Appendix I: Network Analysis GIS Methodology

Introduction

A key element of the *East Portland in Motion* effort was undertaking various analyses to supplement and illuminate the preferences gathered through community needs assessment techniques. While community involvement is essential, it is impossible to gather data from all 165,000 residents of East Portland. Through analysis, an objective overall picture of the relative contribution of each candidate project can be developed.

The Portland Bureau of Transportation (PBOT), in collaboration with Portland State University (PSU), utilized geographic information systems (GIS) and created new geospatial analysis tools to estimate the potential accessibility and connectivity benefits of sidewalk and crosswalk candidate projects listed in *East Portland in Motion*. PBOT staff collaborated with the Willamette Pedestrian Coalition and students in Portland State University's Geography Department and School of Urban Studies in Planning (hereafter called "the researchers") through weekly "GIS jam sessions" held on the PSU campus.

Measuring accessibility and connectivity gains was a multi-step process including: (a) modeling the pedestrian network of East Portland, (b) assigning weights or "impedances" that represent the difficultly or ease of walking along different segments, (c) identifying walking destinations, and (d) running the model both before and after improvements are represented in the network.

In the end, some of the most interesting analytic tools conceived through this process were not fully realized; however, it is hoped that this appendix helps to provide insight into the analysis effort and thinking so that future efforts can more easily build on this work.

A. Modeling the Walkway Network

Modeling the pedestrian network of East Portland was based on four concepts:

1) **The walkway network can't be modeled through the street centerline network.** Throughout the world, most GIS representations of street networks make use of centerlines, an arrangement that suits most cartographic, recordkeeping and analysis needs. However, modeling the walkway network requires a different approach. On busy arterial streets, people walk along the sides of streets, and usually cross intersections from corner to nearest corner. A more accurate way to model the walkway network is have a line segment for each reach of sidewalk and line segments for every crosswalk. In relation to the street centerline network, this means a sidewalk line on either side of the street centerline, and four nodes of the walkway network for a typical four-way street intersection (one at each corner). Credit for the core concept of the walkway network model goes to Ellen Vanderslice, project manager for East Portland in Motion. This model – "unzipping" the streets – more accurately represents the network from the point of view of a

pedestrian, and also allows the user to attach attribute information about the presence and quality of sidewalks and improved crosswalks.

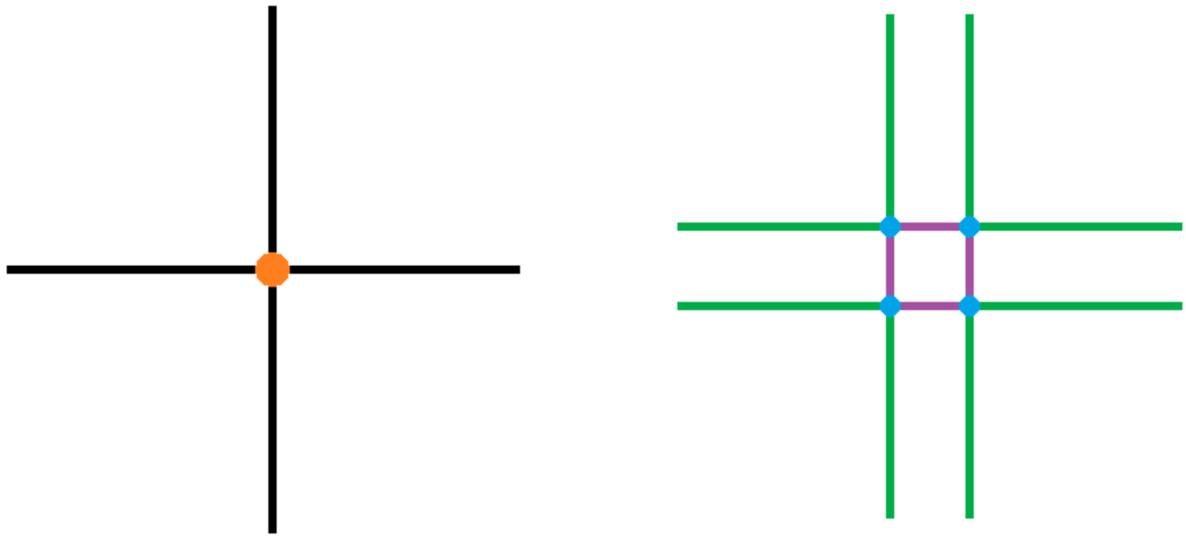

Illustration comparing the line segments and node of a hypothetical street centerline intersection with the line segments and nodes of the walkway network for the same intersection.

The “unzipping” of the street centerline to create the walkway network can be done manually, as it was for some of the analysis, but researcher Scott Parker also developed geospatial tools to perform this function automatically, allowing for the rapid creation of much greater areas of walkway network model. More details about these tools and the creation of the walkway network can be found in a paper by Parker and Vanderslice for the 2011 Walk21 International Conference on Walking.[1]

In creating the walkway network for East Portland in Motion, the researchers decided to unzip only arterial and collector streets. Local streets, trails, driveways, unimproved rights-of-way and alleys were kept as single lines, reflecting their relative ease of crossing.

2) **Trails are also part of the walkway network**
Portland’s street centerline does not include the trail network, where motorized vehicles can’t travel, but these routes can be important connections for pedestrians. Researcher Mike Halleen spent many hours digitizing trails so that this links could be added to the walkway network.

3) **Freeways are not part of the pedestrian network**
Because pedestrians aren’t allowed to walk along freeways, these segments need to be

[1] Parker, Scott, and Ellen Vanderslice, “Pedestrian Network Analysis,” proceedings of Walk21 Vancouver, October 2011. Available for download at http://www.walk21.com/paper_search/results_detail.asp?Paper=899

removed from the walkway network. However, pedestrians must still cross the places where freeway on- or off-ramps intersect the ordinary roadway network. In the walkway network model, this was resolved by creating a type of segment called a non-walk, which allowed for corners and crossings without providing a route for pedestrian trips.

4) **Bridges must allow passage, but not turns**
In the case of Portland's street centerline, owing to the way in which the centerline network was originally created, insufficient differentiation exists between network segments that are at different grades and don't actually intersect, such as the overcrossing of a freeway and the freeway itself. This situation was resolved by modeling this separation in the third dimension and removing inappropriate nodes.

This illustration compare the line segments of a real sample of the street centerline network, including a freeway and ramps, with the line segments of the walkway network for the same area. Note how the "unzipping" has been applied only to the arterial streets, while local streets remain represented by a centerline.

B. Assigning Weights to the Network

Weights were assigned to the unzipped walkway network based on two considerations: (1) street type codes classified by Metro regional government, which serves as a proxy for volume and speed, and (2) presence of sidewalks or marked crosswalks. Weights are in the form of additives or multipliers, which are added to or multiplied by the length (in feet) of a segment. The resulting value is called the *impedance*, and can be understood as "the distance I am willing walk in order to avoid this segment."

Weighting occurs as follows for each type of segment:

Trails become *streetwalks* and remain as single lines. Length remains unchanged, reflecting zero car volume and the lowest-stress pedestrian environment.

Local Streets, Private Roads and Flag Lot Driveways (type codes 1500, 1700, 1740, 1750, 1800 and 1950) also become streetwalks and remain as single lines. Length is first multiplied by 1.1 to represent low (but present) traffic volume. The second multiplier represents presence of sidewalk, and ranges from 1 (for 100% sidewalk coverage) to 1.5 (for 0% sidewalk coverage). Possible impedance values for a 100-foot-long local service street range from 110 to 165.

Neighborhood Collectors (type code 1450) are unzipped into two parallel sidewalks. At intersections with any other type of walkway, crosswalks are also created. Sidewalks are first multiplied by 1.5 to represent moderate traffic volume, then multiplied by a value ranging from 1 to 2 to represent presence of sidewalk. Crosswalks are also multiplied by 1.5. A 200-foot penalty is added to crosswalks that have no improvements to help pedestrians cross (which is the majority case).

Arterials (type codes 1200, 1300, 1400 and 5501) are also unzipped into two sidewalks with crosswalks at intersections. Sidewalks are first multiplied by 2 to represent high traffic volume, then multiplied by a value ranging from 1 to 5 to represent presence of sidewalk. (There is a heavier penalty for lack of sidewalks on these streets compared to neighborhood collectors). Crosswalks are also multiplied by 2. Then, if no marked crosswalk is present, a 1,000-foot penalty is added.

Freeways and Ramps (type codes 1110, 1120, 1121, 1122, 1123, 1221, 1222 and 1223) are classified as *non-walks*, meaning they are not part of the walkway network, but must occasionally be crossed perpendicularly and therefore must remain in the network file.

Connectors are short segments that have no real match in reality, but are necessary to accurately model the walkway network. They are given zero impedance so as to not add unnecessary impedance to the network.

Weighting Based on Street Type and Presence/Coverage of Sidewalks/Crosswalks

Input Segment	**Unzipper Output Segment(s)**	**TSP Class Multiplier**	**Sidewalk Multiplier** (where p = % sidewalk coverage as a decimal)	**Crosswalk Additive** (when no marked crosswalk)	**Example 100' Segment:** Minimum Impedance	**Example 100' Segment:** Maximum Impedance
Trail	Streetwalk	1.0	N/A	N/A	100	100
Local Street	Streetwalk	1.1	1.5 – 0.5p (range: 1 – 1.5)	N/A	110	165
Neighborhood Collector	Sidewalks	1.5	2 – p (range: 1 – 2)	N/A	150	300
	Crosswalks	1.5	N/A	200	150	350
District Collector or Major City Traffic Street	Sidewalks	2.0	5 – 4p (range: 1 – 5)	N/A	200	1,000
	Crosswalks	2.0	N/A	1,000	200	1,200
Regional Trafficway	Removed except ramps	N/A	N/A	N/A	N/A	N/A
	Connectors	0	N/A	N/A	N/A	N/A

C. Identifying Destinations

The researchers measured the accessibility of the pedestrian network by identifying destinations that attract walking trips. Efforts were made to mimic methodology used in the Portland Bureau of Planning & Sustainability's *20-Minute Neighborhoods* analysis. This analysis, part of the city's *Portland Plan*, sought to measure the overall quality of neighborhoods based on the availability of certain goods and services, as well as the quality of the pedestrian environment. Destinations considered in the 20-Minute Neighborhoods analysis are:

- Grocery stores
- Type 1 commercial amenities (convenience and liquor stores)
- Type 2 commercial amenities (restaurants, coffee shops, bakeries, bars, etc.)
- Parks (modeled as park access points)
- Public elementary and middle schools

D. Performing Network Analysis

Two different methods of performing network calculations were used to compute the "least cost" path between points. The researchers used the "closest facility" tool in ArcMap Network Analyst. Researcher Scott Parker also created a custom tool that performs much faster network calculations.

Some of the steps of analysis were:

1) **Create a "before" and "after" network.** The pedestrian network of today is compared to the hypothetical improved network with improvements called for in East Portland in motion. The network of today is modeled as described in sections A and B. The pedestrian network of tomorrow is modeled by changing the weighting appropriately. A walkway segment may have sidewalk coverage increase from 20% to 100%; a crosswalk may change from unimproved to improved.

2) **Run two network analyses.** The least cost path is computed between all possible origin and destination pairs. Each segment is automatically assigned a value reflecting the number of trips that traveled through it, or "traversals." This work was considerably developed by researcher Melelani Sax-Barnett. The analysis is run twice – once with the before network, and once with the after network.

3) **Compare the two runs.** The before and after runs must be compared. This could potentially be done by subtracting the before network from the after network and noting the differences in trip numbers for each segment.

4) **Compare the results of all projects.** The projects that show the most contrast between before and after analyses represent the projects that will, in theory, have the most positive impact on the pedestrian network.

E. Service Area Demographics

In a separate but related analysis, researchers Liz Paterson and C.J. Doxsee measured the demographic characteristics of sidewalk project service areas. A project's service area, or "walkshed," is defined as a one-mile walking distance from all segments of the sidewalk project, as measured along the walkway network. Paterson and Doxsee then attributed US Census Bureau Data to the service areas through apportionment. Apportionment was necessary because the most recently available Census data was provided at the Census Tract level, while project service areas are irregular areas that often overlap two or more Census Tracts. Rather than apportioning data by area, Paterson and Doxsee used a point layer of residential addresses to apportion the data by population. A sample service area is shown below. Results of the analysis are shown in the table on the next page.

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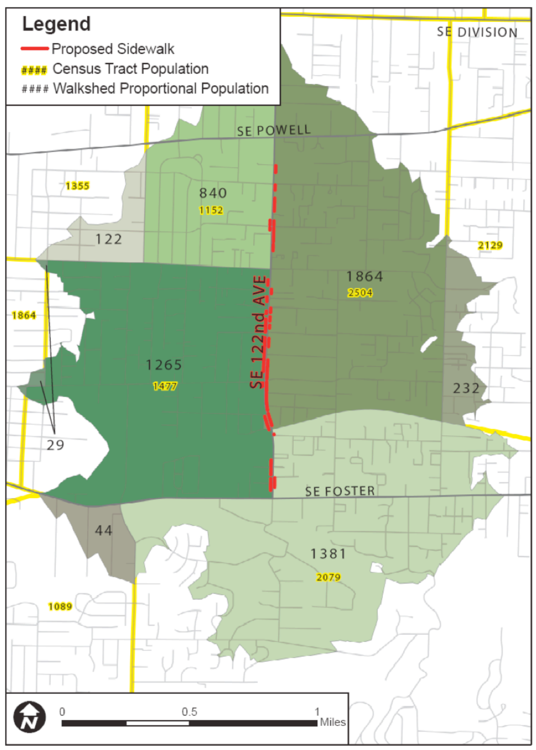

Demographic Characteristics of Sidewalk Project Candidate Service Areas

Map ID #	Street/Segment	Service area population	% 17 and under	% 65 and over	% non-white	% below poverty line	Average vehicles per household
1	NE Sandy Blvd: 85th – 91st	11,324	21.89%	9.27%	25.81%	17.14%	1.62
2	NE Fremont St: 112th – 122nd	9,846	25.85%	12.24%	36.76%	14.67%	1.98
3	NE San Rafael St: 122nd – 132nd	10,206	23.75%	16.62%	27.01%	12.30%	1.82
4a	NE Halsey St: 85th – 92nd	9,103	20.98%	11.72%	27.79%	15.37%	1.63
4b	NE Weidler St: 99th – 112th	13,015	22.79%	16.61%	22.69%	14.92%	1.73
4c	NE Halsey St: 126th – 132nd	10,340	23.85%	16.48%	28.40%	13.34%	1.84
4d	NE Halsey St: 134th – 148th	14,568	24.87%	16.80%	30.98%	17.67%	1.97
4e	NE Halsey St: 148th – 162nd	14,398	24.95%	14.72%	31.73%	20.59%	2.13
5a	NE Glisan St: 135th – 148th	9,953	26.76%	10.01%	29.45%	23.83%	2.15
5b	NE Glisan St: 148th – 162nd	18,269	27.12%	10.15%	31.99%	26.30%	2.21
6a	SE Stark St: 126th – 143rd	20,512	26.94%	11.02%	30.19%	20.39%	1.91
6b	SE Stark St: 148th – 160th	17,134	28.15%	8.91%	31.18%	26.46%	2.07
7a	SE Market St: 99th – 112th	13,858	24.42%	15.71%	28.26%	18.12%	1.57
7b	SE Market St: 112th – 130th	20,974	26.77%	13.44%	28.66%	19.79%	1.77
7c	SE Mill St: 130th – 148th	22,246	27.29%	10.34%	31.07%	19.02%	1.88
7d	SE Millmain/Main: 151st – 162nd	19,071	28.00%	9.39%	30.76%	22.73%	1.94
8a	SE Division St: 101st – 145th	31,304	26.52%	12.23%	30.30%	19.65%	1.76
8b	SE Division St: 148th – 171st	25,294	27.34%	10.64%	27.37%	19.04%	1.95
9	SE Holgate Blvd: 99th – 122nd	21,968	27.62%	10.56%	29.89%	21.38%	1.71
10	SE Foster Rd: 103rd – 122nd	N/A	N/A	N/A	N/A	N/A	N/A
11	SE Flavel St: 84th – 92nd	N/A	N/A	N/A	N/A	N/A	N/A
12	SE Mt Scott Blvd: I-205 – 98th	N/A	N/A	N/A	N/A	N/A	N/A
13	SE 92nd Ave: Lincoln – Powell	9,440	22.24%	15.70%	33.76%	18.88%	1.56
14	SE 99th Ave: Main – Division	11,781	22.85%	17.05%	30.14%	16.88%	1.54
15a	NE 102nd Ave: Sandy – I-84	9,897	22.51%	9.49%	28.08%	15.75%	1.75
15b	NE 102nd Ave: I-84 – Weidler	13,018	22.87%	14.58%	23.13%	14.91%	1.77
16	SE Cherry Blossom Dr: Mor. – Mar.	15,488	24.57%	15.85%	27.18%	18.96%	1.63
17	SE 112th Ave: Market – Holgate	14,555	26.58%	14.48%	28.63%	21.39%	1.70
18	SE 117th Ave: Burnside – Stark	14,860	25.71%	15.15%	28.10%	19.61%	1.76
19a	NE 122nd Ave: Marine – Shaver	6,357	23.19%	9.89%	40.44%	14.78%	1.53
19b	SE 122nd Ave: Powell – Holgate	15,916	27.88%	11.12%	29.25%	20.89%	1.71
19c	SE 122nd Ave: Holgate – Foster	16,941	27.33%	10.54%	26.91%	17.99%	1.74
20a	NE 148th Ave: Rose – Halsey	13,209	25.61%	18.44%	33.98%	19.02%	1.90
20b	NE 148th Ave: Halsey – Glisan	14,581	25.82%	14.16%	30.58%	22.08%	2.06
21	SE 160th Ave: Burnside – Stark	15,515	28.48%	8.91%	30.92%	29.33%	2.21
22a	NE 162nd Ave: Stanton – Russell	7,849	24.13%	17.41%	32.94%	15.25%	2.17
22b	SE 162nd Ave: Taylor – Powell	25,929	27.72%	9.96%	27.95%	22.22%	1.99
23a	NE Prescott St: Sandy – 102nd	11,147	22.25%	8.75%	28.76%	18.10%	1.65
23b	NE Prescott St: 102nd – 121st	9,551	23.11%	8.99%	35.58%	15.68%	1.74
24	NE Fremont St: 102nd – 112th	7,997	23.81%	9.95%	30.82%	15.94%	1.95
25a	NE San Rafael St: 132nd – 142nd	9,407	24.12%	19.08%	31.45%	12.86%	1.84
25b	NE San Rafael St: 142nd – 148th	7,930	24.34%	21.25%	33.06%	14.95%	1.85
26a	SE Mill St: 148th – 151st	13,517	27.16%	9.33%	31.63%	19.23%	1.88
26b	SE Main St: 162nd – city limit	20,031	29.40%	9.56%	29.46%	25.70%	1.97

27	SE Holgate Blvd: 122nd – 136th	16,370	27.62%	10.29%	27.53%	18.69%	1.72
28a	SE Harold St: 102nd – 111th	11,090	27.83%	9.31%	28.44%	20.15%	1.71
28b	SE Harold St: 111th – 122nd	14,585	27.37%	9.81%	27.04%	18.91%	1.74
28c	SE Harold St: 122nd – 136th	12,984	27.40%	10.29%	26.01%	16.33%	1.73
29	SE Ellis St: Foster – 92nd	16,611	25.17%	8.52%	28.62%	18.99%	1.54
30a	SE 104th Ave: Bush – Cora	10,599	27.16%	11.02%	30.06%	22.74%	1.72
30b	SE 104th Ave: Holgate – Harold	12,707	27.50%	10.03%	29.41%	21.29%	1.72
31	NE 111th Dr/Ave: Klickitat – Halsey	12,055	22.87%	16.45%	21.31%	13.60%	1.77
32	NE 112th Ave: Marx – Fremont	8,724	23.31%	9.34%	35.66%	15.62%	1.76
33	SE 117th Ave: Stark – Market	16,677	26.27%	14.42%	28.00%	20.16%	1.76
34a	SE 136th Ave: Division – Powell	14,847	27.65%	10.37%	29.42%	18.63%	1.82
34b	SE 136th Ave: Powell – Holgate	16,092	27.69%	10.19%	28.53%	18.17%	1.79
34c	SE 136th Ave: Holgate – Foster	12,781	27.46%	10.24%	26.81%	16.25%	1.74

Source Data: 2010 Decennial Census, American Community Survey 2005-2009 Five-Year Estimates. Analysis by Liz Paterson and Clinton Doxsee.