Sidewalk Network Data Pilot Project

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Overview

Accurate pedestrian network analyses have traditionally been underutilized by urban planners and by policy makers alike. If pedestrian networks are to be improved, they must first be measured. The common practice of using street centerline data to represent pedestrian networks makes large assumptions that rarely result in realistic analyses. True walkshed analyses enable better ADA compliance planning, pedestrian infrastructure planning, and multi-modal trip planning. This report describes a pilot project designed to explore methodology for creating pedestrian network datasets. We conclude that further work is needed to create network data coverage for better walk infrastructure integration and planning.

Because a significant portion of public transit ridership is from walk-up or roll-on riders, sidewalk network connectivity is vitally important to transit accessibility (Grossman). The current practice within the planning industry has been to represent walksheds with 'as the crow flies' Euclidean buffers of multiple distance bands which serve as proxies for actual walksheds that depend both on connectivity and intersection timing. In research by Metro Transit TOD Office staff, it was found that commercially available walksheds are almost exclusively based on street centerline data rather than a current pedestrian network. Using street centerlines as the basis for creating a pedestrian network will produce an area that appears valid, but likely contains errors; street centerlines ignore sidewalk gaps, obstructions, and signal wait times. This pilot project used ArcMap Network Analyst Extension, a software product which utilizes a more accurate method of calculating a walkshed by using travel-time across an actual sidewalk network, including pedestrian wait times at signalized intersections (ESRI). A walkshed in this context consists of concentric service areas calculated to the 5, 10, and 15-minute walk times from a given physical address. However, the lack of routable sidewalk network data including realistic signal wait times (used to create impedance points) prevents the widespread use of this methodology to measure access. Accurate network datasets and resultant walksheds are needed to better assess pedestrian accessibility to transit stations and other public facilities across the Twin Cities Metro area.

The primary purpose of this pilot project was to determine the amount of time and effort it would take to create a network dataset necessary for a valid walkshed analysis. A secondary goal was to assess the accuracy of this method compared to a street network-derived walkshed. A tertiary goal was to illustrate the value of such a dataset for ADA compliance plans created by municipalities and public agencies. The first two goals were reached; the third has been postponed due to lack of resources.

Background

In the second quarter of 2018 the TOD Office investigated what sidewalk network-ready data sets were available in the Twin Cities metro region. Building on that initial work, the Met Council IS-GIS Office conducted a data needs assessment and a data prioritization survey. Although these surveys indicated strong interest and actual needs for a robust sidewalk network dataset including ADA-compliance attributes, the scope of work required to compile and edit even the simplest network dataset deterred any group from taking on this large project. We used the ArcMap 10.7 Network Analyst Extension, so the limiting factor of this project was staff bandwidth, rather than technology.

The TOD Office agreed to conduct a pilot project jointly with IS-GIS staff, consisting of creating a routable network dataset within 1-mile of three specific points of interest to Metro Transit. The second half of 2018 was used for more research by both TOD staff and IS-GIS staff in determining whether it would be more efficient to utilize existing, incomplete datasets, or to create their own routable network from scratch. The conclusion was reached that a small effort to create a routable network would be the most valuable next step.

Work on this defined pilot project began in the first quarter of 2019 when IS-GIS initiated the creation of the network dataset. Approximately 145 hours went into the completion of this pilot project, including 80 hours to create the network dataset for three sites, 60 hours from the TOD Office, and 6 hours of interdepartmental coordination. Of the 60 hours from the TOD office, approximately 40 hours went into research and development of the project scope conducted between Q2 of 2018 and Q1 of 2019. Determining impedance values and loading those into the crosswalk points took about 18 hours, with about 2 hours spent reviewing network dataset geometry and reviewing the results of the walkshed analysis. In addition, TOD staff spent approximately 20 hours drafting and reviewing this report. It should also be noted that at first, the TOD Office did not know of the availability of signal timing data, so staff spent several hours manually timing a sampling of intersections at each pilot site. TOD staff later received timing data for a sampling of intersections from each respective city. This data was received too late to be included in the walkshed analyses.

Tasks

1. Preparatory work for pilot

Before work on the network dataset could begin, several preparatory tasks were completed. The first task was research conducted by the Metro Transit TOD Office and the Met Council's IS-GIS Office on what types of sidewalk data were available in the Twin Cities Metro, as well as research into best practices for creating walksheds. This research helped to confirm what methodology was appropriate and subsequently used for the pilot project. This research also revealed that most cities across the metro area either do not maintain any sidewalk data, or the sidewalk data that they do have is in a format that seemed likely to require more time to convert than would be needed to create the network data from scratch. As a result, it was decided that it would be most efficient if IS-GIS created its own pilot sidewalk dataset. The Metropolitan Council's GIS Office conducted an internal survey of data needs as well as a data prioritization exercise. The survey results showed that this data is highly desired and could be used by many different groups both internally and externally.

Another preparatory task was selecting the three pilot sites. The sites selected purposely represent three different pedestrian environments, with various degrees of network connectivity. The three sites chosen were, 1) The METRO Green Line Central Station in downtown Saint Paul, 2) the former Metro Transit Police Department headquarters at 2425 Minnehaha Ave S, Minneapolis, and 3) the Broadway Court Senior Apartments in downtown Robbinsdale, in close proximity to the planned Robbinsdale Station on the METRO Blue Line Extension (Appendix A).

2. Creation of a Network Dataset

Origin points that serve as the starting location for the service area analysis were created and geocoded to their physical addresses along street centerline data. The placement of these points on the network is critical to the accurate measurement of a service area. A one-mile Euclidean buffer was then created around each point of origin, to illustrate the maximum extent of sidewalk network that needed to be created for each site, and to ensure that any walkshed analyses would not run-out of network to assess. A 400-meter by 400-meter grid was created using the "Create Fishnet" tool in ArcMap. These 400-meter squares served as visual aids in tracking progress of the creation of the sidewalk data. The sidewalk segments were manually created by tracing aerial imagery as close as possible to actual structures, keeping in mind that the imagery inherently introduces a certain amount of error into network geometry.

Once the sidewalk line segments were created for all sites, they were dissolved into one large multi-part feature. Next, street centerlines were used to intersect the (now dissolved) sidewalk line feature. Using the Planarize Lines tool in ArcMap, the sidewalk lines were split anywhere a sidewalk intersected a street centerline. Output of the Planarize Lines tool was set to "points," and an empty wait-time point representing a crosswalk was added to every crossing. Leaving the crosswalk points alone for now, each one of the new sidewalk segments must be assigned a 'time-to-traverse' value at each of the travel speeds, in seconds. To calculate a walking time value for each sidewalk segment, each segment length was first calculated in meters. Then the walking speed that a pedestrian would need to traverse a given line segment was calculated and stored as an attribute for each of the three speeds (3, 3.5, and 4 MPH). It is necessary to store these attributes for later use as input parameters of the Network Analyst. An example time value calculation for a segment is;

1) 3 miles per hour = 1.34112 meters per second
2) Example sidewalk segment length = 15.2 meters
3) 15.2 meters/1.34112 meters per second = 11.3 seconds to traverse the segment

Next, estimated wait times were manually entered for every signalized intersection. Non-signalized intersections with stop signs were given a marginal 4 seconds of wait time to account for the occasional oncoming vehicle traffic.

Wait times at intersections (with or without marked crosswalks) can be assigned an average value in seconds, representing the estimated time required to cross a signalized intersection legally. For example, when a pedestrian approaches a signalized intersection, they usually must wait more than a minute until they get a walk signal. The most accurate method to estimate wait time at intersections is by basing it on signal data provided by a municipality. TOD staff requested this data from the cities in the pilot project but did not receive the data until after the more direct method had been used. These two methods are compared later in this report.

Once all the necessary input datasets are created, the Network Analyst Extension is used to 'build' the network in ArcMap. This simply means that the network is created, and all of the constituent parts are added to a map document as an integrated network analysis layer. Building the network also enables several analysis tools to become active. On the Network Analyst Tool bar, select the drop-down menu to run the "New Service Area" tool to create walksheds derived from the newly created network dataset. All of the specific analysis parameters are set in the "New Network Dataset Wizard" prior to running a service area analysis. It was decided that the most relevant output from the network analysis would be walkshed polygons of 5, 10, and 15-minute intervals from each origin point (Figure I). Given the sensitivity of a pedestrian network to small adjustments, seconds of total walk time seem to be the most appropriate unit to use for pedestrian scale analyses. This work created a topologically clean network dataset that could be characterized by travel distance, wait time at intersections, and other pedestrian-relevant values.

3. Initial results

After the initial analysis was completed, the TOD office obtained the earlier requested signal timing data. The initial estimated wait times used were found to be consistently under-estimating actual wait times compared to estimates from the provided signal data. In lieu of the provided signal-timing data, estimated crosswalk wait times were originally based on 1) road classification, 2) local knowledge of traffic patterns, and 3) physical measurement of a sampling of signals. In some cases, additional time was added to account for specific delay-causing situations, such as railroad crossings or emergency response vehicles. Using this data, delays at intersections were adjusted and the network analysis generated new estimates of walksheds. Any further research into walkability should scrutinize the wait time values and generate revised walksheds by running the New Service Area tool again.

The walksheds generated in this first step were compared to each other for any obvious patterns and/or inconsistencies. In addition to measuring accessibility, these walksheds can inform site ranking, desirability, and missing links in the network, among other factors (Appendix B). Whether by visual review or quantitative measures, one can compare and easily see how this methodology, even with the initial estimates of wait time, generates more realistic walksheds than using large scale automotive networks.

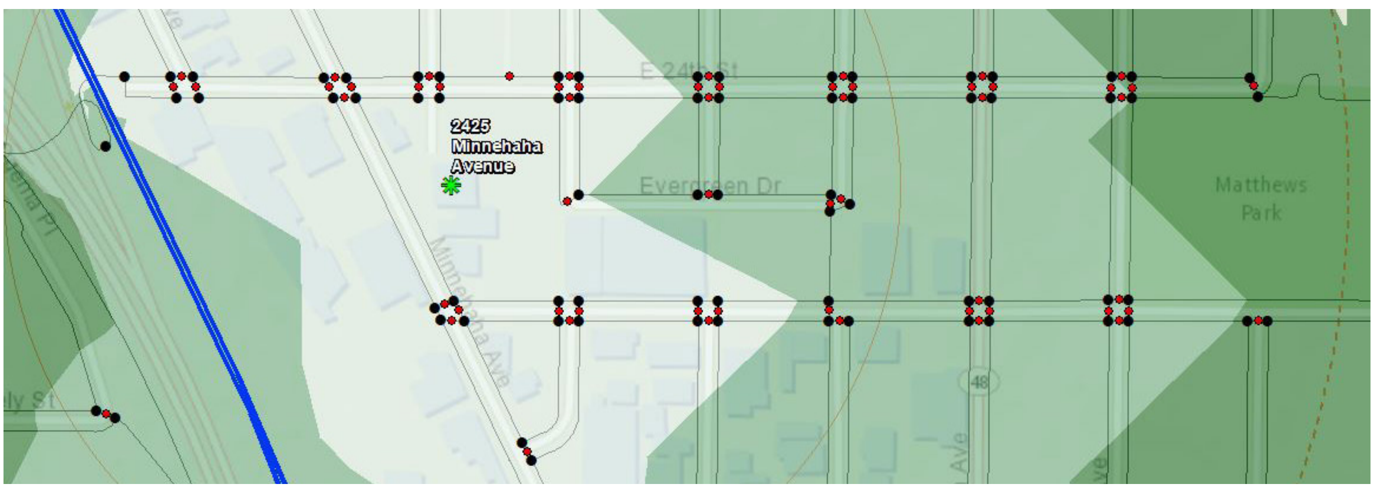

***Figure I:** Network components in context*

Summary

This pilot project provided experience to suggest both additional application of the methods used to generate better walksheds, and further research to determine the best method to incorporate ADA factors into the analysis. Staff recommendations for future work are outlined below.

First, the sidewalk digitization process did leave out some paved trails that do not follow the street network. We learned that paved trails such as the Midtown Greenway and the Hiawatha Bike Trail are an integral part of the pedestrian network and as such, should certainly be included in any walkshed analysis. The advantage of paved multi-use trails is they have many fewer signalized crossings to wait for, and they tend to be a more direct route as a result of using former railroad alignments. In the case of the Midtown Greenway, it serves as a way for pedestrians to overcome the significant barrier that is State Highway 55. Another discovery was that existing infrastructure is not always what is visible in aerial imagery. The pilot project data was digitized based on aerial imagery that is several years old. As a result, some sidewalk infrastructure that no longer exists was digitized, and some new sidewalk infrastructure was missed, as it did not yet exist at the time the imagery was taken (Figure II).

As aerial imagery available to staff is not usually current, there may be better ways to create the network infrastructure. Because the quality and timeliness of network data has a big impact on the validity of the output walksheds, it is recommended that any future expansion of this project incorporate a collaborative approach and acquire vendor-produced datasets of the same vintage. If all of the sidewalk data components in an area of interest were captured at the same time, sourced from the same vendor, as one deliverable, that would eliminate the need for training staff on how to consistently capture data, and all data would be from the same point in time. New technology also provides other data types to use, in addition to imagery.

Another challenging component of the sidewalk pilot project was calculating and estimating crosswalk wait times. TOD staff field-sampled pedestrian wait times at several intersections within each pilot area. Although physically sampling intersections can provide estimated wait times, it is not the most accurate approach, and would be prohibitively time consuming to do on a larger scale. Upon discovering that intersection signal timing data was available, TOD staff requested data for some 90 intersections within the three pilot areas. The intersection signal timing data that was received had to be averaged by intersection, and manually entered into the crosswalk data points file. The time required to do this is reasonable for a pilot project, but much less so in an expanded scenario. An expanded version of this project would greatly benefit from developing an automated method of assigning wait times in bulk.

The scope of this pilot project did not include compiling other important walkability factors such as sidewalk width, grade, surface type, physical obstruction locations and types, and any other qualitative attribute. Any future network dataset should include at least some ADA-defined attributes to help measure and plan for ADA compliance.

The TOD Office completed this pilot project as a well-defined starting point for another office with more capacity and business use cases. The most important recommendation that came out of this project is that given the daunting task of compiling all necessary data, public agencies should collaborate in acquiring data, basing the need on ADA compliance, transit planning, and equity considerations. Although the creation of a regional network dataset is a large undertaking, by pooling resources and contracting with a single data vendor, a regional network dataset could be created at a lower price than simply 'going it alone'. There are economies of scale in big data that would also make this collection more realistic. Collaboration would also allow various agencies to come to agreement on the scope and quality of network data, ensuring regional consistency and agreed upon data integrity.

A walkshed creation methodology can also be a powerful way to conduct scenario planning whereby a given agency creates pedestrian network data to see how potential walksheds change if certain missing sidewalk segments are built or traffic signals reprogrammed. We recommend that all transit planning offices use pedestrian network analysis to evaluate and address transit station accessibility. By analyzing pedestrian access to public transit stations, officials will start to understand that pedestrian networks are a vital component of any robust transportation system

Figure II: *Network before and after intersection reconfiguration*

Citations:

ESRI ArcGIS Desktop, ArcMap10.7. 2019. What is the ArcGIS Network Analyst extension? Web. desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/what-is-network-analyst-.htm Last accessed: 20 Nov 2019.

Figure I: Watercott, C. 2019. ESRI ArcGIS Desktop, ArcMap10.7. 2019. Seward Neighborhood Screen clip.

Figure II (left): Google Imagery screen clip. 2019. Franklin/Cedar/Minnehaha reconfiguration. Last accessed, 20 Nov 2019.

Figure II (right): The Sanborn Map Company. Oblique Analyst Hennepin. Flight Date: Spring 2019. Accessed from Hennepin County Property Information. Web. www16.co.hennepin.mn.us/pins/pidresult.jsp Last accessed: 20 Nov 2019.

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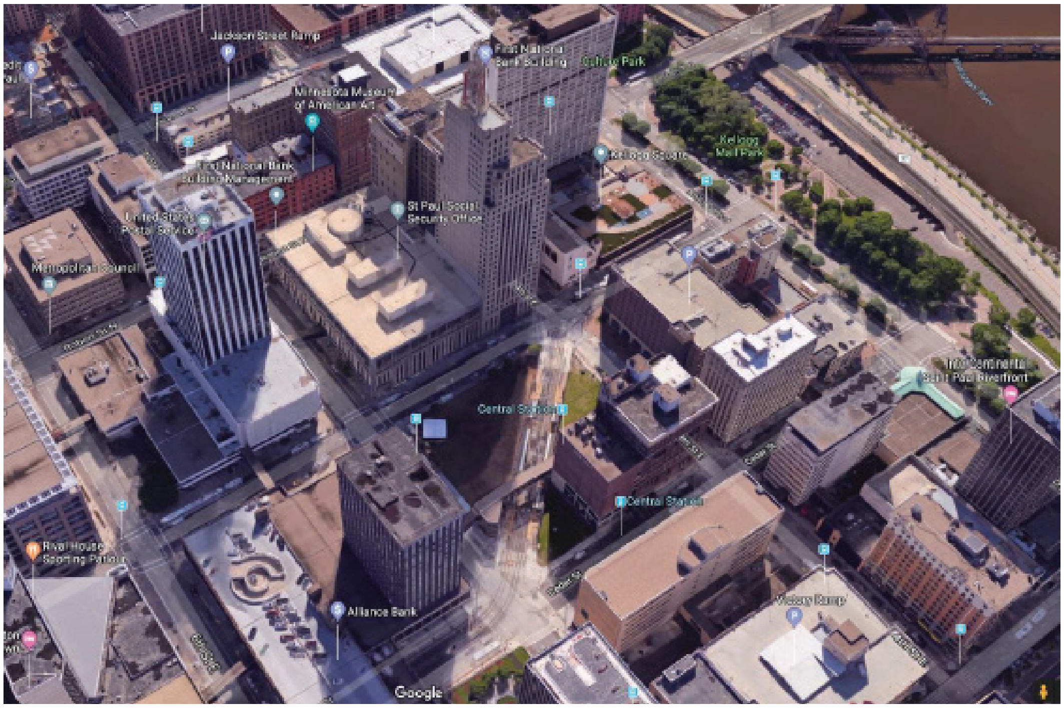
Appendix A: Sidewalk Network Data Pilot Sites

The sidewalk data pilot project will focus on three unique areas to evaluate for the pedestrian network proof of concept. Each of the following sites represent different urban environments in different stages of pedestrian facility development, neighborhood needs, and winter maintenance efforts.

1) Broadway Court Apartments, Robbinsdale: This site is in a suburban downtown area that has a well-established senior community, as well as future plans for an LRT station. The area around the Broadway Court Apartments should be walkable for everyone, but especially so for residents in proximity to the downtown and planned transitway.

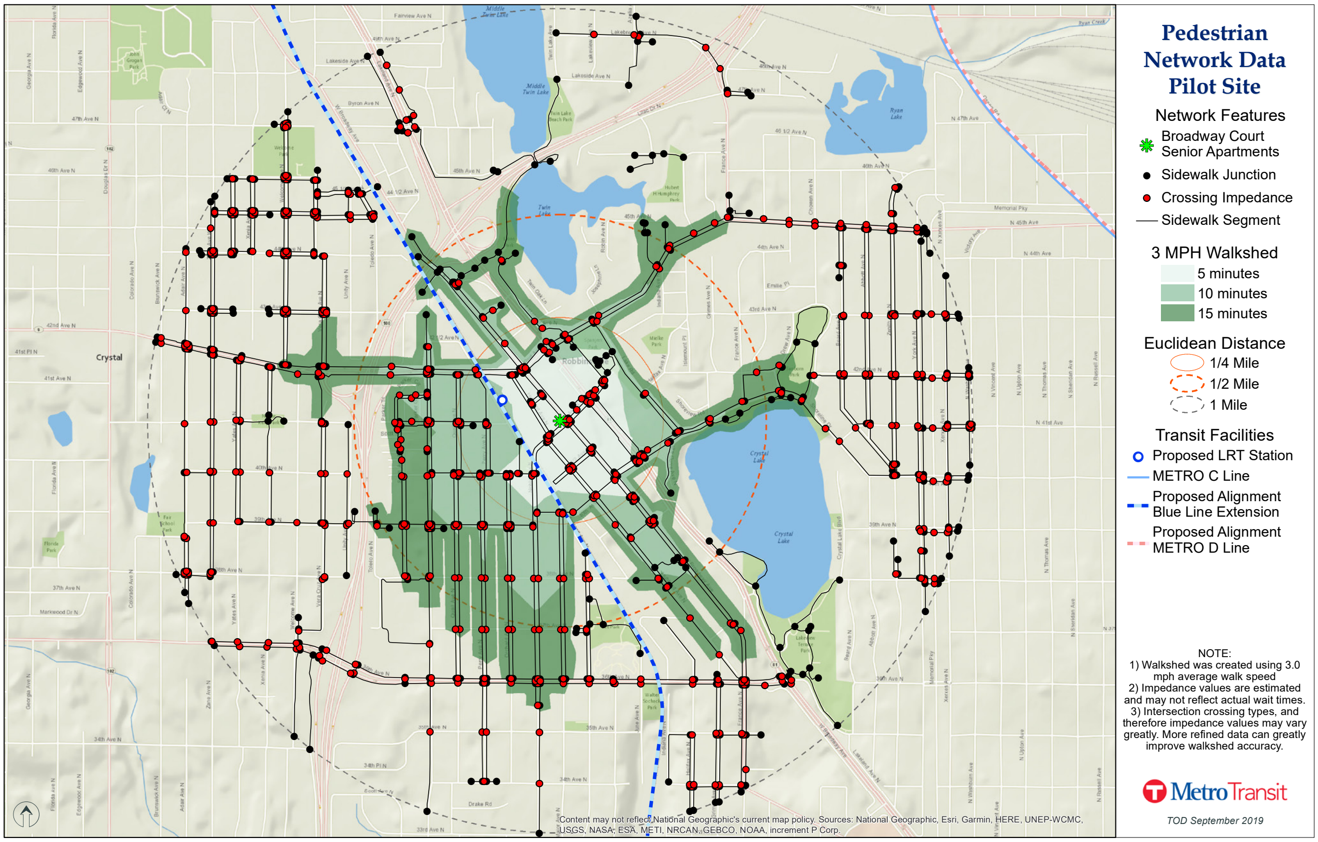
2) 2425 Minnehaha Avenue, Minneapolis: The 2425 Minnehaha site is in a historic low-density neighborhood in south Minneapolis. Area streets and sidewalks are laid-out in a mostly-connected grid that should prove highly walkable. There is established transit service that should be accessible to light industrial, and single-family homes in this neighborhood. State Hwy 55 just west of this site is a well-known dividing line and pedestrian barrier.

3) Central Station, Downtown Saint Paul: The METRO Green Line Central Station in downtown Saint Paul, may be the oldest area of the three sites, but poses unique challenges for pedestrians as well. The Lowertown area specifically, has some significant hills and high-density buildings that require greater capacity pedestrian facilities amidst many public transit nodes. Notably, the Mississippi River is not nearly as significant a barrier as are busy County and State Highways, because of the frequency of bridges with pedestrian network connections.

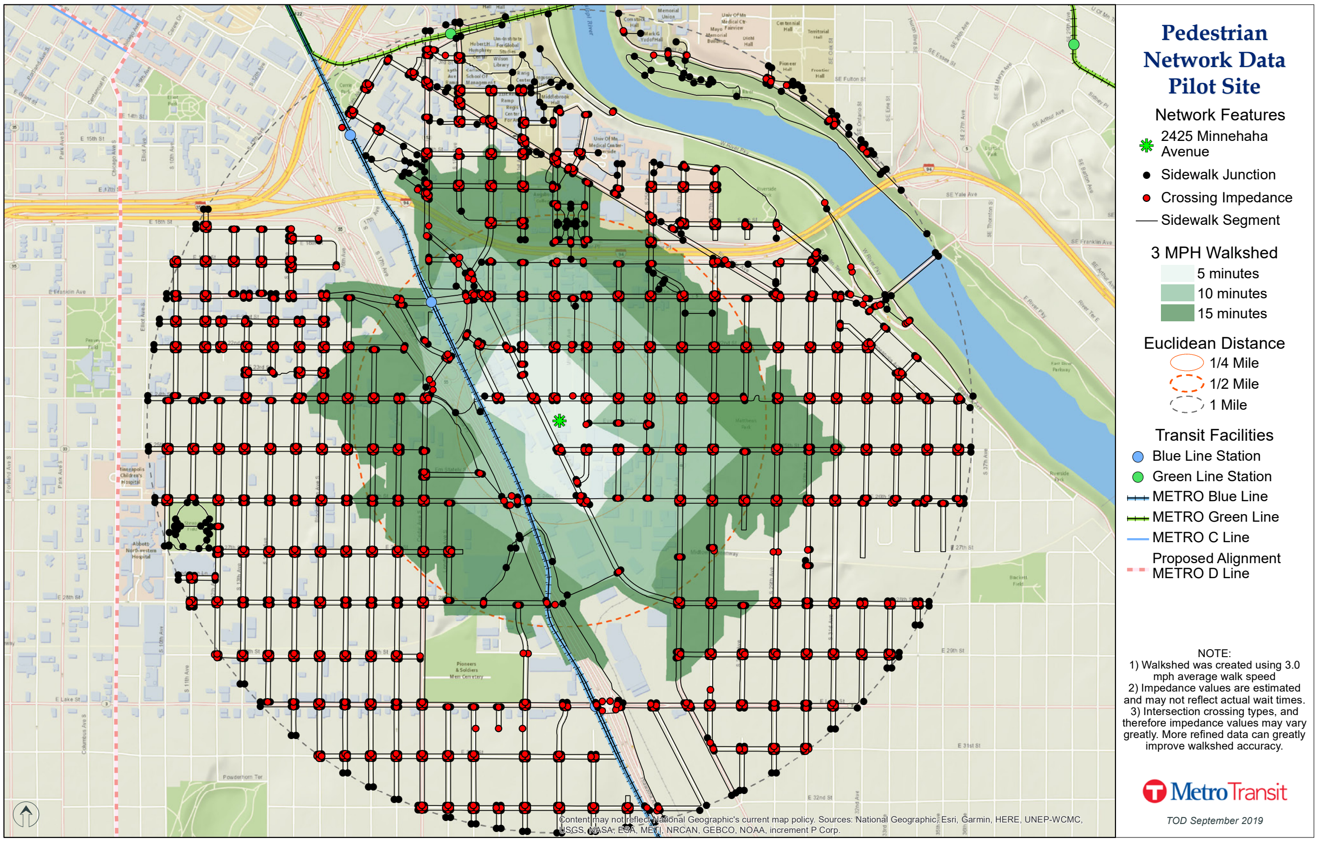


Appendix B:

1) Broadway Court Apartments, Robbinsdale



2) 2425 Minnehaha Avenue, Minneapolis



3) Central Station, Downtown Saint Paul