: *½ mile* Urban: *¾ mile* Suburban: *1 mile* Rural: *2 miles* *Measured according to changes and reductions in overall gaps between buffers. Significant overlap should not occur (excluding overlap due to curvilinearity or converging/diverging facilities, or in large CBDs).* *Interpret in context with other measures.*	 *All Locations*

OTHER MEASURES			
Guiding Principle Addressed	**Description**	**Guidelines**	**Applicability**
GP #1	1. **Net Number of Direct Connections to Regional Bicycle Barrier Crossings** Provides a count of the net number of direct connections from the proposed RBTN change to regional barrier crossings, including existing and planned	Net number of direct connections preferably should not be reduced. *Interpret in context with other measures.*	***All RBTN Proposal Types*** *All Locations*
GP #2 (Continuity Only)	2. **Continuity/Connectivity Between Adjacent City and County Bikeway Networks** Provides a count of the number of city/county bikeway networks that are newly connected by the proposed RBTN change.	Additional connections are viewed favorably. *Interpret in context with other measures.*	***All RBTN Proposal Types*** *All Locations*
GP #7	3A. **Number of Connection Points with State or Regional Trails** Provides a count of the number of state or regional trail access	Number of access points/intersections preferably should not be reduced. Net change in	***All RBTN Proposal Types*** *All Locations*

OTHER MEASURES			
Guiding Principle Addressed	**Description**	**Guidelines**	**Applicability**
	points/intersections. This does not count any intersections with other RBTN facilities (e.g., regional trails that are already designated as part of the RBTN).	connection points is considered for shifts. *Interpret in context with other measures.*	
	3B. **Number of Connection Points with Local Bikeway Networks** Provides a count of the number of local bikeway network access points/intersections.	Number of access points/intersections preferably should not be reduced. Net change in connection points considered for shifts. *Interpret in context with other measures.*	***All RBTN Proposal Types*** *All Locations*
GP #9	4A. **Net Change in BIPOC Individuals and People in Poverty with Access to RBTN** Measures BIPOC and below poverty threshold populations within 1 mile of existing & proposed RBTN facility to determine net change.	BIPOC/below poverty threshold populations should not be reduced.	 *All Locations*
	4B. **Qualitative Agency Self-Assessment of Benefits to Disadvantaged or Vulnerable Populations** Provides opportunity for proposing agencies to describe likely benefits resulting from the addition or change to BIPOC & impoverished populations, as well as to seniors, youth, and people with disabilities.	Description of likely benefits to BIPOC/impoverished populations & for seniors, youth, & people with disabilities resulting from proposed RBTN addition or change. Proposals that improve access or conditions for BIPOC communities and populations in poverty are viewed favorably. Access and conditions for these communities should not be reduced. *Interpret in context with other measures.*	***All RBTN Proposal Types*** *All Locations*

OTHER MEASURES			
Guiding Principle Addressed	**Description**	**Guidelines**	**Applicability**
GP #10	5A. **Proximity to Projected Population and Jobs** Measures the sum of existing and planned (i.e., projected) population and jobs within a ½-mile of the proposed RBTN alignment/corridor centerline.	**Minimum recommended densities:** Initial flexible target guidance based on a combination of empirically derived values, Council/BPPDG input. Urban Center: 5,000 people + jobs / sq mi Urban: 3,000 people + jobs / sq mi Suburban, Suburban Edge, Emerging Suburban Edge: 1,300 people + jobs / sq mi Rural Center, Rural Residential, Diversified Rural, Agriculture: 300 people + jobs / sq mi *Interpret in context with other measures.*	***All RBTN Proposal Types*** *Locations: **U, UC, and S*** *(Rural measured separately with activity per mile ratio)*
	5B. **Activity per Mile Ratio** This measure is assessed for proposed extensions and additions connecting suburban communities and/or rural centers through rural areas. The activity per mile ratio is the sum of jobs and people within a ½-mile of the proposed alignment or corridor centerline, divided by the length of the route.	**Minimum recommended ratios:** Initial flexible target guidance based on a combination of empirically derived values, Council/BPPDG input. 800 people + jobs / mile *Interpret in context with other measures.*	⤢ + *Locations: Suburban to Rural communities*

Table 11 provides details about each measure, including a description, question addressed, data availability and reliability, and the applicable Guiding Principles. For reference, the full language of the guiding principles is on the page following the table.

Table 11. RBTN Measure Details

Measure	Description	Question Addressed	Data Availability and Reliability	Guiding Principles										
				1	2	3	4	5	6	7	8	9	10	11
Directness: Destination Proximity	Measures net change in proximity to regional destinations. Proximity is measured using a 1/10-mile buffer for alignments and includes points within the corridor bandwidth (½-mile bandwidth for core cities, 1-mile outside core) for corridors. For a destination to be considered proximate, there should not be a barrier that severs the destination from the route.	To what extent does the proposed change affect route directness or efficiency for accessing regional destinations?	Metropolitan Council already maintains database of regional destinations.	D	I	D		I	I	I			I	Im
Directness: Out-of-Direction Ratio	Measures two network distances relative to each other to indicate comparative efficiency of two routes. The out-of-direction ratio is calculated for the starting & end points of the proposed route versus the most direct existing RBTN route.	Does proposed addition, extension, or shift provide a new and more direct connection between two or more RBTN facilities? (i.e., does the proposed route provide a new short-cut along an RBTN route?)	Metropolitan Council already maintains RBTN database.	D	I	D		I	I	I			I	Im
Spacing: Spacing Buffer Overlap	Compares the buffers of both the existing and proposed facilities to provide an understanding of the extent to which the route overlaps with buffers of existing parallel routes as well how the gaps between buffers are impacted. Buffers based on the preferred minimum spacing distance between RBTN alignments and/or corridor centerlines that vary with Met Council community type designations.	To what extent is the proposed change consistent with regional spacing guidelines?	Metropolitan Council already maintains RBTN database.	D		I			I				D	
Other Measures														
Measure 1	Connections to existing and planned regional barrier crossings	To what extent would the proposed RBTN improve connections to regional barrier crossings?	Metropolitan Council already maintains database of barrier crossings.	D	I	I	I		I					
Measure 2	City/County bikeway networks connected	To what extent does the proposed RBTN addition, extension, or shift improve continuity & connections between bikeway networks of adjacent cities or counties?	Data about city and county boundaries are readily available.		D*			I	D	D				Im

Measure	Description	Question Addressed	Data Availability and Reliability	Guiding Principles										
				1	2	3	4	5	6	7	8	9	10	11
Measure 3A	Number of State or Regional trail access points/intersections	To what extent does proposed RBTN change connectivity with local, regional, or state bikeway networks? For shifts, what is the net change in number of networks accessed?	Metropolitan Council already maintains a regional bicycle facility database.						I	D				Im
Measure 3B	Local bikeway network access points/intersections							I	I	D				Im
Measure 4A	Population of BIPOC and below-poverty residents with access	Does the proposed change increase or decrease service to socially & economically disadvantaged communities?	Demographic data are readily available and likely already used by the Council. Equity groups can be selected for consistency with the Council's equity goals in Thrive.						I	I	I*	D		Im *
Measure 4B	Qualitative agency self-assessment of benefits to disadvantaged groups and individuals		Qualitative measure.			D			D	I	I*	D		Im *
Measure 5A	Proximity to projected/planned population and jobs	Does the proposed route incorporate existing and planned development density? For RBTN shifts, to what extent does the proposed corridor increase or decrease access to development nodes compared to the existing RBTN alignment/corridor centerline?	Jobs and population data are available from the Census and from the regional land use models.		I	I			I		I		D	Im
Measure 5B	Activity per Mile Ratio	Does the proposed route incorporate existing and planned development density?	2040 Forecast for Jobs and population data are available from the regional land use models.		I	I			I		I		D	Im

I - Indirect
D - Direct
Im – Implicitly
* Implies partial or potential

A. RBTN Guiding Principles

1. **Overcome physical barriers and eliminate critical system gaps**. Specifically addressing gaps and barriers in the regional system will improve convenience and continuity for bicyclists.
2. **Facilitate safe and continuous trips to regional destinations**. Developing and upgrading bicycle facilities along the RBTN will improve the convenience and safety of bicycling along these facilities.
3. **Function as arteries to connect regional destinations and the transit system year-round**. Designating alignments within RBTN corridors and implementing bikeways on the RBTN will provide the needed connections to regional destinations and the regional transit system.
4. **Accommodate a broad range of cyclist abilities and preferences to attract a wide variety of users**. Bicyclists have varying levels of comfort to ride based on facility type (on-street facility vs. off-road trail), roadway characteristics, and personal levels of experience and ability. In some urban, high demand corridors it may be appropriate to develop both an on-street facility and an off-road trail to accommodate the full range of cyclist preferences.
5. **Integrate and/or supplement existing and planned infrastructure**. When developing the RBTN, existing and planned infrastructure should be used when possible to reduce the need to purchase new right-of-way and to minimize the growing financial burden of preserving and maintaining existing facilities.
6. **Provide improved opportunities to increase the share of trips made by bicycle**. Implementing a complete RBTN that provides convenient connections to key regional destinations and the regional transit system will increase the likelihood of choosing bicycling for transportation over other travel modes.
7. **Connect to local, state, and national bikeway networks**. Connecting to other established bicycle networks will expand the reach and effectiveness of the regional network.
8. **Consider opportunities to enhance economic development**. New bicycling investments can be an effective tool for creating local economic development opportunities and to foster the Twin Cities' image as a highly livable region with many bike-friendly destinations
9. **Be equitably distributed throughout the region**. Social equity and regional geographic balance were emphasized in identifying the RBTN. By focusing on population and employment concentrations, the network will be able to attract the greatest number of riders. By also applying the Metropolitan Council's identified Areas of Concentrated Poverty (where at least 50% of the residents are people of color), the network will offer equitable access to bicycling and the economic opportunities and health benefits afforded by bicycle infrastructure.
10. **Follow spacing guidelines that reflect established development and transportation patterns**. The RBTN corridors were developed in a way that applied spacing concepts based on urban and suburban development patterns and plans. The resulting network is denser and has greater accessibility compared to regional bikeway corridors found in other metropolitan regions.
11. **Consider priorities reflected in adopted plans**. The RBTN was developed to reflect local bicycle plans and policies that inform regional priorities.

VIII. APPENDIX B – Test Case Examples

B. Test Case Examples – Spacing Measures

Seven cases were tested for the spacing buffer method, including one shift. For this method, spacing buffers were generated for the entire existing RBTN. Test cases 1, 2, and 7 are briefly reviewed below.

Figure 7. Spacing Buffer Applied to All Spacing Test Cases

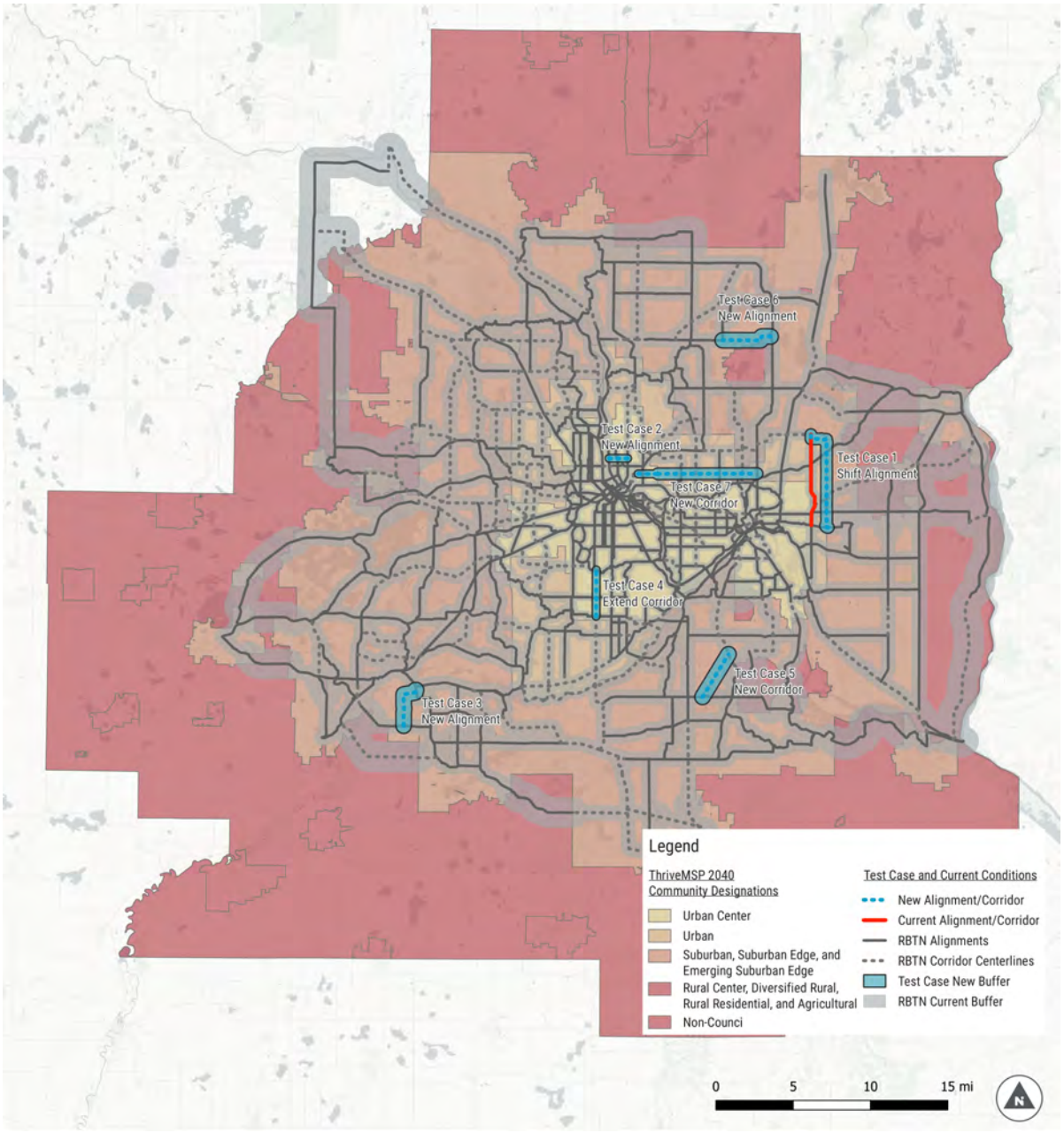
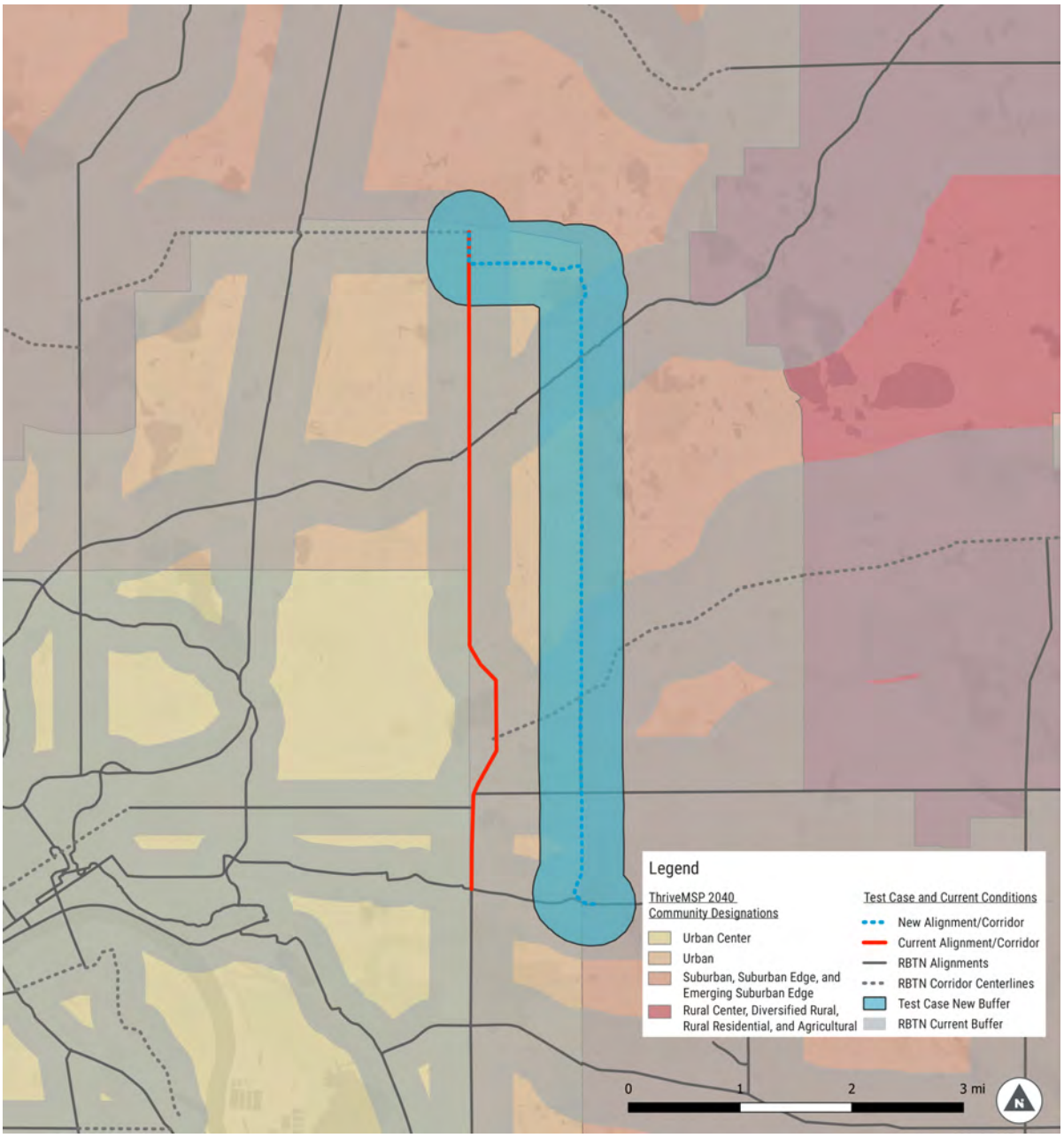


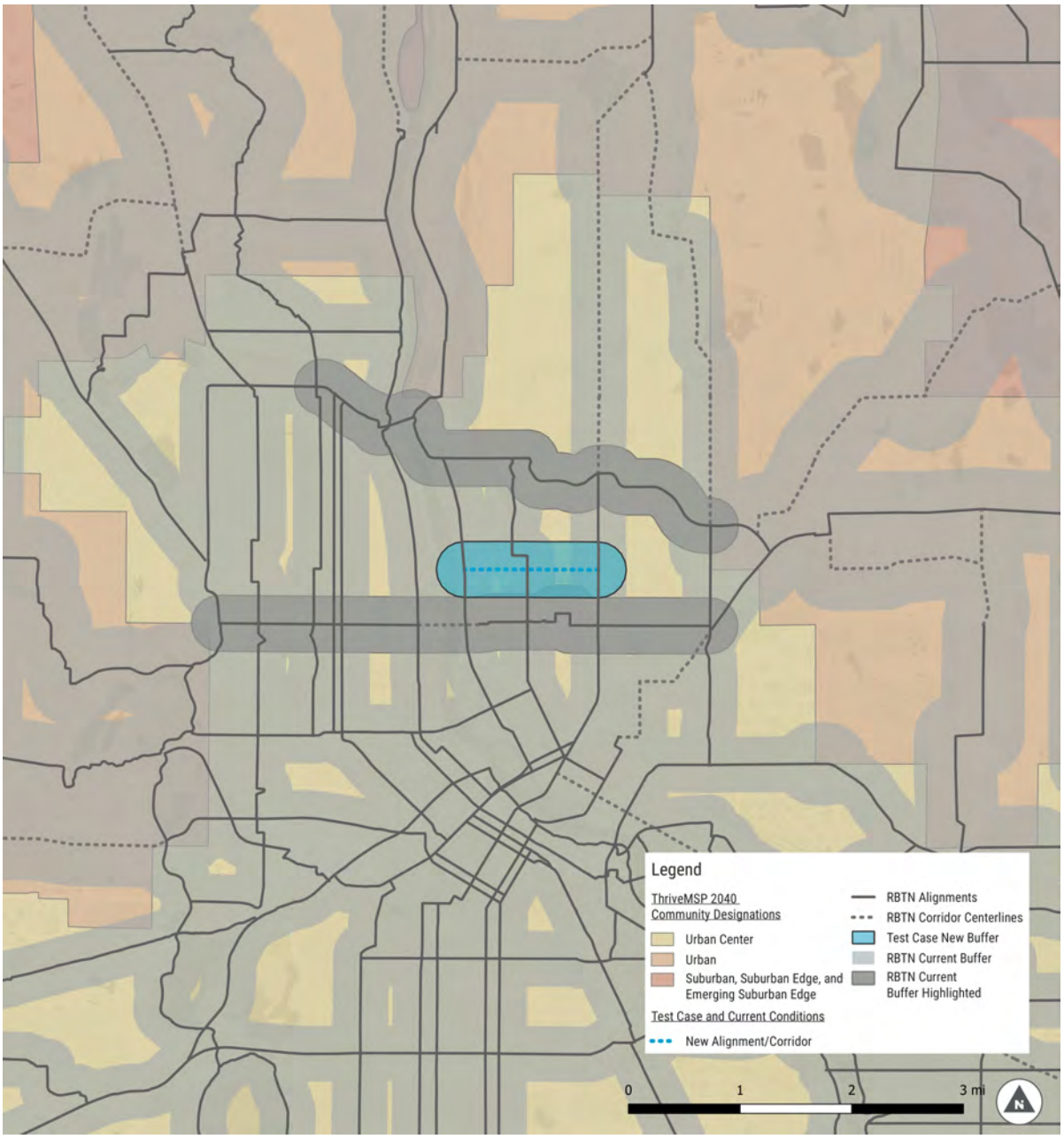
Figure 8. Test Case 1 – Example Shift from McKnight to TH 120



Results interpretation for Test Case 1, Spacing Buffer Method:

- Because this location is within the Urban Thrive Community Area, a buffer of 3/4 mile was drawn around the addition.
- The test case, reflecting a shift from McKnight, shown to in red the west of the test case, **meets the spacing criteria** because there is no significant overlap between buffers of parallel facilities.

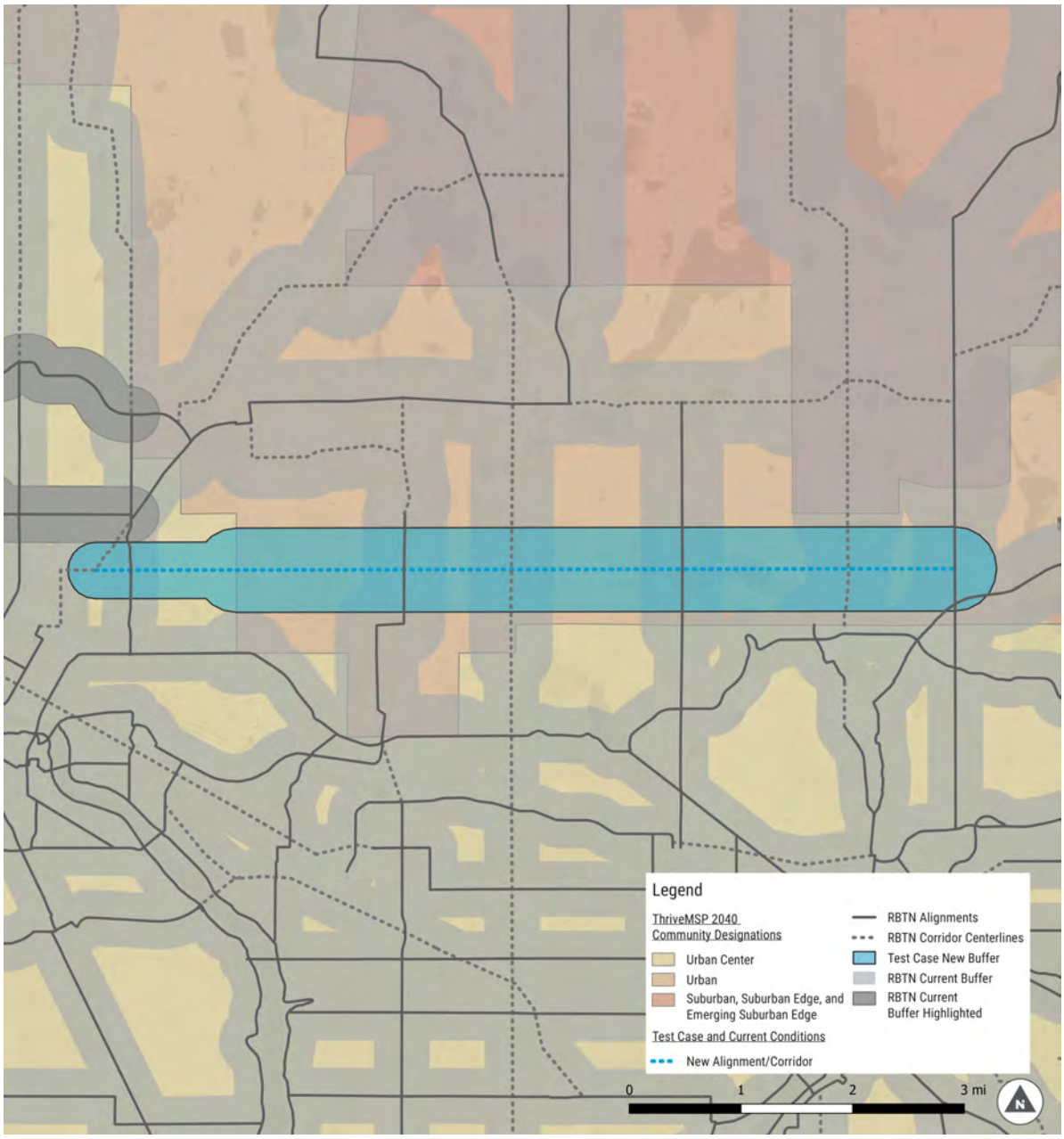
Figure 9. Test Case 2 – Example Corridor Addition Centered Along Lowry Ave NE



Results interpretation for Test Case 2, Spacing Buffer Method:

- Because this location is within the Urban Center Thrive Community Area, a buffer of ½ mile was drawn around the addition.
- The dense coverage of facilities in Urban Center masks relevant spacing overlap. To address this, parallel facilities on either side of the test case were selected for comparison.
- The test case **meets the spacing criteria** because there is no significant overlap between buffers of parallel facilities. Although there is a slight portion of the buffer that overlaps with the buffer of Broadway (the route to the south), this is the result of a small jog between Central and University and not a substantive overlap.

Figure 10. Test Case 7 – Example Corridor Addition Centered Along Broadway and Roselawn Avenues

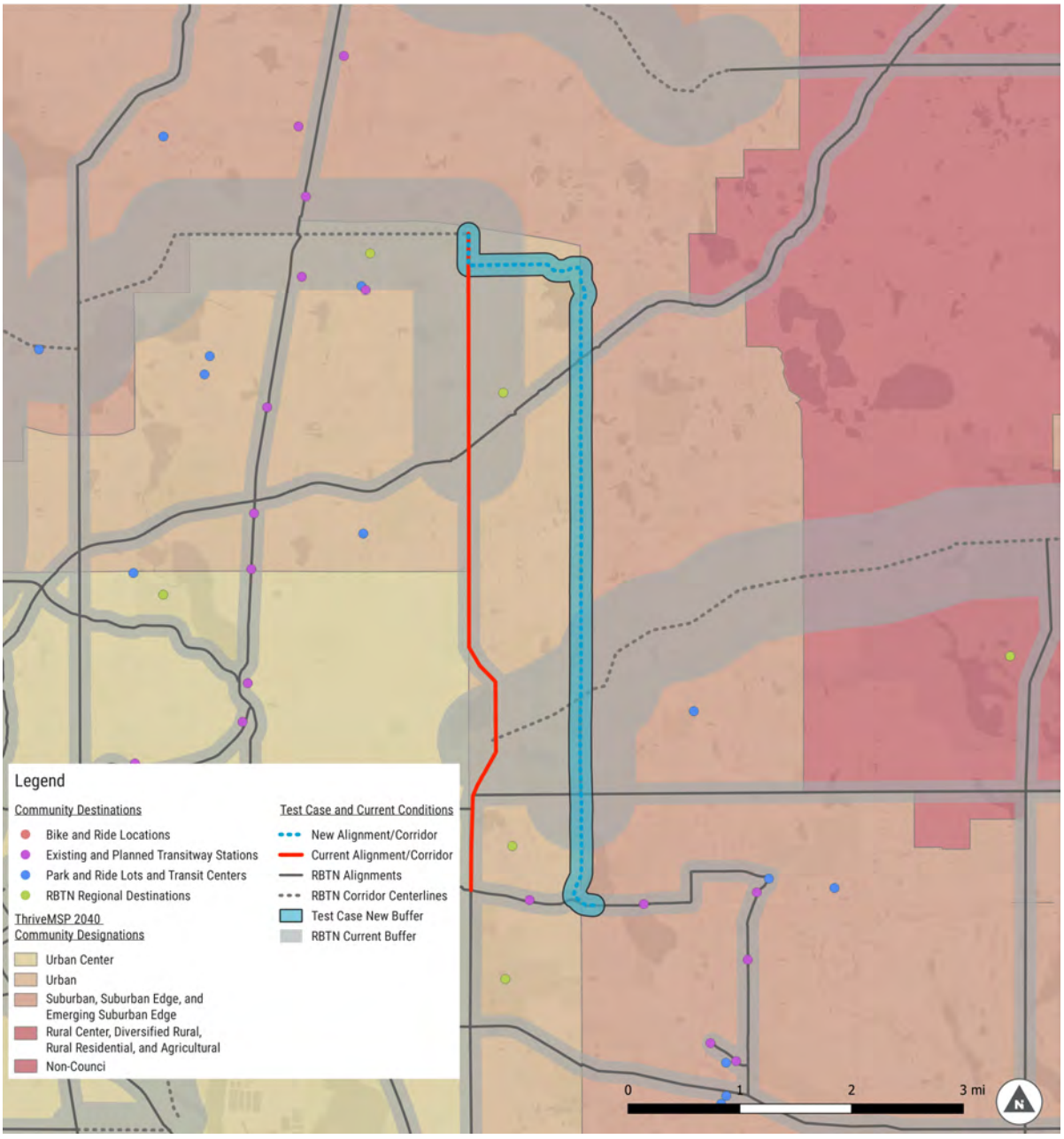


Results interpretation for Test Case 7, Spacing Buffer Method:

- Because this addition falls in both the Urban Center and Urban Thrive Community Areas, a ½ mile buffer was used on the western portion and a ¾ mile buffer was used for the rest of the addition.
- Similar to the above test case on Lowry Ave, this test case **meets the spacing criteria** because there is no significant overlap between buffers of parallel facilities. Although there is a slight portion of the buffer that overlaps with the buffer of the route to the south, this is the result of a convergence and not a substantive overlap. Overall, the new addition appears to be well-spaced.

1. Test Case Examples – Proximity to Regional Destinations Measure

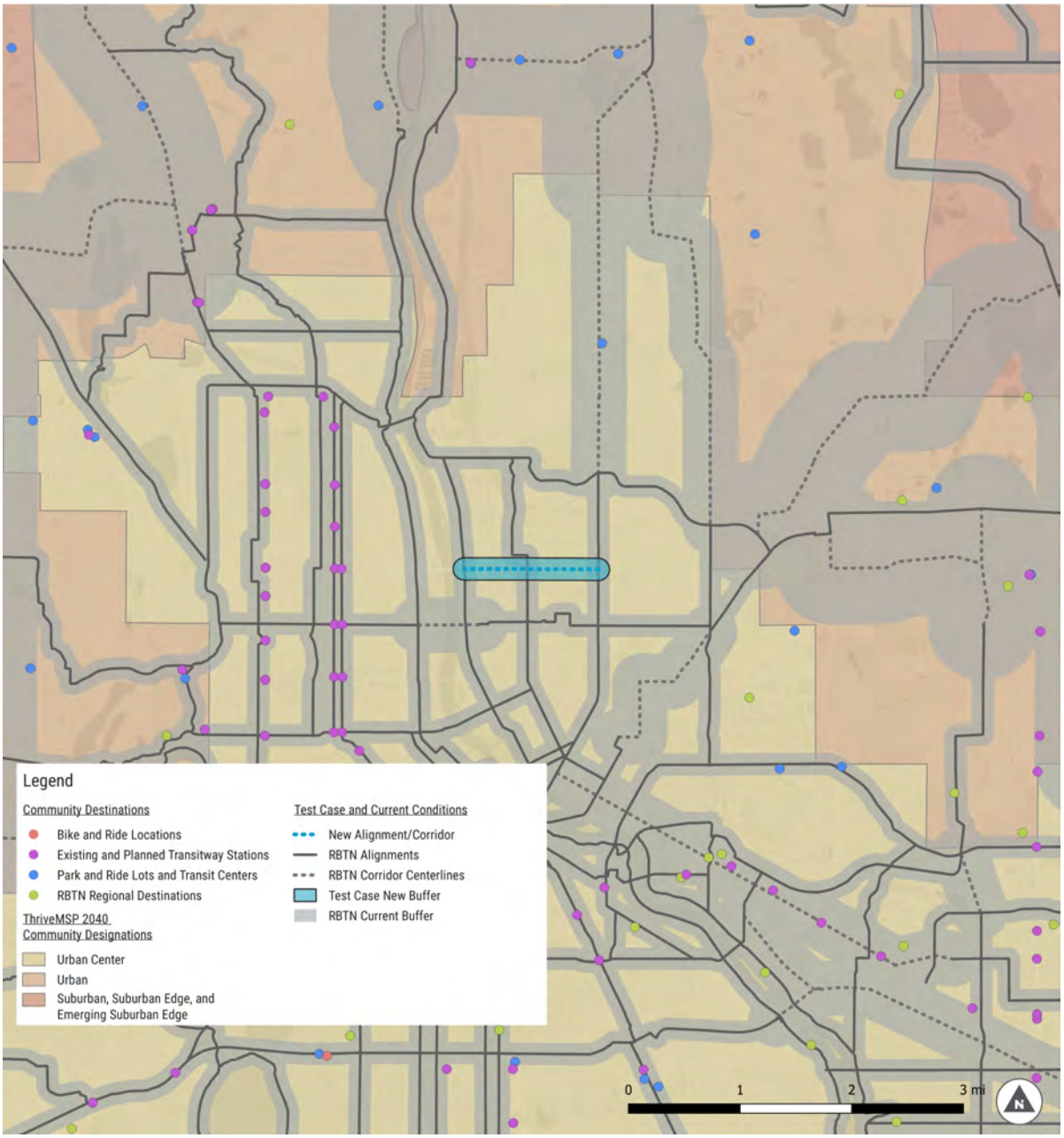
Figure 11. Test Case 1 – Example Shift from McKnight to TH 120



Results interpretation for Test Case 1, Destination Proximity Method:

- Because this addition is an alignment, a 1/10-mile buffer is used.
- Using the Council's destination dataset, this test case appears to have a **possible negative impact** on destination proximity. One destination falls within the old corridor, but it is almost within another alignment's buffer. Council staff should review specific local bike routes to the regional destination via each of the RBTN routes to determine the appropriate rating in this case.

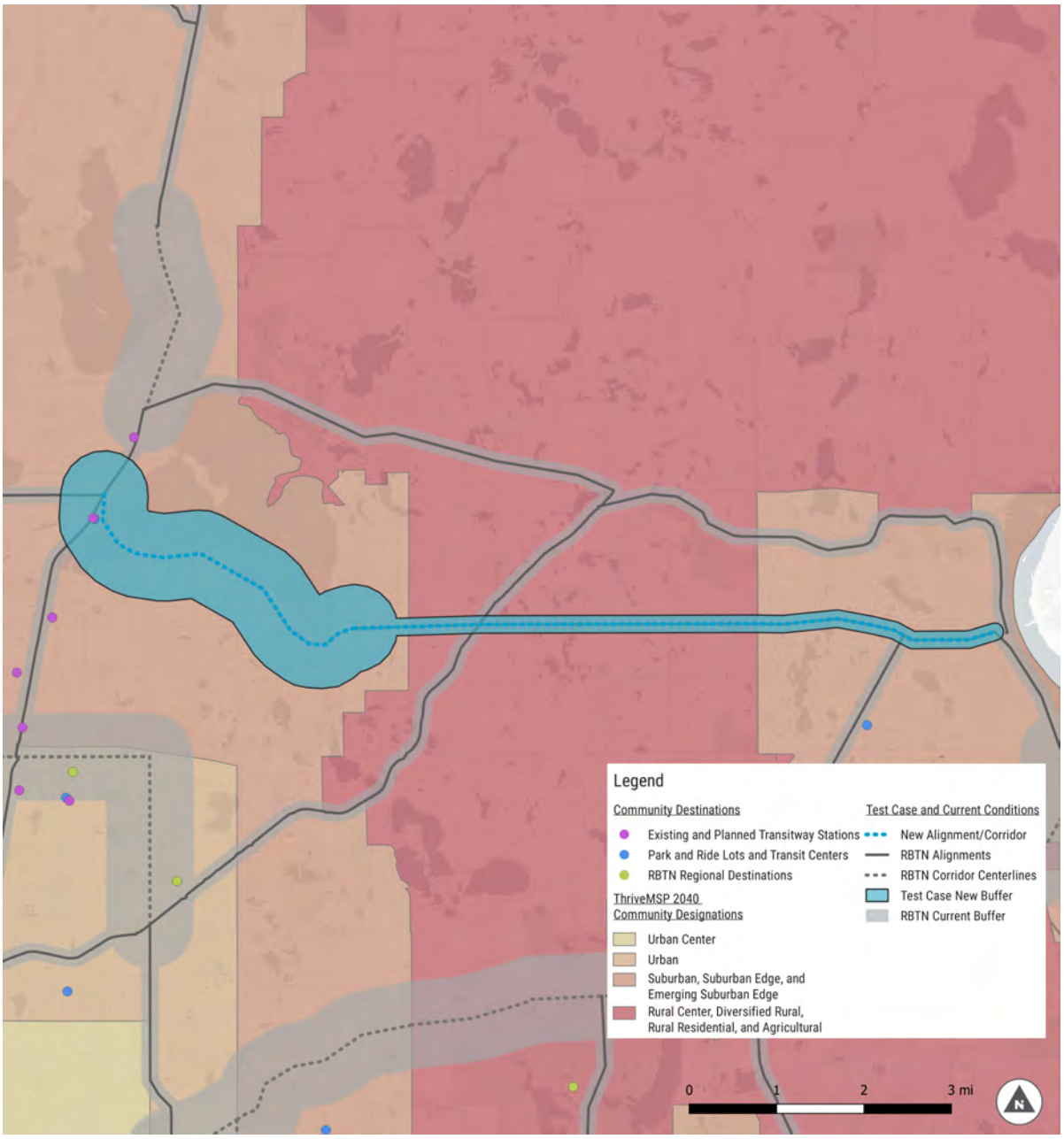
Figure 12. Test Case 2 – Example Addition along Lowry Ave NE



Results interpretation for Test Case 8, Destination Proximity Method:

- Because this corridor is in the urban core, a 1/4-mile buffer is used (based on the ½-mile corridor bandwidth for core cities)
- This test case has **no impact** on destination proximity, because there is no net change in the number of connected destinations (no regional destinations are located within the new corridor buffer).

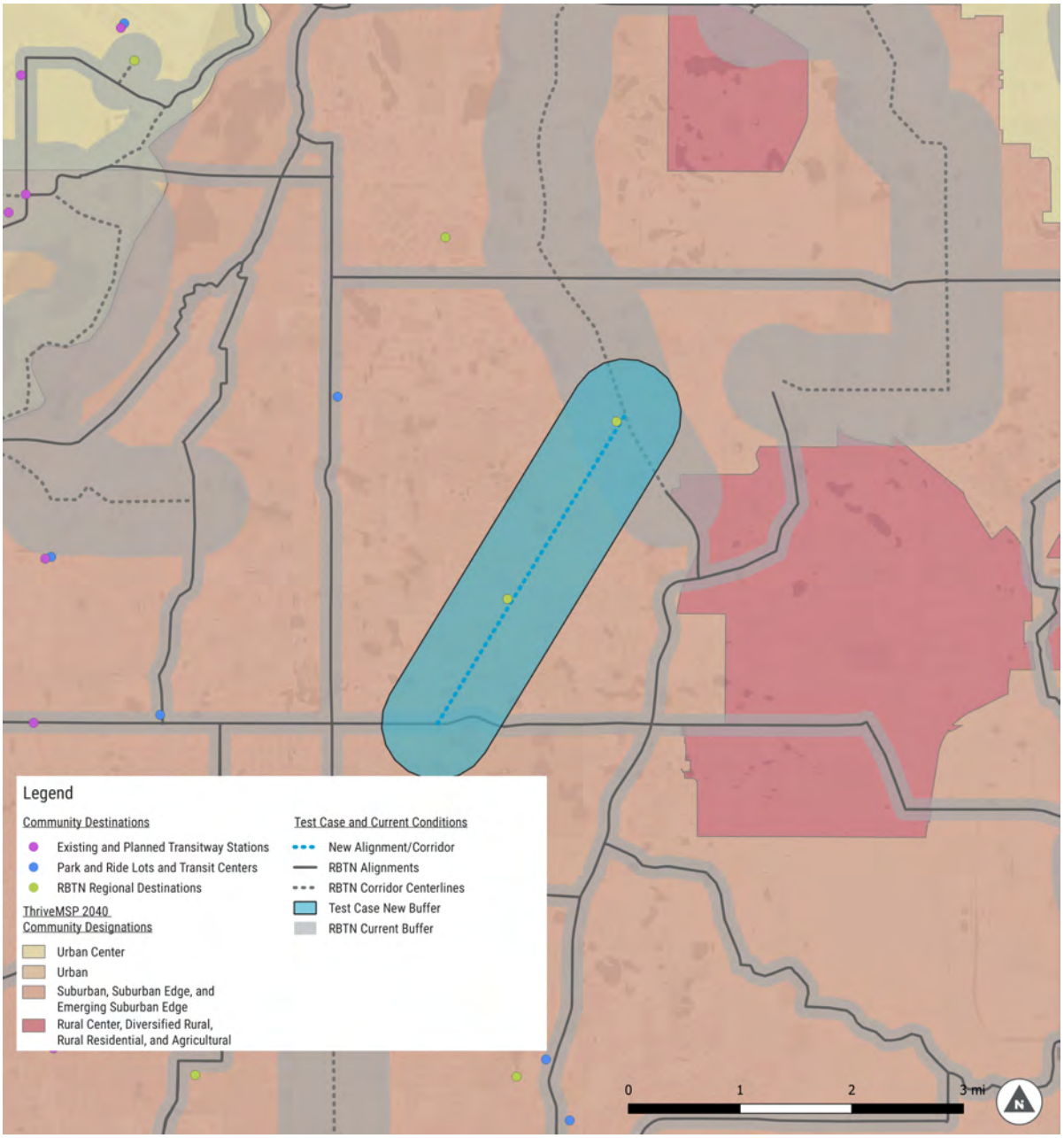
Figure 13. Test Case 8 – Existing Example Along Stillwater Rd



Results interpretation for Test Case 8, Destination Proximity Method:

- Because this addition is comprised both of a proposed alignment (eastern portion of the addition) and a proposed corridor (western portion of the addition) – two buffer sizes are used; 1/10-mile for the alignment (eastern portion) and ½-mile for the corridor (wester portion).
- This test case has **no impact** on destination proximity – although a destination is proximate to the addition, this destination is already accessible via an existing RBTN alignment.

Figure 14. Test Case 5 – Example Addition from Cliff Rd to Jefferson Trail West

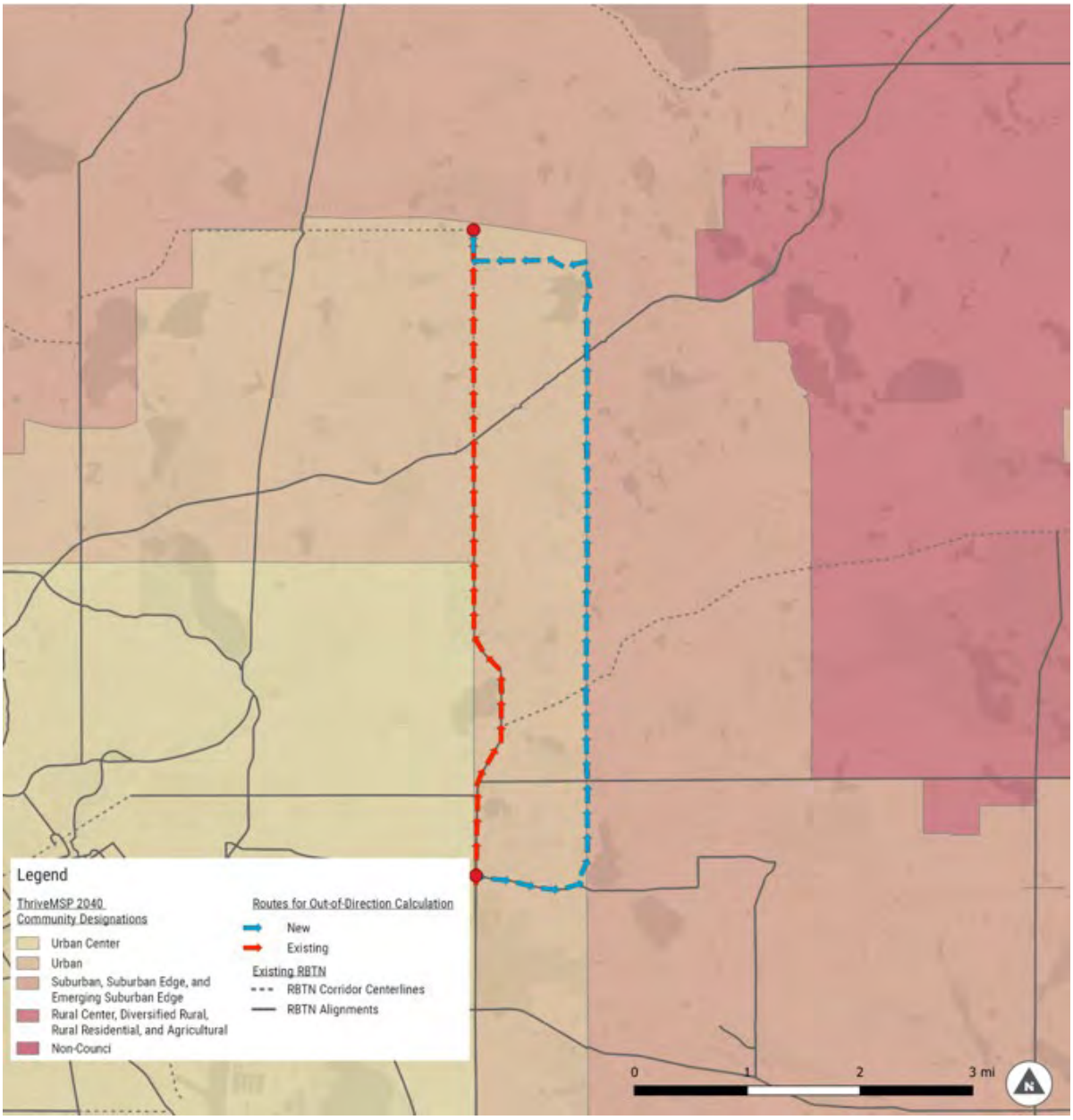


Results interpretation for Test Case 5, Destination Proximity Method:

- Because this addition is a corridor, a ½ -mile buffer is used.
- This test case has a **medium impact** on destination proximity, because one new destination is newly connected to the RBTN.

2. Test Case Examples – Out-of-Direction Ratio Measure

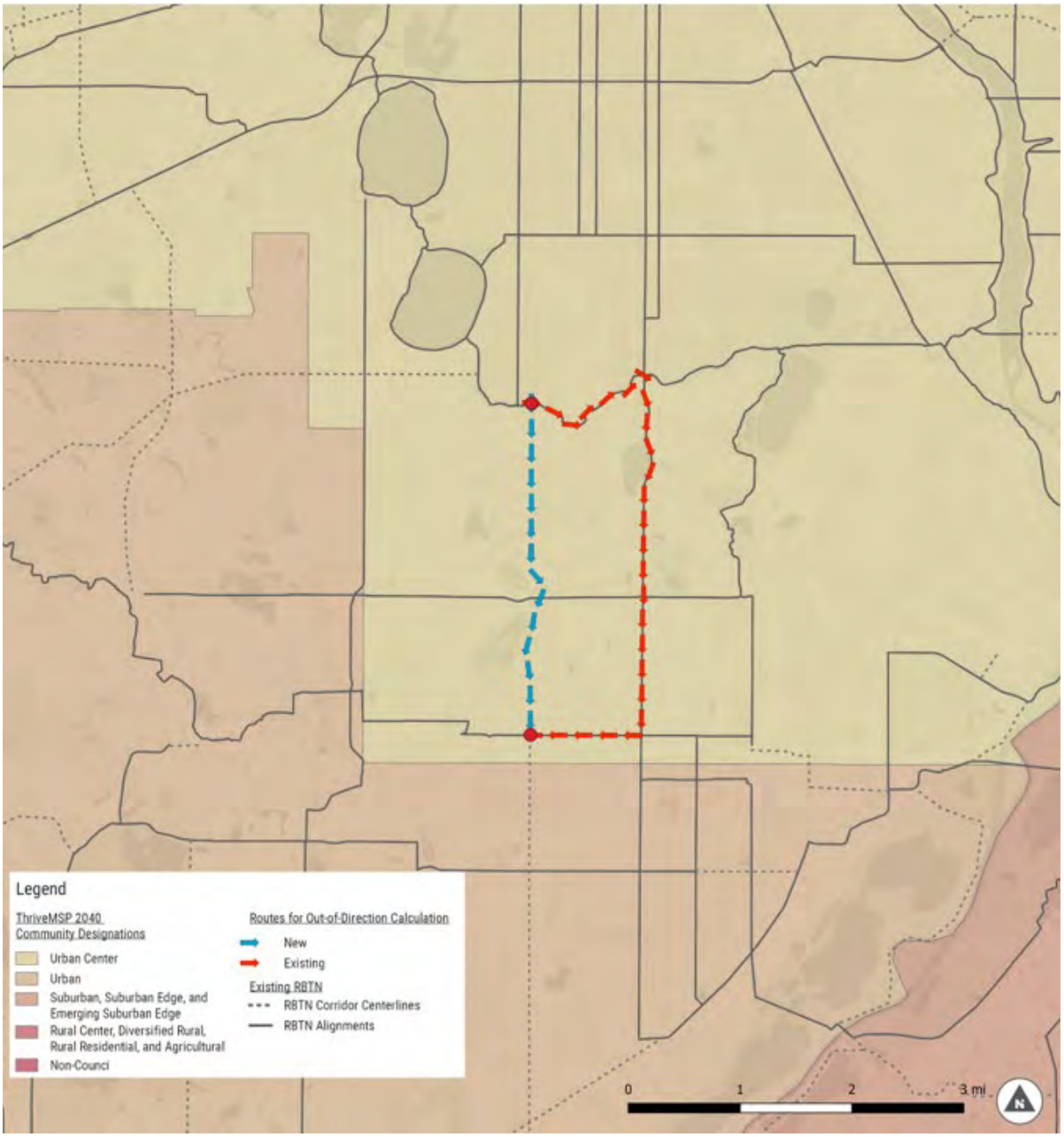
Figure 15. Test Case 1 – Example Shift from McKnight to TH 120



Results interpretation for Test Case 1, Out-of-Direction Ratio:

- Length using existing corridor centerline or alignment: 6.0 mi
- Length using new corridor: 8.0 mi
- Out-of-Direction Ratio: 1.33
- If the existing corridor were part of someone's trip and had previously provided the most efficient route, this shift would add two miles. This change would result in an **adverse impact** for this criterion.
    - 2-mile increase on a 5-mile trip = 40% longer
    - 2-mile increase on a 10-mile trip = 20% longer

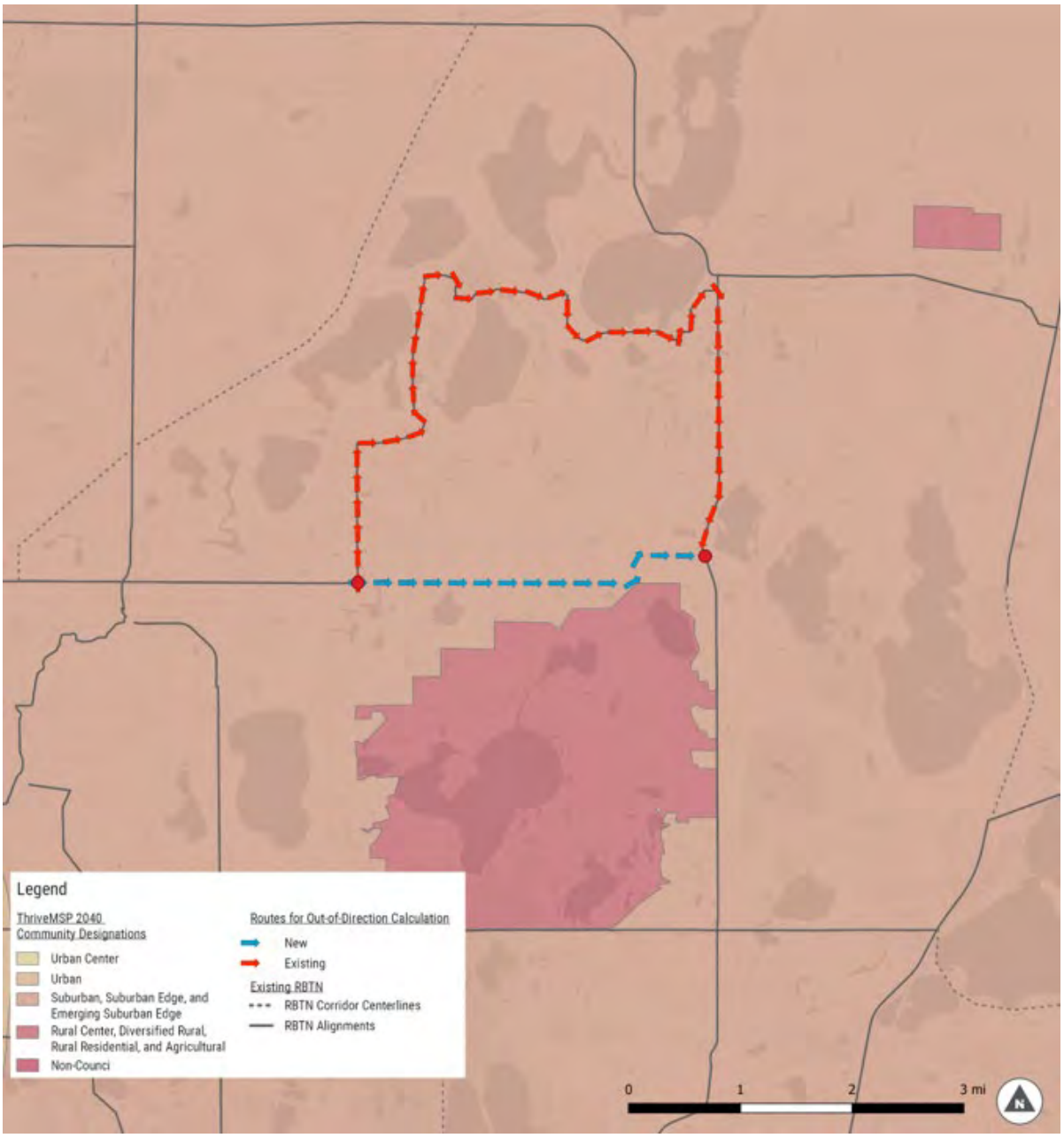
Figure 16. Test Case 4 – Example Extension along Lyndale Ave



Results interpretation for Test Case 1, Out-of-Direction Ratio:

- Length using existing corridor centerline or alignment: 5.6 mi
- Length using new corridor: 3.0 mi
- Out-of-Direction Ratio: 0.54
- For a trip where the new corridor is the most efficient route, this shortcut saves 2.6 miles. This change would result in **high impact** for this criterion.
    - 2.6-mile decrease on a 5-mile trip = 52% shorter
    - 2.6-mile decrease on a 10-mile trip = 26% shorter

Figure 17. Test Case 6 – Example Addition along Ash St/CR J

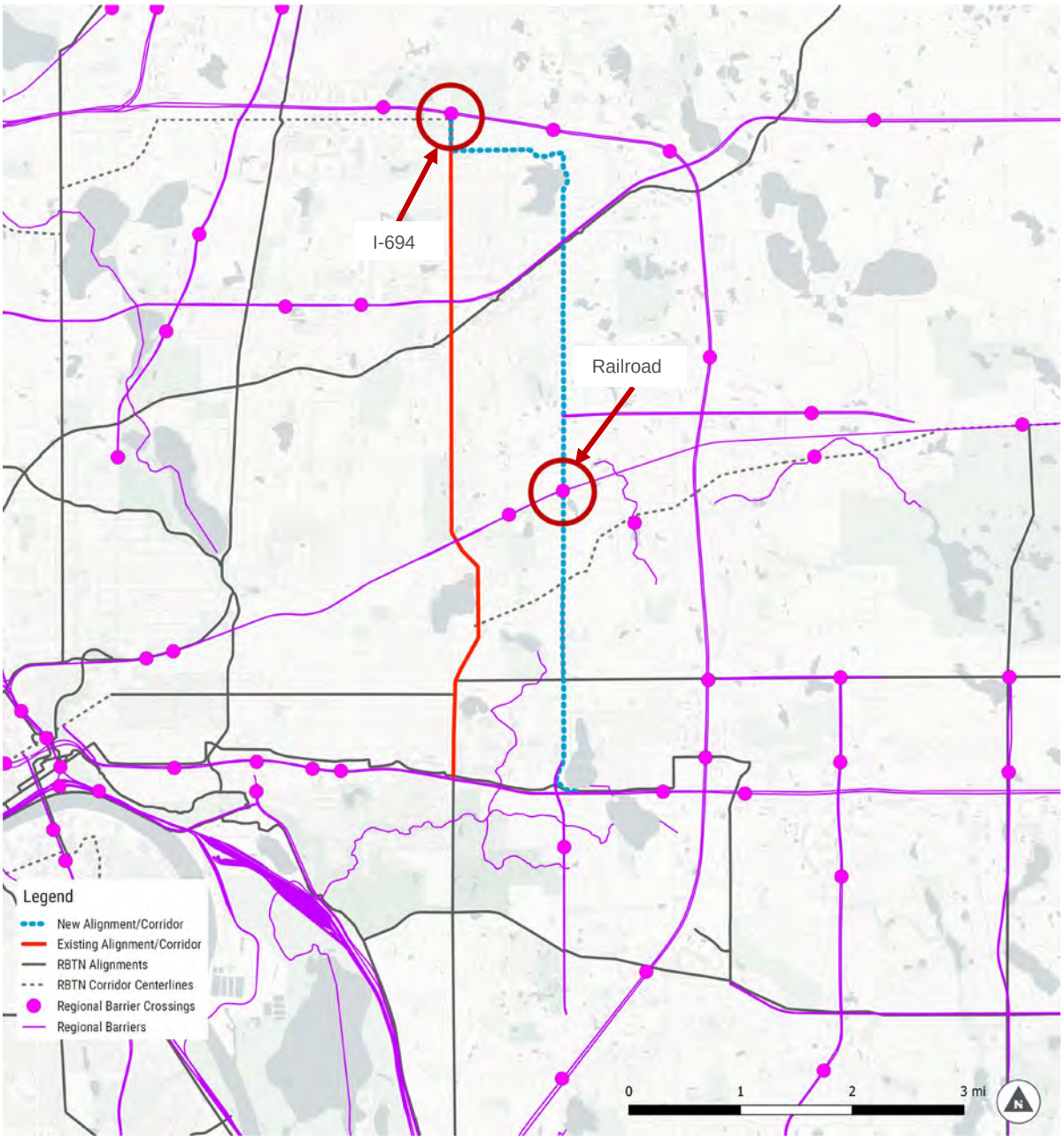


Results interpretation for Test Case 1, Out-of-Direction Ratio:

- Length using existing corridor centerline or alignment: 9.34 mi
- Length using new corridor: 3.31 mi
- Out-of-Direction Ratio: 0.35
- For a trip where the new corridor is the most efficient route, this shortcut saves 6 miles. This change would result in **high impact** for this criterion.
    - 6-mile decrease on a 10-mile trip = 60% shorter

3. Test Case Examples – Connections to Existing and Planned Regional Barrier Crossings

Figure 18 Test Case 7 – Example Shift from McKnight Rd to TH 120



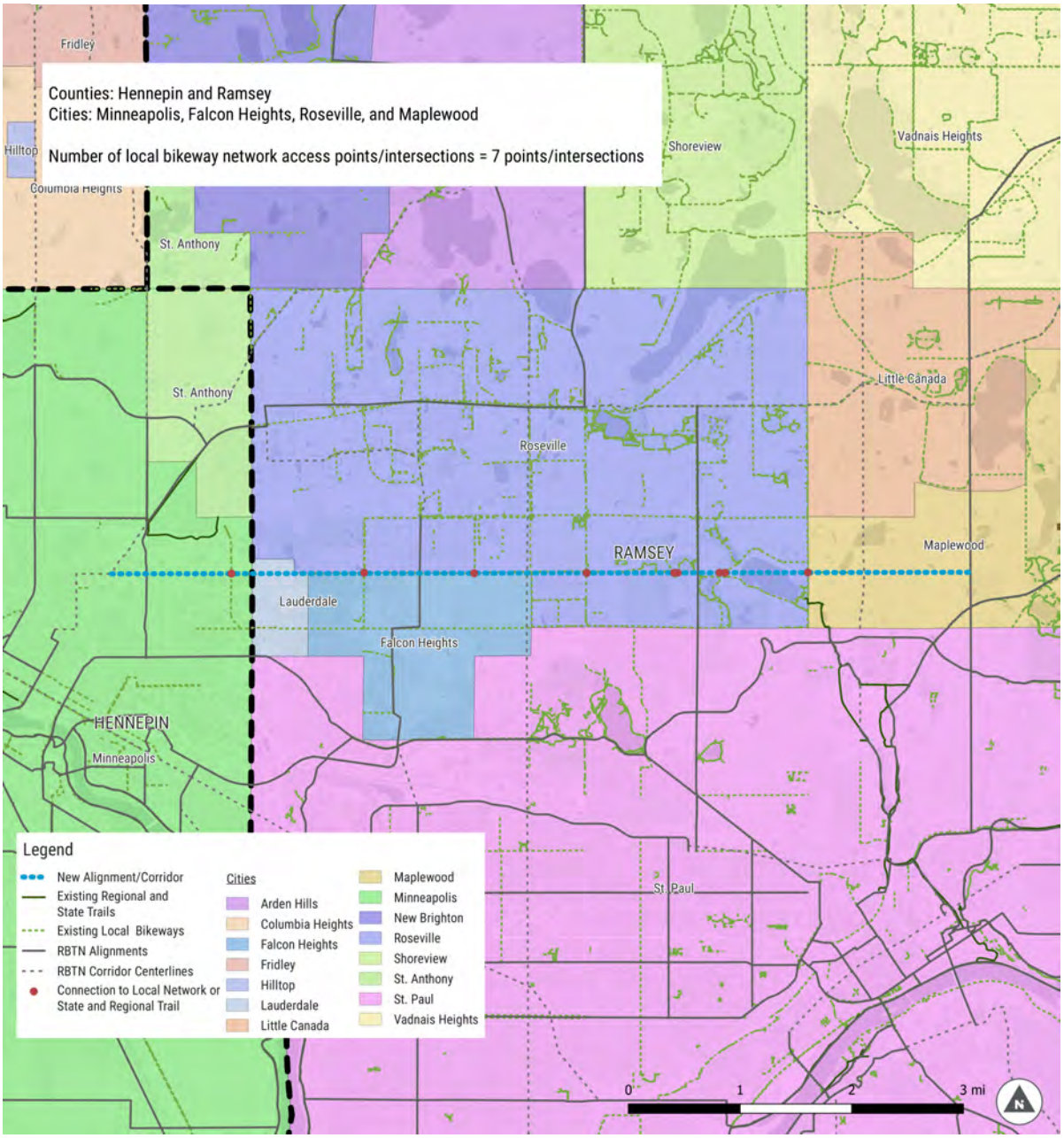
Results interpretation for Test Case 7, connections to existing and planned regional barrier crossings:

- The existing route has one direct connection to regional barrier crossings
- The new route has two direct connections

The proposed shift would increase the net number of connected regional barrier crossings by +1

4. Test Case Examples - Connectivity

Figure 19 Test Case 7 – Example Addition along Broadway and Roselawn



a. Measure 2

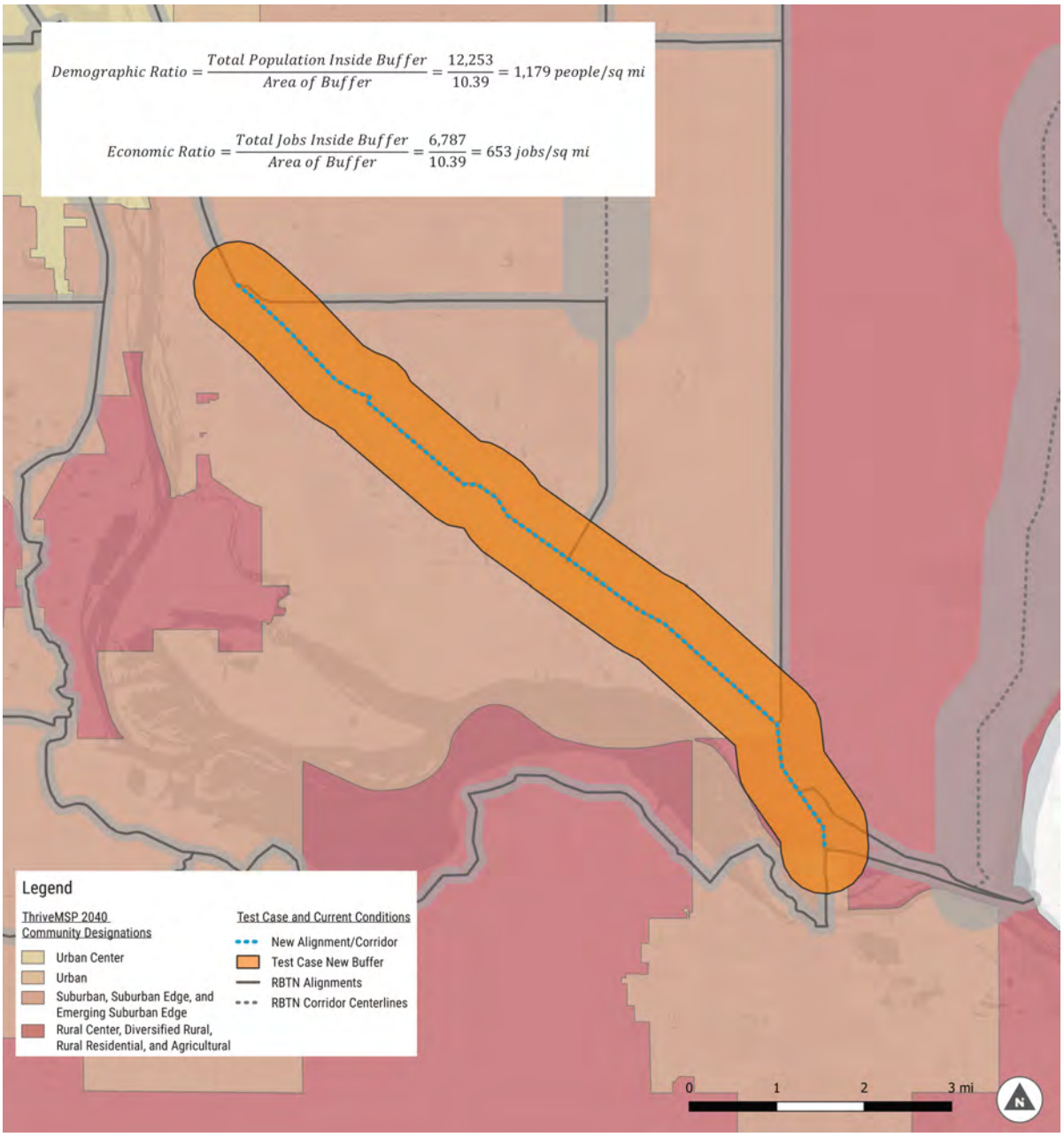
- Count the number of cities and counties with bikeway network connections
  - Counties: Hennepin and Ramsey
  - Cities: Minneapolis, Falcon Heights, Roseville, and Maplewood
- Note: Lauderdale not counted because there is no local bikeway network connection point
- Total of 6 jurisdictions connected

b. Measures 3A/3B

- 3A: No access points to state or regional trails
- 3B: Seven access points/ intersections to local bikeway network
- Note: Connections to other RBTN facilities not counted

5. Test Case Examples – Proximity to Projected Population and Jobs

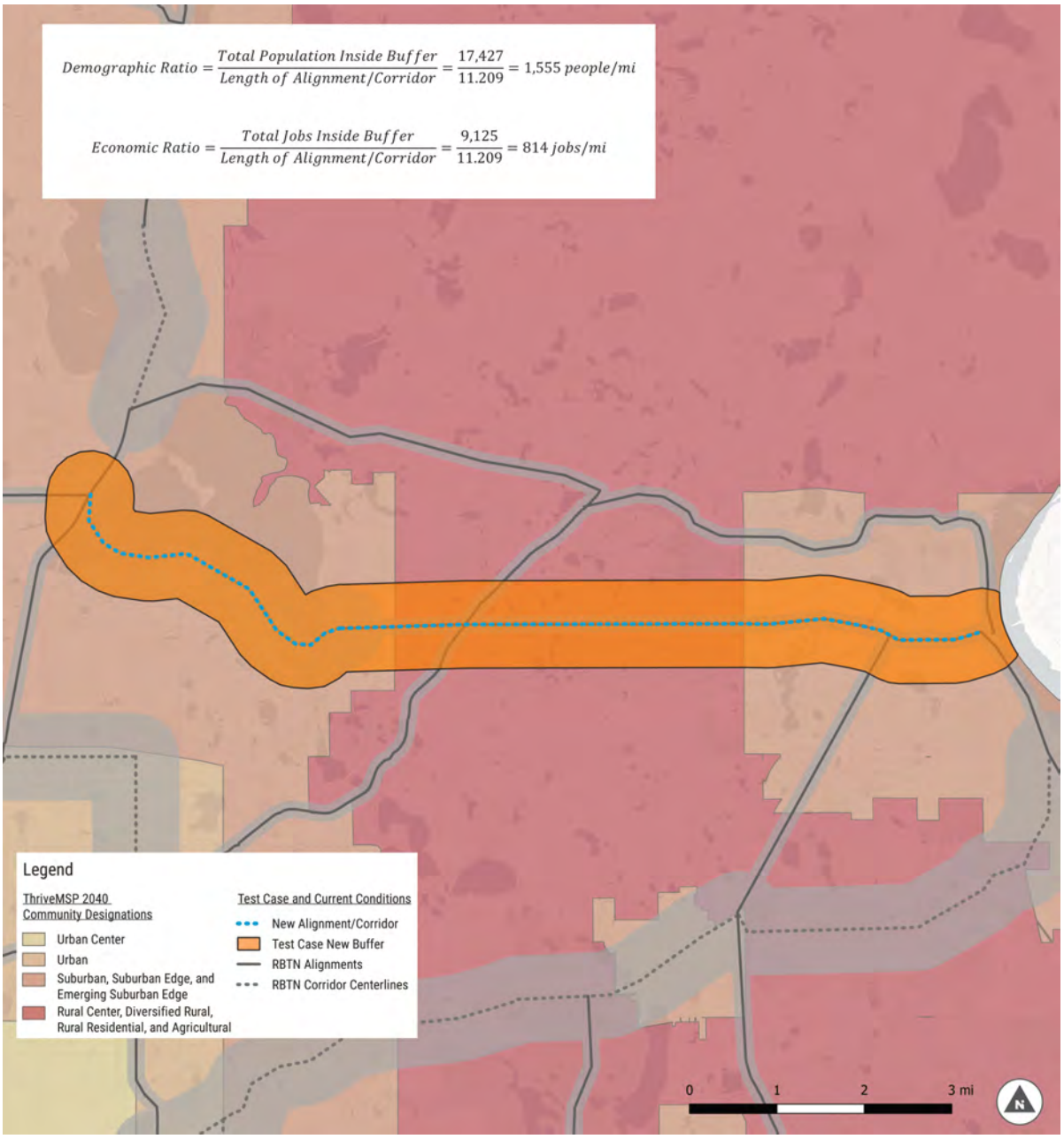
Figure 20 Test Case 10 – Existing Example of Connection along US-10 to Hastings



- RBTN Facilities connecting to Hastings, MN
    - Population: 12,253
    - Jobs: 6,787
    - Area: 10.39 square miles
- 1,179 people / square mile
- 653 jobs / square mile
- 1,889 people + jobs / square mile
    - *Exceeds target of 1,300 for Thrive Suburban/Suburban Edge/Emerging Suburban Edge communities*

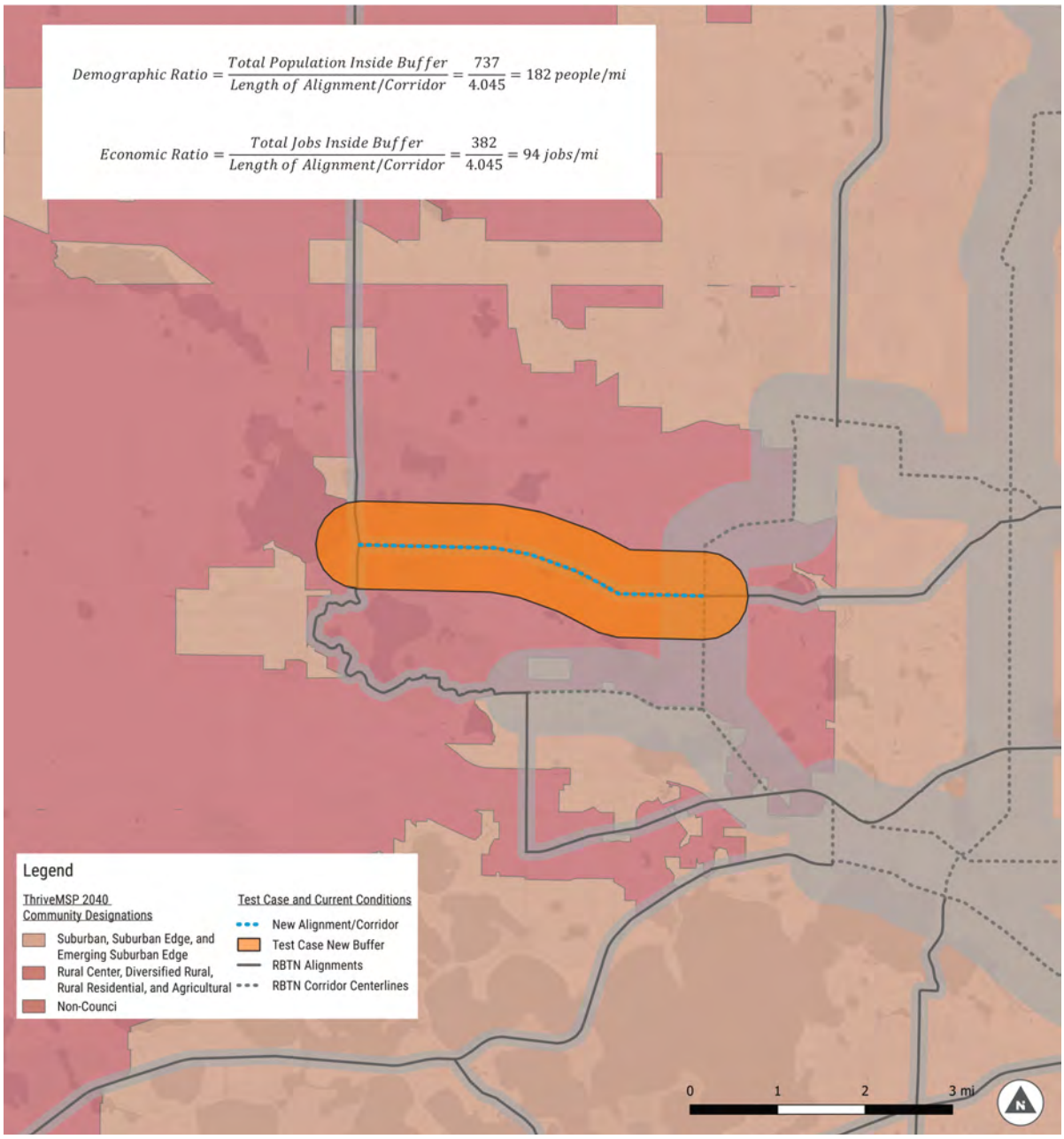
6. Test Case Examples – Activity per Mile Ratio

Figure 21. Test Case 8 – Existing Example of Connection to Stillwater, MN



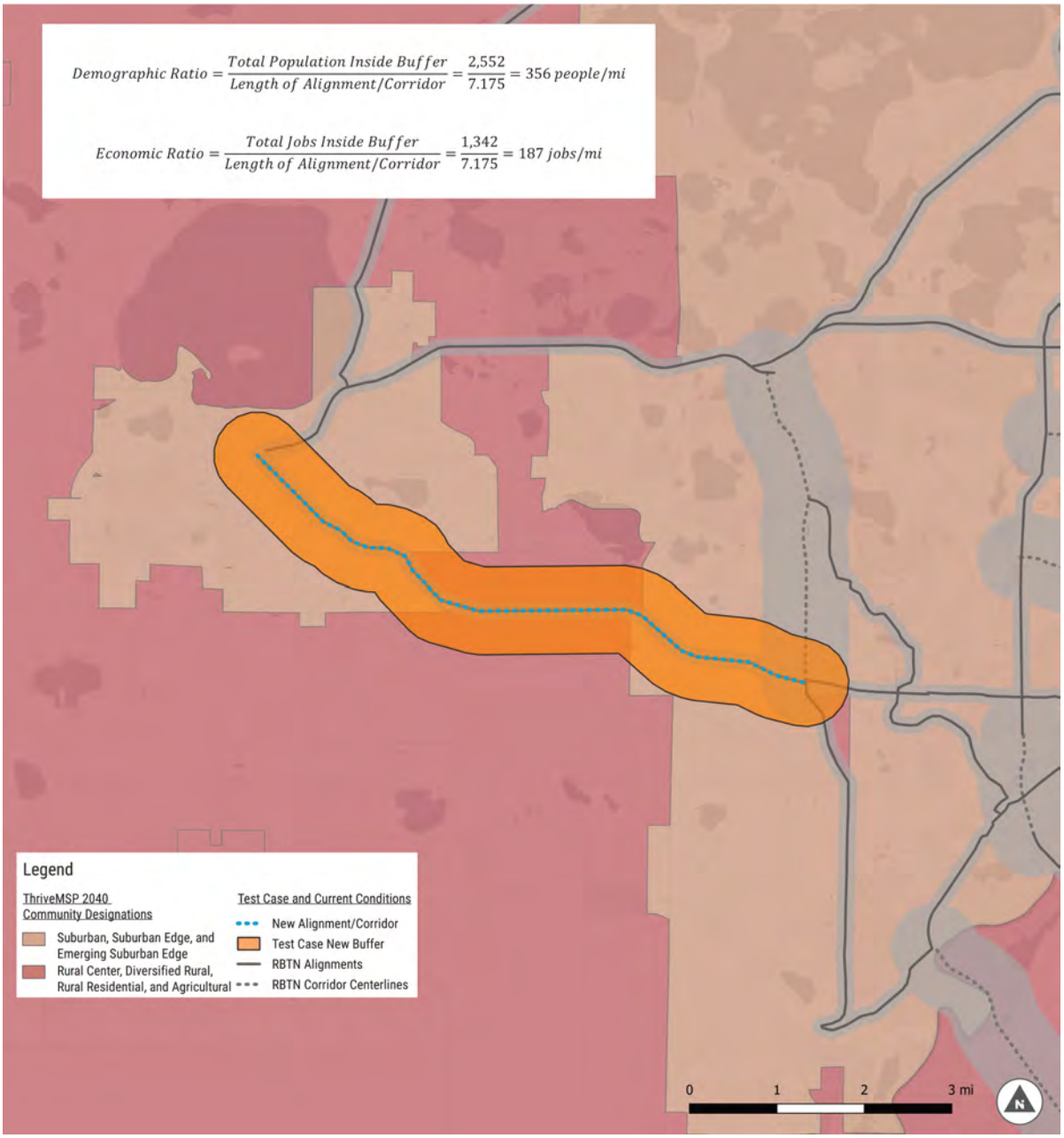
- RBTN Facilities connecting to Stillwater, MN
    - Population: 17,427
    - Jobs: 9,125
    - Length: 11.209
- 1,555 people/mile
- 814 jobs/mile
- 2,369 people + jobs / mile
- Meets target threshold of 800 pop + jobs per mile

Figure 22. Test Case 9 – Example Extension along CR 24 in Hennepin County



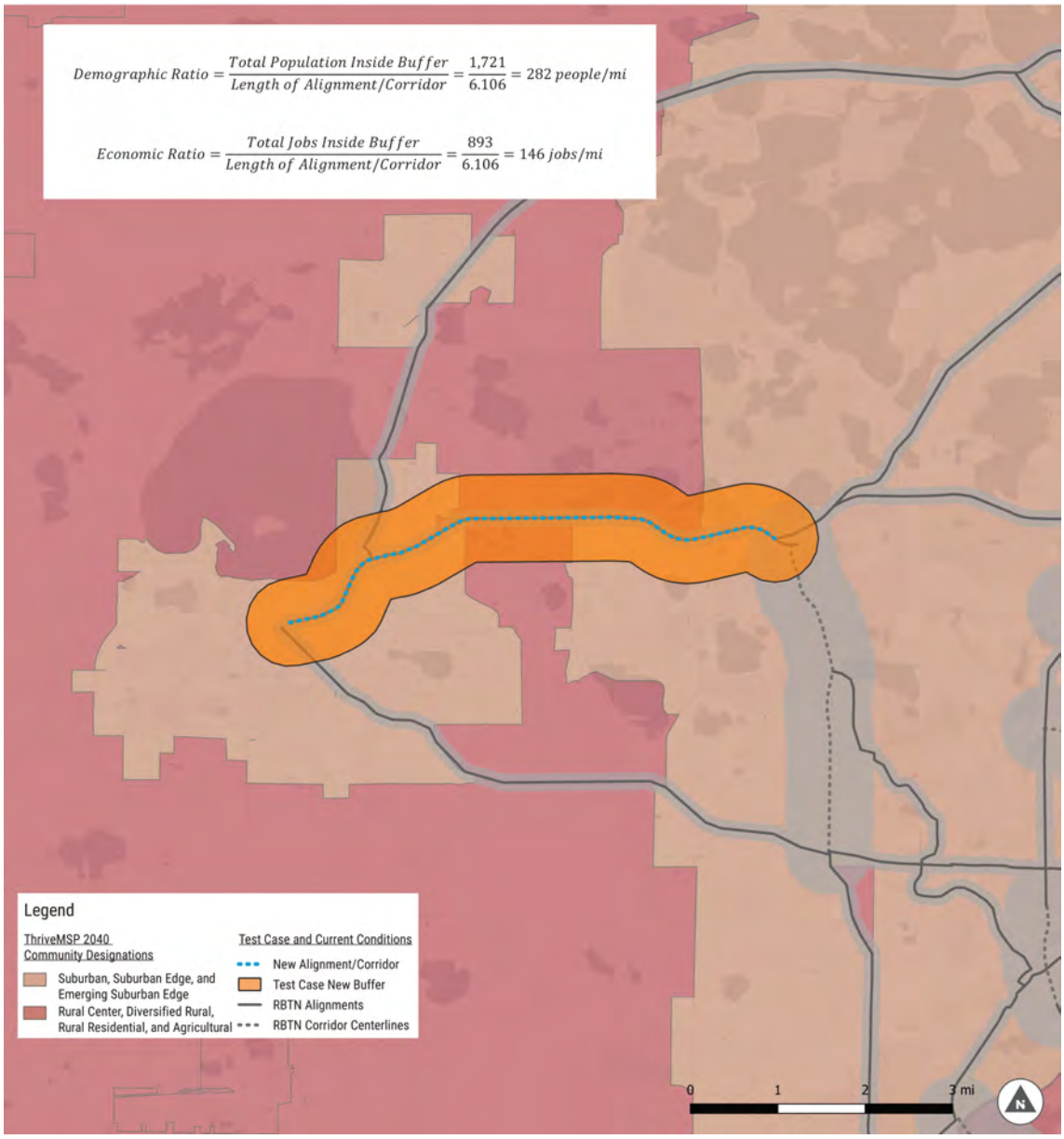
- Test Case through Medina, MN connecting to Baker Park Reserve
    - Population: 737
    - Jobs: 382
    - Length: 4.045
- 182 people/mile
- 94 jobs/mile
- 277 people + jobs / mile
- Lower than recommended threshold of 800 people + jobs per mile

Figure 23. Test Case 11 – Existing Example along Engler Blvd (CSAH 10) in Carver County



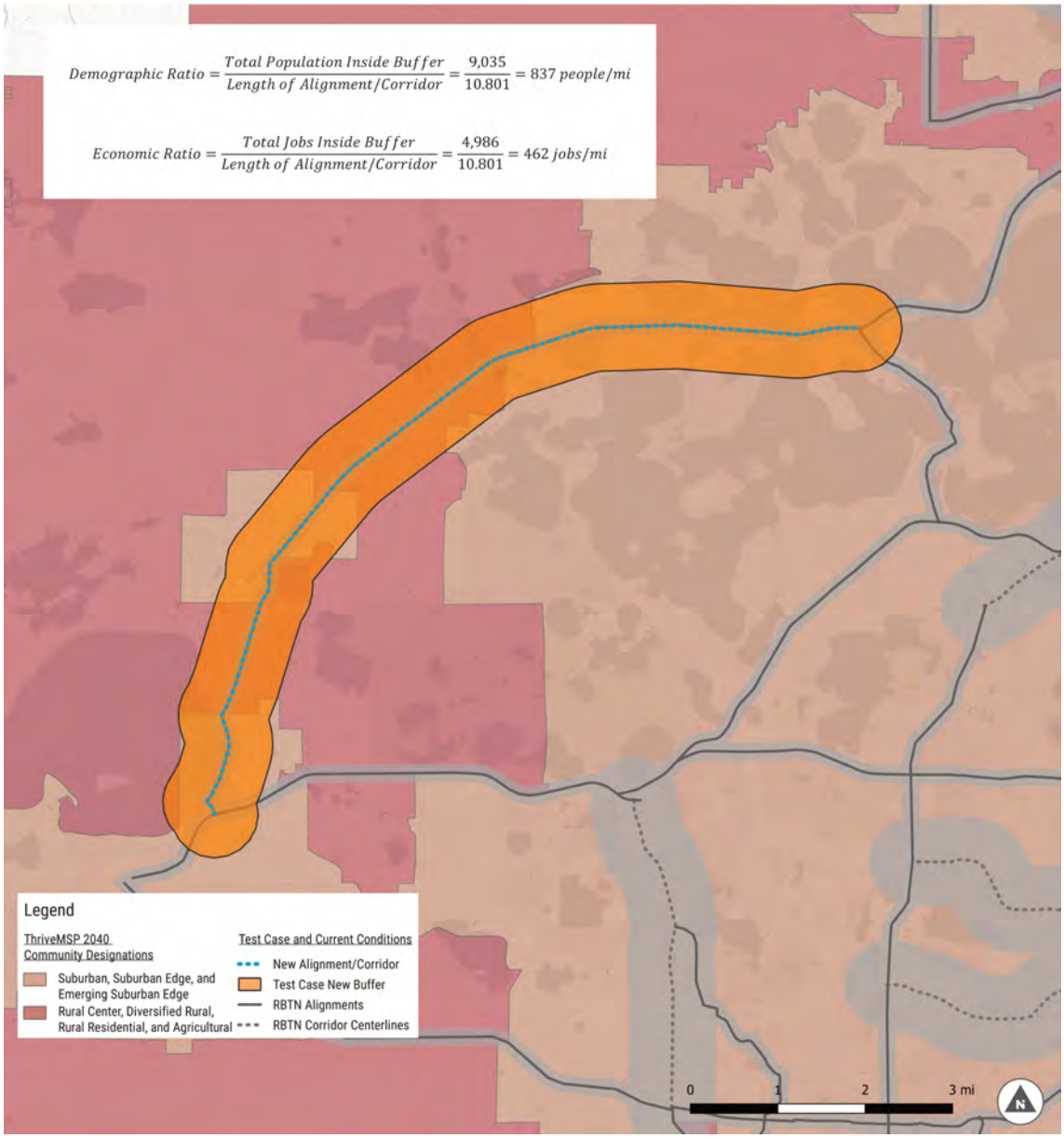
- RBTN Facilities connecting to Waconia, MN
    - Population: 2,552
    - Jobs: 1,342
    - Length: 7.175
- 356 people/mile
- 187 jobs/mile
- 543 people + jobs per mile
- Lower than recommended threshold of 800 people + jobs per mile

Figure 20. Test Case 12 – Existing Example along MN Trunk Highway 5 in Carver County



- RBTN Facilities connecting Victoria to Waconia, MN
    - Population: 1,721
    - Jobs: 893
    - Length: 6.106
- 282 people/mile
- 146 jobs/mile
- 428 people + jobs per mile
- Lower than recommended threshold of 800 people + jobs per mile

Figure 24. Test Case 13 – Existing Example along Dakota Rail Trail in Hennepin and Carver County



- RBTN Facilities connecting Spring Park to Waconia, MN
    - Population: 9,035
    - Jobs: 4,986
    - Length: 10.801
- 837 people/mile
- 462 jobs/mile
- 1,299 people + jobs per mile
- Meets target threshold of 800 pop.+ jobs per mile

IX. APPENDIX C – Measurement Procedures

A. *Steps for calculating Spacing*

1. Dissolve Thrive MSP Community, creating four categories:
   - Urban Center
   - Urban
   - Suburban, Suburban Edge, Emerging Suburban Edge
   - Diversified Rural, Rural Residential, Agricultural
2. Merge Corridor and Alignment
3. Clip the output from step 2 [Merged corridor and alignment] with the selection (URBAN CENTER) with the output from step 1 [Dissolved Thrive MSP Community created urban area]
4. Buffer the output from step 3 [Clipped Merged corridor and alignment] with the selection (URBAN CENTER) with the output from step 1 [Dissolved Thrive MSP Community created urban area]
5. Clip the output from step 2 [Merged corridor and alignment] with the selection (URBAN) with the output from step 1 [Dissolved Thrive MSP Community created urban area]
6. Buffer the output from step 3 [Clipped Merged corridor and alignment] with the selection (URBAN) from [Dissolved Thrive MSP Community created urban area]
7. Clip the output from step 2 [Merged corridor and alignment] with the selection (SUBURBAN) with the output from step 1 [Dissolved Thrive MSP Community created urban area]
8. Buffer the output from step 3 [Clipped Merged corridor and alignment] with the selection (SUBURBAN) with the output from step 1 [Dissolved Thrive MSP Community created urban area]
9. Merge all outputs from step 4,6 and 8 [Buffered Clipped Merged corridor and alignment with the selection from Dissolved Thrive MSP Community created urban area] (4)(6)(8)
10. Difference the output from step 9 [Merged corridor and alignment with the selection (Urban, Urban Center, Suburban)] with the output from step 1 [Dissolved Thrive MSP Community created urban area]
11. Buffer the output from step 10 [Difference Merged corridor and alignment] with the selection (Urban, Urban Center, Suburban) with the output from step 1 [Dissolved Thrive MSP Community created urban area]
12. Merge all outputs from step 9 and 10 [Buffered Clipped Merged] and [Buffered Difference corridor and alignment with created urban area]
13. Dissolve the output from step 12 [Merged Buffered Clipped Merged and Buffered Difference corridor and alignment with created urban area] (12)

    Note:
    - For instance, if the alignment falls into two Thrive Community you should split the segment where intersects both communities, then do two separate buffers. For example, Test Case 7 falls into the URBAN CENTER and URBAN, you should split and then perform 0.25 miles to the segment within the URBAN CENTER, then you make another Buffer with 0.375 within the URBAN
    - If this step happens, merge both buffers, then dissolve the merge buffer
    - Merge all the buffer created in the last step

14. *Dissolve Merged buffers*

B. Steps for calculating Directness – Destination Proximity

1. Dissolve Thrive MSP Community, creating four categories: (if this step was performed in the Spacing Calculation, it does not have to redo this step)
    - Urban Center
    - Urban
    - Suburban, Suburban Edge, Emerging Suburban Edge
    - Diversified Rural, Rural Residential, Agricultural

2. Buffer the Alignment by 0.1 miles
3. Clip corridor centerlines with the selection (URBAN CENTER) from the output from step 1 dissolved Thrive MSP Community created urban area
4. Buffer the output from step 3 [Clipped corridor centerlines with the selection (URBAN CENTER) from Thrive MSP Community created urban area] by 0.25 miles
5. Clip corridor centerlines with the selection (URBAN) from the output from step 1 dissolved Thrive MSP Community created urban area
6. Buffer the output from step 5 [Clipped corridor centerlines with the selection (URBAN) from dissolved Thrive MSP Community created urban area] by 0.75 miles
7. Clip corridor centerlines with the selection (SUBURBAN) from the output from step 1 dissolved Thrive MSP Community created urban area
8. Buffer the output from step 7 [Clipped corridor centerlines with the selection (SUBURBAN) from dissolved Thrive MSP Community created urban area] by 0.5 miles
9. Clip corridor centerlines with the selection (RURAL) from the output from step 1 dissolved Thrive MSP Community created urban area
10. Buffer the output from step 9 [Clipped corridor centerlines with the selection (RURAL) from Dissolved Thrive MSP Community created urban area] by 1 mile
11. Merge:
    - [Buffered Alignment by 0.1 miles] (2)
    - [Buffered Clipped corridor centerlines with the selection (URBAN CENTER) from dissolved Thrive MSP Community created urban area by 0.25 miles] (4)
    - [Buffered Clipped corridor centerlines with the selection (URBAN) from dissolved Thrive MSP Community created urban area by 0.75 miles] (6)
    - [Buffered Clipped corridor centerlines with the selection (SUBURBAN) from dissolved Thrive MSP Community created urban area by 0.5 miles] (8)
    - [Buffered Clipped corridor centerlines with the selection (RURAL) from dissolved Thrive MSP Community created urban area by 1 mile] (10)

12. Dissolve all merged step above

Note:

- Similar to the Spacing Analysis, if the alignment/corridor falls into two Thrive Community, split the segment where intersects both communities, then do two separate buffers. For example, Test Case 7 falls into the URBAN CENTER and URBAN, you should split and then create 0.25-mile buffer to the segment within the URBAN CENTER, then make another Buffer with 0.5 mile within the URBAN
- If this step happens, merge both buffers, then dissolve the merge buffer
- Merge all the buffer created in the last step
- Dissolve Merged buffers

C. *Steps for calculating Measure 4.A.:* Net change in population of BIPOC & people in poverty within 1 mile of RBTN alignment/corridor centerline

Note that 'people in poverty' is based on the region's definition: the population of those whose incomes fall below 185% of the federal poverty level. Using available data on poverty and race at the census block group level:

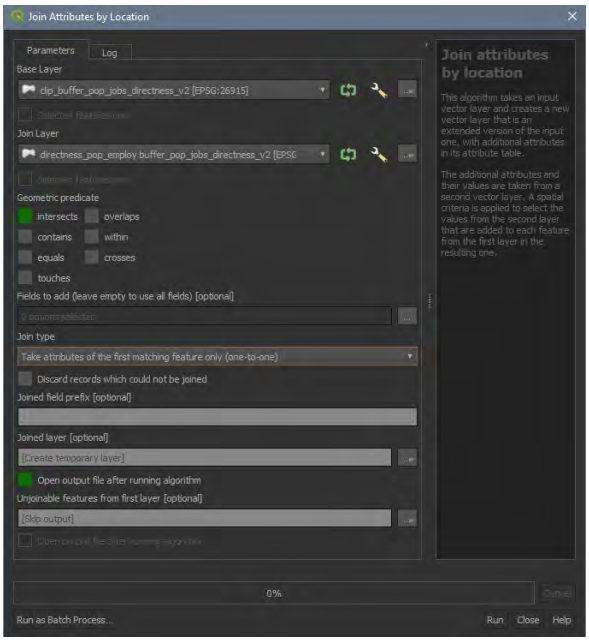
1. For all census block groups intersecting a 1-mile buffer around the *proposed* alignment/corridor centerline, calculate:
    a. The total BIPOC population
    b. The total population in poverty (below 185% of the federal poverty level)

2. For all census block groups intersecting a 1-mile buffer around the *existing* alignment/corridor centerline, calculate:
    a. The total BIPOC population
    b. The total population in poverty (below 185% of the federal poverty level)

3. Perform the following calculations:
    a. *Net change in BIPOC residents with RBTN access* (1a – 2a)
    b. *Net change in people in poverty with RBTN access* (1b – 2b)
    c. ***Net change in total BIPOC/people in poverty with RBTN access (3a + 3b)***

D. *Steps for calculating Activity per Mile Ratio and Measure 5.A.*

1. Import the Census Population/Employment spreadsheet
2. Import the Census Block Group polygon shapefile
3. Join the output from step 1 [Census Population/Employment spreadsheet] with the output from step 2 [Census Block Group polygon shapefile] – use the block group identification as the join field and join target
4. Create a new column and name as "orig_area"
5. Calculate areas for each block group – use "$area" function to calculate the original area
6. Create the proposed Corridor/Alignment segment to apply the measure
7. Buffer created the proposed Corridor/Alignment segment
8. Clip the output from step 3 [Joined Census Population/Employment spreadsheet] with the output from step 6 [Census Block Group polygon shapefile with the Buffer created the proposed Corridor/Alignment segment]
    - Input Layer: Population/Employment Census
    - Overlay Layer: Buffer proposed Corridor/Alignment
9. Join Attributes by Location – Join the output from step 6 [Buffered created the proposed Corridor/Alignment] segment] with the output from step 7 [Clipped the joined Census Population/Employment spreadsheet with the Census Block Group polygon shapefile with the Buffer created the proposed Corridor/Alignment segment]



10. Create a new field for the new area – then use “$area” function to calculate the new area
11. Export the Attribute Table as an Excel file
12. Create new columns on the Excel Spreadsheet. Named the field as – “wavg_pop” (Weighted Average Population) and “wavg_emp” (Weighted Average Employment)
13. Create a Pivot Table Select case name, and Weighted Average Population, Weighted Average Employment and Area
14. Copy the Pivot Table results to a new sheet
15. Dissolve the joined output from step 9
    - Click on the Dissolved field(s) option and dissolve by a common “field” – for example: ‘case_new,’ which is the case name
16. Import the new spreadsheet created with the Pivot Table results
17. Join the table with the dissolved joined shapefile