Safe Routes from Schools to Parks: South Side Milwaukee Pilot Study

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Client Information

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Vision Statement

Walking field trips are a great way to educate students about their communities and safety. Not only that, but walking to nearby places of interest also provides needed exercise and and helps to cultivate a culture of pedestrian safety (City of Los Angeles 2015). Also, when teachers can incorporate trips to local parks into their teaching strategies, our communities see a direct return from their investment into parks, and will be more likely to support future park improvement efforts. According to the National Parks Service, field trips to parks benefit the schools and students by reinforcing classroom instruction in a manner that is not possible in a classroom setting (NPS: 2018). The parks themselves benefit as well because the potential exists for promotion of stewardship, and for the park to become an instrumental part of the community. While many schools on Milwaukee's south side are within a reasonable walking distance to a park, a major barrier to educators is the lack of established safe routes to these areas. This project will design a data driven method for determining the safest routes from schools to parks, and will provide a pilot example of how it can be utilized. At the conclusion of this project, the DPW will have access to a simple GIS framework intended for future use in city planning.

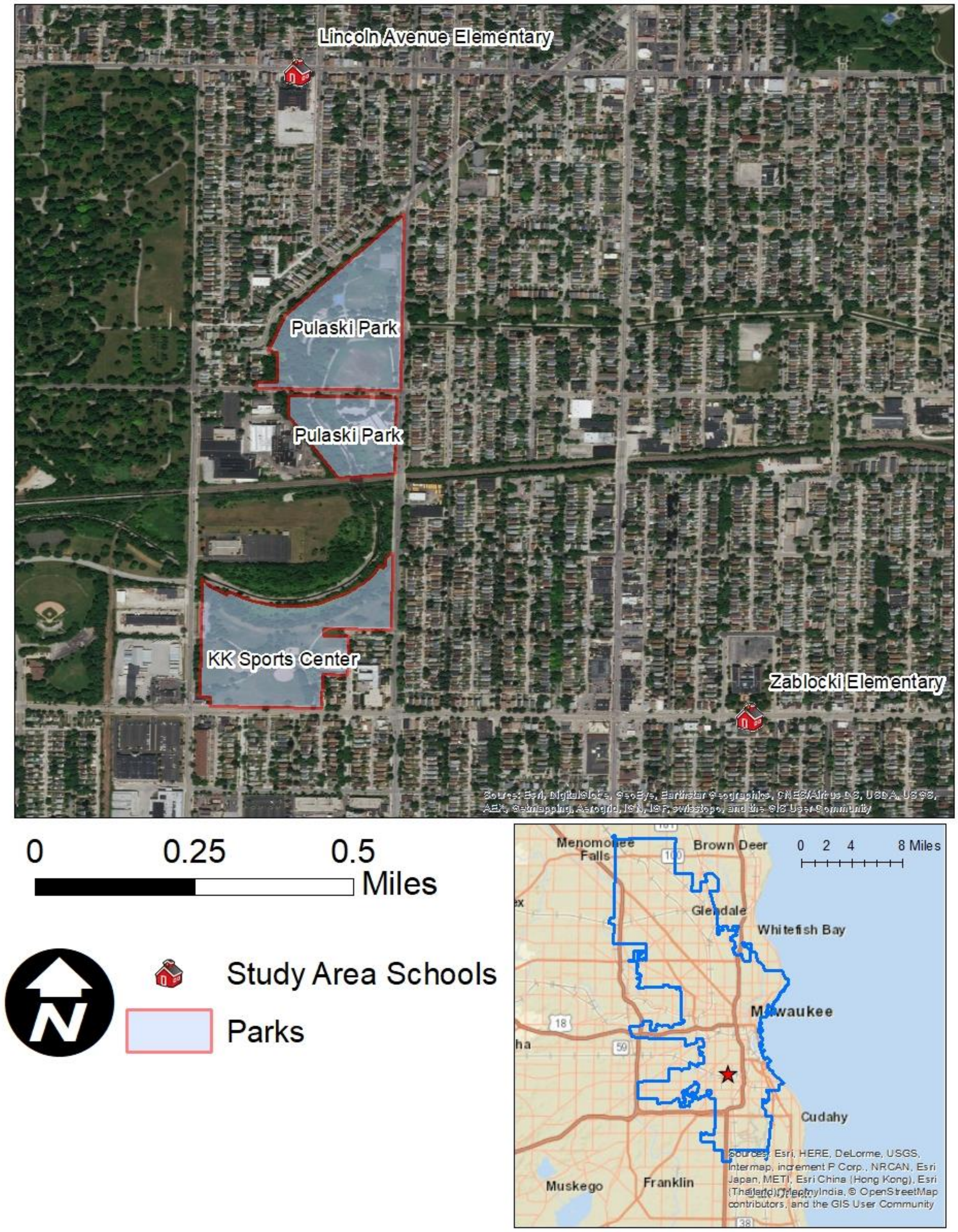
Milwaukee DPW mission statement

The Department of Public Works (DPW) coordinates planning, construction, and maintenance of Milwaukee's infrastructure system. The DPW Infrastructure Services Division has the responsibility for the design, construction, operation and maintenance of all streets, alleys, bridges, public way lighting, traffic control signs and signals, sewers, and underground conduit systems. Safety is a requirement that guides all maintenance and construction projects conducted by the DPW with the major goal of always providing safe and convenient access for all users to places like parks and schools throughout the city.

Project Scope

Due to a restricted timetable, this pilot effort is limited in scope to two schools on Milwaukee's south side; however, the methods for this project will be designed with the intention that they can easily be replicated for any school or park. These two schools; Zablocki Public Elementary School and Lincoln Avenue Elementary, were selected because they are located within an acceptable walking distance from the KK Sports Center or Pulaski Park. This distance was chosen in accordance with the City of *Los Angeles Walking Activity Handbook* which states that; "For the youngest students, a half mile or so may be the maximum distance given their walking speed and stamina"(City of Los Angeles 2015:2). *The Safe Routes to Parks Action Framework* created by the National Recreation and Park Association (NRPA) also uses a half mile maximum distance when describing their GIS analysis methods (NRPA 2016:3). The KK Sports Center and Pulaski Park were chosen because they possess attributes that are considered desirable to schools such as softball diamonds, basketball courts, flag football fields, and access to the Oak Leaf Trail and KK River. While this case study focuses on a restricted geographic area, one of the deliverables for this project is a geodatabase containing city-wide data so that the Milwaukee DPW has the ability to replicate the process anywhere in the city. Two final routes were produced for this case study, each illustrating the safest routes from a different school to its respective park. The study also produces other test routes, shown in Appendix A. Routes might look great in ArcGIS, but before sending children to walk these routes, they needed to be tested. Therefore, after potential routes were identified, project designers walked the routes and ground truthed them while making observations of attributes, such as speed limit, vehicle activity, sidewalk quality and the presence, or absence of stop signs, speed bumps, or other signage.

Elementary Schools within 1/2 mile of KK Sports Center & Pulaski Park



Conceptual Model

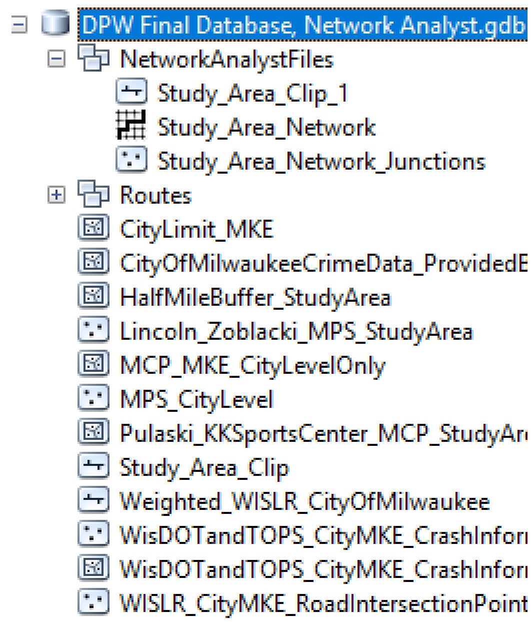
The primary goal of the project was to produce a framework using Esri network Analyst that can predict the safest routes for children and educators to walk from their school to local parks. The Department of Public Works will be able to use the model to focus improvement efforts on streets determined to be safe routes from schools to parks that provide opportunities for education and exercise. This model could benefit the city of Milwaukee DPW, Milwaukee Public Schools, and Milwaukee County Parks by advancing policy change and encouraging a healthy community design. This has the potential to enhance livability and quality of life for city residents by fostering a commitment to active transportation and improving support for pedestrian safety.

Neighborhood organizations could hypothetically use some version of the project's modeling results to advance and aid in getting kids of every income, race, ability, and ethnicity to use and have access to safe routes from community schools to parks. It is our hope that in the future, the Milwaukee Public School system would consider partnering with Milwaukee county parks and the DPW in an attempt to cultivate support to champion safe route implementation from schools to parks throughout Milwaukee. Our networking and analysis are intended to provide the county government (Department of Public Works, Milwaukee County Parks, or the Planning and Transportation Department) with critical evidence and practice based guidance dealing with safe routes. At the root of this project, the goal became to create a useful tool for multiple parties.

Data Model

Data	Attribute Name	Description	Purpose	Source
WI DOT crash data	Crash Weight	Point features for vehicle crashes 2012-2017	Crashes reflect reckless behavior	Wisconsin TOPS
WISLR road network	Walk time (seconds)	Line segment lengths converted to estimated walk times 2018	Safe routes still need to be reasonable lengths	WISLR
WISLR road network	Arterial Weight, Curb Weight	Line features for all roads 2018	Arterial streets are less safe	WISLR
WISLR road network	Signal Weight	Point features for signalized intersections 2018	Signalized intersections are safer locations to cross	WISLR
Milwaukee City crimes	Crime Weight	Point features for crimes 2017	Crimes reflect reckless behavior	COMPASS
Milwaukee Public Schools	School Name	Point features for MPS 2014	Cartographic/ Locational	Wisconsin Department of Public Instruction
Milwaukee County Parks	Park Name	Polygon features for MCP 2009	Cartographic/ Locational	AGSL

WISLR road network data was used to obtain walk-time in seconds, signalized intersections, and the arterial and curb weights. The WISLR data was given to the group by Dr. Schneider; however, the original data contained duplicate segments that needed to be removed. Crash data for the city of Milwaukee from 2012-2017 was obtained from the Wisconsin TOPS lab at the University of Wisconsin-Madison. A data request form was submitted and the data was kindly provided to us by Richard Lange. Included with the associated documents for this project are the data request form used to obtain the crash data as well as a user guide that has also been provided by the Wisconsin TOPS lab. Crime data for 2017 was obtained from the Milwaukee COMPASS Project, which is a federally-funded initiative that aims to build and support collaborative efforts to improve and sustain cities. All data has been compiled into a file geodatabase and organized so that it can be easily understood.



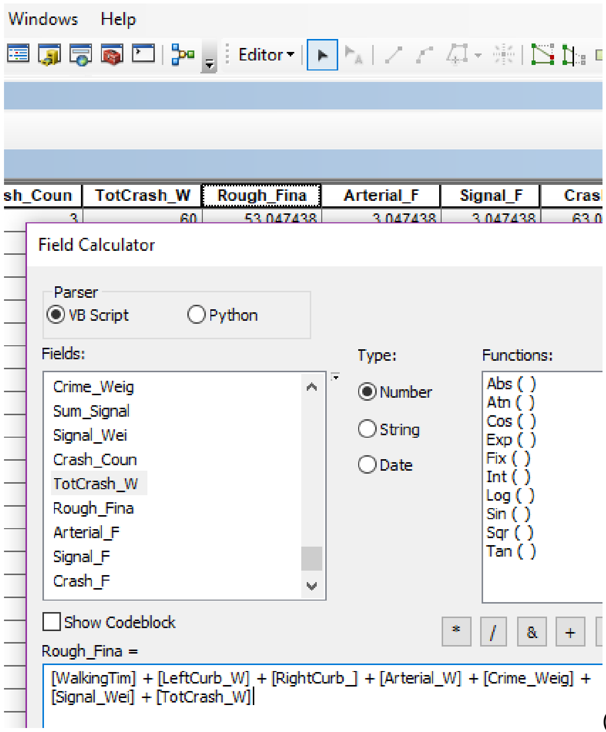
Workflow

1) Spatially join Milwaukee county crime points, TOPS crash data points and signalized intersection points with WISLR road network to get total counts for each segment at a city level.
2) Use field calculator in ArcGIS to produce an estimated walk time in seconds for each segment.
3) Use field calculator to create final weighted walk time in seconds column.
4) Select Milwaukee county parks (Pulaski & KK Sports Center).
5) Clip manipulated WISLR line network to ½ mile buffer around park.
6) Use clipped data to create new network dataset in geodatabase.
7) Select schools (Lincoln Elementary & Zablocki Elementary).
8) Load stops, or enter school and park stop addresses into Esri Address locator.
9) Load line cost barriers using final weighted walk-time in seconds.
10) Use network analyst to solve the route.

11) Ground truth all of the routes.
12) Move stop locations based on ground truthing results.

Data manipulation

Buffers, clips, spatial joins, field calculations, and Network Analyst were the ArcGIS tools used to manipulate and analyze the data for this study. Crash data and crime data were spatially joined to the original WISLR road network file which the group received from Dr. Schneider. Then the field calculator was used in ArcGIS to create weights that were converted to walk-time in seconds for each WISLR segment. If a segment contained characteristics considered by the model to be unsafe for pedestrians, such as a high frequency of crashes or whether or not a segment was part of an arterial street, then that segment was assigned a higher walk-time in seconds in the final weighted total. Essentially, the routes avoid higher total walk-times in seconds. Using ArcMap's "field calculator", an example of how to execute the math for our case study is explained in the following image:



(mid-study example)

Using this mathematical equation is a way to save the user time and space in terms of geoprocessing data within network analyst. Our study considered many alternatives, and this technique was deemed the most efficient. Therefore, instead of uploading multiple costs into Network Analyst, this study recommends the use of mathematical impedance weights. The weights below were achieved by spatially joining WISLR attributes with attributes from the data in the delivered geodatabase such as crashes and crimes, and giving them a weight per segment. One method to make sure point data spatially joins properly to line files, like WISLR, involves buffering point files a certain radius to make sure every line segment gets an accurate join count. This technique has some pitfalls, but increases spatial join accuracy significantly. Fundamentally, each segment has a weighted walk-time in seconds as a length of travel.

"Final Route" Math

Walk-time in seconds (feet of WISLR segment/3.5) + Left curb weight (0,1, or 2 coded in WISLR * (-5)) + Right curb weight (0,1, or 2 coded in WISLR * (-5)) + Arterial weight (0 or 1 coded in WISLR * 100) + Crime weight (crime count per segment in geodatabase WISLR file * 30) + Signal weight (count per segment in geodatabase WISLR file * (-30)) + Crash weight (crashcount per segment in geodatabase WISLR file * 20) = Final Route

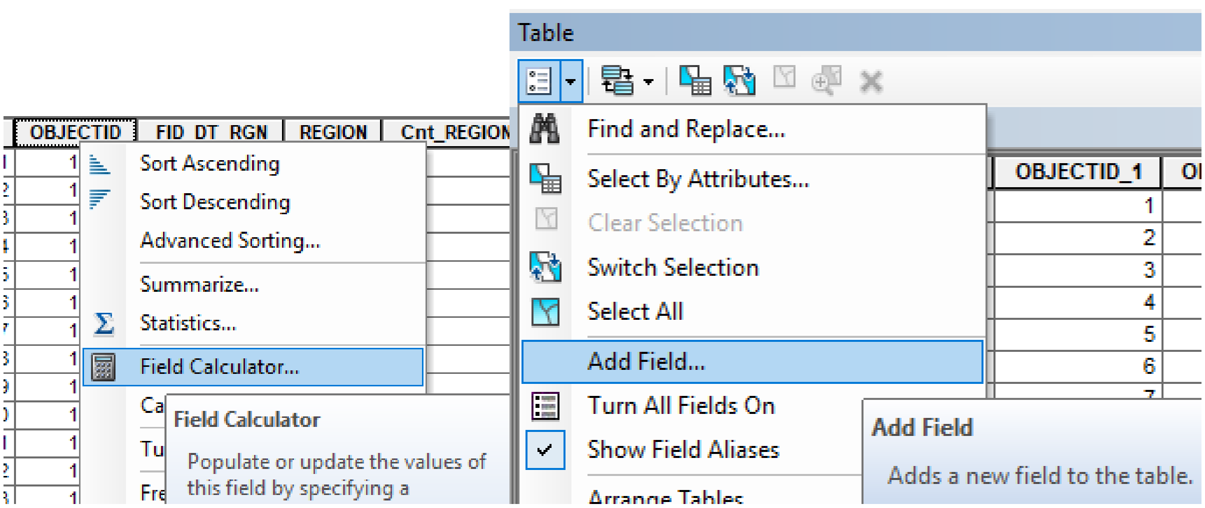
The cleaned WISLR geodatabase file provided by this study contains all routes for the case study that account for attributes such as walk-time and the above arterial weight by themselves. These routes were mapped below (Appendix A), and were ground truthed as well. Our example weights are used to both test the method and to show a user a possible conception of how to weight impedance. The main driver was the mean value of data such as arterials versus other means to avoid segment over-weighting. For example, walk-time has a large weight, and its mean value is around 100 seconds per segment city-wide based on column statistics in the WISLR table. We found arterials to be useful, so we weighted accordingly in comparison. We found signalized intersections be somewhat inaccurate, so this data was weighted less. The crash means were high per-segment, and to avoid overweighting, the study did not multiply the counts by a high factor. A cost received a higher walk-time, while benefits had a negative effect on perceived walk-time, hence the above values.

This mathematical scheme is purely an example based on user judgment. It provides a framework for how to generate mathematical weights that aid the Network

Analyst method, described below. It is the study's goal to inspire further critique of this math, as well new mathematical conceptions. Below is finalized tabular information as a view of how complex one can weight per-route statistics for the analysis below. It is easy to "add field," run a field calculation on "double" style data with the "field calculator," and check the "statistics" option for mean value, or other statistical, information. It is this report's goal to highlight the processing time and space this technique saves based on extensive trial and error.

Walking Time Seconds	Right Curb Weight	Left Curb Weight	Arterial Weight	Crime Join Count	Crime Weight
155.97764	-5	-5	0	0	0
96.387017	-5	-5	0	0	0
4.71085	-5	-5	0	0	0
207.919931	0	0	100	0	0

Signal Join Count	Signal Weight	Crash Join Count	Crash Weight	Final Study Weight	Final Arterial Weight
0	0	3	60	205.97764	155.97764
0	0	1	20	106.387017	96.387017
0	0	1	20	14.71085	4.71085
0	0	12	240	547.919931	307.919931

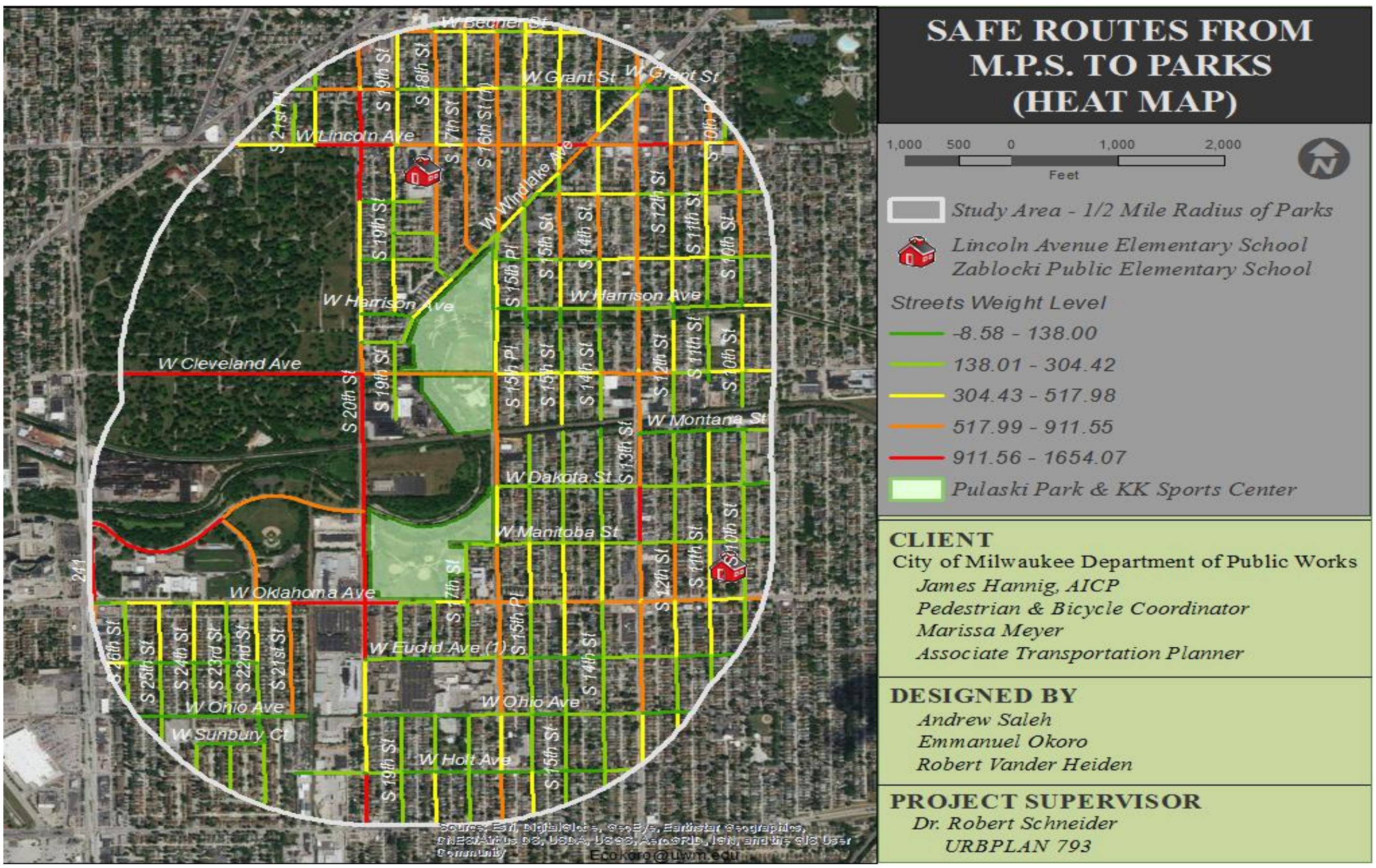


Network Analyst

The main GIS tool or method this study implemented was Network Analyst. Network Analyst is an Esri software extension that provides network-based spatial analysis tools for solving complex routing problems over a related topological surface. By the end of our case study, many different options for analysis were formulated. The process began with Esri ArcMap Network Analyst extension tutorial training, which is a free service Esri provides via any internet browser. In order to fully understand network analyst results, it is suggested that any beginner level user start with these Esri tutorials. Below, a guide is provided as a more relatable tutorial to our data model. It was the goal of this study to gain case study results, and this tutorial is one product of our research.

Impedance factors for determining sate routes

______When a user first dives into Network Analyst, the assumption may be that setting up costs along topology is fairly simple. This is simply not true; it takes many hours to figure out proper impedance factors, and than further, how to implement these factors. One of the major concerns for the DPW was different types of reckless behavior that may put children in danger while traveling to or from the parks. Therefore, a major goal during the planning phase of this project was to create a model that reflected this concern. As a result, the model employs walk-time in seconds, road type, curb presence, crash events, crime events, and unsignalized intersections as impedance factors that affect safety along final routes, as the mathematics suggest. These variables are in some way associated with safety or reckless behavior, justifying their manipulation. For example, roads with no curbs could be seen as less safe. Walk-time in seconds, while not directly linked with safety, was a necessary variable so that the routes were not only safe, but also were a reasonable length. Walk-time is therefore understood as *the* dependant variable. A visual is provided below as an alternative to the mathematical section above. This is also considered a reference to understand why the routing behaves as it does throughout the rest of the study.

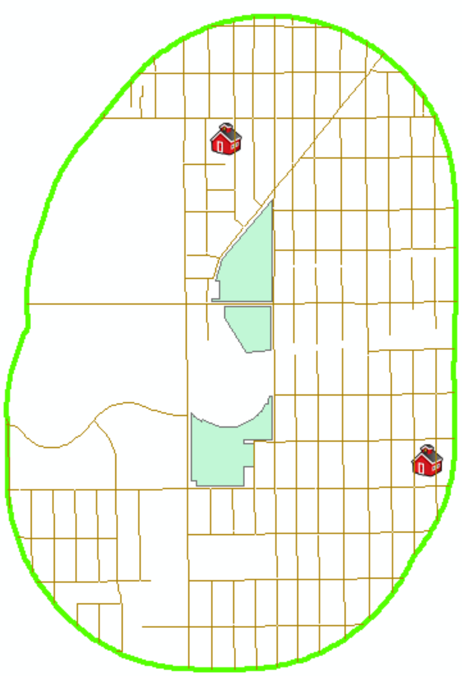


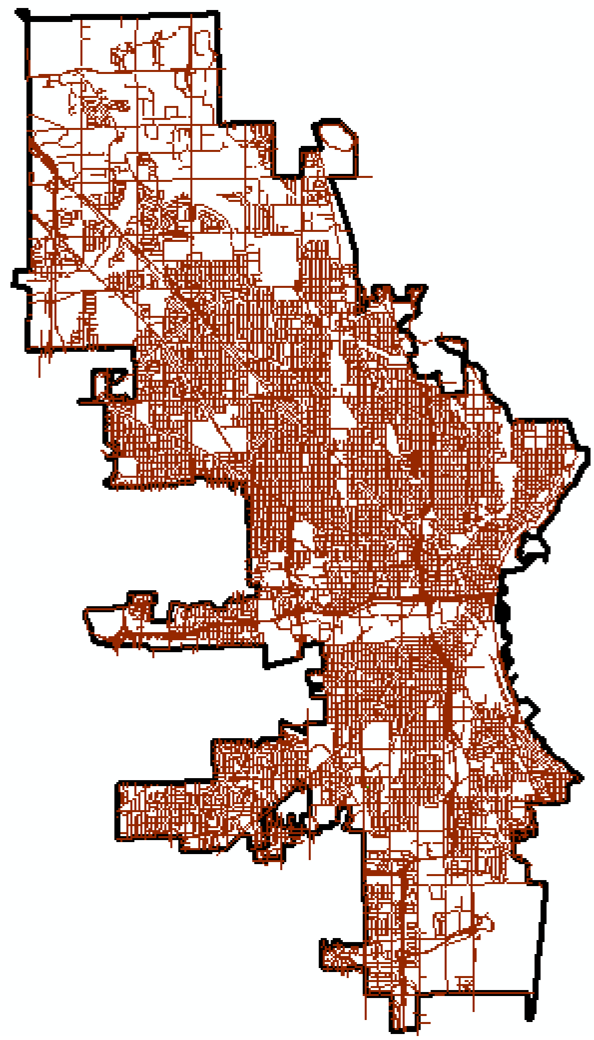
<u>Setting Up the Network</u>

______After determining the impedance factors, a network dataset must be established in the file geodatabase. This study's case dataset was provided as an example with an associated basic network, located within the delivered geodatabase. The mathematics above are made to keep the network functions simple yet powerful in terms of result generation and post-analysis inspection. In this study's case, ground-truthing guidance was aided by this process. A guide for setting up the network is provided below:

<u>Steps:</u>

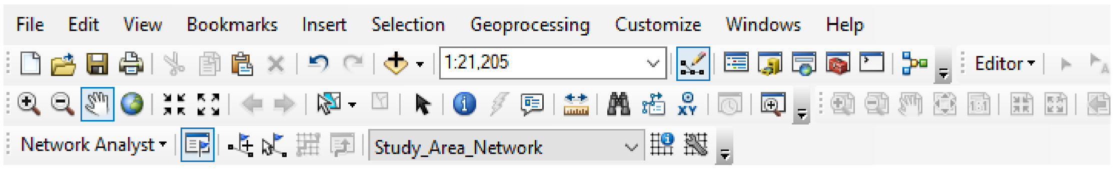
1. Create a buffer around any selected parks for case studies, or use the Milwaukee City Limit geodatabase file to analyze the city (0.5-mile case study = based on literature. This could be increased in future studies for a larger catchment sampling).

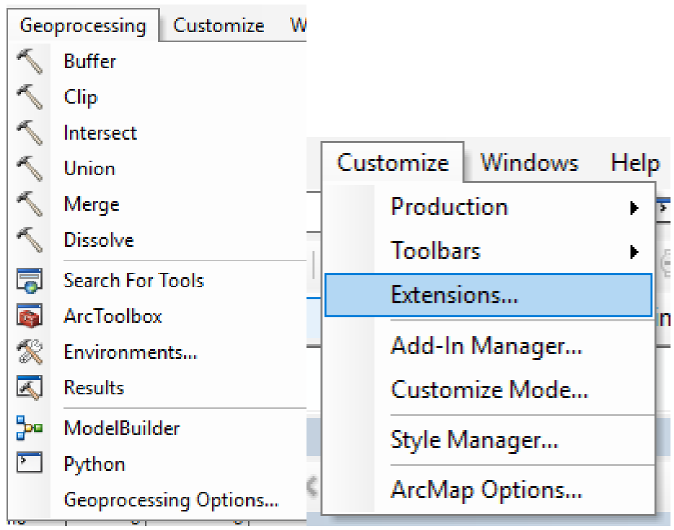




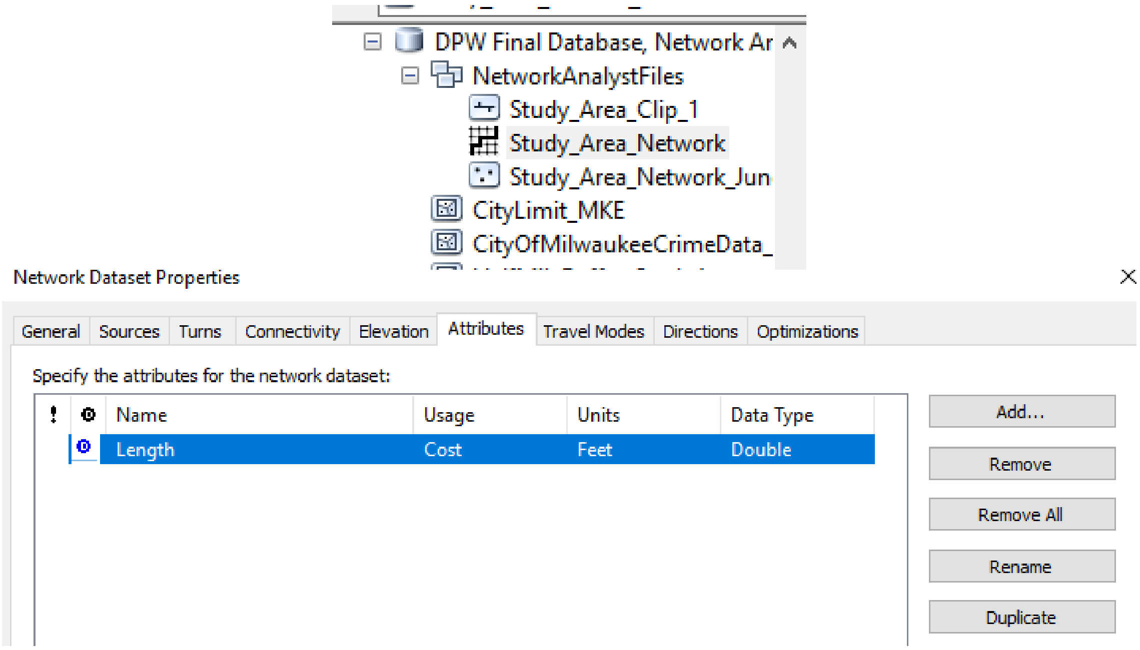
2. Clip data, such as this study's WISLR roadways data, to a study area buffer to conduct the network analysis. This study provides pre-clipped city-level data

ready for analysis; however, clipping to a smaller area is recommended. Make sure the Network Analyst toolbar is in your ArcMap session, that geoprocessing extents are set under the ArcMap “geoprocessing” drop-down, and that Network Analyst is activated under the ArcMap “customize” drop-down.

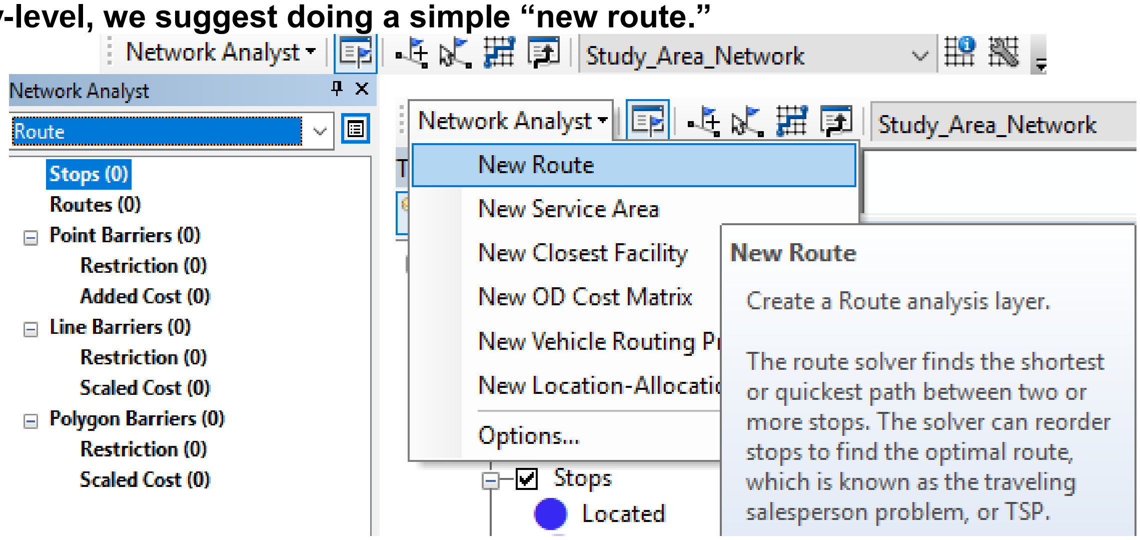




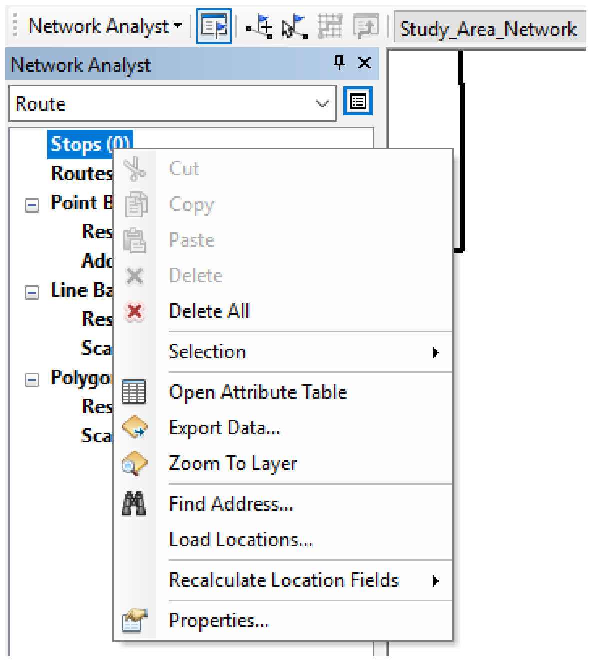
3. Use the clipped data to create a network for the Network Analyst extension. To do this, right-click the geodatabase, add a dataset with imported data the study needs; then, right-click the dataset, and create a new network. City-level data may require some geoprocessing run-time, and the properties (example below) can also be checked or altered by right-clicking the network in ArcCatalog.

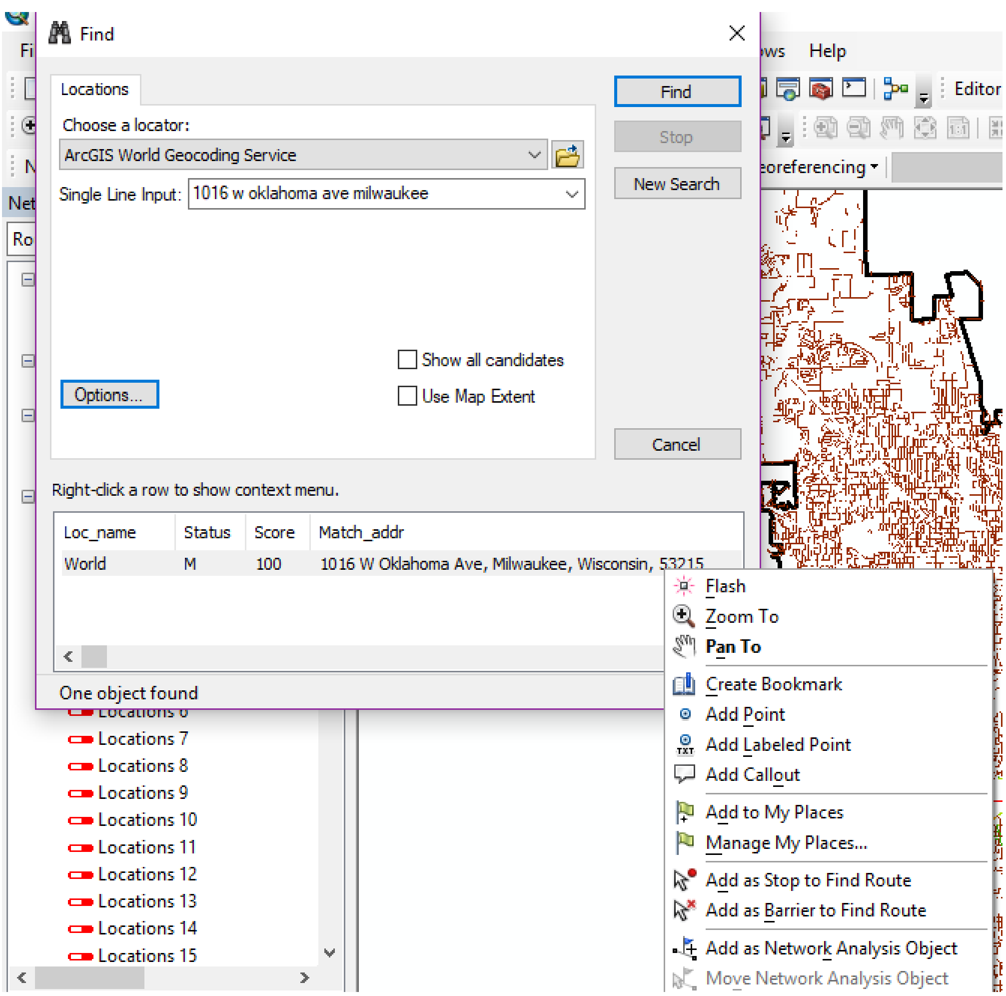


4. Start a new route. This can be achieved by using the Network Analyst toolbar with the user's activated network from Step 3 simply by clicking "Network Analyst". The drop-down provides many routing options. To take this data to a city-level, we suggest doing a simple "new route."

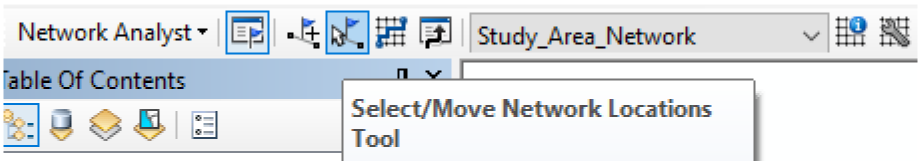


5. Add stops. This can be accomplished using the "find address" or "load locations" options after selecting and right-clicking "stops." If you want to add a stop from "find address," there is diagram for this below. Use "add as network analysis object".

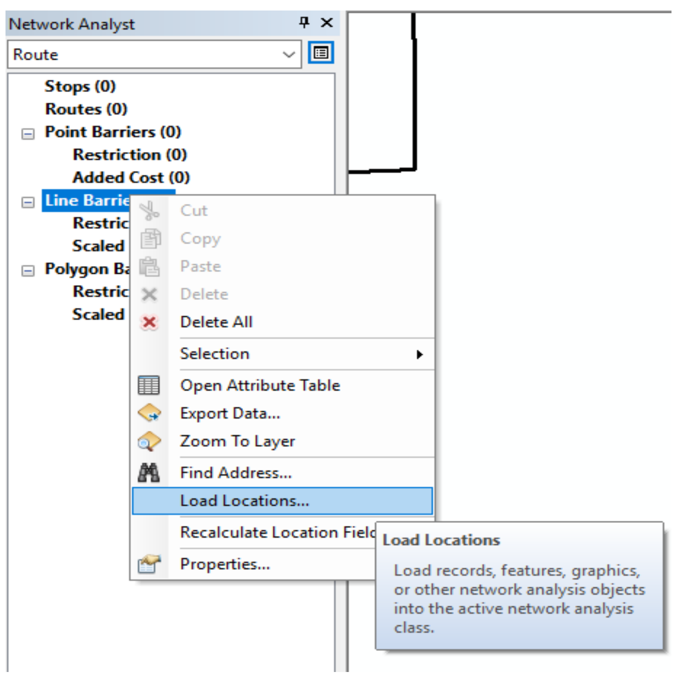

Network Analyst
Study_Area_Network
Network Analyst
Route
Stops (0)
Cut
Copy
Paste
Delete
Delete All
Selection
Open Attribute Table
Export Data...
Zoom To Layer
Find Address...
Load Locations...
Recalculate Location Fields
Properties...

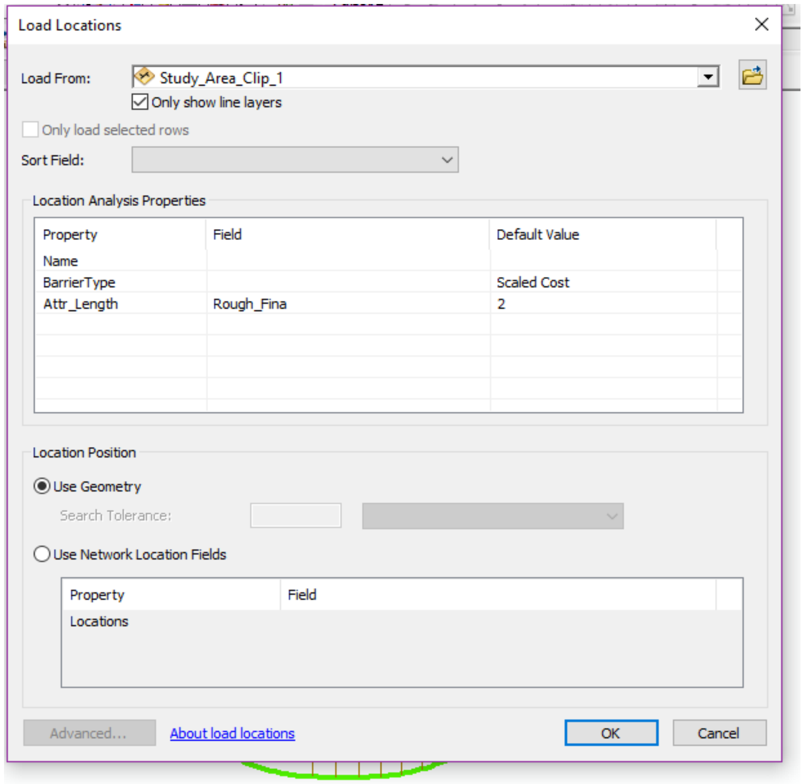

Find
Locations
Choose a locator:
ArcGIS World Geocoding Service
Single Line Input: 1016 w oklahoma ave milwaukee
Find
Stop
New Search
Show all candidates
Use Map Extent
Options...
Cancel
Right-click a row to show context menu.
Loc_name
Status
Score
Match_addr
World
M
100
1016 W Oklahoma Ave, Milwaukee, Wisconsin, 53215
One object found
Flash
Zoom To
Pan To
Create Bookmark
Add Point
Add Labeled Point
Add Callout
Add to My Places
Manage My Places...
Add as Stop to Find Route
Add as Barrier to Find Route
Add as Network Analysis Object
Move Network Analysis Object
Locations 7
Locations 8
Locations 9
Locations 10
Locations 11
Locations 12
Locations 13
Locations 14
Locations 15
Help
Editor

6. Move stops if needed by selecting the stop point and using the “Select/Move Network Locations” tool on the Network Analyst toolbar. Our study required use of this during testing.

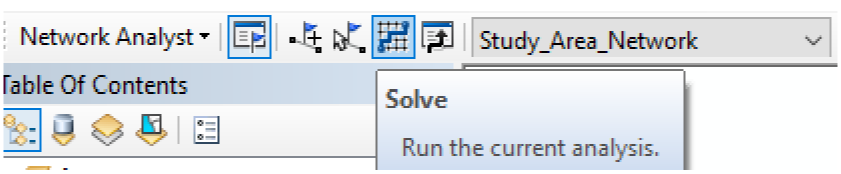


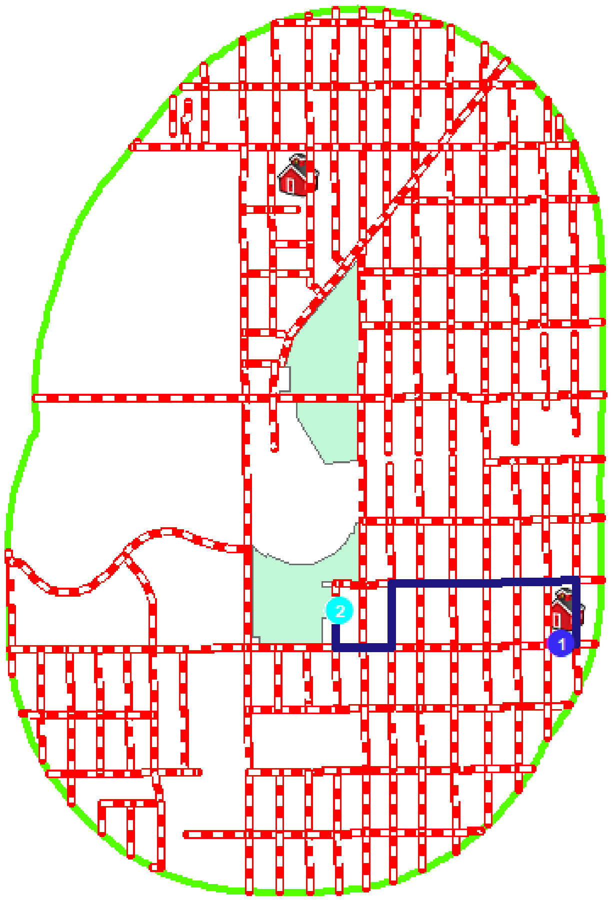
7. Add restrictions or costs. Our mathematical examples are provided of how this study implemented one cost-barrier to reduce geoprocessing time and space. Below is an example of setting up a test cost. Make sure to set the default value as a scaled cost with a value above “2,” as “1” is a null value for line costs.

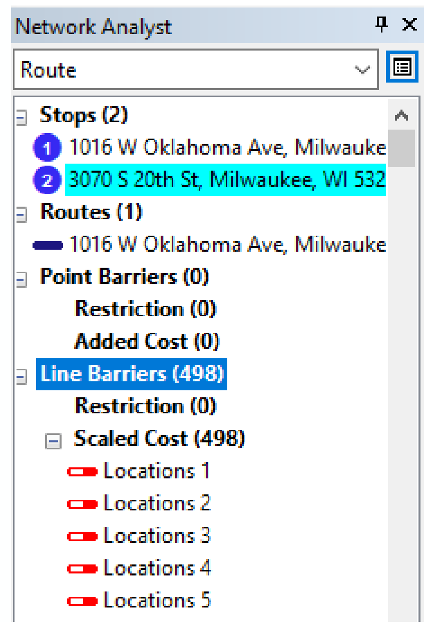




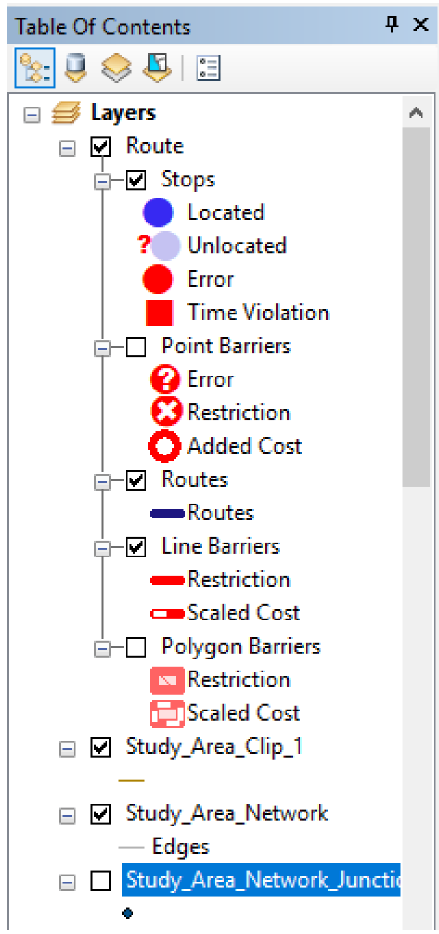
8. Solve the route. This is achieved with the Network Analyst toolbar, and the network should have a cost overlay, similar to the case study image below, to run the route over.

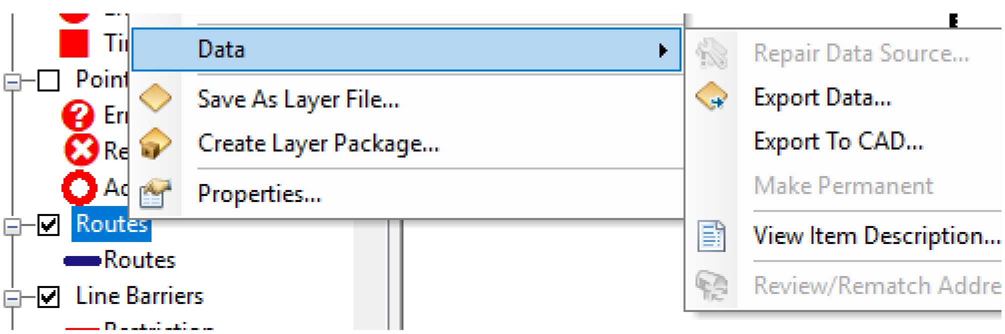






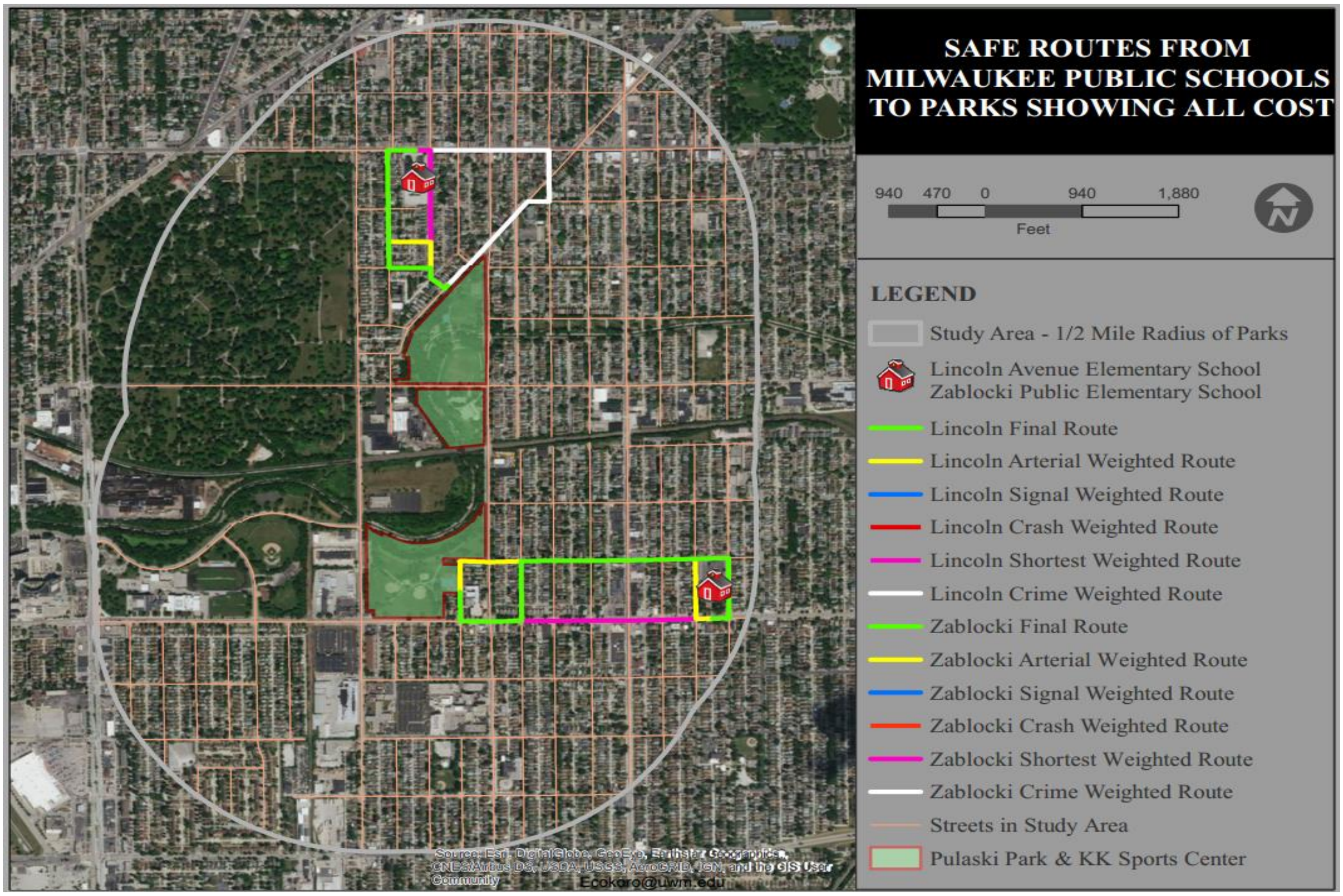
9. Export the route. Simply right-click on the route in ArcMap's "table of contents" and choose "Export Data" and save the route as a feature class in your geodatabase.



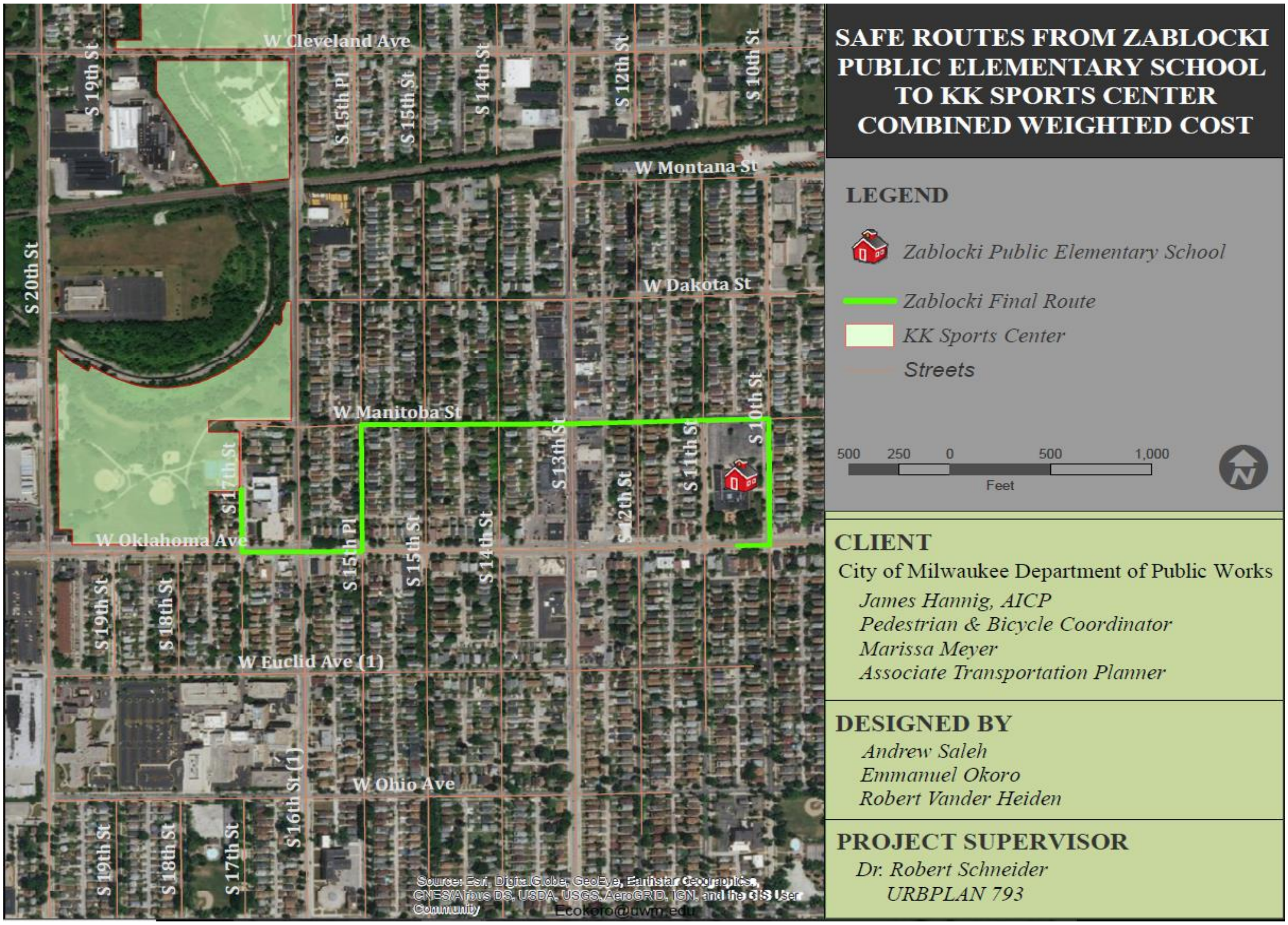


10. Ground truth the route. Physically walk the route to assess the level of safety and identify areas for infrastructure improvements (see ground truthing section of this report).

<u>Milwaukee South Side Pilot Study Results</u>



Above is a summary map showing the results of all the weighted costs that was taken into account during the analysis and ground truthing. The routes as shown in the above map are laying on top of each other. Each shows the best route (considering individual cost plus wak-time in seconds as an impedance) from Lincoln Avenue Elementary School to Pulaski park, and Zablocki Public Elementary School to the KK Sports Center. See Appendix A for individual weighted route maps.



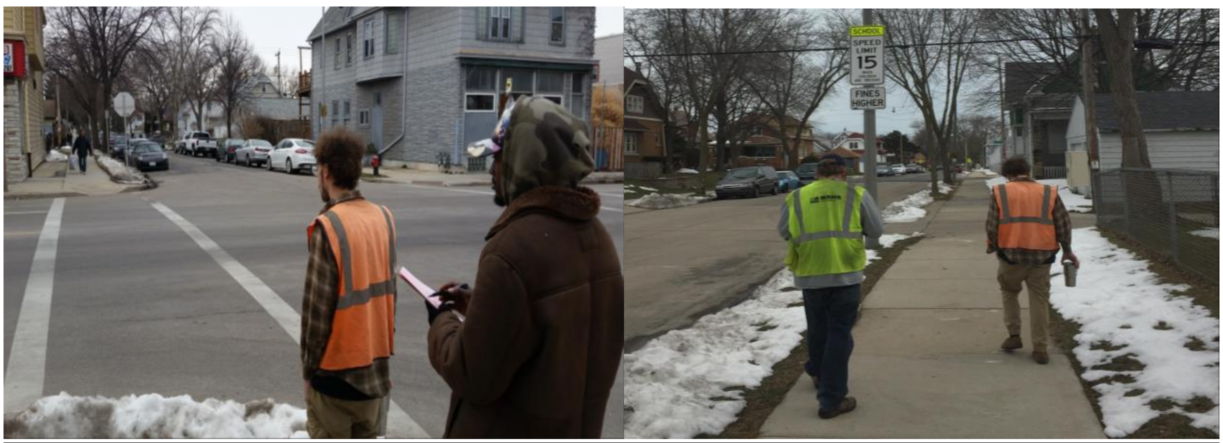
According to our results, the safest route departs from Zablocki Elementary School on W. Oklahoma Ave. then turns left heading north on 10th street until taking a left onto W. Manitoba Street heading west. This could be avoided by simply moving the departure point to the back of the school on Manitoba Street. Next, the route then turns left from Manitoba onto 15th street heading south and then takes a right onto W Oklahoma Avenue. In this case the signalized intersection is the safest place to cross and the route reflects that fact, while also considering other per-segment weights. The heat map in the impedance section of this report gives an idea of why a route potentially turns, and where. Finally, the route turns right onto 17th street to arrive at the KK Sports

Center; however again, the arrival point could be changed based on the most appropriate entrance to the park. Since Zablocki Elementary is located further from the KK Sports Center than Lincoln Elementary is to Pulaski park, the study's findings support the fact that this final route provides more utility in that the route does not follow what could be considered to be the most obvious path.

According to our results, the safest route for the second school in our study area departs from Lincoln Elementary school heading west on Lincoln Avenue. Then the route turns left on 19th street heading south until making another left turn on W. Arthur and continues until 18th street, where the route takes a right turn and crosses Windlake

Avenue, arriving at the northwest portion of the park. In this case, the route did not choose to cross at the signalized intersection at 16th and Windlake Avenue. However, this is due both to the amount of crashes at this intersection, and the additional walk time in seconds that would be added to the route simply due to length.

Ground truthing the routes



Group members traveled together to the study area and ground truthed all routes to see if the final route really did produce the safest path from the schools to the parks. Immediately, it became apparent that the geocoded stops were not the best locations for the origins of these routes. Geocoded addresses produced origins on busy arterial streets. At both schools it was obviously safer for pedestrians to exit and enter the properties from the rear exits, which where located on residential streets. Stops should therefore be carefully considered before finalizing routes, or adjusted after ground truthing efforts have been completed.

Sidewalk quality was observed along routes to identify any possible tripping hazards. While there was some unevenness due to tree root growth, the sidewalks along both final routes were found to be acceptable by the group. It is possible that when better data is available for sidewalk networks in Milwaukee, this type of analysis could be applied to sidewalks as well.

Another quality the group observed while ground truthing was the presence of any obstructions to drivers' vision that might prevent that driver from seeing pedestrians.

This was due to factors at crosswalks such as blind turns, hills, fences, or bushes. While blind turns were observed on some of the routes that were produced based on walk-time and parked cars were occasionally troublesome, the group felt the final routes were mostly free from any major obstructions. This study assumes that arterial streets will have high traffic volumes and residential streets are expected to have low traffic volumes. This was observed to be true on all the routes produced in this study area; however, this may not always be the case in all areas and some residential streets could receive higher traffic volumes.

At every intersection, the quality of the crosswalks were assessed by the group. Crosswalk assessment consisted of observing the state of the painted lines and signage

at unsignalized intersections; and also, the timing of signals at signalized intersections. For example, near Zablocki Elementary, this study found many new Oak Leaf Trail, school zone, and pedestrian crossing signs near the vicinity of the school. On the one hand, these observations supported our final routing weights, but on the other hand, these observations also found that signs do not necessarily reduce reckless behavior.

While signalized intersections were considered to be safer in this analysis, after ground truthing this does not appear to be a universal truth by any means. Signalized intersections are usually areas of high traffic stress. Though there may be additional signage in these types of areas, there are many safety concerns as well. Crossing arterial streets at less busy segments can be safer; however, the group found that signage may need to be improved in these areas. Current Wisconsin pedestrian laws state that at any crosswalk, drivers must yield to a pedestrian or person riding a bicycle. The problem is that not all drivers follow this law, and it rarely seems to be enforced. An example of one of these problem intersections is 13th street and Manitoba street on the final route from Zablocki to the KK sports center. Even though there were bright pedestrian crossing signs, the group witnessed a woman with a stroller struggle for a number of minutes to cross 13th street while no passing cars would yield to her. Suggestions for how intersections like these should be improved are in the recommendations section of this report. The idea is that, based on observations in this ground truthing section of the report, high-level recommendations can be produced from visiting local routes in-person as an applied and planned method of creating the safest route from a school to a park specifically weighted to avoid reckless behavior.

Project deliverables

1. Geodatabase
2. Final Report
3. Associated documents and source materials

Strengths of the Model

The central strength of the model is that it is a data driven way to plot the safest route from schools to parks, and helps to identify specific target areas where any actions taken by the DPW can have the most positive effect on safety. This case study serves as an example for how simple GIS analysis can guide decisions about safety, and improve the quality of life for the residents of the city of Milwaukee. With additional support from MPS and Milwaukee County Parks, there is certainly potential for this project to grow and become more refined. It is also possible that by using the data created during this project the DPW could easily find the safest route between any two locations that are entered into the network as stops.

The idea is that our data and associated maps were a part of a test. The test was essentially to see what kind of routes network analyst would produce with our shapefiles and implemented impedance mathematics. The study weights are based on mean values and inferred data quality. These weights can be adjusted at the provided city-level if the DPW wants to implement their own final weights. We highly suggest using arterials, crashes, and walk-time in seconds per WISLR segment as a starting point based on our test results. These shapefiles and associated results are considered strong takeaways for future analysis or mathematical function creation.

Another strength of the model is its efficiency. Esri Arc extension online tutorials tend to teach users with data that is easy to use and catered to the tutorial. Simply throwing your own data in ArcMap and expecting Network Analyst to work as it did in a tutorial is risky. The above network analyst guide provides a method in which schools and parks can be connected safely that is derived from a more real world data handling scenario. Therefore, we suggest using this guide for simple routing before consulting Esri online for simple routing as it uses mathematical impedance, which will save the user time in multiple ways.

In terms of providing a good data sample to work with at a city-level, the geodatabase provided by this study is easy to use, contains source information, and has updated files. The deliverable is in a “file” format, which means in can be accessed by any user. It was constructed to be manipulated by GIS users of all levels. It also hopes to inspire the addition of new relevant geospatial data to aid and refine impedance weighting for future studies. The network dataset was designed to be user friendly, and contains only one clipped WISLR geodatabase file with columns based on our mathematical impedance. This help data size and runtime reduction, as suggested above in the Network Analyst mathematics section. Time and geoprocessing power would be key to the DPW implementing routing efficiently at a city-level. With the delivered weighted city-level WISLR file, efficiency is conceivablely as high as it could be. This conclusion is based on a simple concept: less shapefiles in Network Analyst equals better runtime. Why upload layer upon layer into Network Analyst (these could have hundreds of thousands of locations at a city-level) when only one cost is needed to overlay a network’s topology as a multivariate perceived walk-time.

Problems

One of the problems with the model is the inclusion of signalized intersections in the data model. While it is assumed that signalized intersections are safer locations for pedestrians to cross arterial streets, this may not be true in all areas. Another problem involves determining the locations of stops. Geocoded addresses do not produce the best results and stops usually need to be adjusted after ground truthing the routes. This is not a big deal, but it would be nice to address this issue before ground truthing. It is possible that improved data such as GPS points for all entrances to the schools, could resolve this issue in the future. Additionally, some schools are located very close to their local park, and as a result, the route is very simple. This type of analysis might seem somewhat unnecessary, and the delivered exported geodatabase routes show the length differences between the schools.

One big question became: could the need to ground truth city-level data to make a network more accurate be considered a problem. At a city-level, this seems time consuming; but, with evidence from our study, one could argue otherwise. For example, this study's ground truthing exercise took one day. If the method was systematized, the exercise could potentially be performed on four to five schools in an average work day. On the other hand, students have different drop off and exit points at schools based on the time of day sometimes. Also, our schools were fairly accessible, but a two school sample size is not statistically significant enough to suggest it would be this easy to data collect and ground truth all over Milwaukee. The jury is out, as it seems ground truthing also has the issue of opening a can of worms, so who really knows how many questions would arise per case study, or throughout the city as a whole.

One can of worms our ground truthing opened involved alleys. When our group arrived to Lincoln Avenue Elementary, we noticed there were alleys all over the neighborhood. The question we considered was: how do these affect WISLR networking? We also questioned whether alleys were considered dangerous, and how arbitrary that notion is. The only option at this point for considering alleys in a network would be to digitize raster data manually. The usefulness of this digitization is up for debate, and a consideration for future networking studies.

Data quality is always a problem any solid GIS analysis must consider. For example, duplicate WISLR segments exist in the statewide file if one just downloads it online. These errors were removed with a QGIS technique due to software licensing limitations, but there is an Esri extension that can remove duplicate segments as well (if one has access). This raised a question amongst the group members conducting this study: would using DIME (a biking road line shapefile) produce a different network topology. Essentially, is there a better topology to work with than WISLR. As edited, the file is great, and provides vital weighting information, but the consideration is warranted. Also, what if point values do not fall on networks in a network study? This study solved the issue with buffers as a join count option, but the idea is simply that GIS data is never as straightforward as one may expect.

The last important problem to discuss is the idea of implementing industry standard Network Analyst Origin-Destination Matrix or Vehicle Routing Problem methods beyond the basic routing our study conducted. At a study area level, this suggestion may seem like a way to vamp up a study's networking results. At a city-level though, geoprocessing power and time become the problem of this implementation. Overloading a network with too many costs or processes between many locations, again, is a big issue to consider based on the trials and errors from this study. Our Network Analyst section is suggested as *the* routing method the DPW should start with as it aids in avoiding networking pitfalls, while the mathematical weights are adjustable by what the analyst wants to aim for. The idea of mathematical implementation is the important part, as it avoids cost overlay on top of cost overlay, saving time, power, and allowing unlimited weighting.

Further Recommendations and Conclusions

It is the opinion of this study's group that this type of analysis should be done on a case by case basis, and that schools also make an effort to promote pedestrian safety among students as well. While manipulated WISLR data for the entire city is provided, it is also recommended that the DPW clip this data to smaller areas such as individual neighborhoods. This reduces the time it takes to import a cost and run Network Analyst, especially in combination with join counts and field calculations. Additionally, while a ½ mile walking radius was used here for elementary school aged children, this distance could be increased for middle or high school aged children.

Ground truthing the routes proved to be an essential part of this project. It is recommended that any routes produced using this model always be ground truthed in a similar manner. One benefit of this ground truthing process is that once these routes have been identified, the DPW can focus their efforts in specific areas that will have a known effect on the lives of the people in the case community. When problems such as uneven sidewalks are identified and fixed, the routes become safer and are more likely to be used not only by schools; but, by the rest of the neighborhood as well, increasing community health. At intersections where residential streets cross arterial streets such as 13th and Manitoba, which was mentioned previously in this report, it is suggested that a number of improvements be made to increase safety for pedestrians attempting to cross. First, the Milwaukee County Police Department must be informed of the problem so that they can increase enforcement in these areas. In addition to increased enforcement by police, the installation of flashing pedestrian signs, in-street pedestrian signs, curb extensions, and re-painting the lines on the pavement would reduce the likeliness that any children will be injured trying to access a local park with their class. Not only that but, "investing in walking infrastructure saves money in the long-run: The National Safety Council estimates the cost of a pedestrian fatality at $4.3 million, while a curb extension costs as little as $50,000, and a high visibility crosswalk costs about $1,200" (2012. Sam Schwartz Engineering PLLC and America Walks:4). Increasing education about pedestrian safety will also help to reduce the frequency of injuries. When children learn about safety at school they are more likely to pass this information on to other members of their family. This helps to spread information and could inspire a change in local attitudes toward pedestrian safety.

References

2012 Sam Schwartz Engineering PLLC and America Walks. *Steps to a Walkable Community A Guide for Citizens, Planners, and Engineers.*

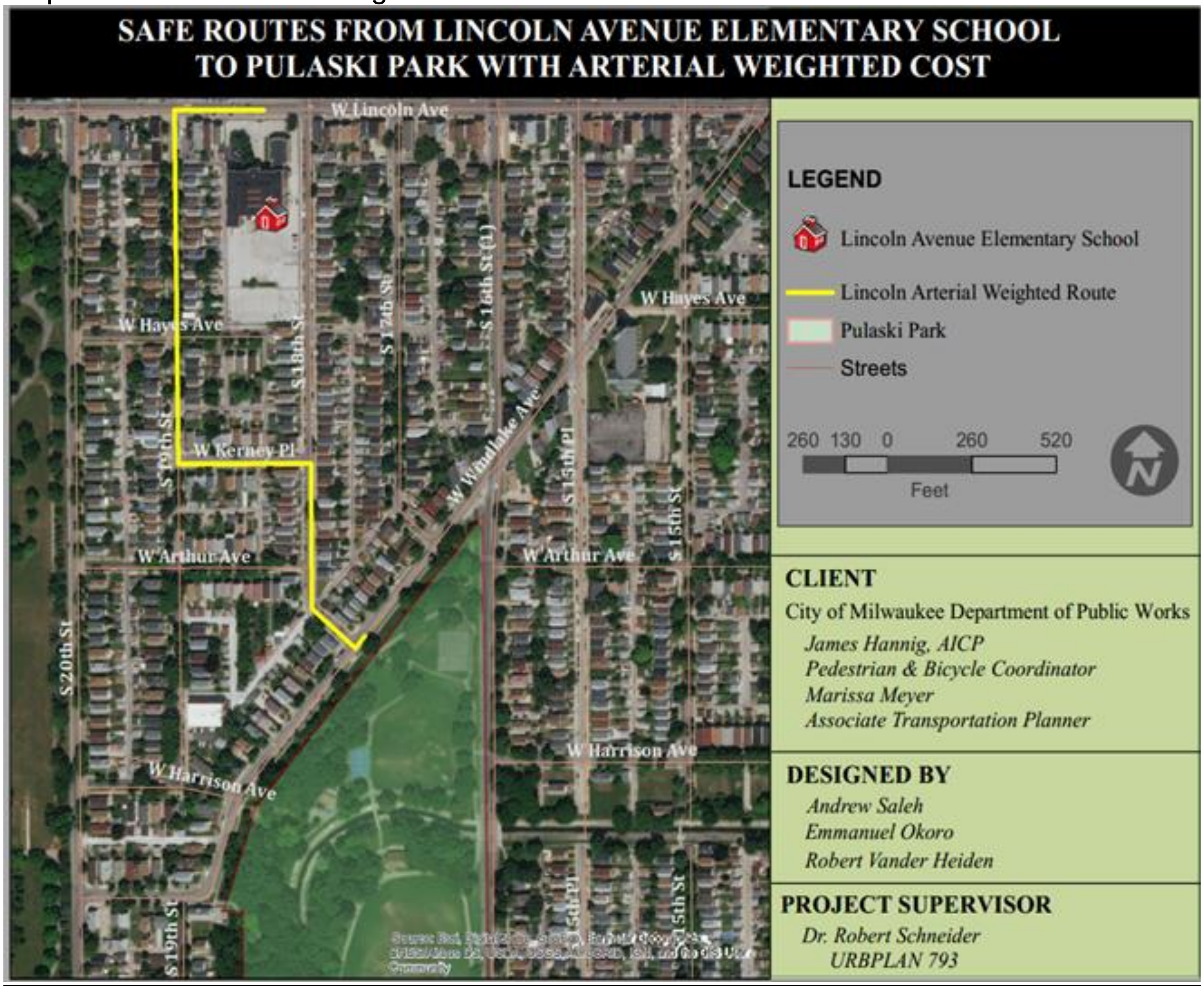
2015 City of Los Angeles. *City of Los Angeles Walking Activity Handbook*.

2016 National Recreation and Park Association (NRPA)*The Safe Routes to Parks Action Framework.*

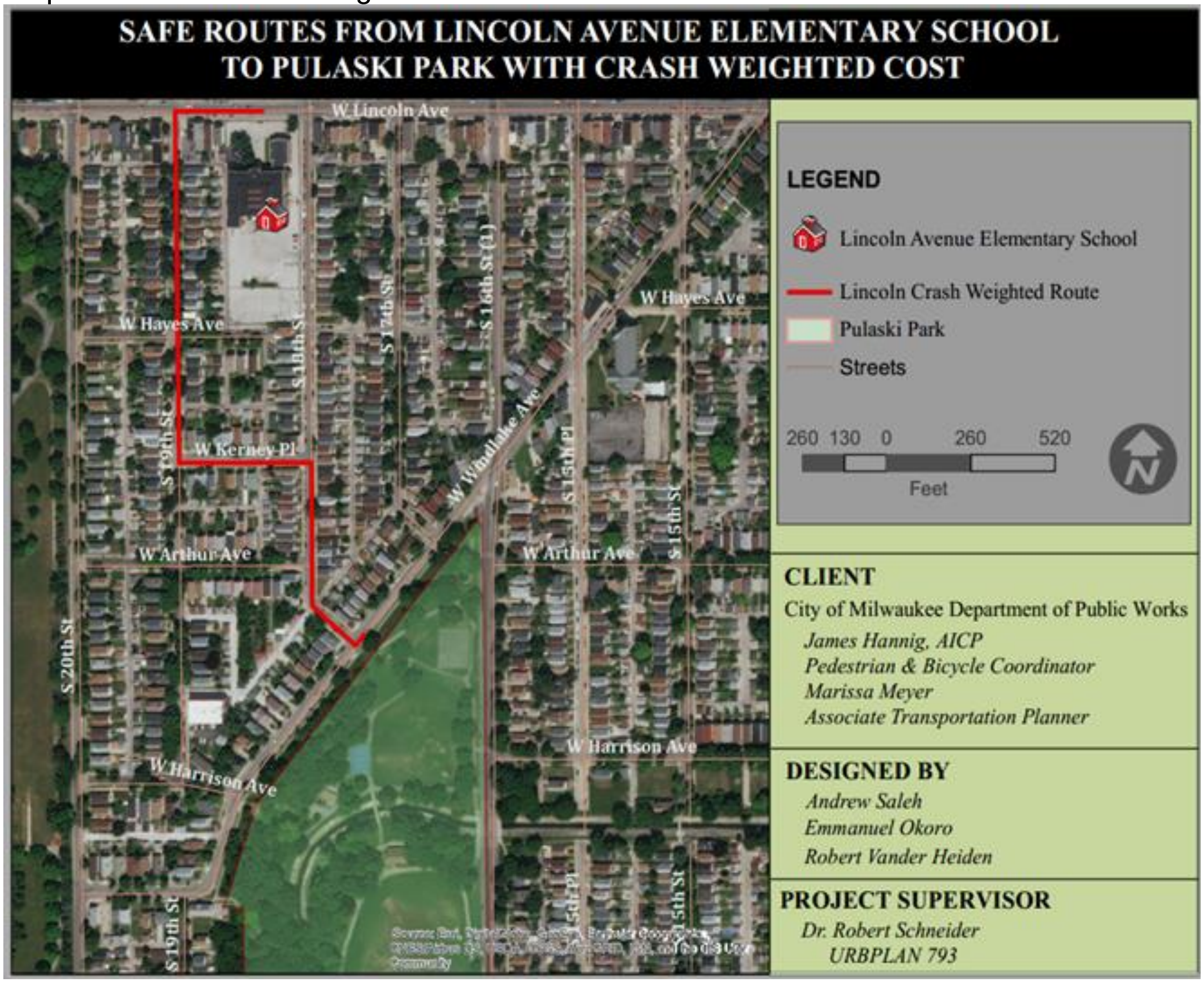
2018 Esri online and Arc software.

Appendix A, Ground Truthed Test Maps (cited in data model and delivered geodatabase)

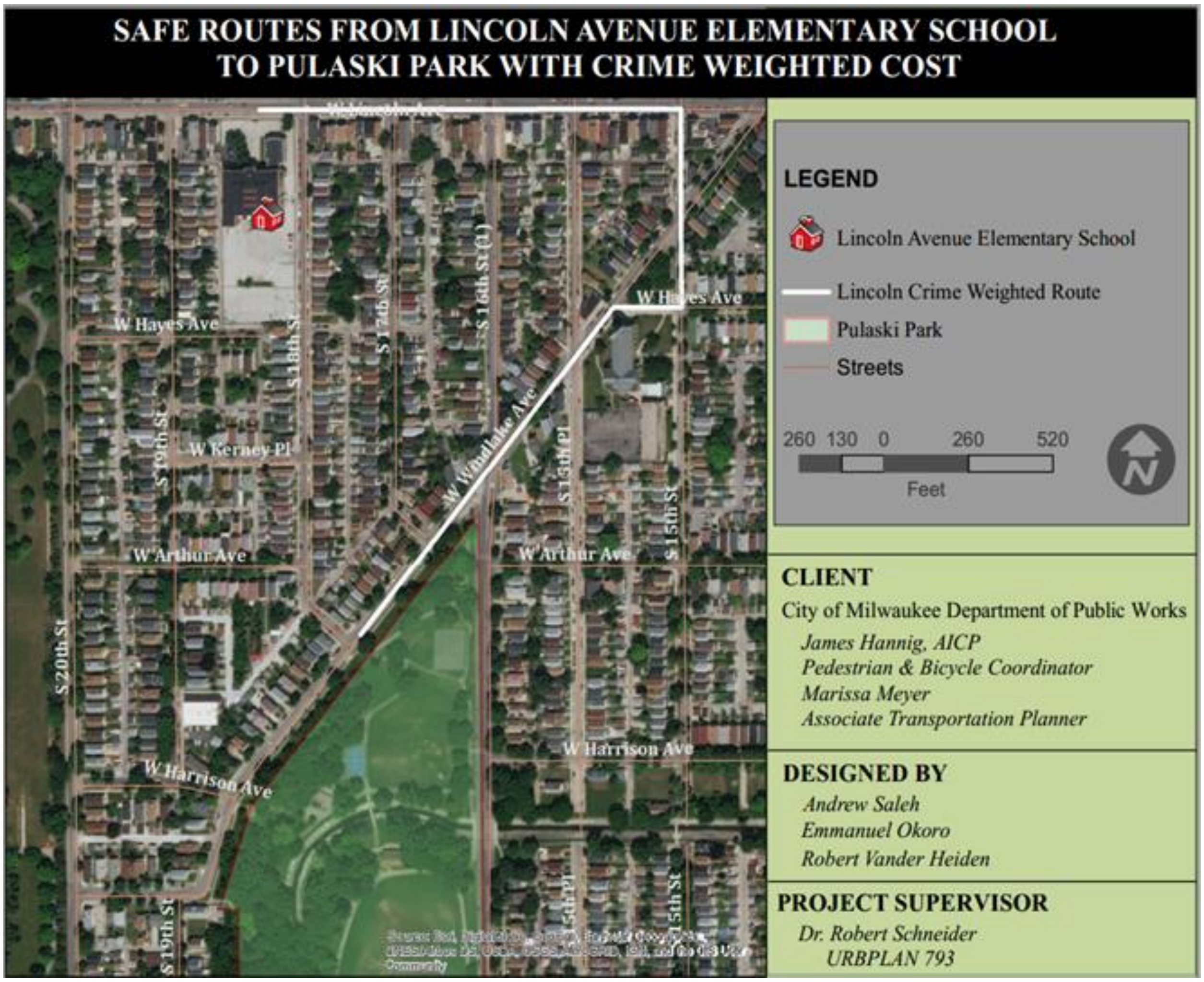
Map 1: Lincoln Arterial Weighted Route



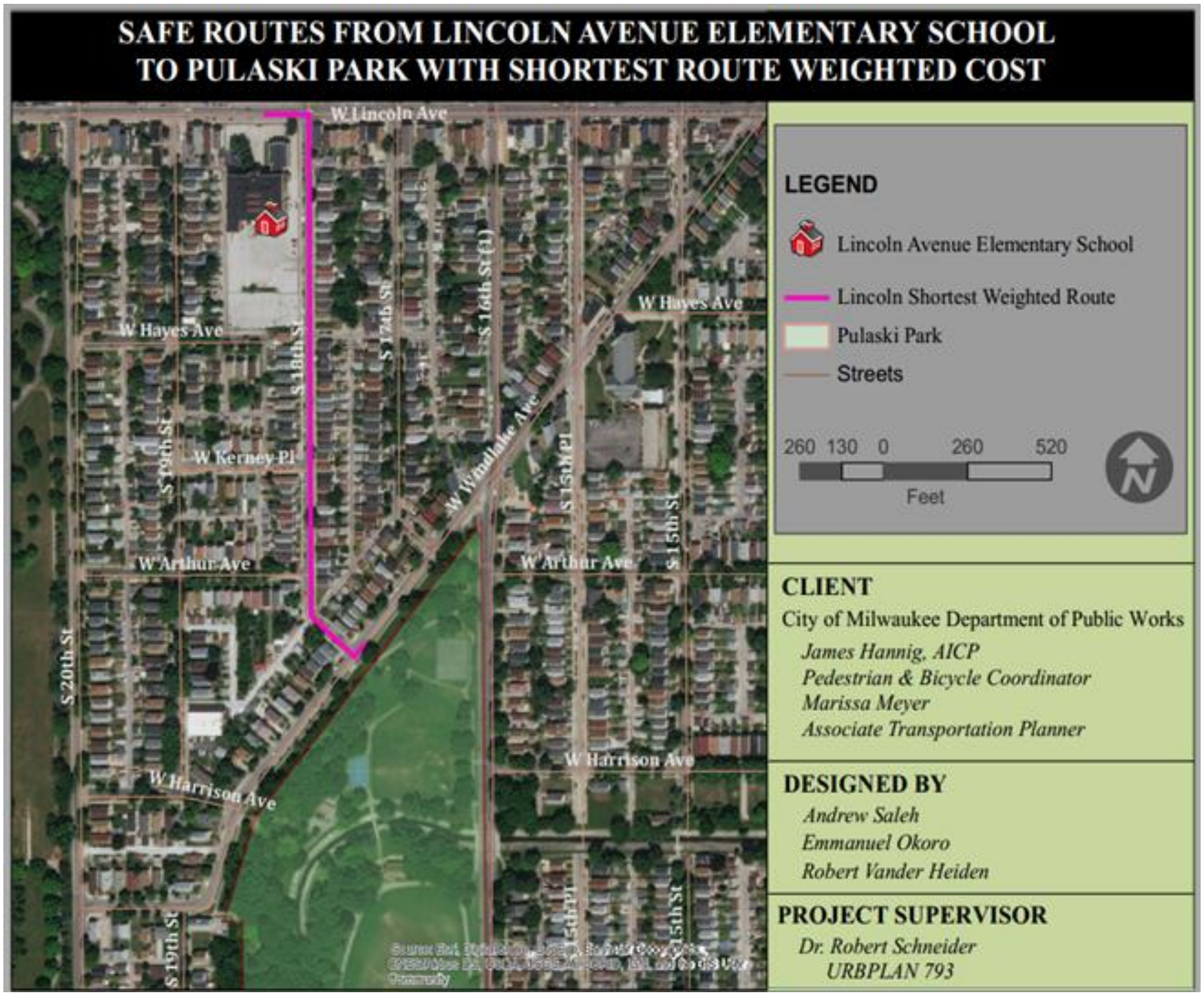
Map 2: Lincoln Crash Weighted Route



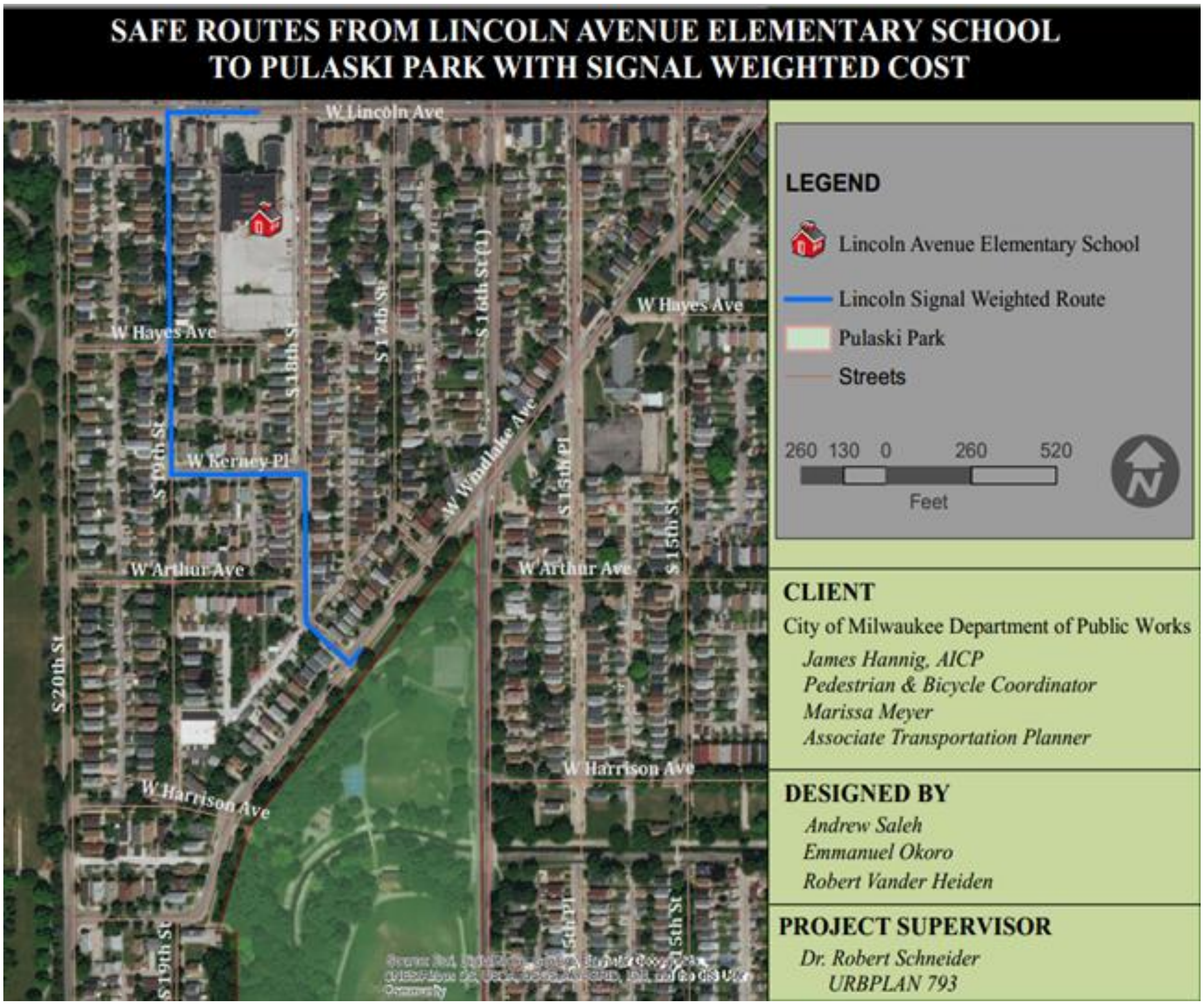
Map 3: Lincoln Crime Weighted Route



Map 4: Lincoln Shortest Weighted Route

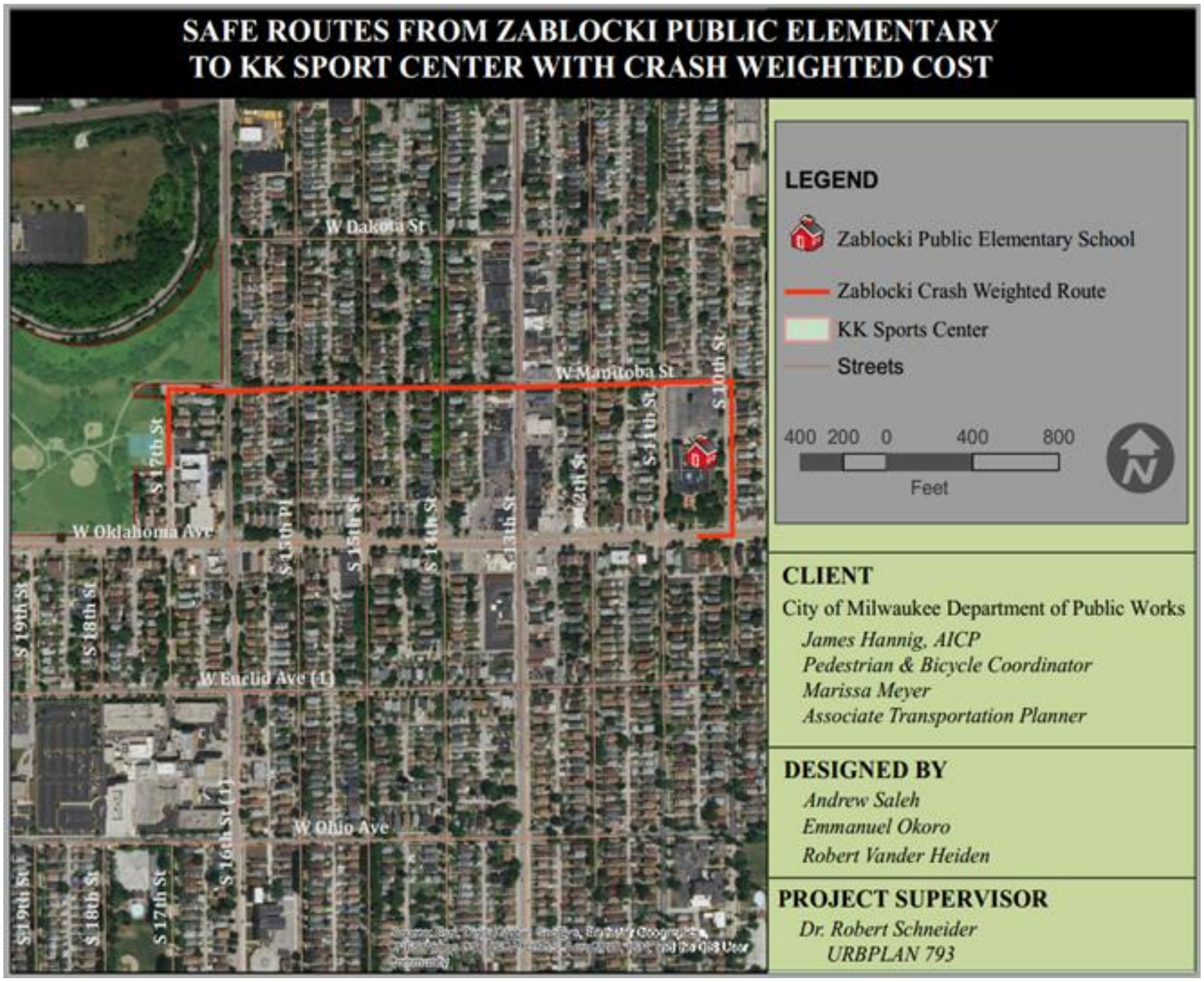


Map 5: Lincoln Signal Weighted Route

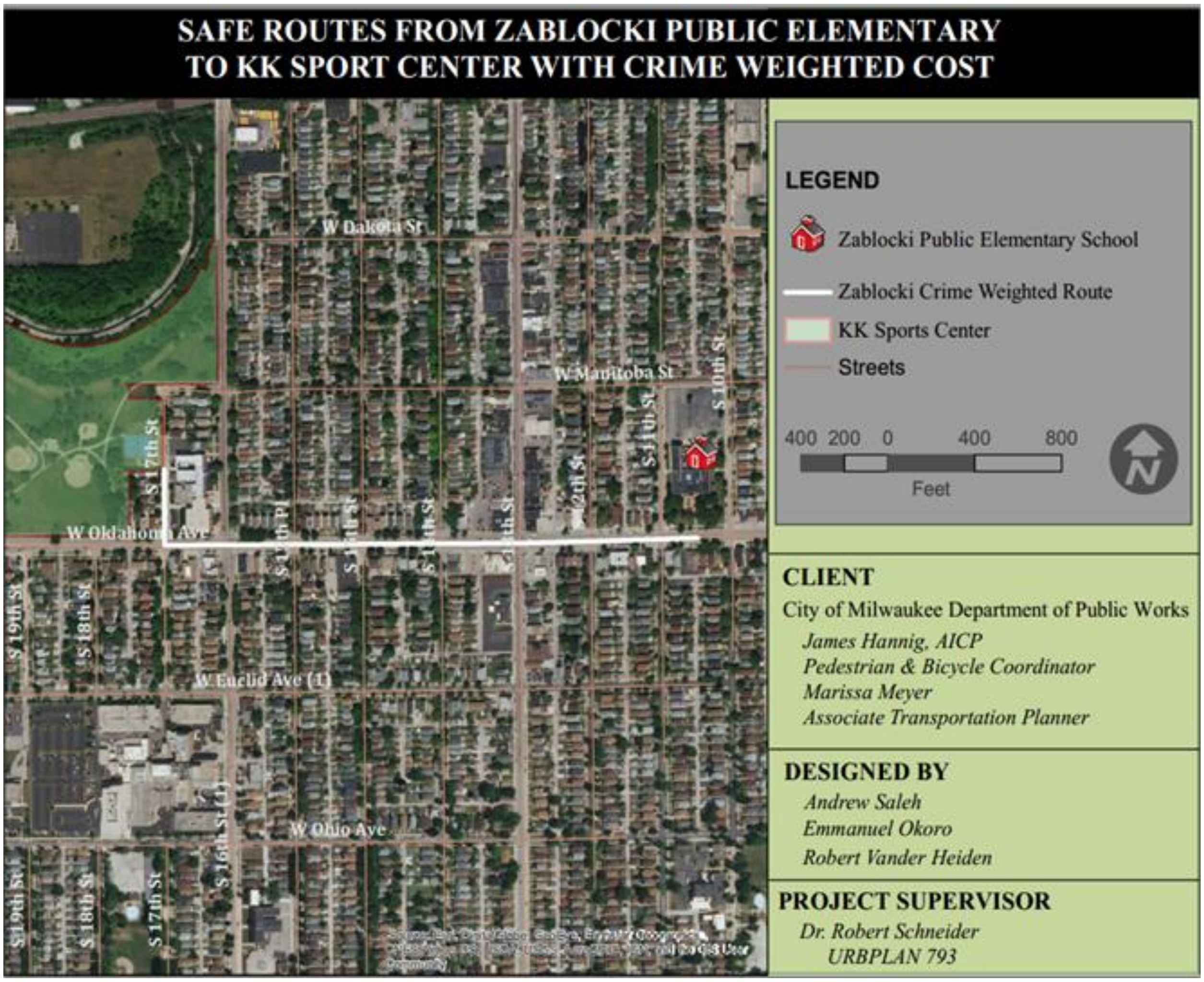


Map 6: Zablocki Arterial Weighted Route

Map 7: Zablocki Crash Weighted Route

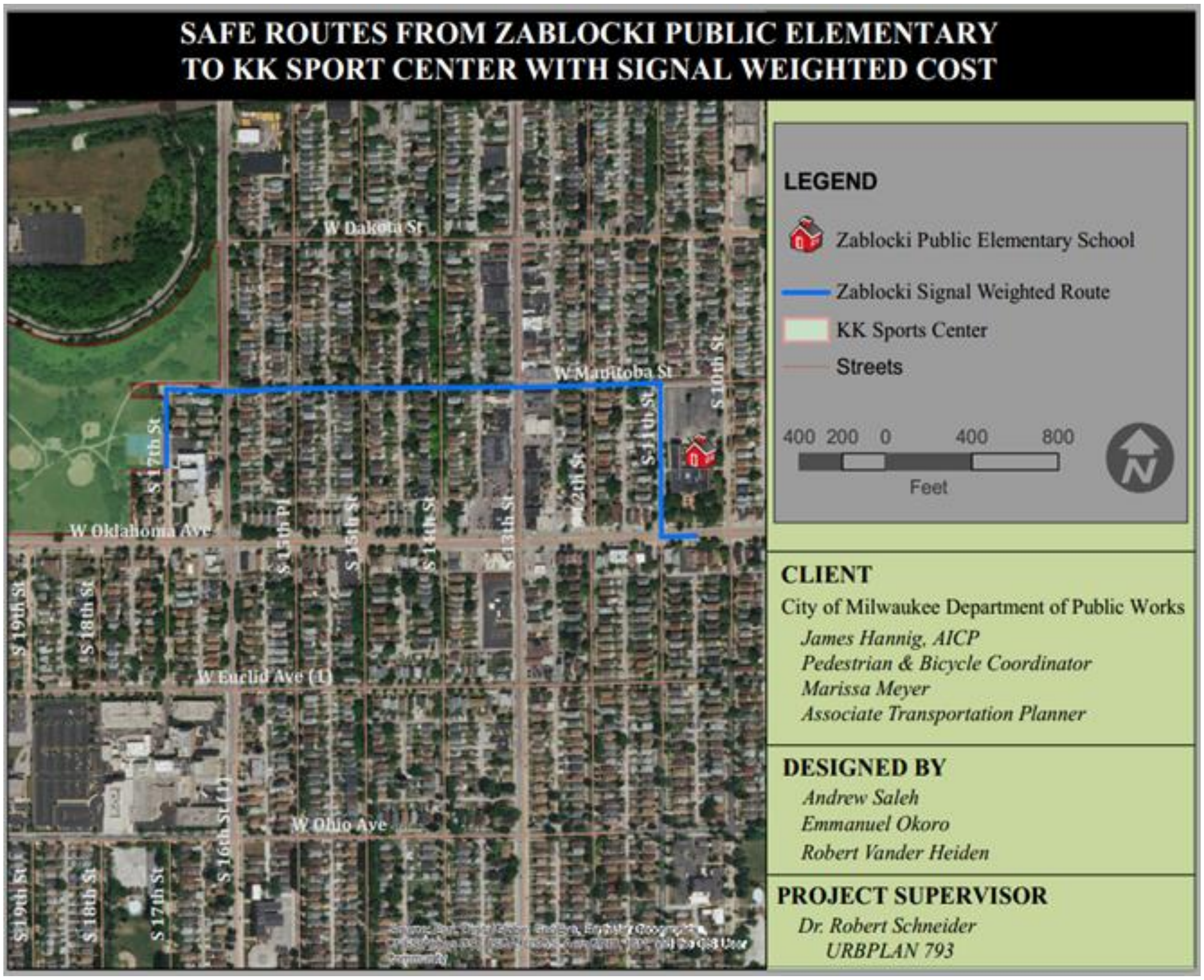


Map 8: Zablocki Crime Weighted Route



Map 9: Zablocki Shortest Weighted Route

Map 10: Zablocki Signalized Weighted Route


SAFE ROUTES FROM ZABLOCKI PUBLIC ELEMENTARY
TO KK SPORT CENTER WITH SIGNAL WEIGHTED COST
W Dakota St
W Manitoba St
W Oklahoma Ave
W Euclid Ave (1)
W Ohio Ave
S 17th St
S 15th Pl
S 15th St
S 14th St
S 13th St
S 11th St
S 10th St
S 19th St
S 18th St
S 16th St (1)
LEGEND
Zablocki Public Elementary School
Zablocki Signal Weighted Route
KK Sports Center
Streets
400 200 0 400 800
Feet
N
CLIENT
City of Milwaukee Department of Public Works
James Hannig, AICP
Pedestrian & Bicycle Coordinator
Marissa Meyer
Associate Transportation Planner
DESIGNED BY
Andrew Saleh
Emmanuel Okoro
Robert Vander Heiden
PROJECT SUPERVISOR
Dr. Robert Schneider
URBPLAN 793

Appendix B, Workload Table

Safe Routes from Schools to Parks														
Project Members: Andrew S., Emmanuel O., and Robert VH.														
Project Task Outline	**Hours**	**Task Lead**	**Feb.**		**March**				**April**				**May**	
			21	**28**	**7**	**14**	**21**	**28**	**4**	**11**	**18**	**25**	**2**	**9**
Strategic project planning and associated documents														
In-house meeting within project members	36	A	*	*	*	*	*	*	*	*	*	*	*	*
Vision, scope and conceptual models	30	R	*	*	*	*	*	-	-	-	-	-	-	-
Create/Update strategic project planning table	10	A	-	*	*	*	*	*	*	*	*	*	*	*
Present plan draft to class	2	A	-	-	*	*	*	-	-	-	-	-	-	-
Revise plan based on class feedback	20	R	-	-	*	*	-	-	-	-	-	-	-	-
Present revised plan to client	2	A	-	-	*	*	*	-	-	-	-	-	-	-
Prepare final vision & scope document based on client's feedback	21	R	-	-	-	*	*	*	*	-	-	-	-	-
Literary research and implementation	10	R	-	*	*	-	-	-	-	-	-	*	*	*

Geodatabase data collection, analysis, and organization													
Milwaukee county parks	5	A	*	*	*	*	*	*	-	-	-	-	-	-
Milwaukee county crime	5	A	-	*	*	*	*	*	*	-	-	-	-	-
WisDOT crash	7	R	*	*	*	*	*	*	*	-	-	-	-	-
Milwaukee Public Schools	5	R	*	*	*	*	*	*	-	-	-	-	-	-
WISLR Street Assets	10	A	-	*	*	*	*	*	*	-	-	-	-	-
Street analysis and network modeling method	16	A	-	-	*	*	*	*	*	*	*	-	-	-
Research analysis methods	10	R	-	-	-	*	*	*	*	-	-	-	-	-
Collect and organize all tabular data	15	A	-	-	-	*	*	*	*	*	*	*	*	-
Clean geodatabase to fit project goals	15	A	-	-	-	-	-	*	*	*	*	*	*	-
Data and Network Analyst implementation and production													

Design GIS methodology	16	A	-	-	-	*	*	*	*	*	*	-	-	-
Learn ArcGIS Network Analyst	16	A	-	*	*	*	*	*	*	-	-	-	-	-
Final mapping, tabular, and walkability grading scale work														
Test walkability of routes in field	6	E	-	-	-	-	-	-	-	-	*	-	-	-
Map creation and design	10	E	-	-	-	-	-	-	*	*	*	-	-	-
Meeting with client	3	R	-	-	-	-	*	-	-	-	-	-	*	-
Editing and finalizing maps	10	E	-	-	-	-	-	-	-	*	*	*	*	-
Final report and associated documents														
Writing report and powerpoint production	25	R	-	-	-	-	-	-	-	*	*	*	*	*
Present findings	6	A	-	-	-	-	-	-	-	-	-	*	*	-
Compile all documents or files and deliver to client	4	R	-	-	-	-	-	-	-	-	-	-	-	*

*A = Andrew, E = Emmanuel, R = Robert, * = Done, and - = Nothing.*