McMAHON
TRANSPORTATION ENGINEERS & PLANNERS

Alewife Critical Sums Analysis

Envision Cambridge

McMahon Associates

Prepared for the City of Cambridge

Revised January 25, 2019

Alewife Critical Sums Analysis

Alewife Critical Sums Analysis Methodology

Table of Contents

Attachments

Alewife Critical Sums Analysis

Section A: Overview

The City of Cambridge's Critical Sums Analysis (CSA) methodology served as the basis for this analysis. The process is based on methodology previously used by City of Cambridge for the 2001 *Eastern Cambridge Planning Study* (ECaPS), 2001 Citywide Rezoning, and 2005 *Concord-Alewife Plan*, and refined in 2011-2012 for the *Kendall Square-Central Square (K2C2) Study*. The methodology used in these studies is largely based on the 1985 Highway Capacity Manual (HCM) for calculating critical lane movements (critical sums).

Critical movements are the sum of the northbound left and southbound through/right compared to the southbound left and the northbound through/right. The same is done for the eastbound and westbound intersection approaches. The greater of the northbound/southbound is added to the greater of the eastbound and westbound to calculate the critical sum for the intersection. The 1985 methodology does not explicitly provide planning analysis calculations for the critical sum of rotaries. For the two rotaries in this study, the critical sum was calculated by adding the entering volumes on each approach with the conflicting volumes. The highest total of the approaches is the critical sum. The following pages explain the methodology.

The intersections evaluated for the Alewife area plan are indicated in Figure 1, below.

Section B: Existing Traffic Volumes

Existing traffic volumes for all seven intersections for the existing year 2016 were documented from three traffic impact statements (TIS) for projects in the study area. The traffic count data source for each intersection is listed in Table 1.

Table 1: Existing Traffic Volumes Sources

Intersection	Date Counted	Data Source
1. Alewife Brook Parkway & Route 2	September 29, 2016	Lanes and Games TIS
2. Alewife Brook Parkway & Cambridge Park Drive	June 28, 2016*	35 Cambridge Park Drive TIS
3. Alewife Brook Parkway & Rindge Ave	June 28, 2016*	35 Cambridge Park Drive TIS
4. Alewife Brook Parkway & Concord Ave Rotary	Wednesday October 5, 2016	55 Wheeler St TIS
5. Alewife Brook Parkway & Fresh Pond Parkway Rotary	Wednesday October 5, 2016	55 Wheeler St TIS
6. Concord Ave & Fawcett	Wednesday October 5, 2016	55 Wheeler St TIS
7. Concord Ave & Blanchard Rd	Wednesday October 5, 2016	55 Wheeler St TIS

*Counts were conducted when schools were no longer in session. A 4% growth factor was applied to account for additional school related traffic, based on City of Cambridge TIS Guidelines

The vehicle volumes recorded from these TISs were adjusted to represent a typical month.[1] They were all found to be above the average volume and adjusted down according to the rates in Table 2.

[1] Adjusted based on count station located on I-93 0.1 mile north of Shore Drive (location H8449) data collected in 2015

Table 2: Existing PM Peak Hour Traffic Volume Adjustment

	PM Peak Hour Volume From TIS	TIS Month 2016	Adjustment Factor	Adjusted Volume[2]	Difference
1. Alewife Brook Parkway & Route 2	5,498	Sept	.96805	5323	-175
2. Alewife Brook Parkway & Cambridge Park Drive	3,927	June	.97895	3844	-83
3. Alewife Brook Parkway & Rindge Ave	3,851	June	.97895	3769	-82
4. Alewife Brook Parkway & Concord Ave Rotary	3,590	Oct	.94357	3388	-202
5. Alewife Brook Parkway & Fresh Pond Parkway Rotary	3,215	Oct	.94357	3033	-182
6. Concord Ave & Fawcett	1,430	Oct	.94357	1350	-80
7. Concord Ave & Blanchard Rd	2,070	Oct	.94357	1955	-115

[2] Adjusted volume equals PM peak hour volume from TIS multiplied by adjustment factor to represent a typical month in 2016.

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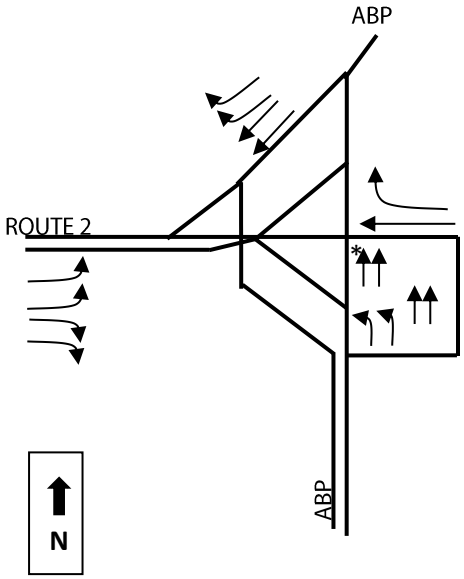
Section C: Critical Lane Movement Calculations

The formulas applied to each intersection are listed below. A conservative method was used to calculate the critical sum at rotaries (Intersections 4 and 5), assuming one lane per movement on each approach. Assuming multiple lanes per movement would divide the left and through volumes by multiple lanes, resulting in less conflicting traffic. The conservative approach assumes the highest conflicting volumes. For further detail on the calculation of critical lane movements, refer to Attachment A.

Intersection 1: Alewife Brook Parkway (ABP) and Route 2



NB/SB:

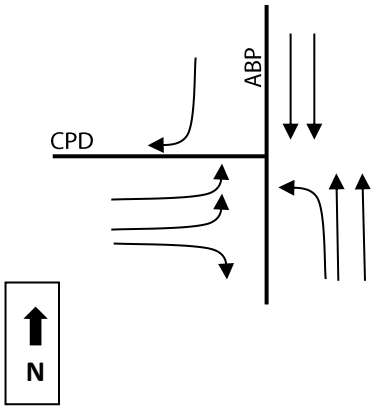
$[\frac{NBT*}{2}]$ or $[\frac{SBT}{2} + \frac{NBL}{2}]$

EB/WB:

$[\frac{EBL}{} + WBT]$

*Does not include preceding thrus or illegal lefts

Intersection 2: Alewife Brook Parkway (ABP) and Cambridge Park Drive



NB/SB:

$[\frac{NBT}{2}]$ or $\left[\frac{SBT}{2} + NBL\right]$

EB/WB:

$\left[\frac{EBL}{2}\right]$ or $[EBR]$

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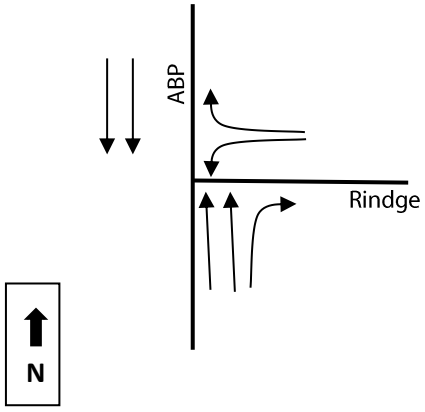
Intersection 3: Alewife Brook Parkway (ABP) and Rindge Ave



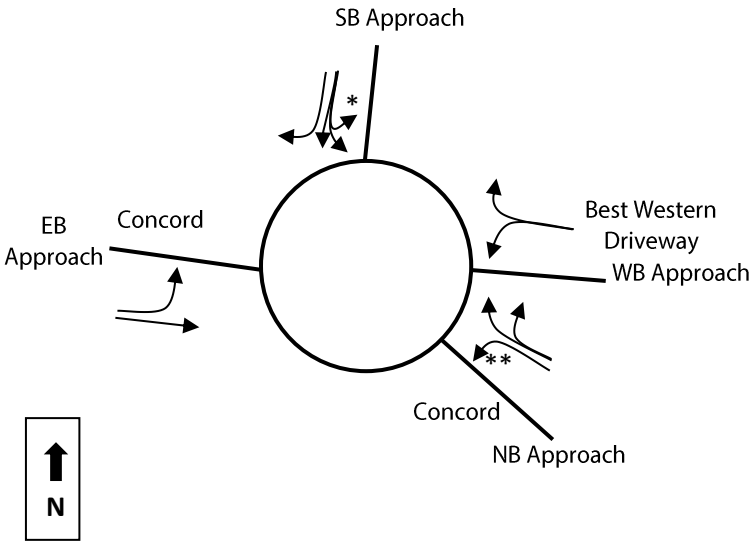
NB/SB:

$[\frac{NBT}{2}]$or$[\frac{SBT}{2}]$

EB/WB:

$[WBR]$or$[WBL]$

Intersection 4: Concord Ave and Alewife Brook Parkway (ABP) Rotary



*SBU

**NBU

NBHR & SBHL assume entering Best Western driveway (based on volumes).

NBU/SBU = Northbound/Southbound U-turn

NBHR/SBHR = Northbound/Southbound hard right

NBHR & SBHL assume entering Best Western driveway.

Highest of All Approaches:

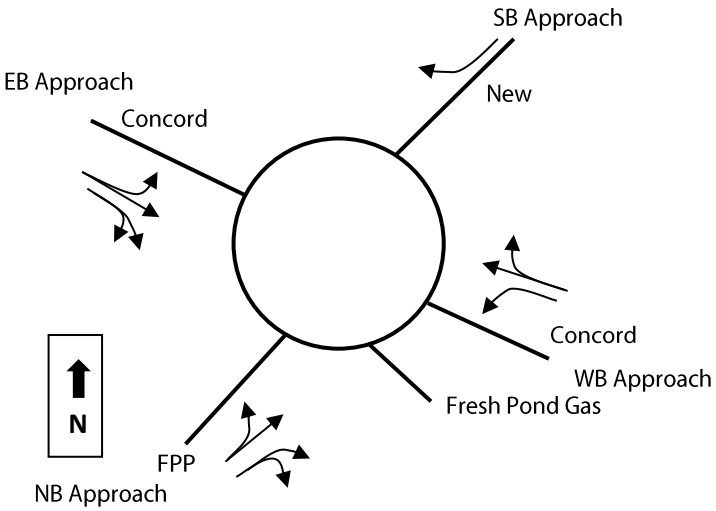
NB Approach: $[(NBU + NBR + NBHR + NBL)] + [(SBU + SBHL) + EBL]$ *or*

WB Approach: $[(WBR + WBL)]$+$[(NBU + NBR + NBL) + SBU + EBL]$ *or*

EB Approach: [*EBT+EBL*]+ $[NBU + WBL + (SBU + SBHL + SBL)]$ *or*

SB Approach: $[(SBR + SBL + SBHL + SBU)] + [(NBU + NBL) + WBL]$

Intersection 5: Concord Ave and Fresh Pond Parkway Rotary (FPP)



NBHR = Northbound hard right

EBHR = Eastbound hard right (to FPP)

NBHR, EBR assume entering Fresh Pond Gas

Highest of All Approaches:

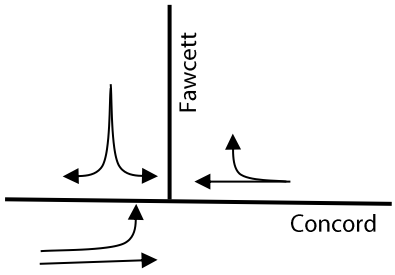
NB Approach: $[(NBT + NBL + NBR + NBHR)]+[(EBT + EBL + EBR)]$ *or*

WB Approach: $[(WBT + WBL + WBR)]+[(NBT + NBL) + EBL]$ *or*

EB Approach: $[(EBT + EBL + EBR + EBHR)]+[WBL]$ *or*

SB Approach: $[SBR]+[NBL + (WBT + WBL)]$

Intersection 6: Concord Ave and Fawcett St



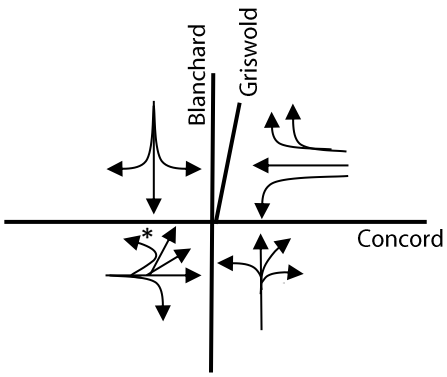
NB/SB:

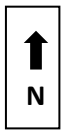
[SBR] or [SBL]

EB/WB:

[EBT] or [(WBR+WBT)]+EBL]

Intersection 7: Concord Ave and Blanchard Rd





NB/SB:

[(SBR+SBT+SBL)+NBL] or
[(NBL+NBT+NBR+NBHR)+SBL]

EB/WB:

[(EBL+EBHL+EBU)+WBT]or
[WBL+(EBL+EBHL+EBT+EBR+EBU)]

*EBU = Eastbound U-turn

NBHR = Northbound hard right

EBHL = Eastbound hard left

WBHR = Westbound hard right

WBHR, EBHL, and NBR enter Griswold

Section D: Trip Generation Rates

The study area was divided into five sub-areas (see Figure 2) to evaluate trip generation based on land use. The additional square footage of each land use type for each scenario was provided by the *Envision Cambridge* project team for each sub-area. The scenarios include the existing condition and two future conditions: 60% build out at existing zoning and 60% build out at proposed zoning. The proposed zoning scenario represents a shift in land use mix to more commercial uses, and also an increase in residential land use. The goal of the rezoning is to create a mixed-use walkable neighborhood that also promotes bicycling and transit. Trip generation for each development scenario was determined by applying ITE trip generation rates by land use to the additional square footage of new development by land use type, provided by the *Envision Cambridge* project team, with Utile providing land use information, and Nelson\Nygaard providing trip generation, mode share, and trip distribution associated with the land use scenarios. Methodologies were reviewed by City of Cambridge staff through interim updates and project coordination meetings. The land use by square footage is summarized in Figure 3 and Table 3.

Figure 2: Study Area Sub-Areas

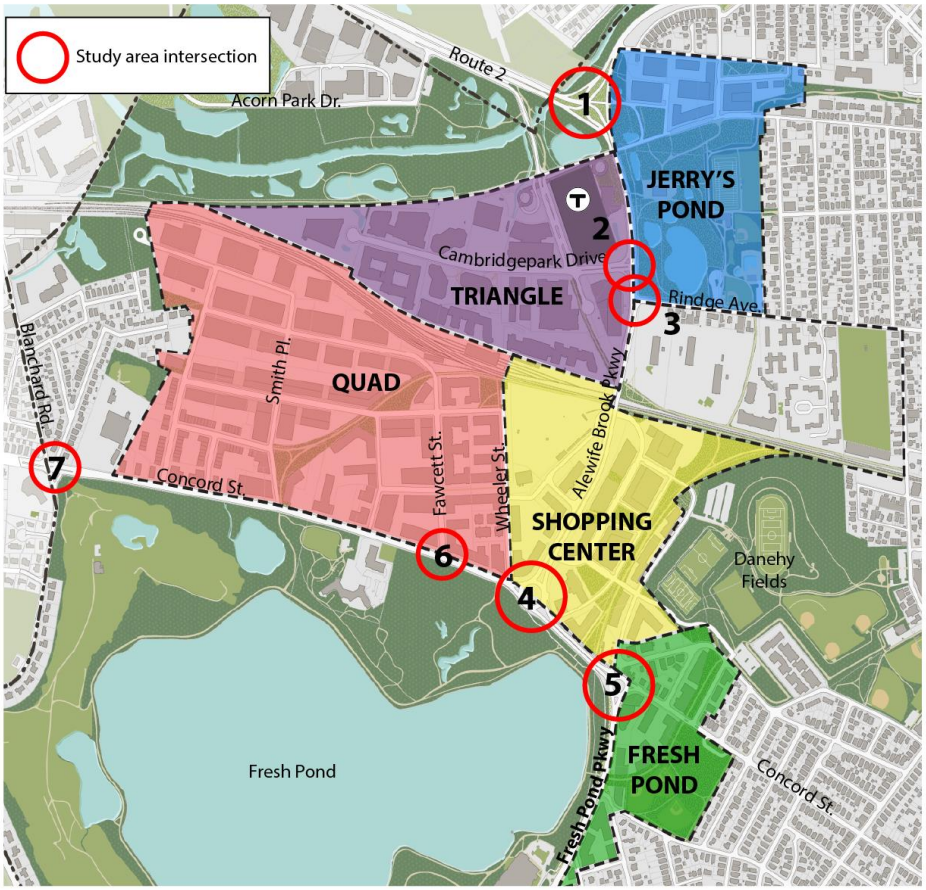


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Figure 3: Total Millions of SF for All Subareas by Land Use

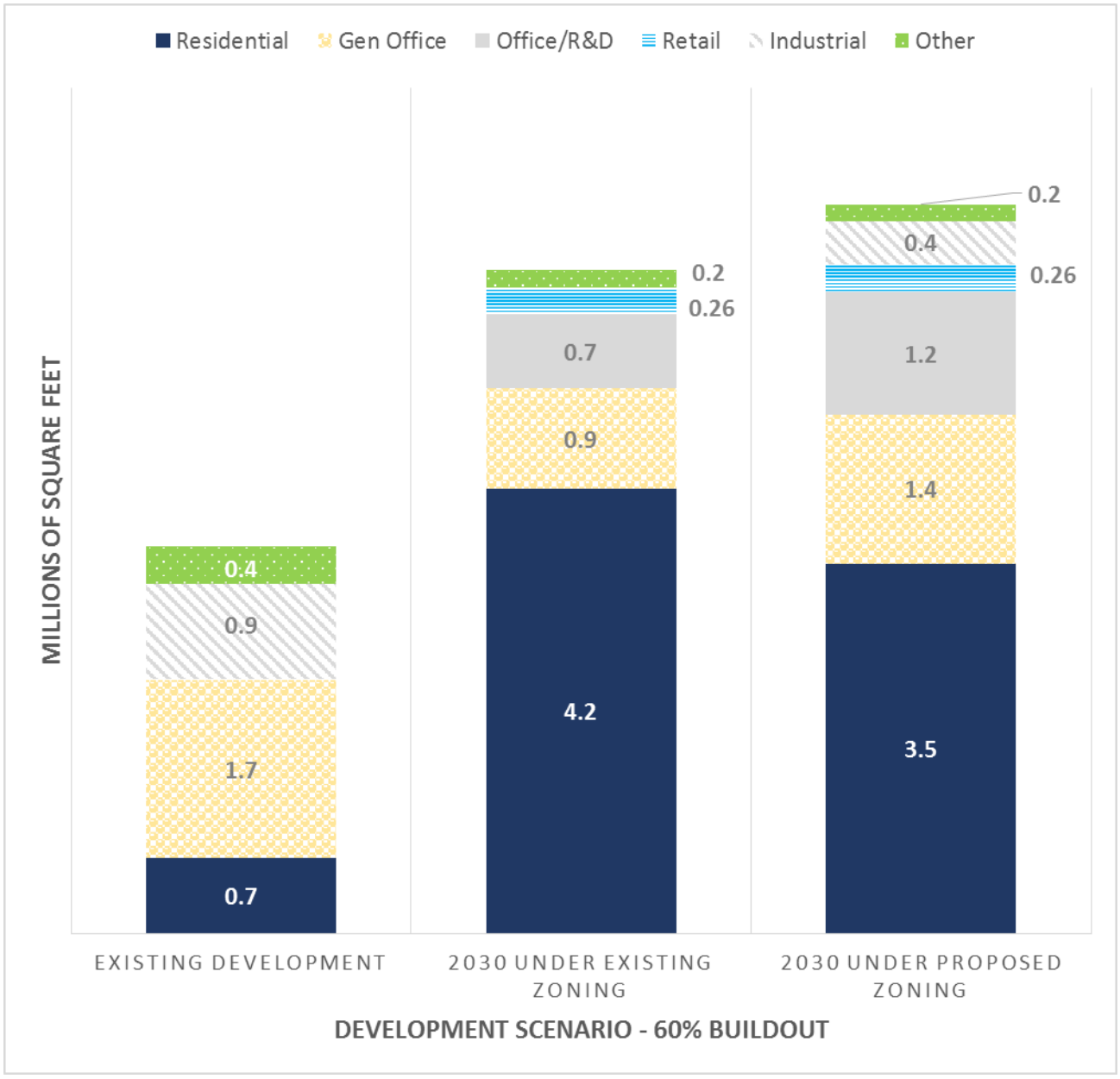
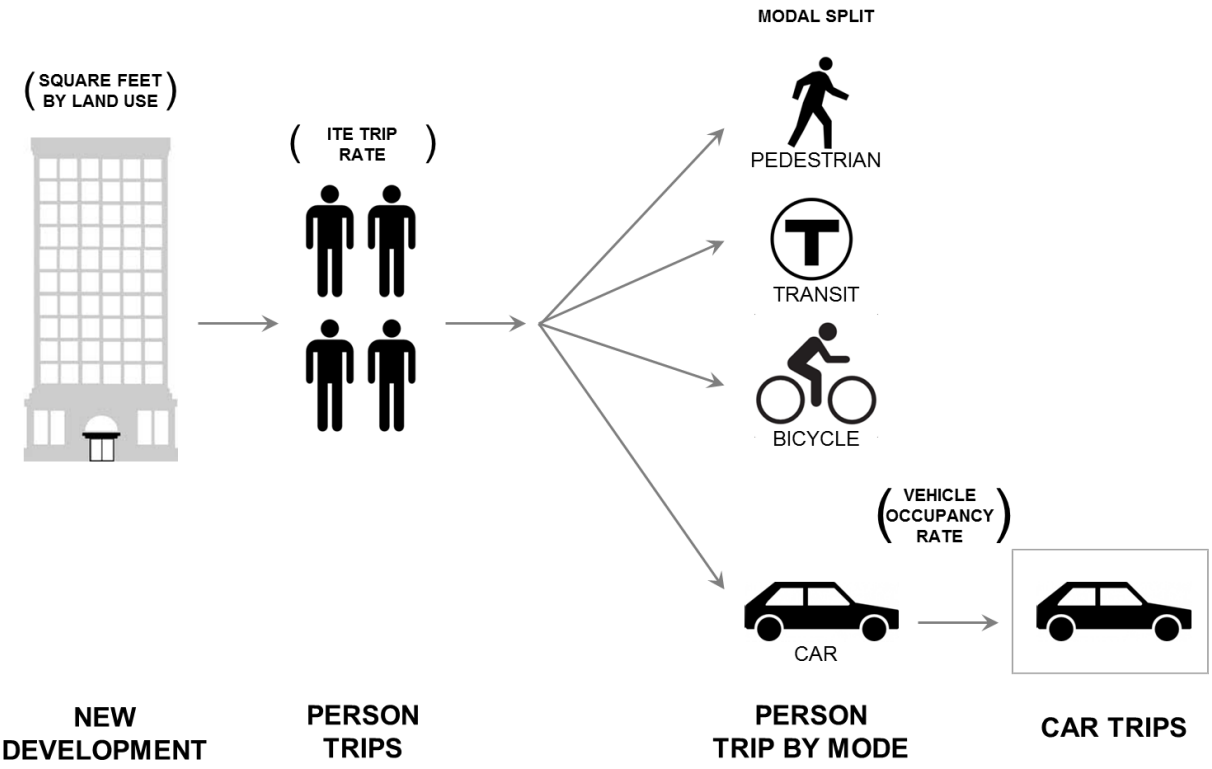


Table 3: Total Millions of SF for All Subareas by Land Use

Development Scenario	Residential	Gen Office	Office/R&D	Retail	Industrial	Other
Existing Development	712,430	1,682,830	0	17,010	894,240	356,060
2030 Under Existing Zoning - 60% Buildout	4,212,290	944,825	704,565	256,980	0	158,770
2030 Under Proposed Zoning - 60% Buildout	3,502,630	1,404,655	1,164,395	261,080	410,720	158,770

General Procedure

- The PM peak period was used for the analysis, as this is the period when traffic volumes tend to be the highest. This also reflects the methodology used in the 2005 Concord-Alewife Planning Study.
- New trips were generally calculated as follows:



- Associated trip generation rates are from the ITE Trip Generation Manual 9th Edition – these rates were used to calculate the total of tall trips generated by land use (walk, bike, transit, and vehicle), also called person trips. The trip generation rates are summarized by land use and ITE Code in Table 4. Prior to the critical sums analysis, Nelson\Nygaard performed a trip generation analysis based on land use in each subarea. The trip generation rates applied from this analysis were considered and discussed below along with other considerations for the retail and residential trip generation rates.

    - Retail: Shopping Center (Land Use Code 820) was used for the critical sums analysis to provide consistency with the Nelson\Nygaard methodology for trip generation. The 3% reduction in trips applied by Nelson\Nygaard to reflect land use mix and transportation context is reflected in the application of mode shares.

    - Residential: Rates for apartment, condominium (used for the 2005 Concord-Alewife study), and low-rise apartment (used by Nelson\Nygaard with a reduction) were considered. Apartment (Land Use Code 220) was selected due to the lower variation among the three categories considered. The Nelson\Nygaard methodology of applying a reduction based on data from four residential Transportation Impact Studies (TISs) was not applied as this only calculates auto trips, which under City methodology for Critical Sums analysis, is determined through a mode share.

Table 4: ITE Land Use Codes and Trip Rates

Land Use	ITE Code	Average Daily Trip Rate (per 1000 SF GFA)	Average AM Trip Rate (per 1000 SF GFA)	Average PM Trip Rate (per 1000 SF GFA)
R&D	760	8.11	1.22	1.07
General Office	710	11.03	1.56	1.49
Industrial	130	6.83	.82	.85
Retail	820	42.7	.96	3.71
Residential	220	6.65	.51	.62

Source: ITE Trip Generation Manual 9th Edition

- Square footage by land use and study sub-area was used to calculate base trips, per the ITE methodology.
- The ITE trips were then converted to person-trips based on a factor of 1.07[3], provided by the City of Cambridge, based on data from U.S. Census.
- The City provided an average apartment size of 1,000 SF per dwelling unit for calculating residential trips.

[3] National average from the American Community Survey 2005-2009.

- Land-use-specific modal splits[4] were then applied to determine the number of person-trips which were taken by automobile. Auto mode shares were provided for the Quadrangle sub-area, Triangle sub-area, and one for the remainder of sub-areas, as shown in Table 5. Separate mode shares were determined for both residential and commercial trips. See Attachment B for further information.

Table 5: Applied Auto Mode Share

Sub-Area	Residential Auto Mode Share	Employee Auto More Share
Triangle	28%	46%
Quad	30%	58%
Other Sub-Area	37%	48%

- A vehicle occupancy factor of 1.1 was then applied to determine the total PM vehicle automobile trips. These vehicle occupancy factors were calculated[5] based on U.S. Census data.

The total PM vehicle trips were split into arrival and departure trips using the ITE distribution percentages for each land use. They were then categorized into residential and commercial trips based on the generating land use. This analysis was performed for the 2030 existing zoning future scenario, which is comprised of a 60% build out under existing zoning by the year 2030. The analysis was then completed under the 2030 proposed zoning scenario with 60% build out. The proposed zoning scenario shifts the use mix in new development to include more commercial (office and office R&D) space than the existing zoning scenario. The resulting number of residential and commercial arriving and departing trips for each sub-area are documented in Attachment C.

Section E: Trip Distribution

The trip distribution was comprised of two parts: (1) determining the percentage of trips exiting and entering the study area along major corridors, and (2) applying those percentages through intersections within the network for each sub-area (see Figure 2). This was done for both employee (commercial) and residential trips.

Study Area Trip Distributions

- Trip distributions were determined by examining available sources including seven TISs[6] provided by the City, U.S. Census and American Community Survey (ACS) data documented in the TISs, PTDM data documented in the 35 Cambridgepark Drive TIS, the trip distributions documented in the 2005 Concord-

[4] Based on TIS assumptions and actual surveyed data. Provided by City of Cambridge on 12-11-17.
[5] American Community Survey 2006-2010 U.S. Census data. Residence place information is from CTPP2000 Table 1-002 and 2006- 2010 ACS Table B08301 and workplace information is from CTPP2000 Table 2-002 and 2006-2010 ACS Table B08406.
[6] Trip distributions from 35 Cambridgepark Drive, 180R Cambridgepark Drive, and 55 Wheeler Street are documented in attachment C. TISs for 160 Cambridgepark Drive, 130 Cambridgepark Drive, 165 Cambridgepark Drive were evaluated and include the same distributions as 180R Cambridgepark Drive. The TIS for 80-90 Fawcett St. includes distributions based on the 2005 Concord-Alewife Planning Study.

Alewife Planning Study, and trip distributions for the Alewife area prepared by Nelson\Nygaard for *Envision Cambridge*. For detailed information on the comparisons refer to Attachment D.

- 2000 U.S. Census and 2006-2010 American Community Survey (ACS) data illustrate that a majority of trips entering/exiting the study area are going to/coming from the east, suggesting Boston/Cambridge centric commute patterns.
- PTDM data documented in the 2016 35 Cambridgepark Drive TIS suggests a more even distribution of trips throughout the network, with an increase in westbound trips.
- The trip distributions documented by Nelson \ Nygaard for *Envision Cambridge* were found to be more representative of the more even distribution of trips illustrated by the PTDM data.
- The corridor trip distributions developed by the Nelson \ Nygaard analysis were reviewed and applied to study area corridors based on likely origins/destinations outside of the study area. As more specific PTDM data was not available for each subarea of the study area, this was largely based on general knowledge of the area and the PTDM data from the 35 Cambridgepark Drive TIS. Corridor-wide distributions are illustrated in Attachment E.

Intersection Trip Distributions

- The percentage of existing trips entering and exiting each sub-area were dispersed throughout the network to determine the percentage of trips moving through each study intersection.
- Access points to each study area were based on probable vehicle paths to and from the study area sub-areas given the roadway network for each area.
- Trips were distributed to reflect the unique commercial and residential destinations in each sub-area.
- Local travel routes were identified through a desktop analysis. All streets were considered in the analysis in order to provide a realistic distribution network. This results in a portion of trips not passing through study area intersections.
    - Triangle: Assumed that all eastbound trips on Route 2 access the sub-area through Alewife Station Access Road, before entering the study area.
    - Quad: Assume some eastbound trips enter from Concord Avenue before reaching Fawcett Street (entering via turning left onto Moulton Street-Spinelli Place). Some westbound trips are assumed to enter from Concord Avenue after passing Fawcett Street (entering via turning right onto Moulton Street-Spinelli Place)
    - Jerry's Pond: Assume trips on Rindge Avenue are already in sub-area and are not distributed into the network. Assume trips on Alewife Brook Parkway heading south do not enter network.
    - Shopping Center: Assume 10% of commercial trips on Concord Avenue east of Alewife Brook Parkway exit via Bay State Road. Assume 17% of residential trips entering/15% of trips exiting on Concord Avenue-east do not enter study area. Assumes 25% commercial trips exit via Terminal Road to Alewife Brook Parkway south, 15% exit through driveways in between rotaries, 2% enter via driveways.
    - Fresh Pond: Assume 23% of commercial trips enter sub-area before entering study area intersections. Assume 15% of commercial trips exiting and 10% of trips entering from Concord Avenue-east do not enter the study area. Assume 15% of residential trips on Concord Avenue- east

do not enter/exit the study area and 3% of trips entering/exiting on Fresh Pond Parkway do not enter study area.

- See Attachment F for intersection distributions.

Section F: Critical Sums Calculation

- The resulting critical sum calculated for each intersection for the existing condition and the two future scenarios are listed in Table 6. The threshold at which operations begin to deteriorate is 1,500 vehicles for typical intersections and 1,800 vehicles for rotaries in the peak hour. Intersections over these thresholds are noted in red. Two intersections exceed the threshold with existing traffic volumes and in the existing zoning build out. Three additional intersections exceed the threshold under the proposed zoning build out.

Table 6: Critical Sums Analysis Results

	Existing (2016)		Existing Zoning 2030 Build Out (60%)		Proposed Zoning 2030 Build Out (60%)	
Intersection	Total Volume	Critical Sum	Total Volume	Critical Sum	Total Volume	Critical Sum
1. Alewife Brook Parkway & Route 2	5498	1699	5814	1853	5872	1863
2. Alewife Brook Parkway & Cambridge Park Drive	3844	1267	4380	1436	4441	1430
3. Alewife Brook Parkway & Rindge Ave.	3769	1305	4353	1433	4426	1427
4. Alewife Brook Parkway & Concord Ave Rotary	3388	2152	4460	2640	4781	2670
5. Concord Ave & Fresh Pond Parkway Rotary	3003	1375	3921	1786	4117	1840
6. Concord Ave & Fawcett St.	1350	708	2261	1335	2693	1687
7. Concord Ave & Blanchard Rd.	1955	1096	2702	1490	3080	1640

Section G: Mode Share Sensitivity Analysis

A sensitivity analysis was conducted to determine what auto mode share would help meet the City's planning objectives without additional intersections exceeding the critical sums threshold. The analysis shows that an auto mode share of 40% for all land uses would result in no new intersections exceeding the threshold, as seen in Table 7 (intersections over the thresholds are noted in red). Further detail on the sensitivity analysis is provided in Attachment G.

Table 7: Critical Sums Analysis Results with 40% Auto Mode Share Goal

	Existing (2016)		Existing Zoning 2030 Build Out (60%)		Proposed Zoning 2030 Build Out (60%)	
Intersection	Total Volume	Critical Sum	Total Volume	Critical Sum	Total Volume	Critical Sum
1. Alewife Brook Parkway & Route 2	5498	1699	5804	1850	5792	1841
2. Alewife Brook Parkway & Cambridge Park Drive	3844	1267	4370	1433	4360	1416
3. Alewife Brook Parkway & Rindge Ave.	3769	1305	4339	1429	4329	1414
4. Alewife Brook Parkway & Concord Ave Rotary	3388	2152	4409	2622	4522	2593
5. Concord Ave & Fresh Pond Parkway Rotary	3033	1375	3884	1766	3932	1771
6. Concord Ave & Fawcett St.	1350	708	2202	1283	2411	1464
7. Concord Ave & Blanchard Rd.	1955	1096	2661	1461	2842	1532

The mode share target of 40% can be achieved through the Envision Cambridge plan's recommendations, which include the following:

- Aggressive parking requirements (establish low maximums)
- Enhanced transportation demand management
- Improved bus service and new infrastructure connections (shuttle buses, signal prioritization, bike/ped bridge)

Findings

- Traffic volumes and critical sums have decreased during the peak hour at all but one study area intersection since 2005. This is consistent with relatively stable traffic volumes documented throughout Cambridge, while development continues to increase.
- Under existing zoning at 60% build out, the same intersections are over the threshold as are today.
    - Alewife Brook Parkway & Route 2
    - Alewife Brook Parkway & Concord Avenue Rotary
- Under proposed zoning, residential trips decrease, but employee trips increase because more office and office R&D space is proposed, particularly in the Quad subarea.
- As a result, under proposed zoning with no improvements to mode share, five of the seven study area intersections are over the thresholds.
- As shown in Table 7, an auto mode share of 40% would result in no new intersections exceeding the critical sums threshold. This mode share can be achieved through implementation of the Envision Cambridge plan recommendations, including the following:
    - Aggressive parking requirements (establish low maximums)
    - Enhanced transportation demand management
    - Improved bus service and new infrastructure connections (shuttle buses, signal prioritization, bike/ped bridge)

Alewife Critical Sums Calculations

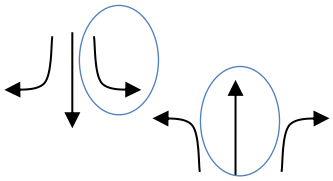
Methodology – Specific Scenarios (Based on 1985 HCM)

The City of Cambridge's Critical Sums Analysis (CSA) methodology served as the basis for this analysis. The process is based on methodology previously used by City of Cambridge for the 2001 *Eastern Cambridge Planning Study* (ECaPS), 2001 Citywide Rezoning, and 2005 *Concord-Alewife Plan*, and refined in 2011-2012 for the *Kendall Square-Central Square (K2C2) Study*. The methodology used in these studies in largely based on the 1985 Highway Capacity Manual (HCM) for calculating critical lane movements (critical sums).

Critical movements are the sum of the northbound left and southbound through/right compared to the southbound left and the northbound through/right. The same is done for the eastbound and westbound. The greater of the northbound/southbound is added to the greater of the eastbound and westbound to calculate the critical sum for the intersection. The 1985 methodology does not explicitly provide planning analysis calculations for the critical sum of rotaries. For the two rotaries in this study, the critical sum was calculated by adding the entering volumes on each approach with the conflicting volumes. The highest total of the approaches is the critical sum. The following pages explain the methodology.

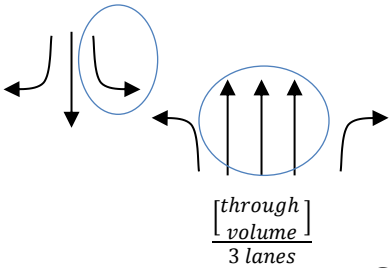
Exclusive Turn Lanes

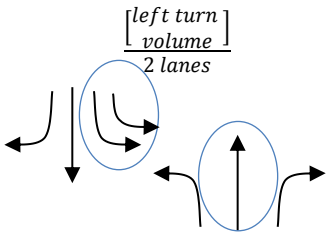
When each movement has its own lane, the through volume is simply added to the opposing left-turn volume.



Multiple Lanes for a Movement

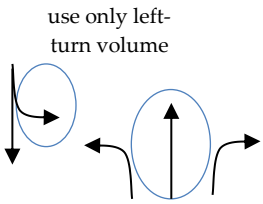
When a given movement has multiple dedicated lanes, the total volume for that movement is divided by the number of lanes for that movement to determine the volume per lane. The lane volume is then used to calculate the critical sum (rather than the total volume for that movement).



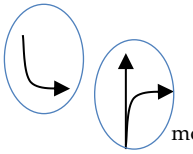


Shared-Lane Scenarios

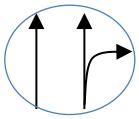
When the opposing left turn shares a lane with the through movement, only the left turn volume is used to calculate the critical sum.

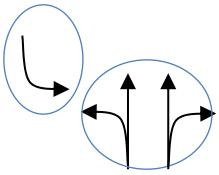


When the through and right movements share a lane, the sum of the two volumes is added to the opposing left-turn volume.

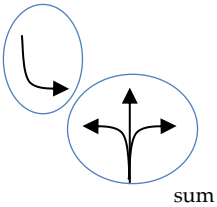


When multiple lanes are available for through-right movements or when left turns share a lane group with other movements (and lane volumes are not known), an average volume is used for each lane – i.e. the total volume for the lane group is divided by the number of lanes. If lane volumes are known, the higher volume is used.



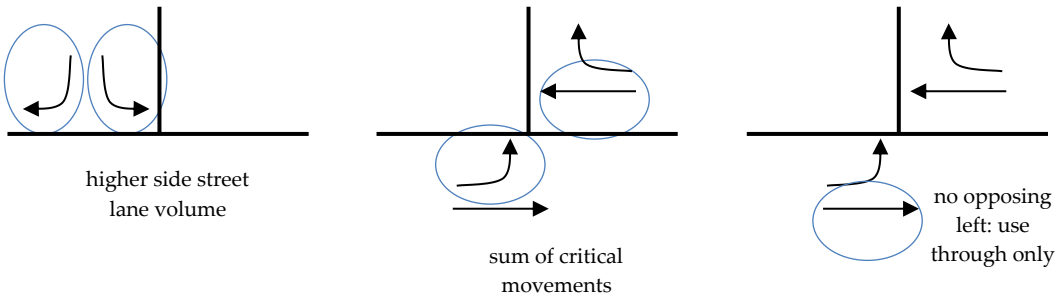


When an approach only has one lane, the sum of all movements is added to the opposing left-turn volume.



Three-Leg Intersections

The higher lane volume on the side street approach is counted as the critical movement, since there is no opposing traffic flow. For the main street approaches, the opposing through and left movements are used.

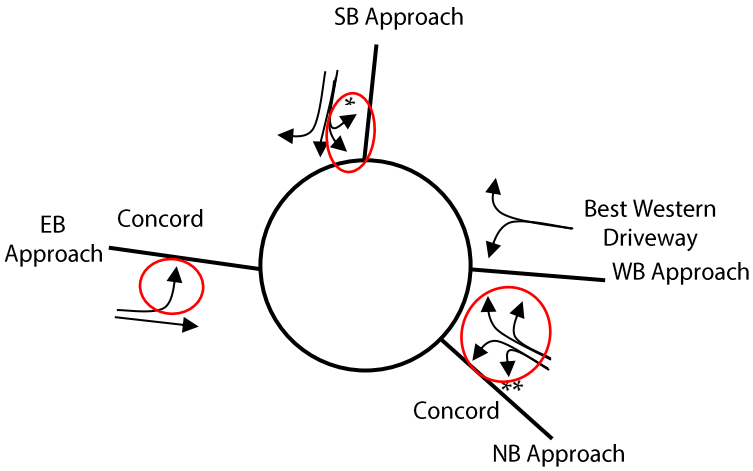


Rotary Methodology

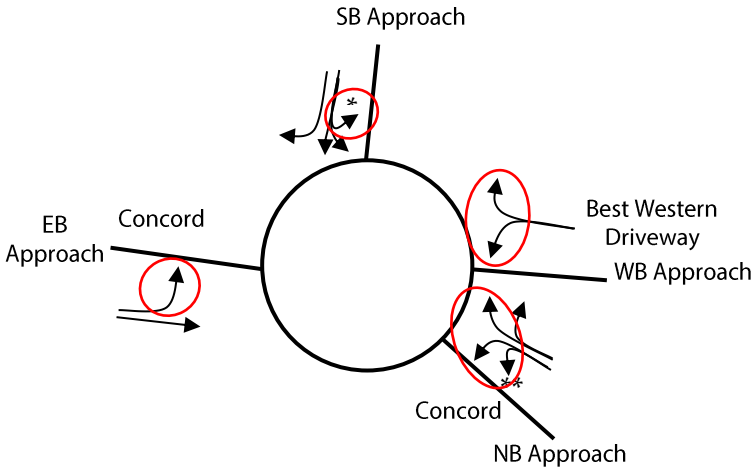
There are seven study area intersections, as shown in **Error! Reference source not found.**. The Critical Sums formulas used for each intersection are provided below.

Highest of All Approaches:

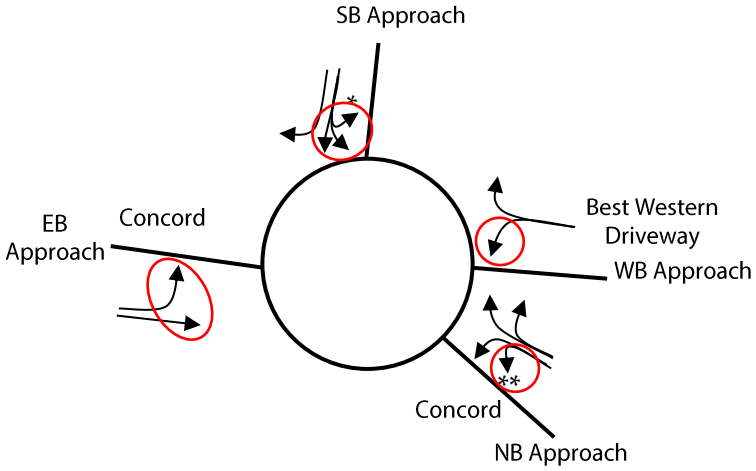
NB Approach:
$[(NBU + NBR + NBHR + NBL)] + [(SBU + SBHL) + EBL]$ *or*



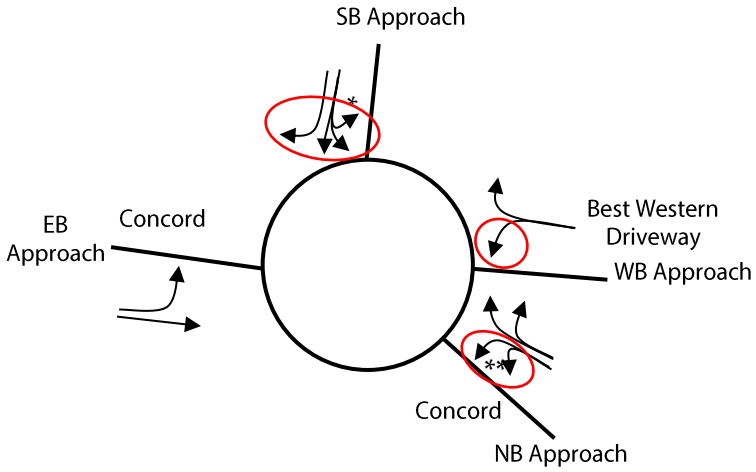
WB Approach: $[(WBR + WBL)]+[(NBU + NBR + NBL) + SBU + EBL]$ *or*



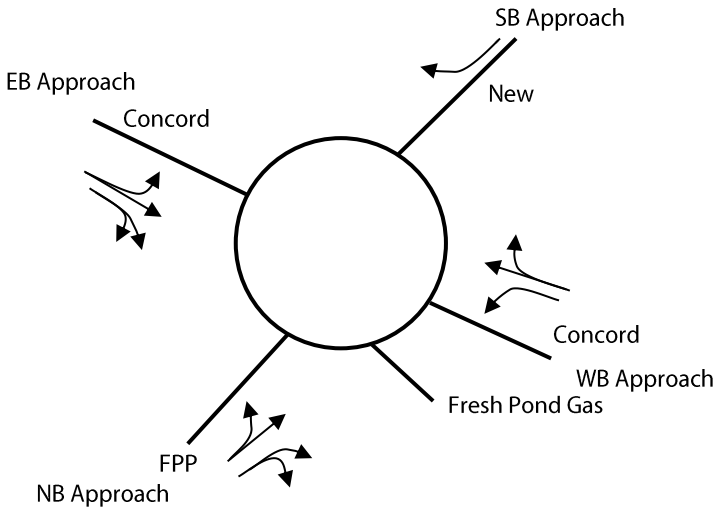
EB Approach: $[EBT+EBL]+ [NBU + WBL + (SBU + SBHL + SBL)\ ]$ *or*



SB Approach: $[(SBR + SBL + SBHL + SBU)] + [(NBU + NBL) + WBL]$



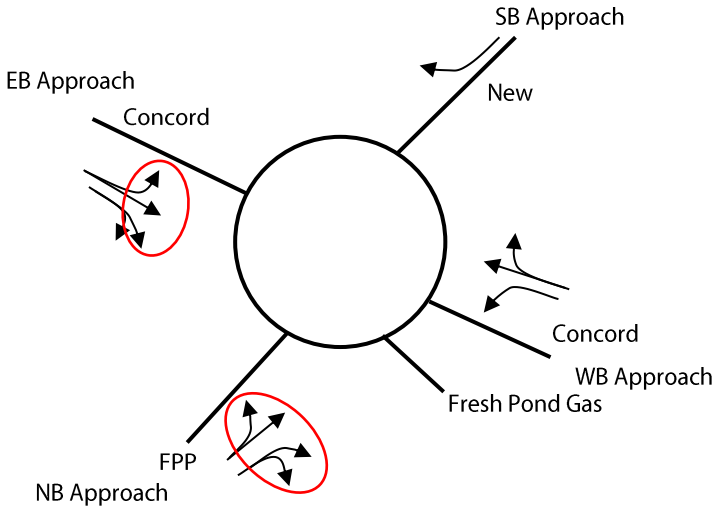
Intersection 5: Concord Ave and Fresh Pond Parkway Rotary (FPP)



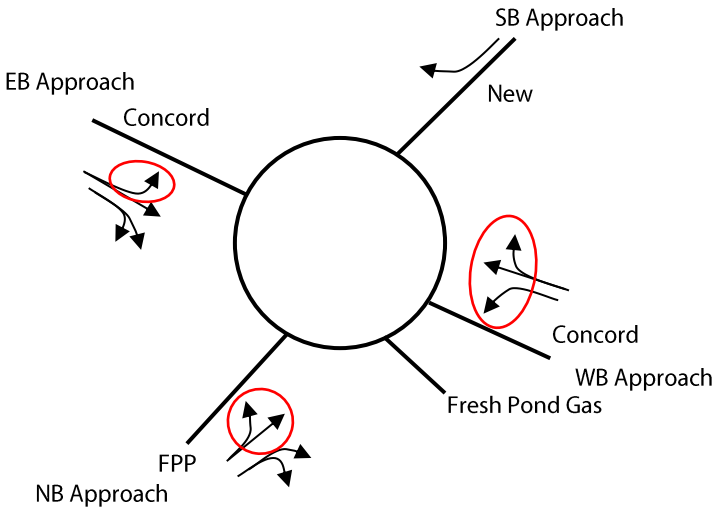
NBHR = Northbound hard right
EBHR = Eastbound hard right (to FPP)
NBHR, EBR assume entering Fresh Pond Gas

Highest of All Approaches:

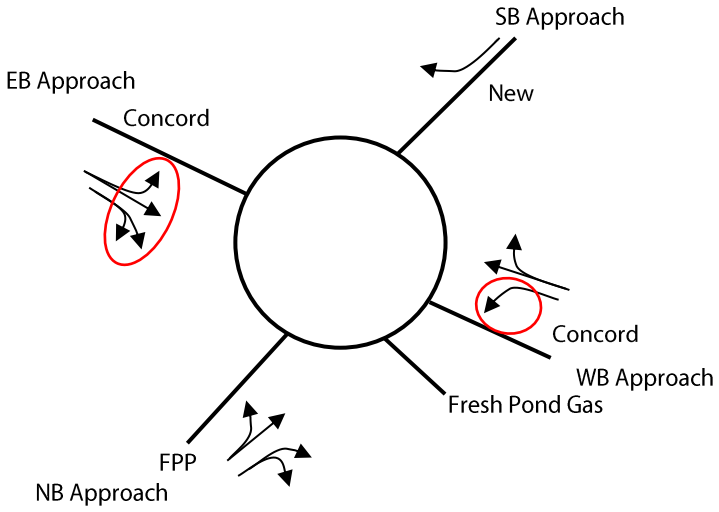
NB Approach: $[(NBT + NBL + NBR + NBHR)]+[(EBT + EBL + EBR)]$ *or*



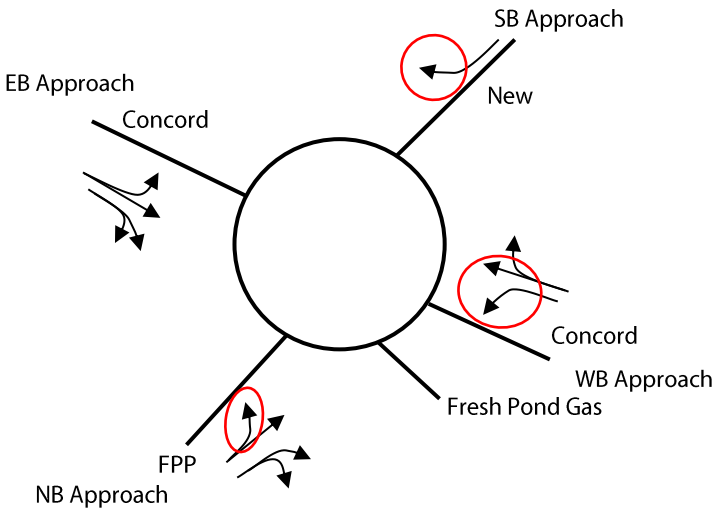
WB Approach: $[(WBT + WBL + WBR)]$+$[(NBT + NBL) + EBL]$ *or*



EB Approach: $[(EBT + EBL + EBR + EBHR)]$+$[WBL]$ *or*



SB Approach: $[SBR]$ +$[NBL + (WBT + WBL)]$



Alewife Critical Sums Analysis - Attachment B
Envision Alewife Critical Sums Assumptions--Developed by Stephanie Groll and Adam Shulman
12/11/2017

Residential

Triangle

	TIS Assumptions			Actual surveyed				Commercial: Annual TDM Monitoring			
	Project	SOV	HOV	Total Auto	SOV	HOV	Total Auto	Source	Project	SOV	HOV	Total Auto
	160 CPD	43	8	51	29	1	30	2017 TDM monitoring	200 CPD 2015	45	0	45
	165 CPD	42	8	50					200 CPD 2016	71	5	76
	130 CPD	42	8	50					200 CPD 2017	70	5	75
	88 CPD	25	5	30								
	Critical Sums	26	2	28	**Rationale** 10% lower SOV, HOV twice as high as actual at 160 CPD				**Critical Sums**	41	5	46
									Rationale 10% lower SOV than 2015 demonstrated possible SOV rate, HOV equal to 2016/17 rate of 5%, which was better than 2015 and reflects new use of ridehail services			

Quadrangle

	TIS Assumptions			Actual surveyed				Annual TDM Monitoring			
	Project	SOV	HOV	Total Auto	SOV	HOV	Total Auto	Source	Project	SOV	HOV	Total Auto
	80-90 Fawcett	54	11	65	25	0	25	2014 TDM monitoring	10 Wilson Rd 2015	75	6	81
	Concord Wheeler I	49	21	70					10 Wilson Rd 2016	66	4	70
	Concord Wheeler II	35	4.4	39.4	31	2	33	2016 Survey for 55 Wheeler TIS	767 Concord 2015	43	10	53
	95 Fawcett	35	4.4	39.4					767 Concord 2016	45	11	56
	55 Wheeler	33	3	36					767 Concord 2017	50	10	60
	Critical Sums	28	2	30	**Rationale** 10% lower SOV, 10% higher HOV than 55 Wheeler TIS assumption.				**Critical Sums**	50	8	58
									Rationale 10% lower SOV than avg of 2016 10 Wilson and 2016 767 Concord. 10% higher HOV than avg of 2016 10 Wilson and 2016 767 Concord			

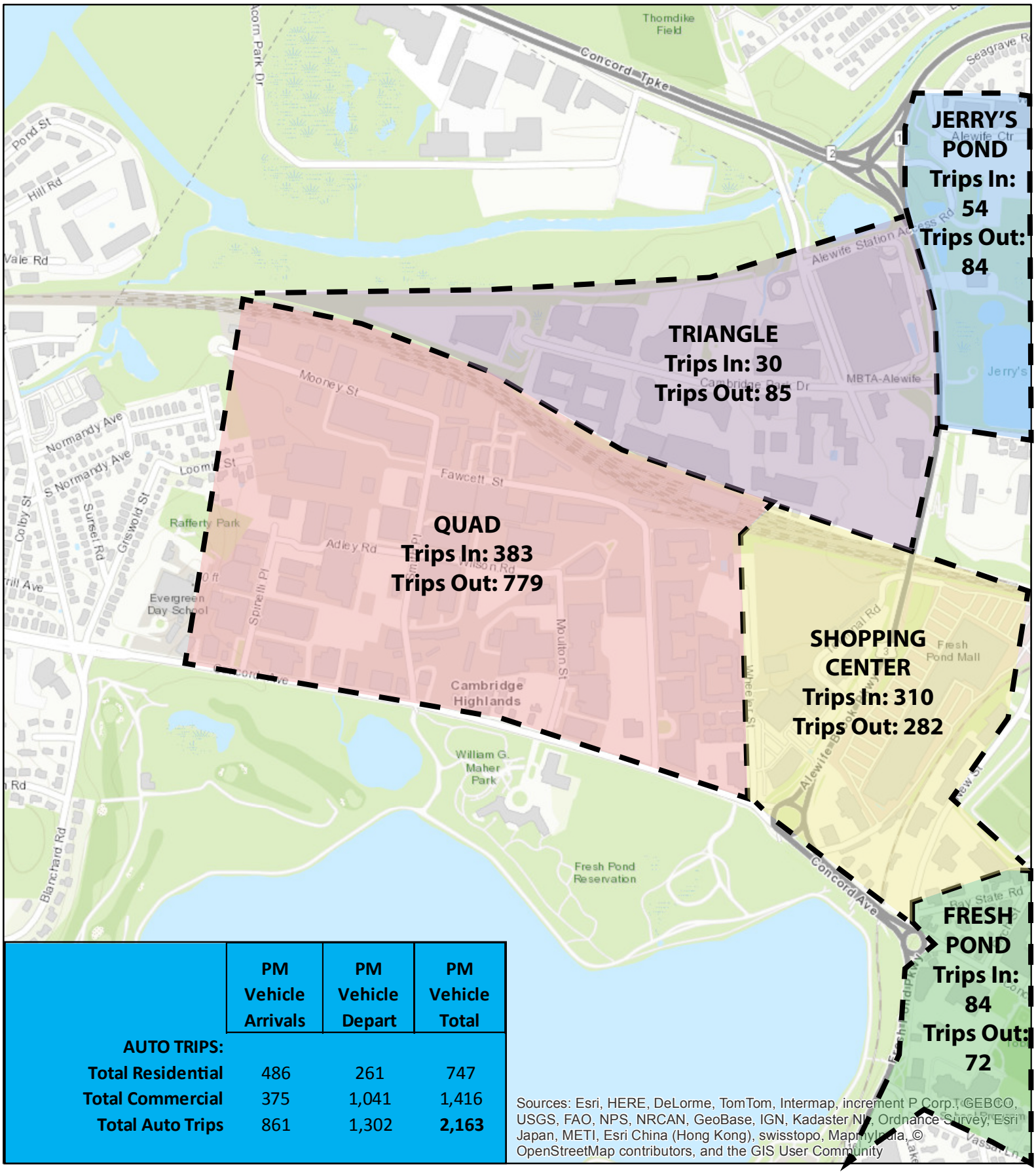
Other

	TIS Assumptions			Actual surveyed				Annual TDM Monitoring			
	Project	SOV	HOV	Total Auto	SOV	HOV	Total Auto	Source	Project	SOV	HOV	Total Auto
	Vox I/Faces	68	7	75	35	4	39	2016 TDM Monitoring	Discovery Pk 2015	55.4	4.2	59.6
	Vox II/Lanes&Games	35	4	39					Discovery Pk 2016	55	2	57
	77 New Street	37	8	45					Alewife Intercept Study	54	3	57
									Concord Wheeler I Retail	49	23	72
									355 Fresh Pnd Pkwy Employees 2017	45	0	45
	Critical Sums	32	5	37	**Rationale** 10% lower SOV and 15% higher HOV than actual at Vox I 2016 for rounding				**Critical Sums**	45	3	48
									Rationale 10% lower SOV than avg of 2016 Discovery Park and 2017 355 Fresh Pond Pkwy employees. 15% higher HOV than avg of 2016 Discovery Park and 2017 355 Fresh Pond Pkwy employees for rounding			

Notes:

1. We based our Critical Sums SOV/HOV rates on the best available data from TIS assumptions and actual surveyed data.
2. The wide geographic range in the "Other" category presents a challenge to arrive at one number--some areas are close to T and some are far. Also, note that "Other" is the highest SOV rate for residential, but it's only the 2nd highest for commercial. This could be the result of variation in a very few data points (ex. Disco Park is unusual b/c it charges for parking).

Estimated Automobile Trips by Sub Area



	PM Vehicle Arrivals	PM Vehicle Depart	PM Vehicle Total
AUTO TRIPS:			
Total Residential	486	261	747
Total Commercial	375	1,041	1,416
Total Auto Trips	861	1,302	**2,163**

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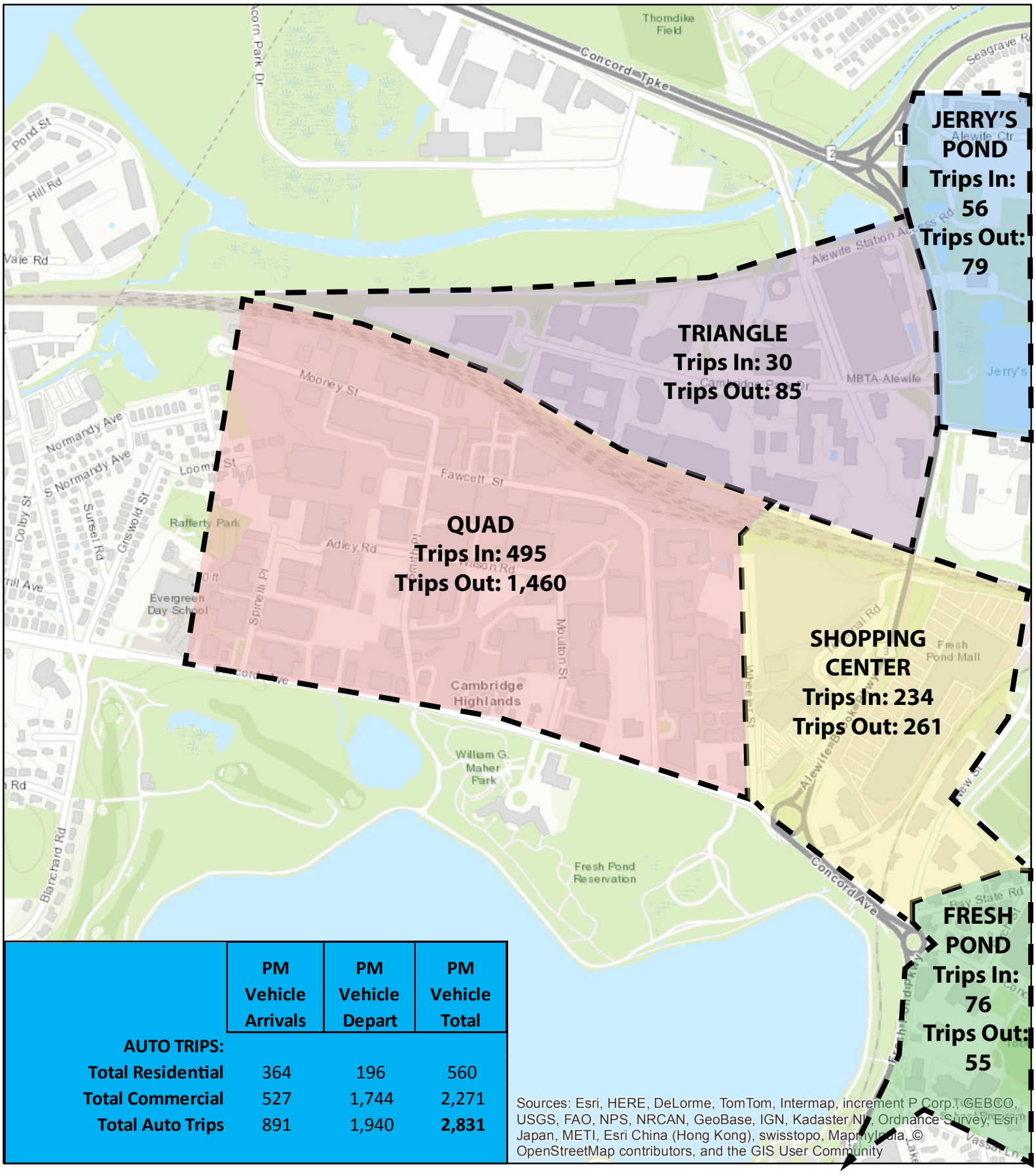
Attachment C: 60% Buildout **Existing Zoning**
Alewife Critical Sums Analysis
3-27-18

Estimated Automobile Trips by Sub Area



	PM Vehicle Arrivals	PM Vehicle Depart	PM Vehicle Total
AUTO TRIPS:			
Total Residential	364	196	560
Total Commercial	527	1,744	2,271
Total Auto Trips	891	1,940	**2,831**

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Attachment C: 60% Buildout **Proposed Zoning**
Alewife Critical Sums Analysis
3-27-18

Trip Distribution Analysis Worksheet

		Triangle								Quadrangle			Shopping Center		Jerry's Pond		Fresh Pond Parkway	
		Residential				Commercial				Residential			Res.	Comm.	Res.	Comm.	Res.	Comm.
Roadway	Source:	2005 Concord-Alewife Study	35 CPD	180 R CPD	NN	2005 Concord-Alewife Study	35 CPD	PTDM	NN	2005 Concord-Alewife Study	55 Wheeler	NN	NN	NN	NN	NN	NN	NN
Route 2 (north-west)	In	15%	46%	14%	10%	28%	47%	24%	20%*	3%	8%	3%	17%*	22%	50%	50%	9%	8%
	Out	15%	45%	8%*	15%	28%	43%	29%	27%	3%	7%	3%	24%	22%	50%	50%	9%	8%
Alewife Brook Parkway (east)	In	20%	20%	9%	20%	35%	18%	11%	10%	8%	8%	8%	14%	16%*	20%	20%	10%	8%
	Out	26%	26%	34%*	28%	37%	24%	15%	16%	8%	8%	8%	17%	18%*	20%	20%	10%	8%
Rindge Avenue	In	20%	5%	60%	13%*	4%	4%	12%	13%*	4%	1%	4%	10%	6%	2%	7%	2%	5%
	Out	0%	0%	0%	0%	0%	0%	0%	0%	4%	1%	4%	2%	4%	2%	7%	2%	5%
Concord Avenue east	In	3%	5%	6%	10%*	5%	5%	12%*	15%	30%	23%	15%	17%	15%*	7%	2%	15%	15%
	Out	17%	5%	21%	10%*	7%	7%	15%	15%*	30%	19%	15%	15%*	15%*	7%	2%	15%	15%
Fresh Pond Parkway	In	20%	20%	6%	25%	20%	20%	20%	20%	32%	40%*	25%*	21%	20%*	8%	8%	43%	43%
	Out	20%	20%	30%	25%	20%	20%	20%	20%	32%	44%	25%*	21%	20%*	8%	8%	43%	43%
Concord Avenue west	In	18%	2%	3%	17%	4%	2%	12%*	13%*	14%	10%	25%	14%	10%	10%	8%	15%	10%
	Out	18%	2%	3%	17%	4%	2%	12%*	13%*	14%	10%	25%	14%	10%	10%	8%	15%	10%
Blanchard Road north	In	2%	1%	1%	3%	2%	2%	2%	2%	7%	6%	15%	5%	9%	1%	1%	4%	9%
	Out	2%	1%	2%	3%	2%	2%	2%	2%	7%	6%	15%	5%	9%	1%	1%	4%	9%
Blanchard Road south	In	2%	1%	1%	2%	2%	2%	7%	7%	2%	4%	5%	2%	2%	2%	4%	2%	2%
	Out	2%	1%	2%	2%	2%	2%	7%	7%	2%	5%	5%	2%	2%	2%	4%	2%	2%

KEY: red = over 5% difference from 2005 study

*< 10% difference from 2005 study

Sources:

35 CPD: 35 Cambridgepark Drive TIS (2016), based on PTDM zip code data for drivers only

180R CPD: 180R Cambridgepark Drive TIS (2014), based on 2000 Census Data

NN: Nelson Nygaard corridor trip distribution applied from internal draft Envision Cambridge powerpoint dated February 16, 2017

PTDM: PTDM zip code data for Alewife area available in 35 Cambridgepark Drive TIS. Employee origins and destinations by municipality were used as the basis for assigning trip distributions to the study area.

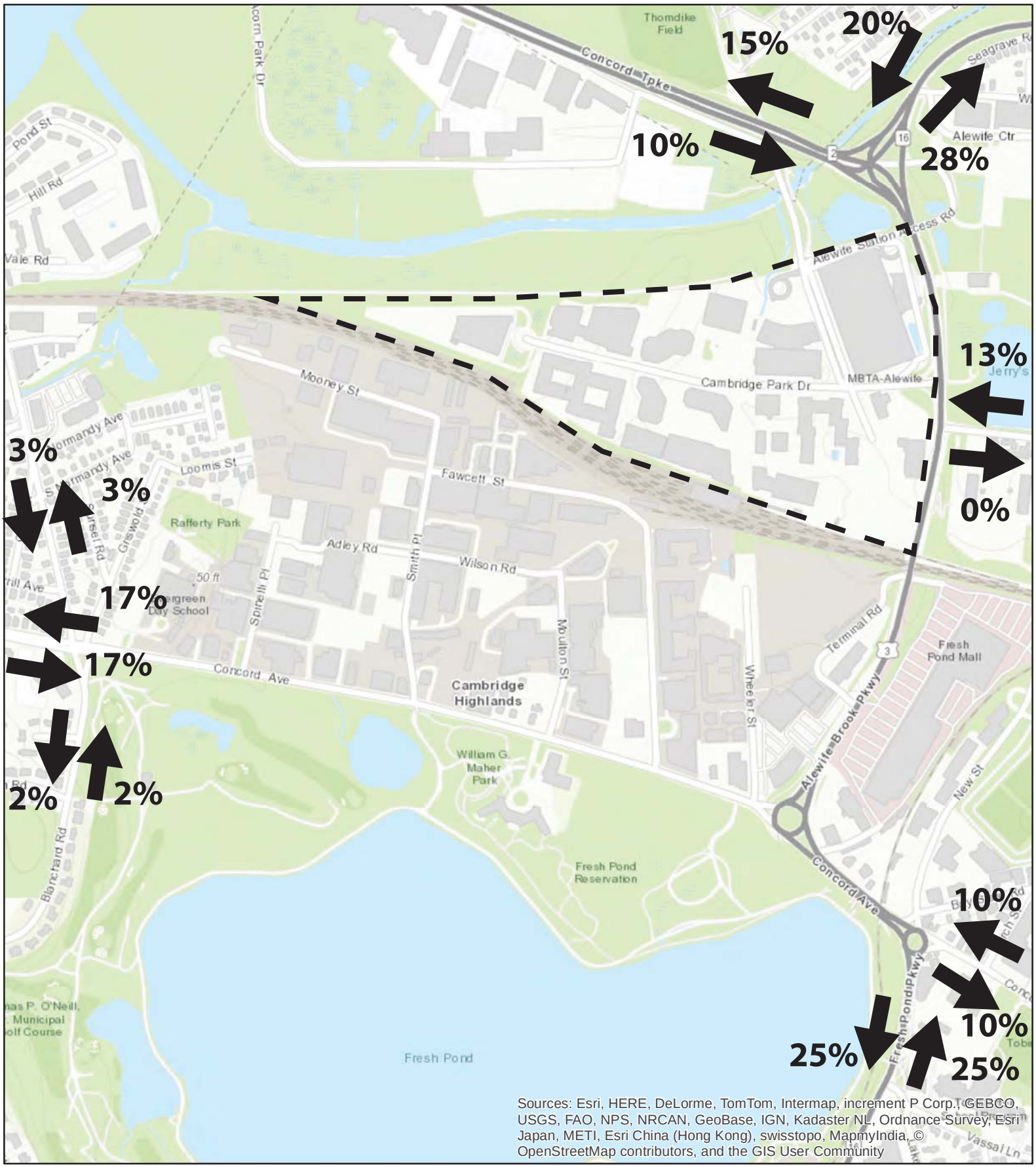
DRAFT Proposed Trip Distributions
Alewife Critical Sums Analysis 2017

- Based on a review of available documents and discussion with City of Cambridge staff on Monday, November 27, 2017, the proposed trip distributions for the Alewife Critical Sums Analysis McMahon recommends using are provided on page 2 and illustrated in the attached diagrams.
    - The trip distributions are primarily based on the corridor-wide trip distributions presented in Nelson\Nygaard's transportation analysis for Envision Cambridge.
    - The Nelson\Nygaard trip distributions were compared to the trip distributions used in the 2005 Concord-Alewife Study, several TISs, and PTDM data available for the Alewife area. This comparison illustrates changes in trip distributions based on 2000 U.S. Census data used in some of those documents compared to more current 2010 U.S. Census data, PTDM data and traffic counts.
    - The data comparison shows trip distribution patterns have shift to more trips to and from west of the Alewife area, resulting in a more even distribution throughout the network than the 2000 data focus of trips to/from the Cambridge/Boston area to the east.
- Due to this change in overall commuting patterns, an update to the trip distributions used for the 2005 Concord-Alewife Study is warranted for this 2017 Critical Sums analysis.
- The "Trip Distribution Analysis Worksheet" show distributions used in the 2005 Concord-Alewife Study, 35 Cambridgepark Drive, 180R Cambridgepark Drive, and 55 Wheeler Street. The TISs reviewed after this effort use the same data (2000 U.S. Census) and so are not listed separately in this document.
    - The other TIS include 160 Cambridgepark Drive, 130 Cambridgepark Drive, 165 Cambridgepark Drive (based on 2000 U.S. Census), and 80-90 Fawcett Street (based on 2000 U.S. Census and 2005 Concord-Alewife Study)

Proposed Trip Distribution

Proposed Trip Distribution											
		Triangle		Quad		Shopping Center		Jerry's Pond		Fresh Pond Parkway	
Roadway		Residential	Commercial	Residential	Commercial	Residential	Commercial	Residential	Commercial	Residential	Commercial
Route 2 (north-west)	In	10%	20%	3%	5%	17%	22%	50%	50%	9%	8%
	Out	15%	27%	3%	5%	24%	22%	50%	50%	9%	8%
Alewife Brook Parkway (east)	In	20%	10%	8%	7%	14%	16%	20%	20%	10%	8%
	Out	28%	16%	8%	7%	17%	18%	20%	20%	10%	8%
Rindge Avenue	In	13%	13%	4%	3%	10%	6%	2%	7%	2%	5%
	Out	0%	0%	4%	3%	2%	4%	2%	7%	2%	5%
Concord Avenue east	In	10%	15%	15%	10%	17%	15%	7%	2%	15%	15%
	Out	10%	15%	15%	10%	15%	15%	7%	2%	15%	15%
Fresh Pond Parkway	In	25%	20%	25%	25%	21%	20%	8%	8%	43%	43%
	Out	25%	20%	25%	25%	21%	20%	8%	8%	43%	43%
Concord Avenue west	In	17%	13%	25%	20%	14%	10%	10%	8%	15%	10%
	Out	17%	13%	25%	20%	14%	10%	10%	8%	15%	10%
Blanchard Road north	In	3%	2%	15%	15%	5%	9%	1%	1%	4%	9%
	Out	3%	2%	15%	15%	5%	9%	1%	1%	4%	9%
Blanchard Road south	In	2%	7%	5%	15%	2%	2%	2%	4%	2%	2%
	Out	2%	7%	5%	15%	2%	2%	2%	4%	2%	2%

TRIANGLE RESIDENTIAL



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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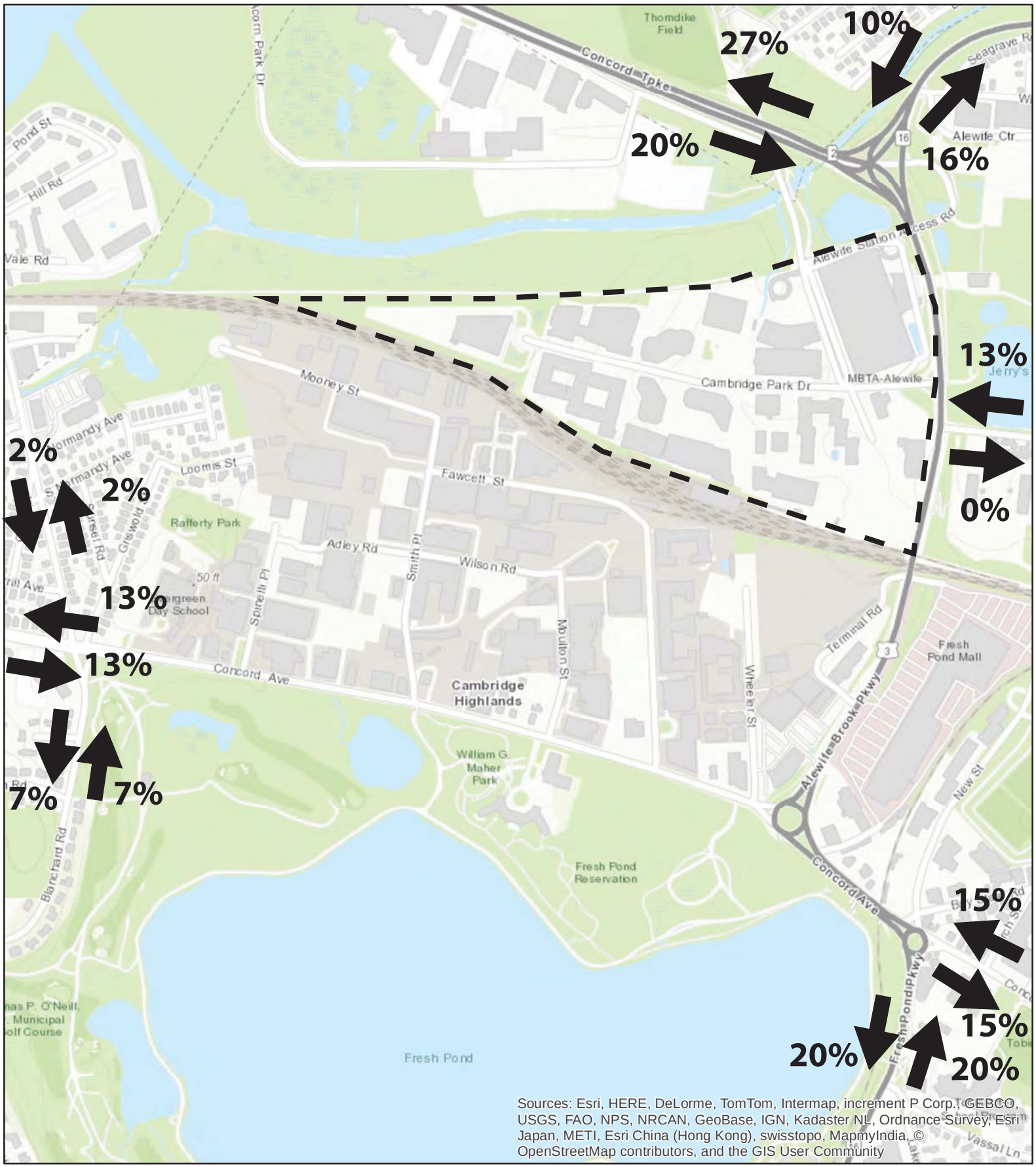
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

TRIANGLE COMMERCIAL



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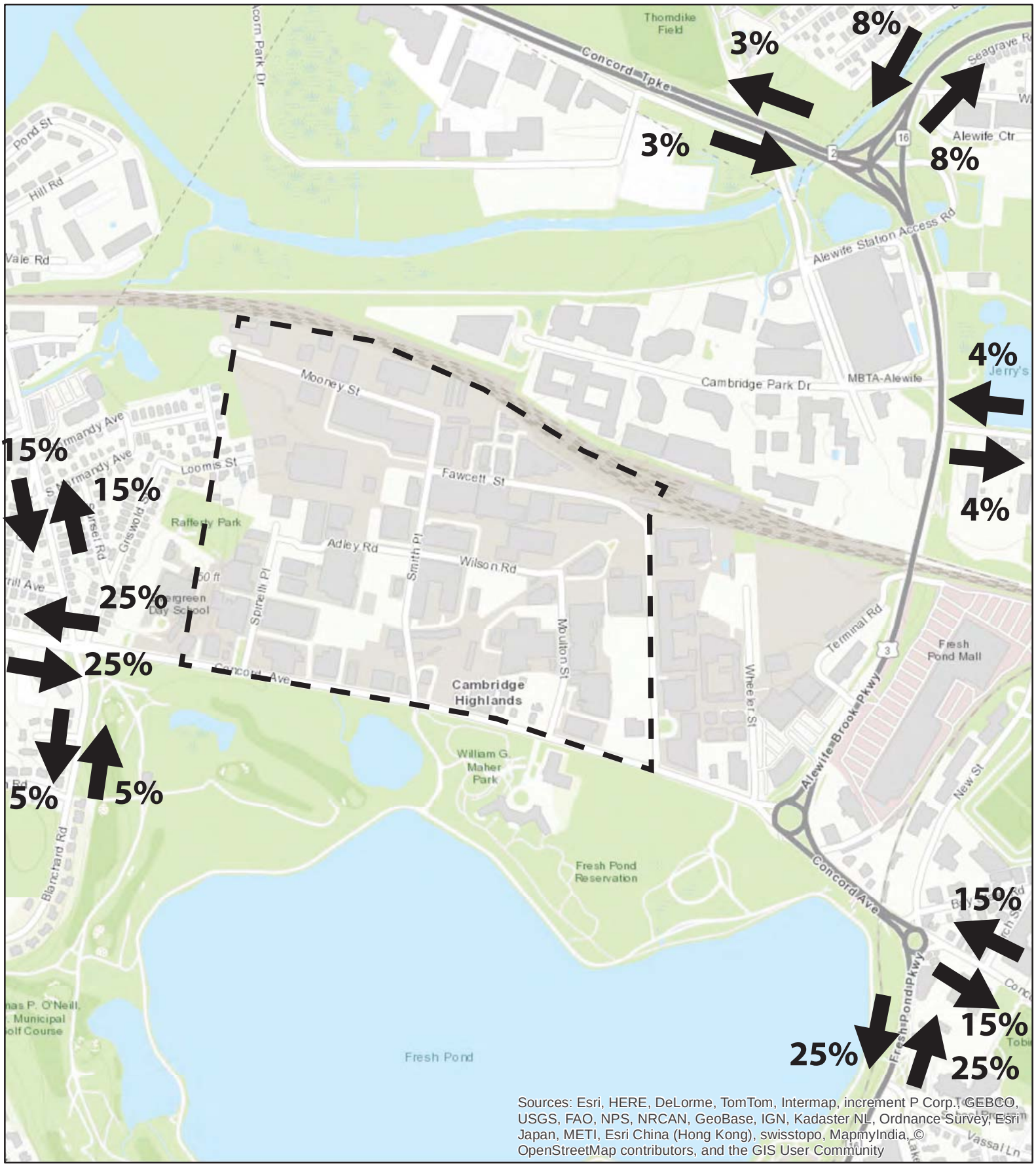
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

QUAD RESIDENTIAL



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Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

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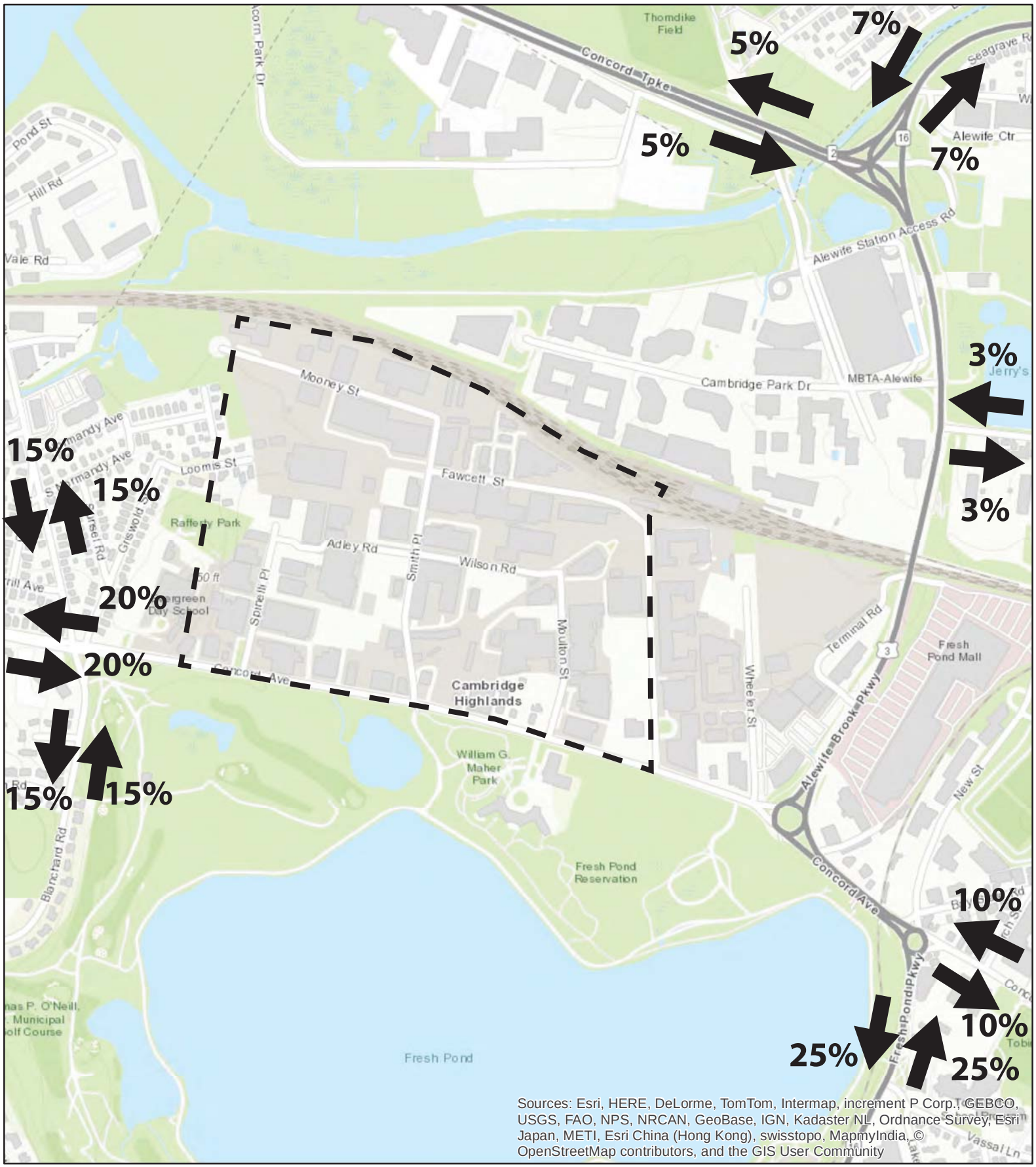

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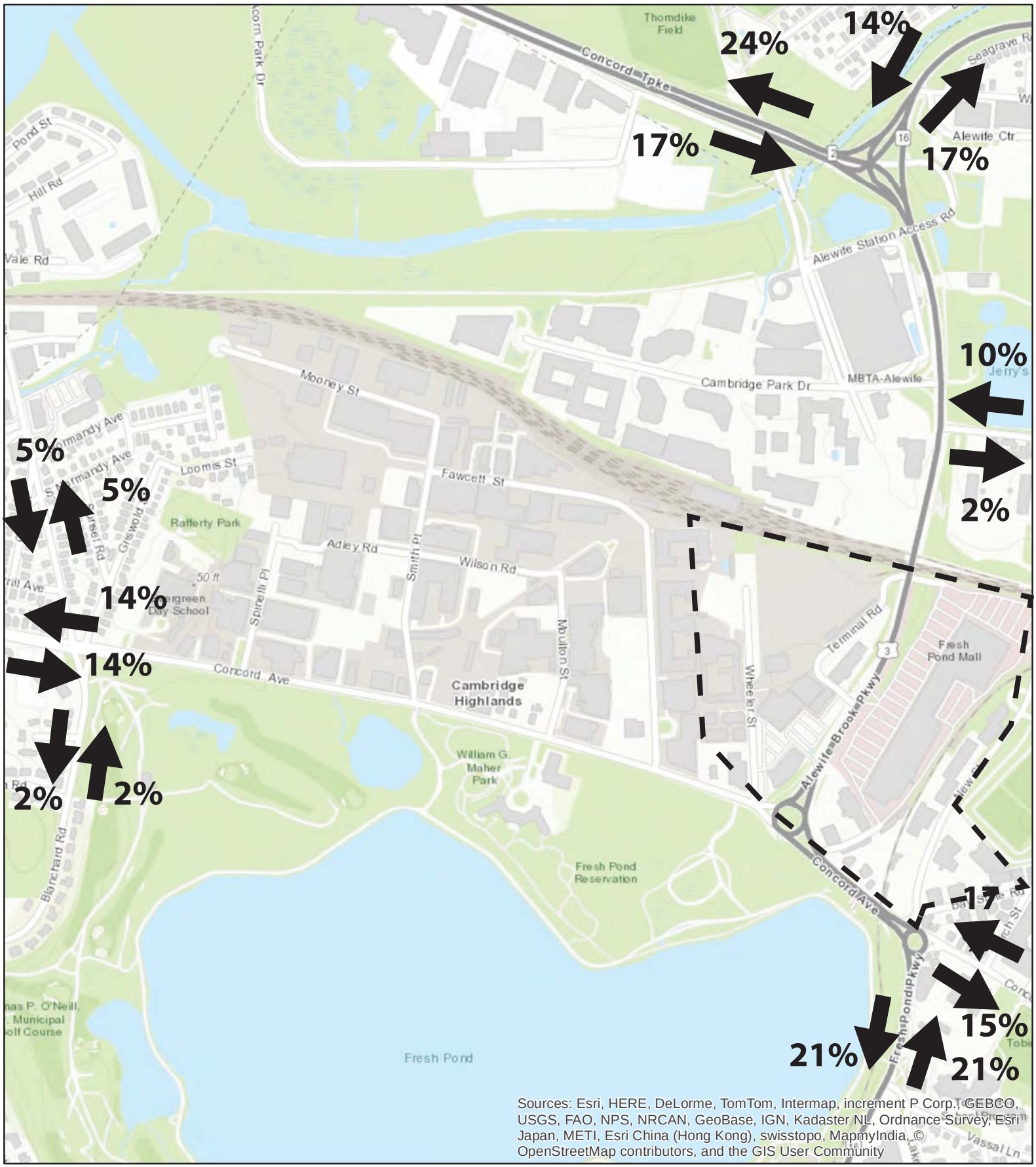
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

SHOPPING CENTER RESIDENTIAL



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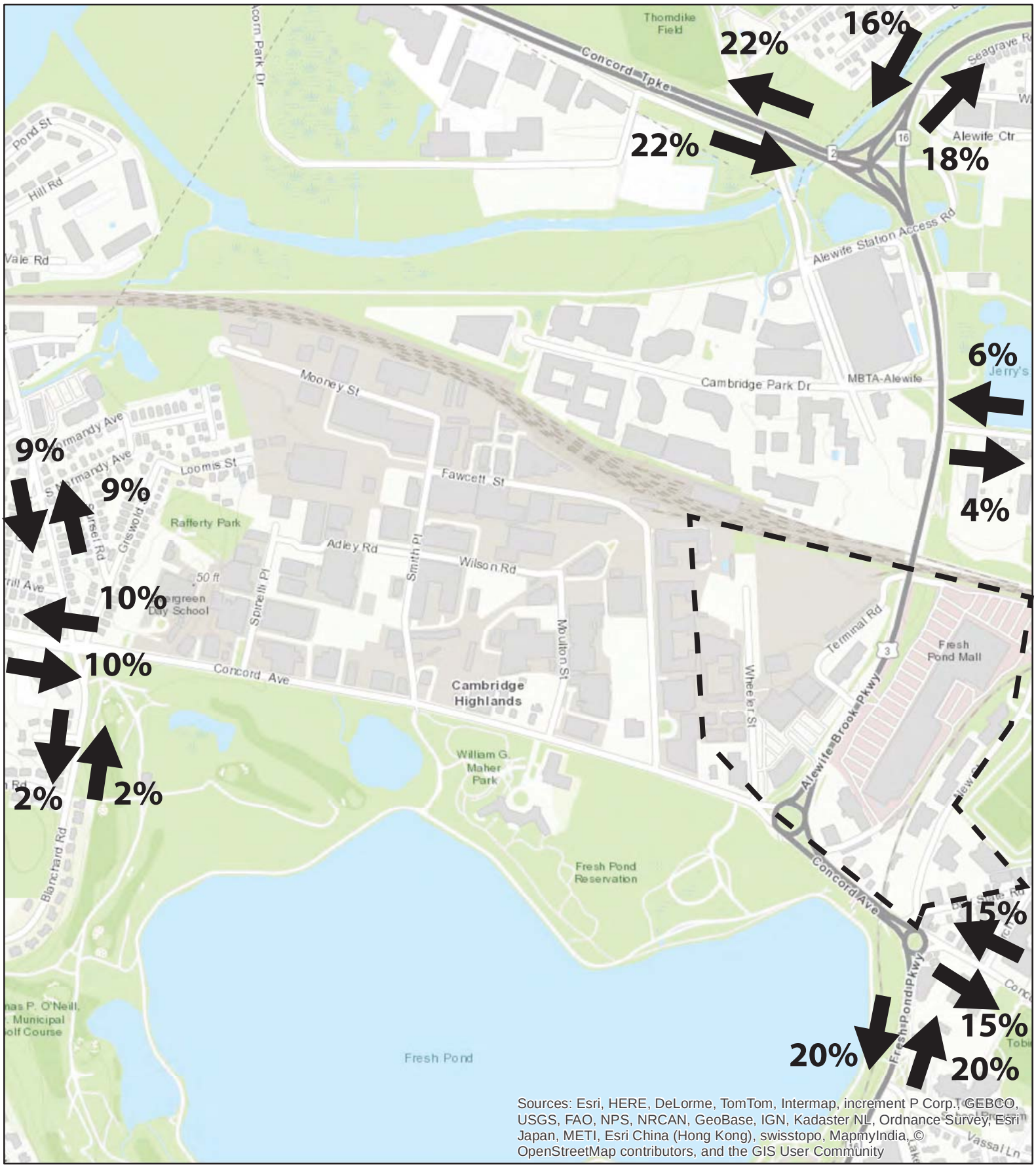
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

SHOPPING CENTER COMMERCIAL



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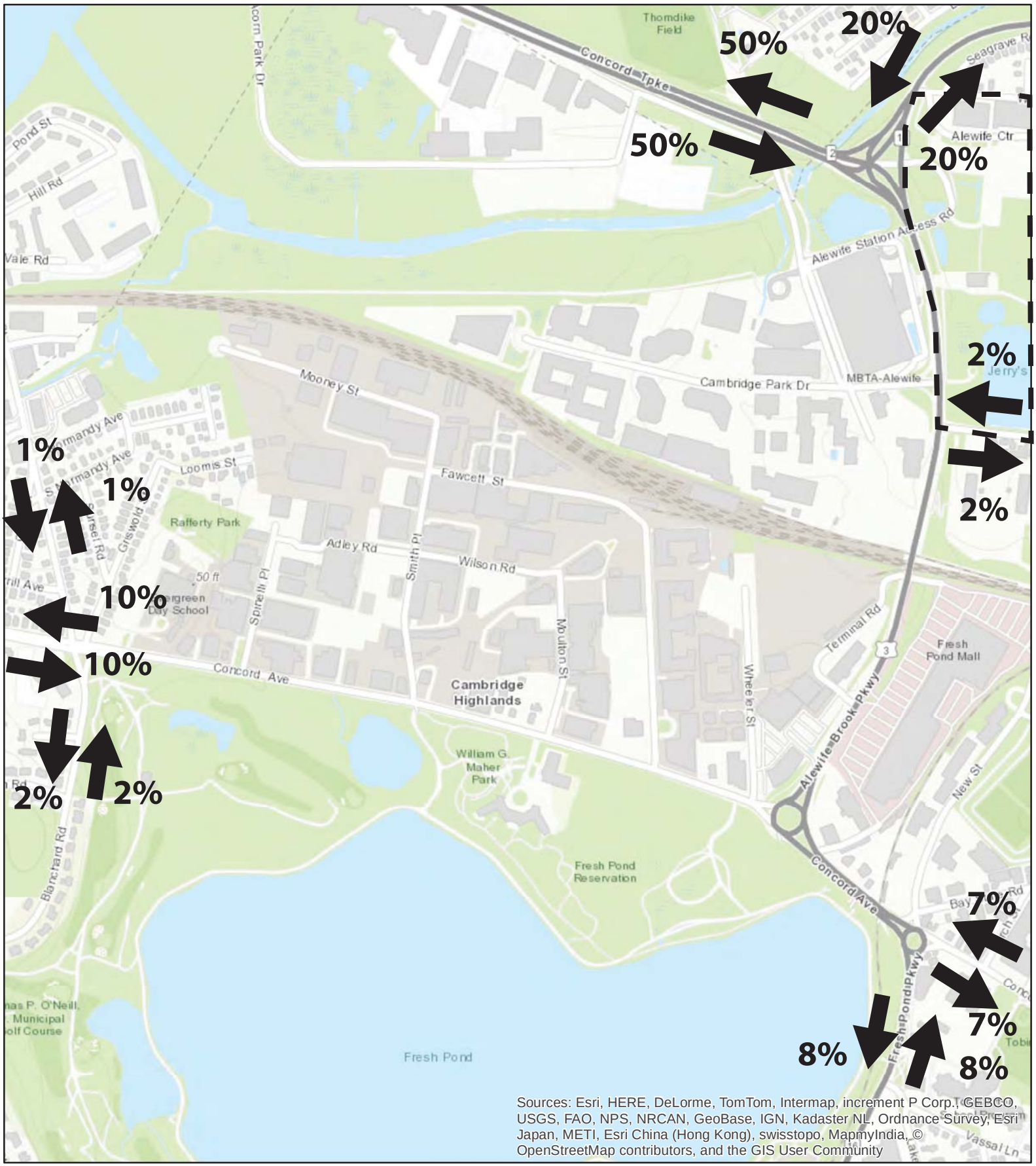
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

JERRY'S POND RESIDENTIAL



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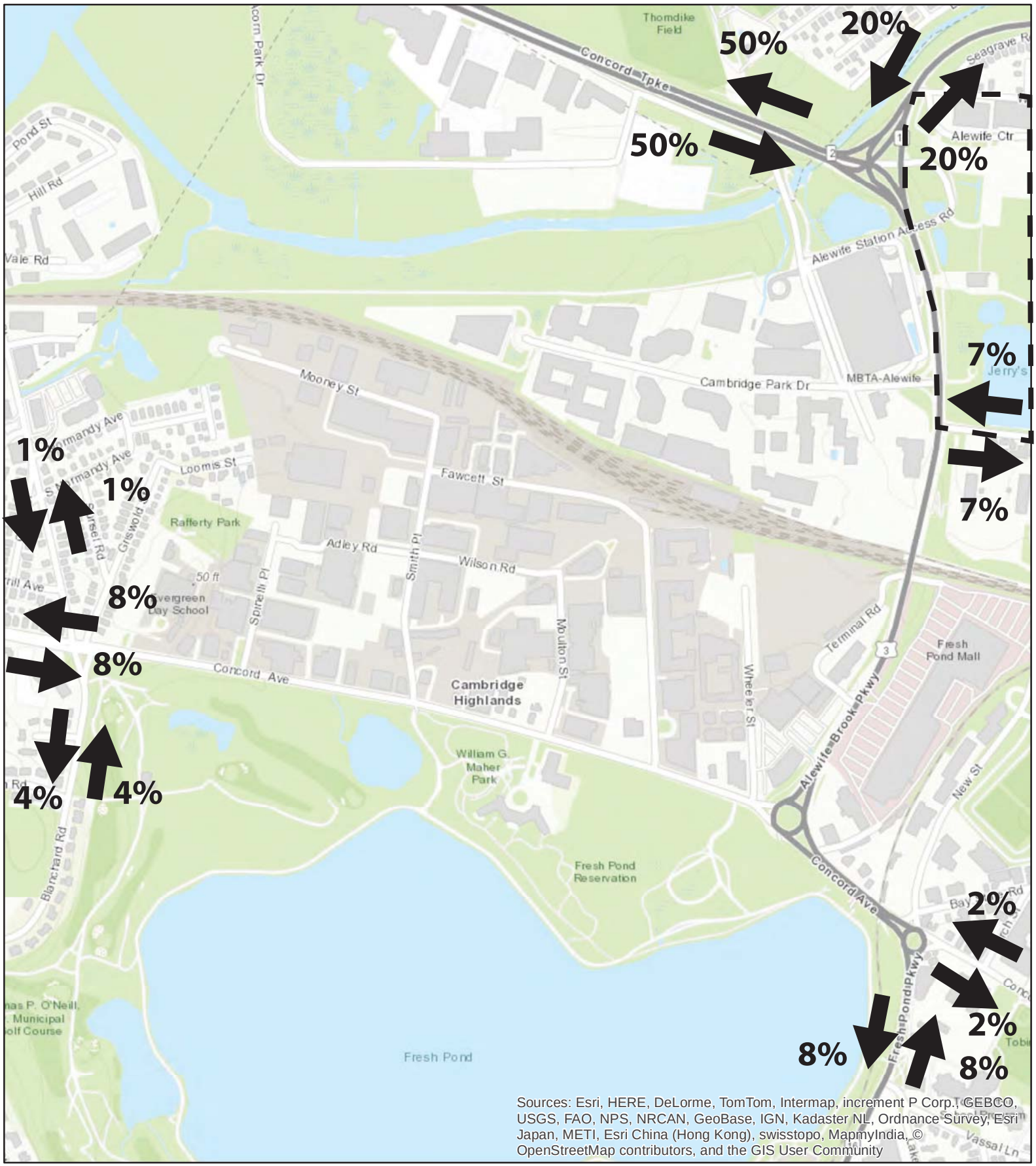
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

JERRY'S POND COMMERCIAL



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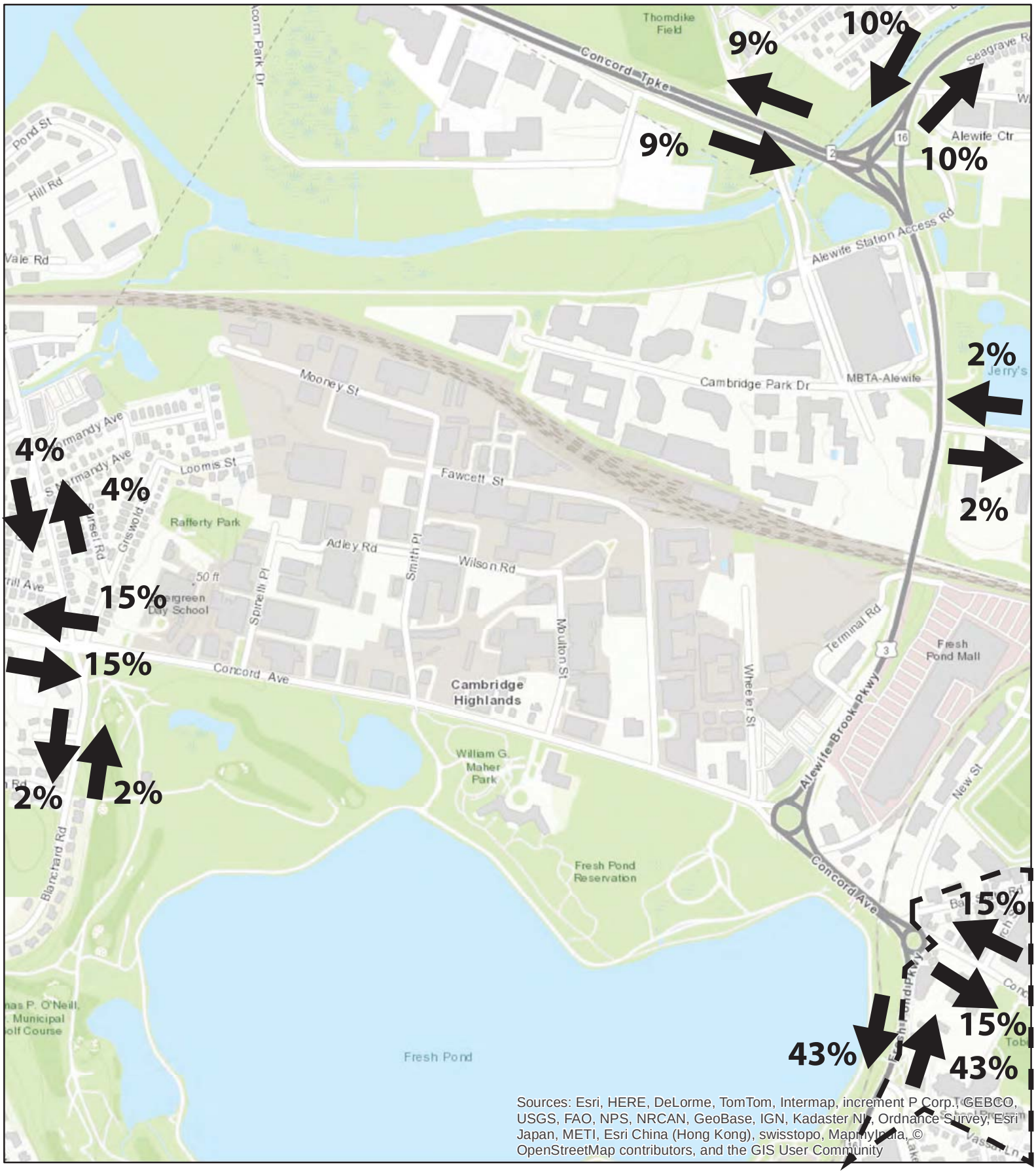
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

FRESH POND PARKWAY RESIDENTIAL



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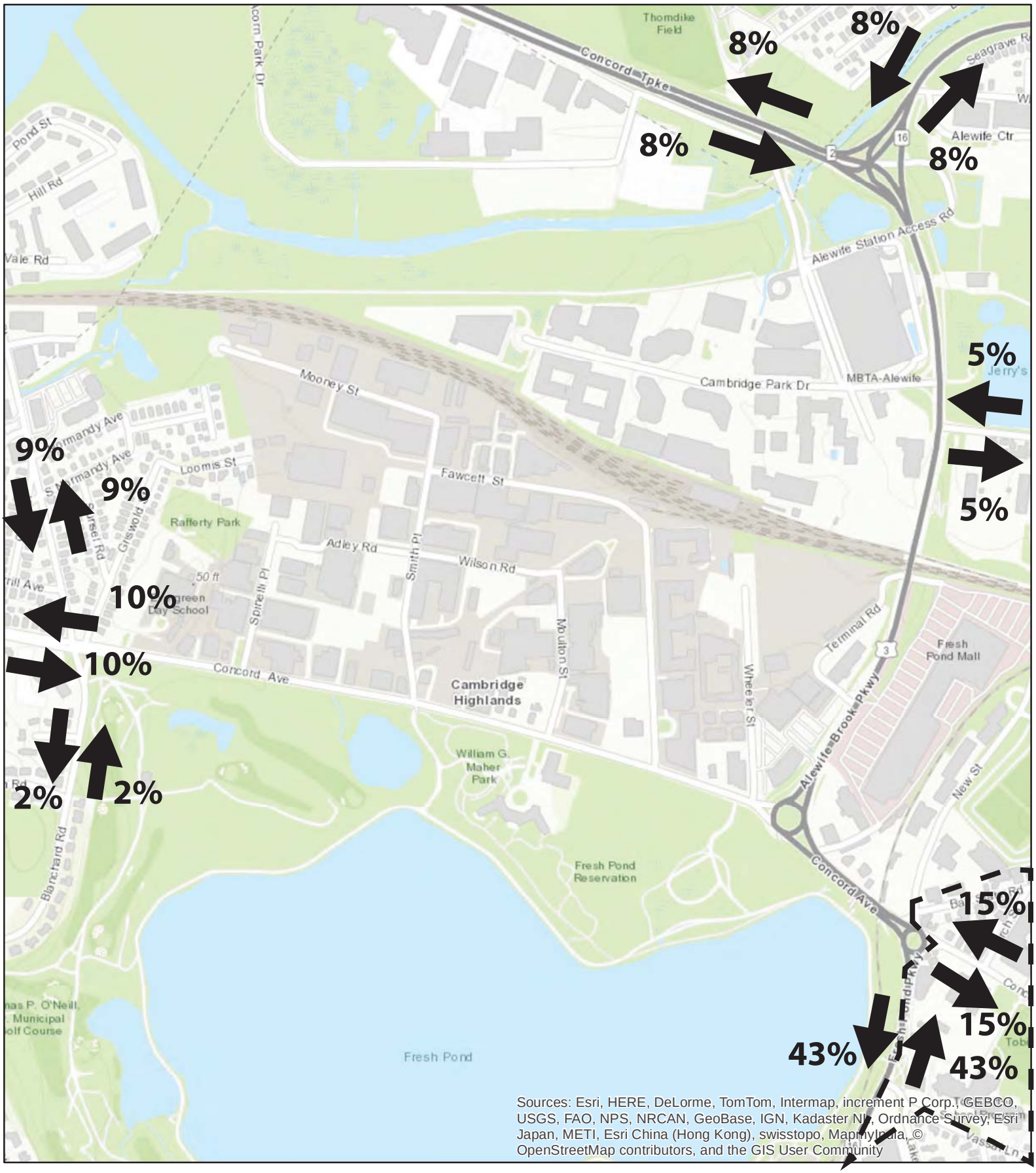
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

FRESH POND PARKWAY COMMERCIAL



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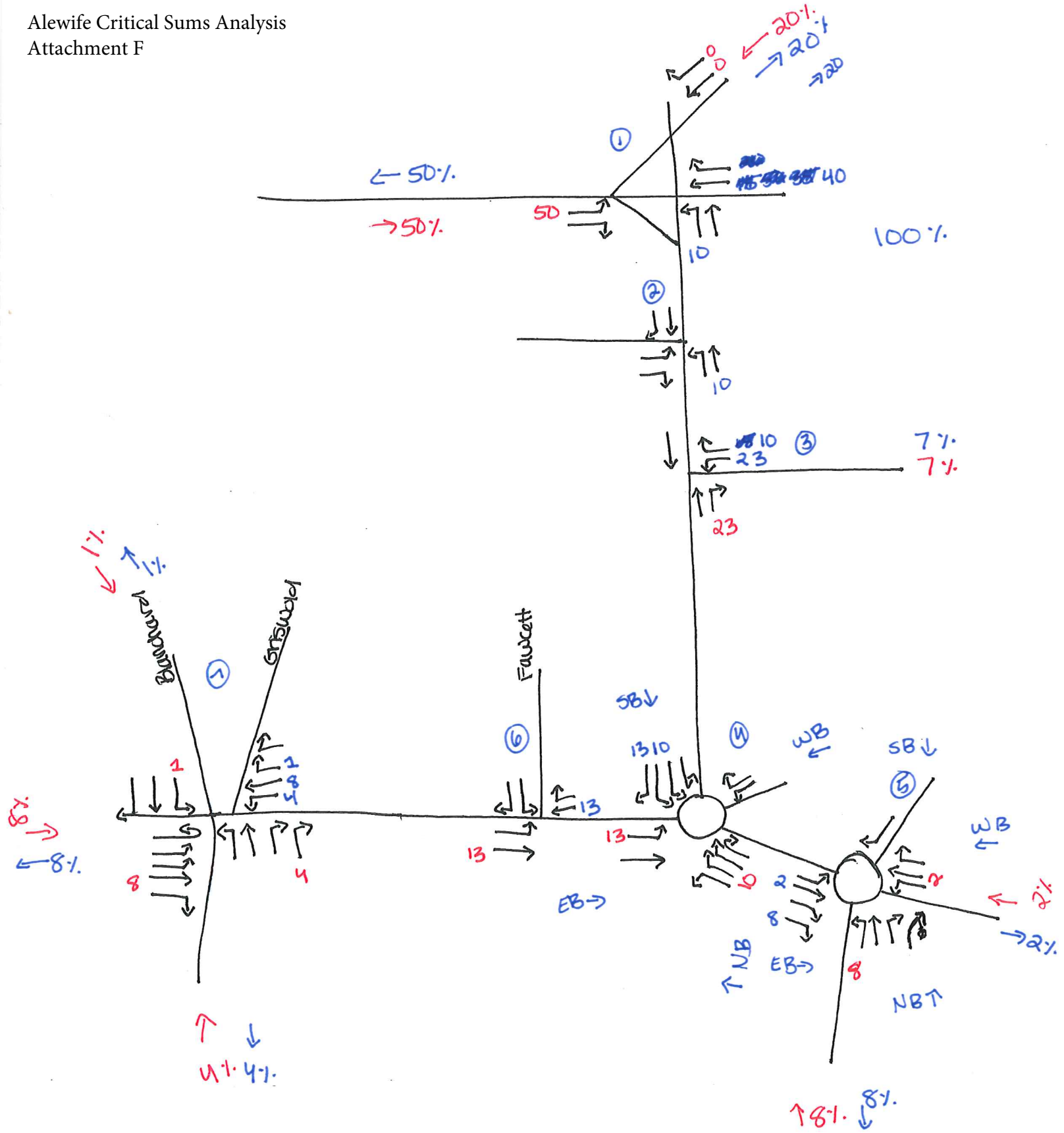
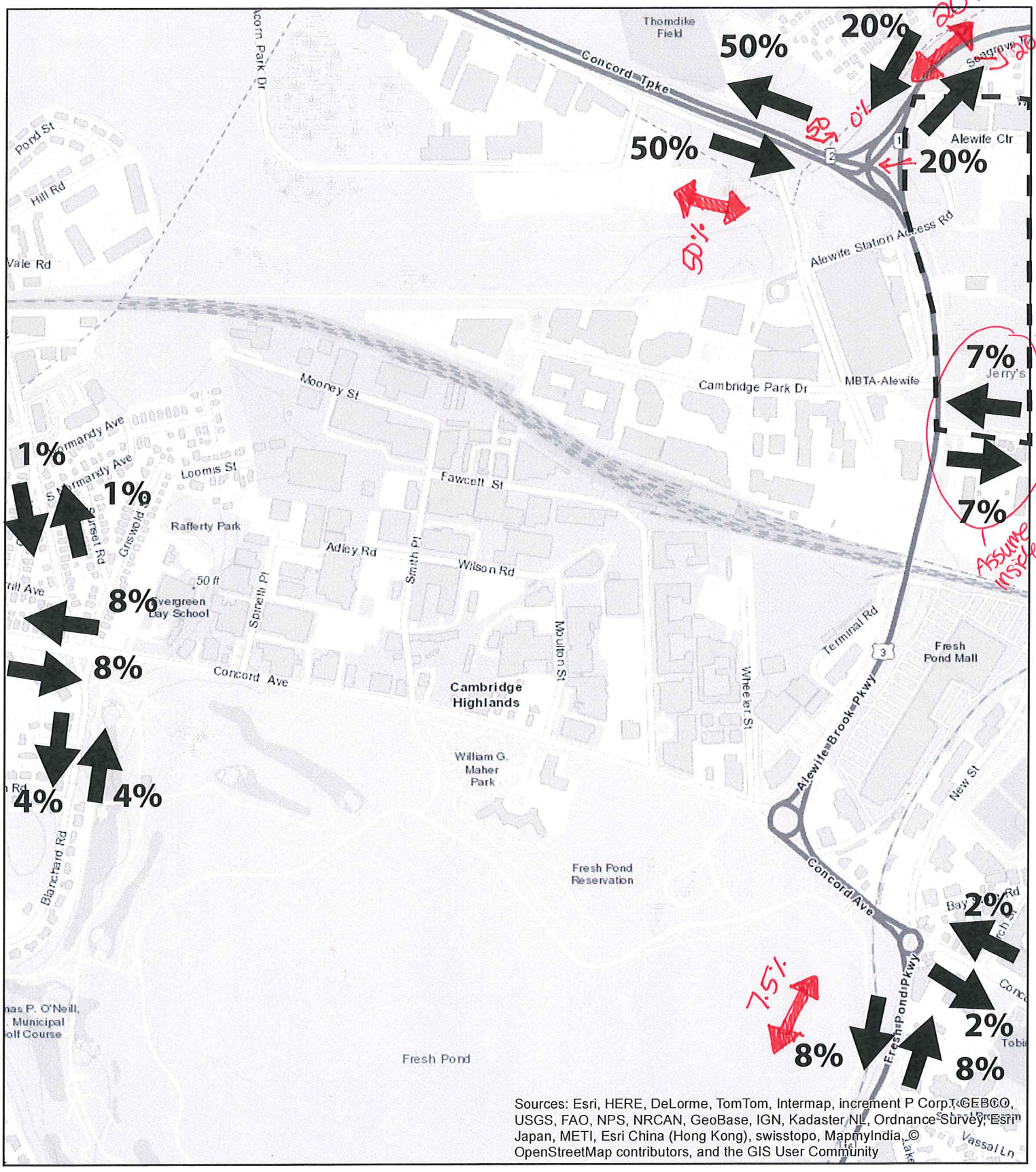
Attachment E: Proposed Trip Distributions
Alewife Critical Sums Analysis
Draft 11-29-17

Alewife Critical Sums Analysis
Attachment F



JERRY'S POND COMMERCIAL



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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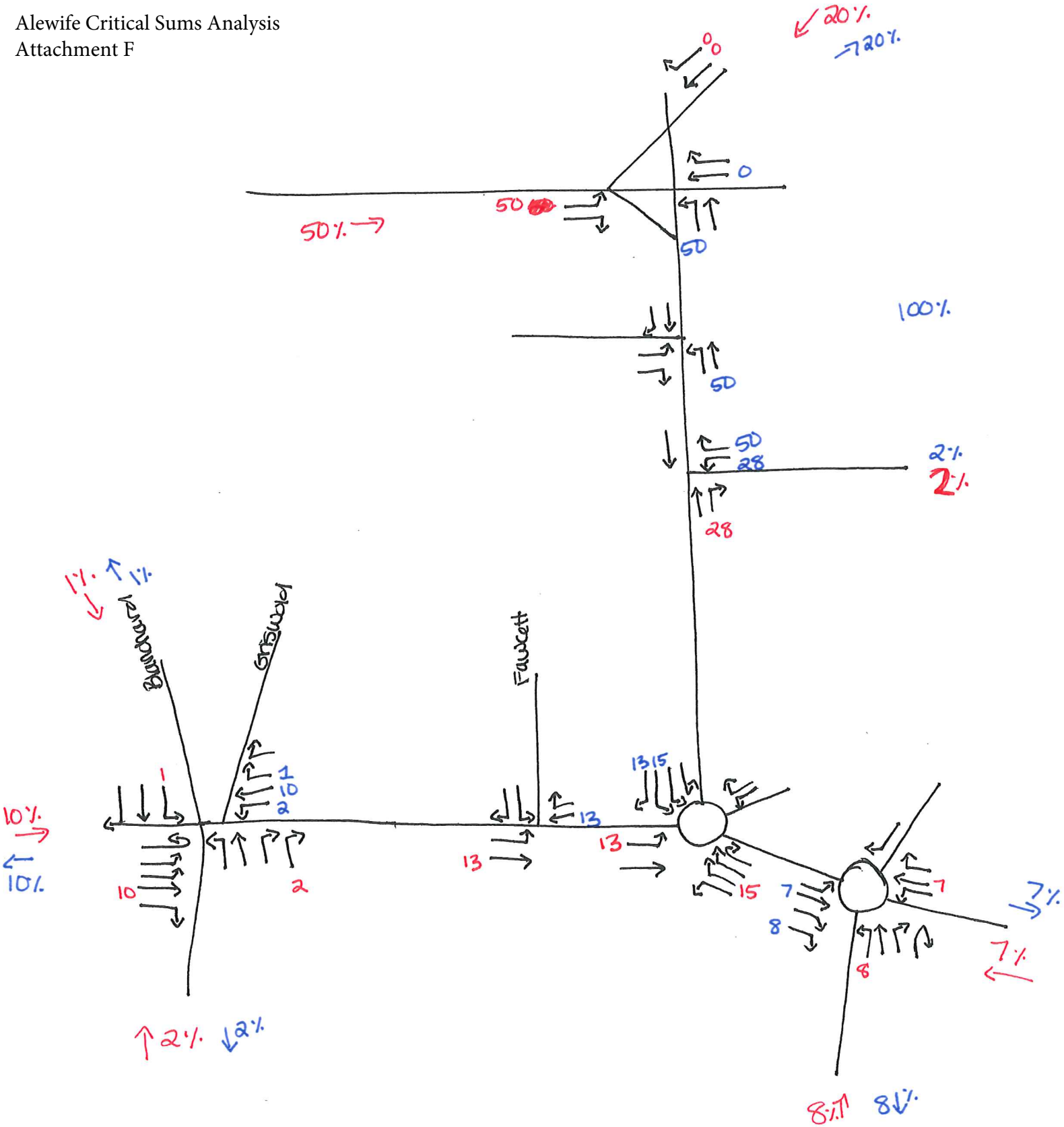

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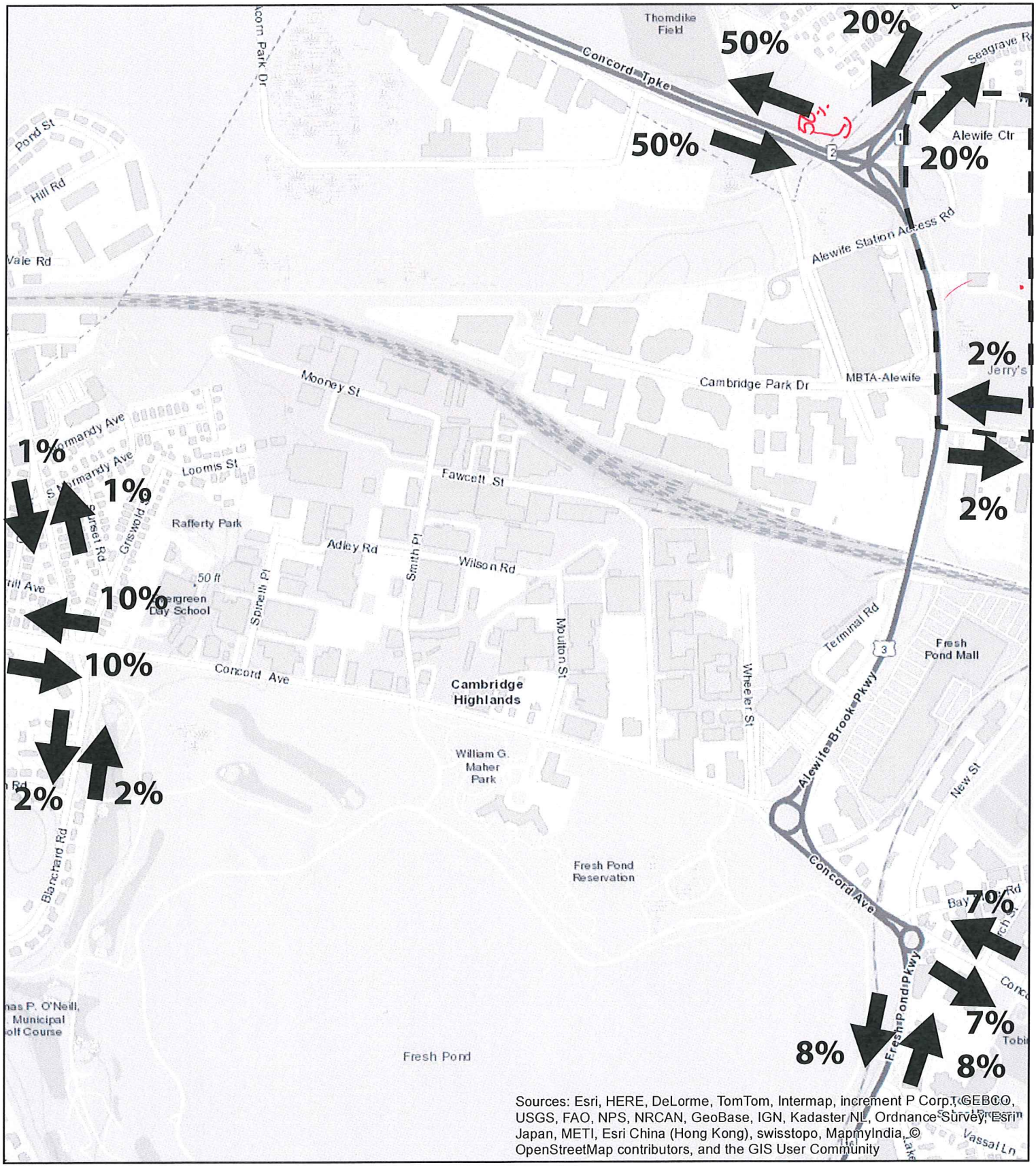

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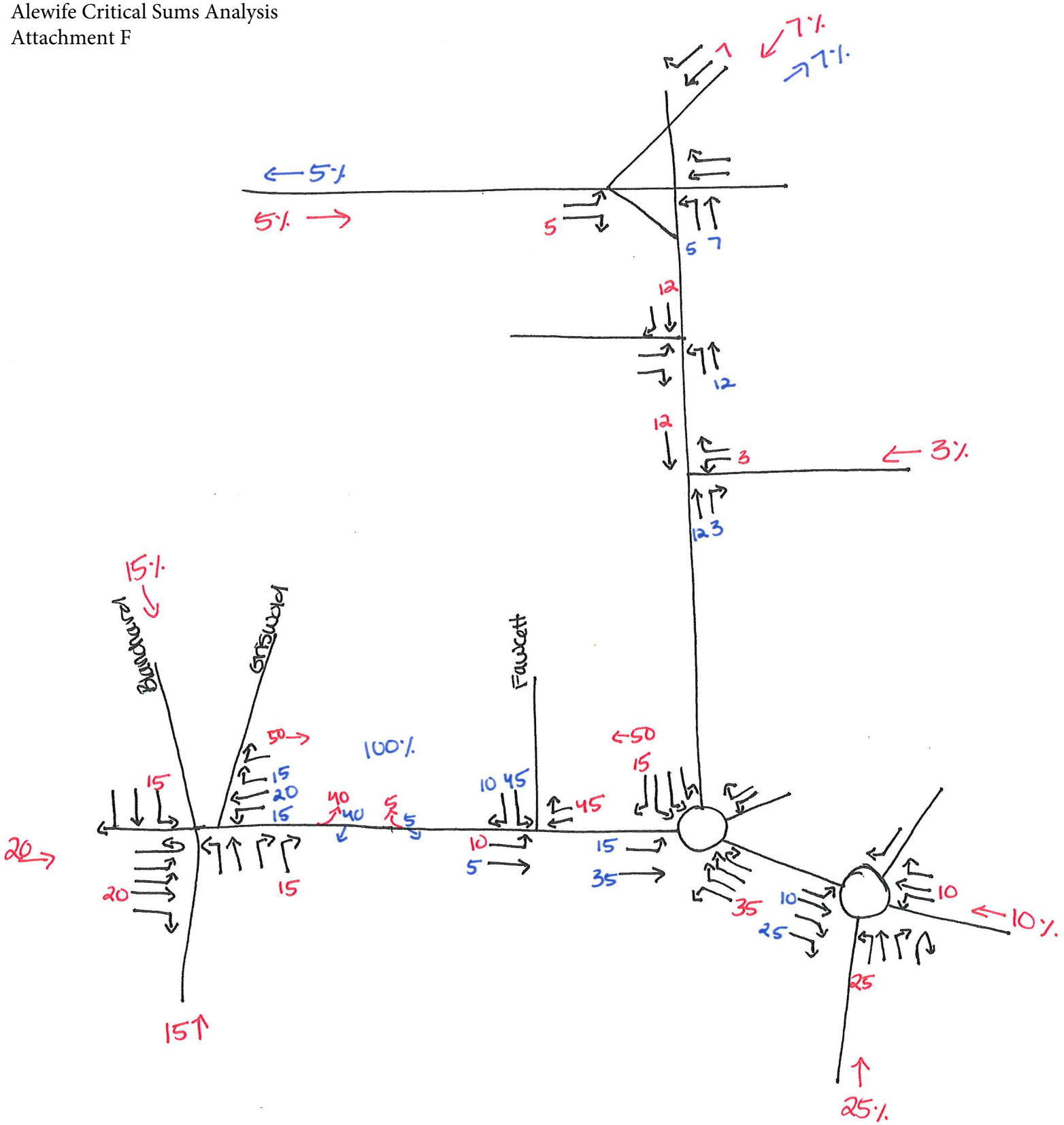

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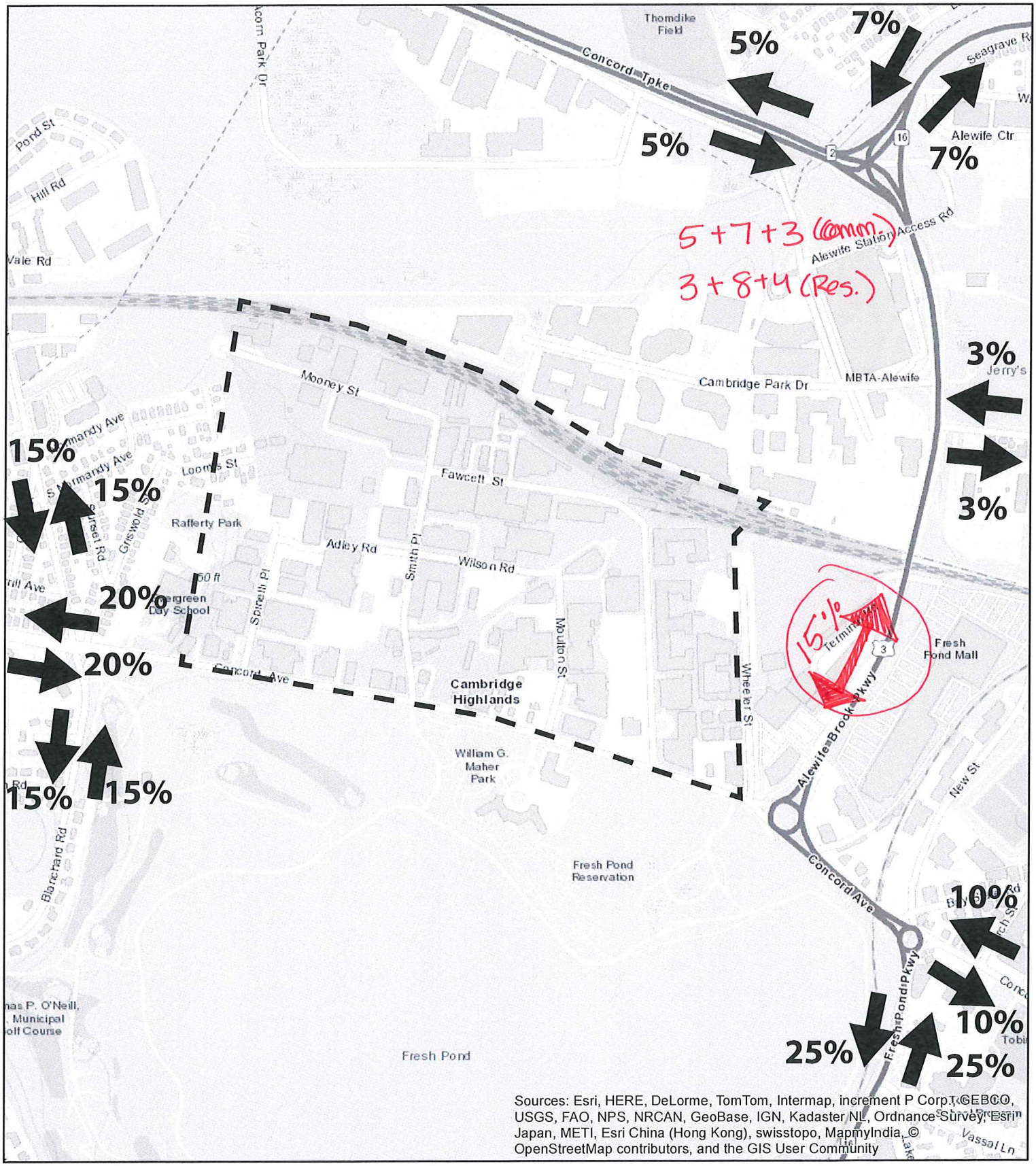

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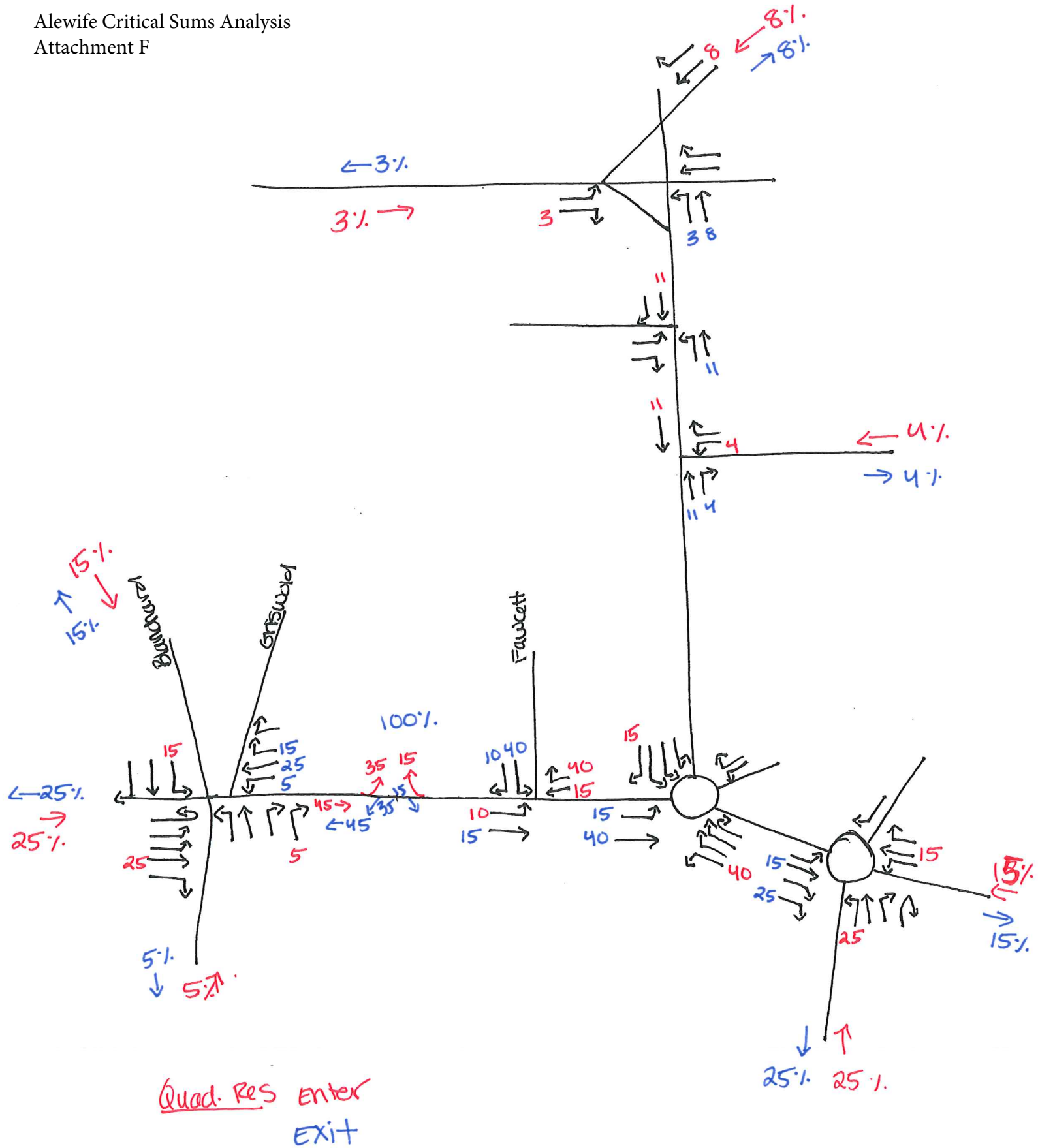

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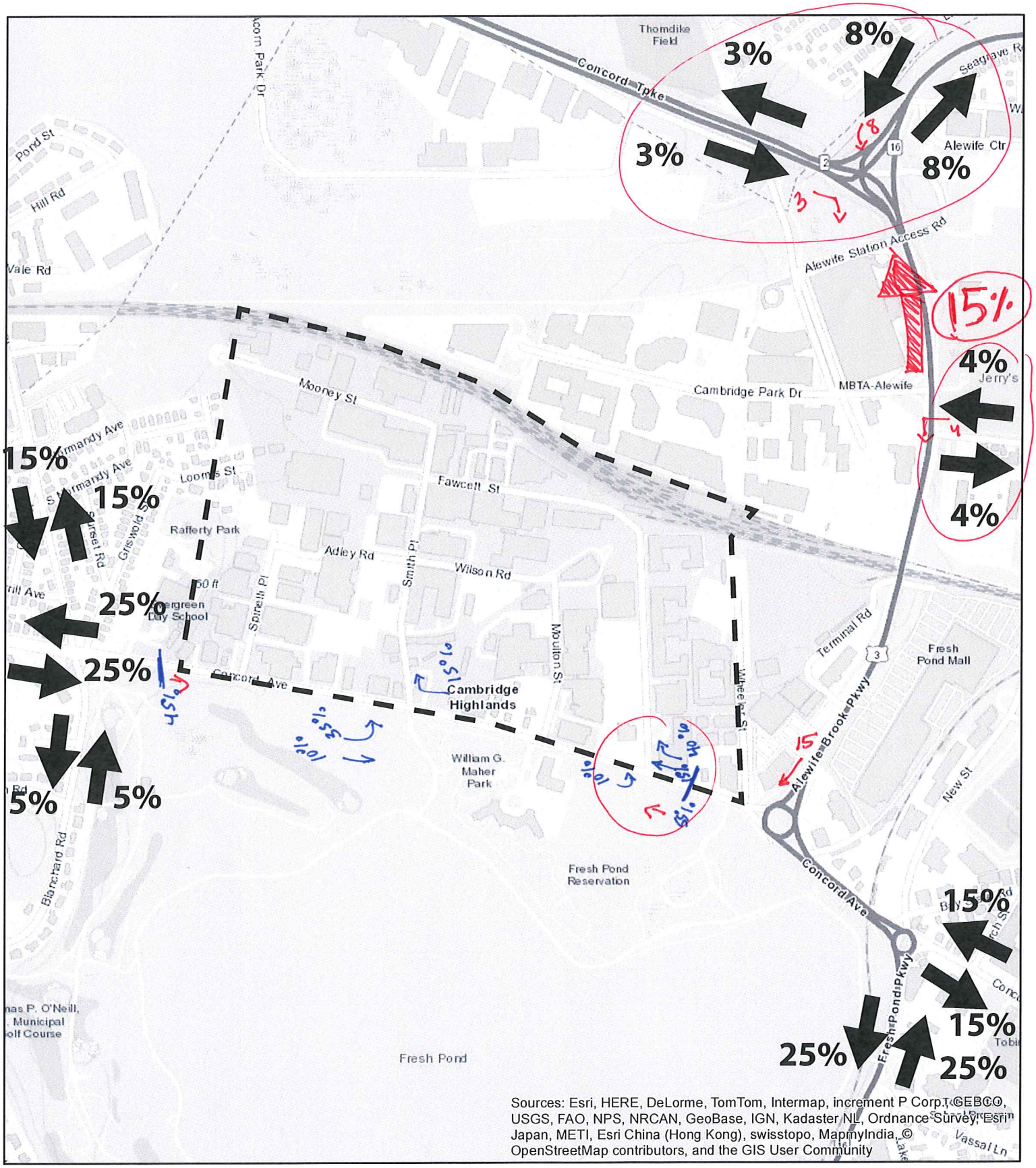

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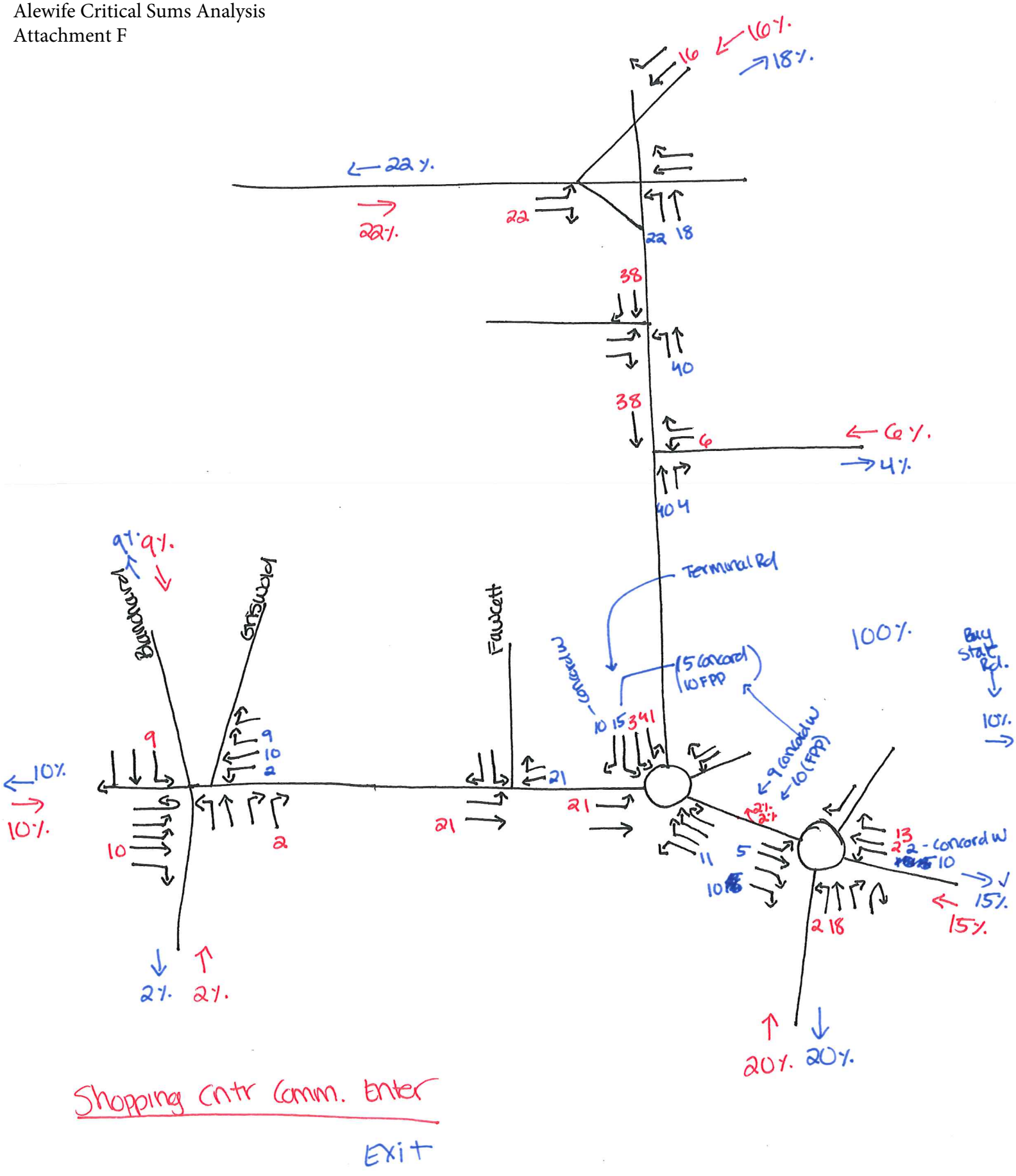

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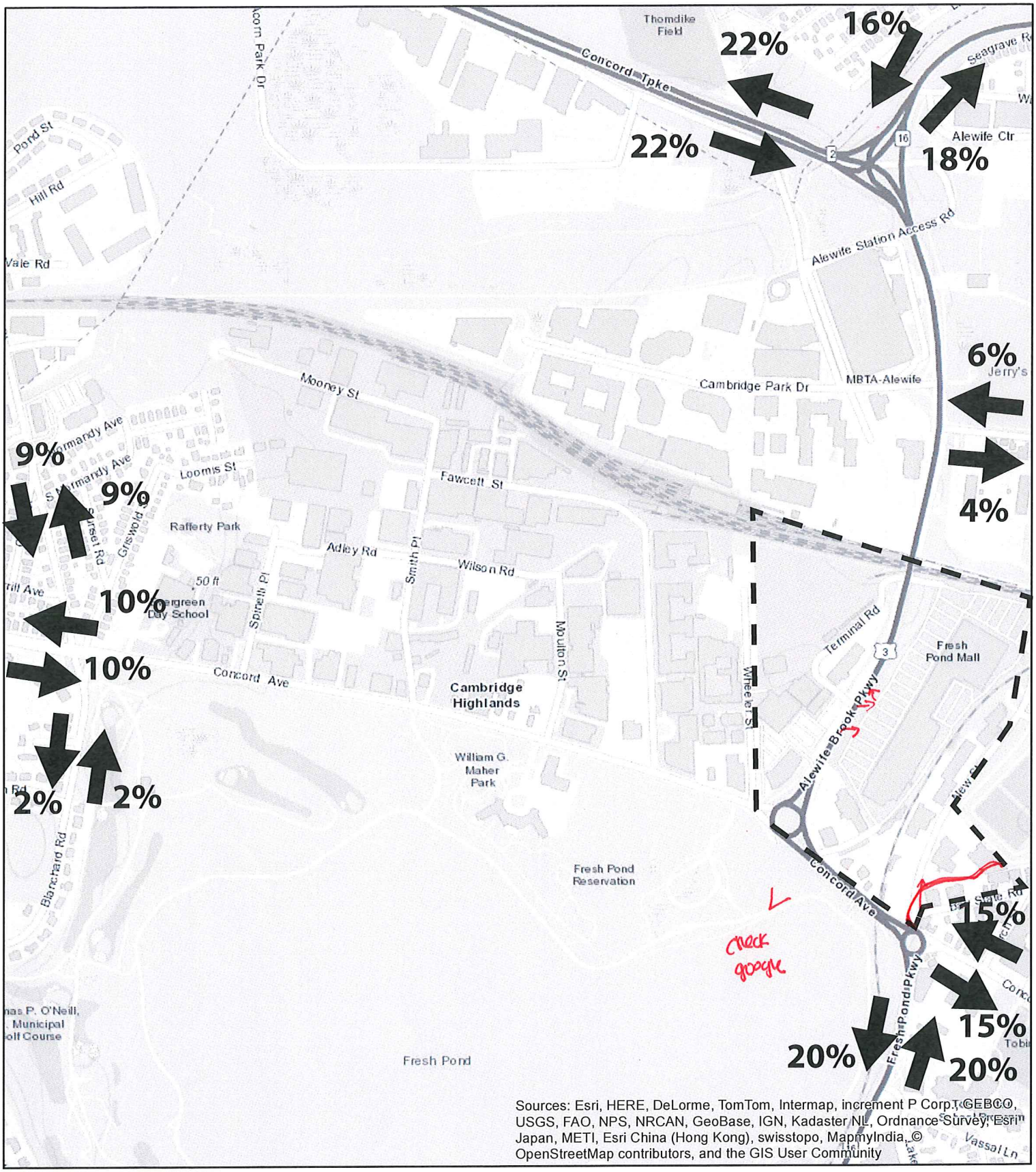

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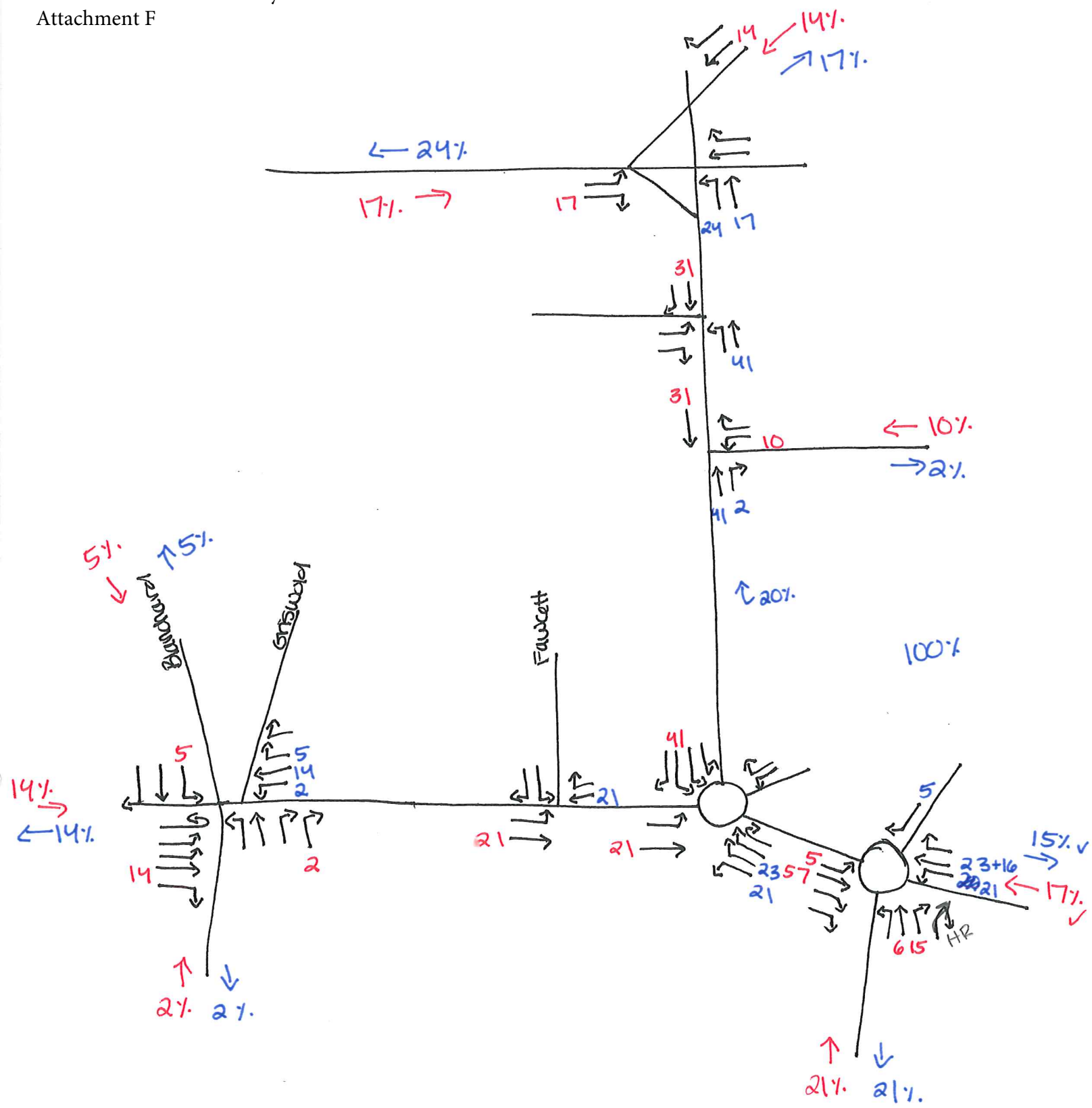

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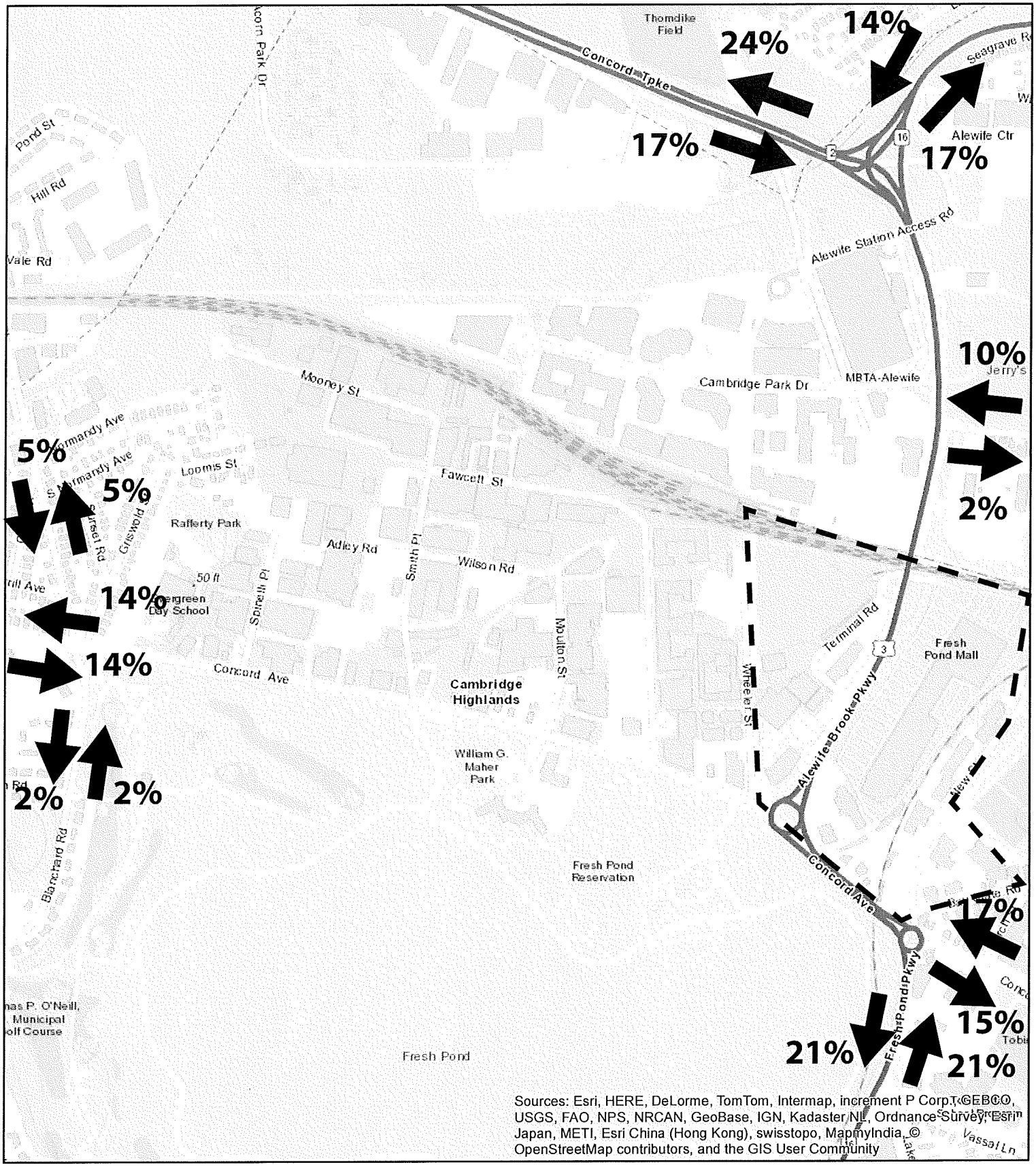

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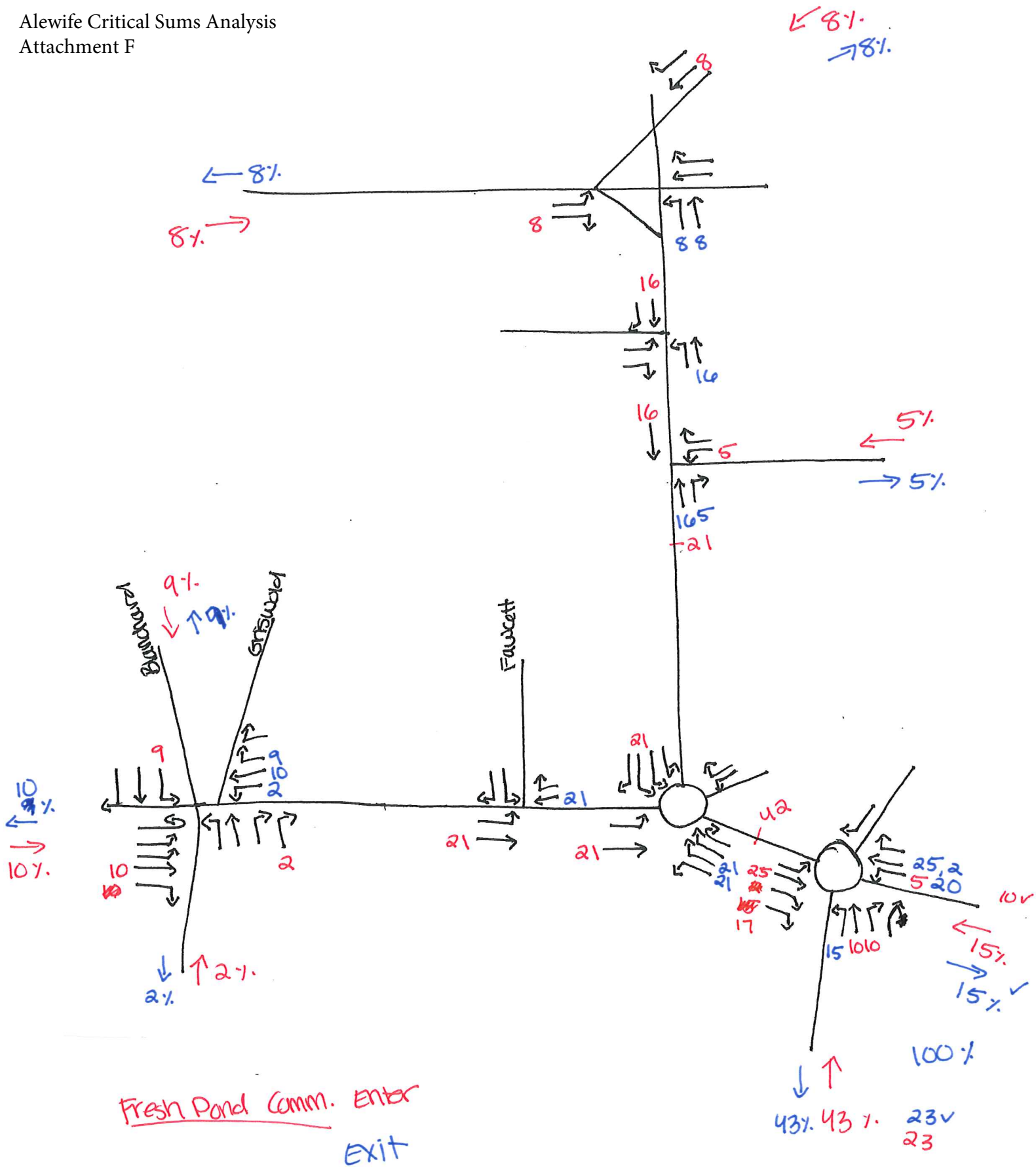

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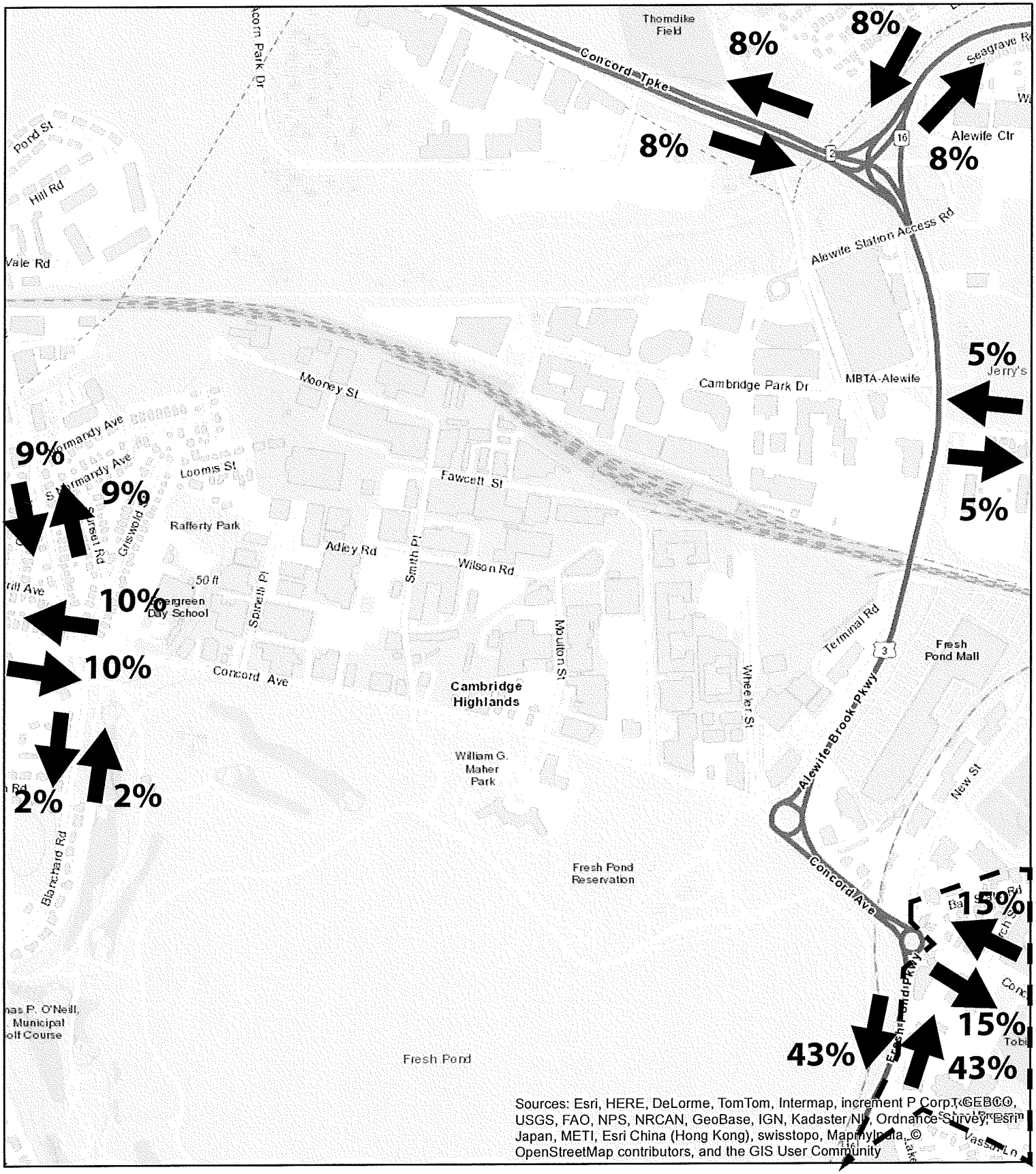

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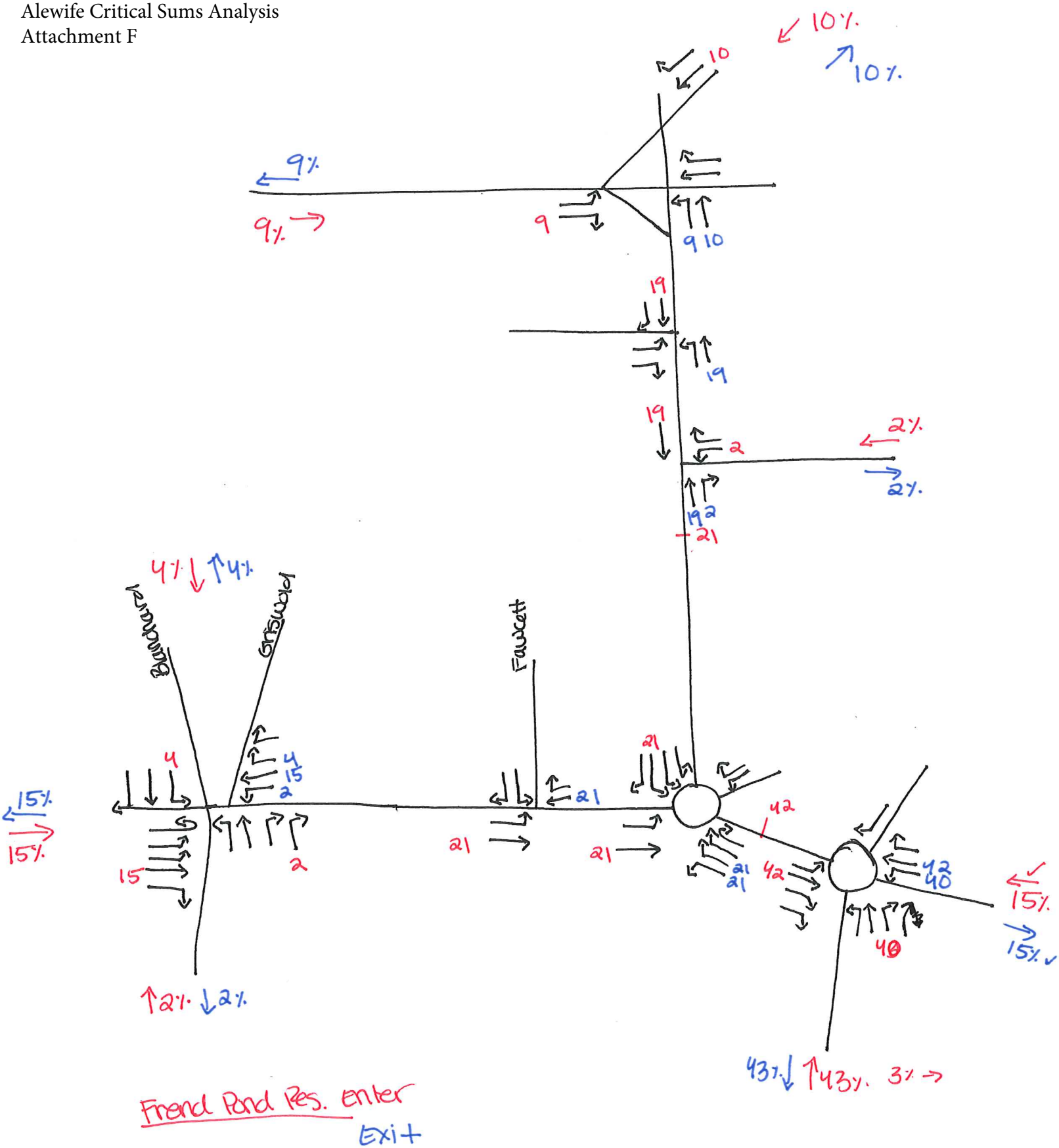

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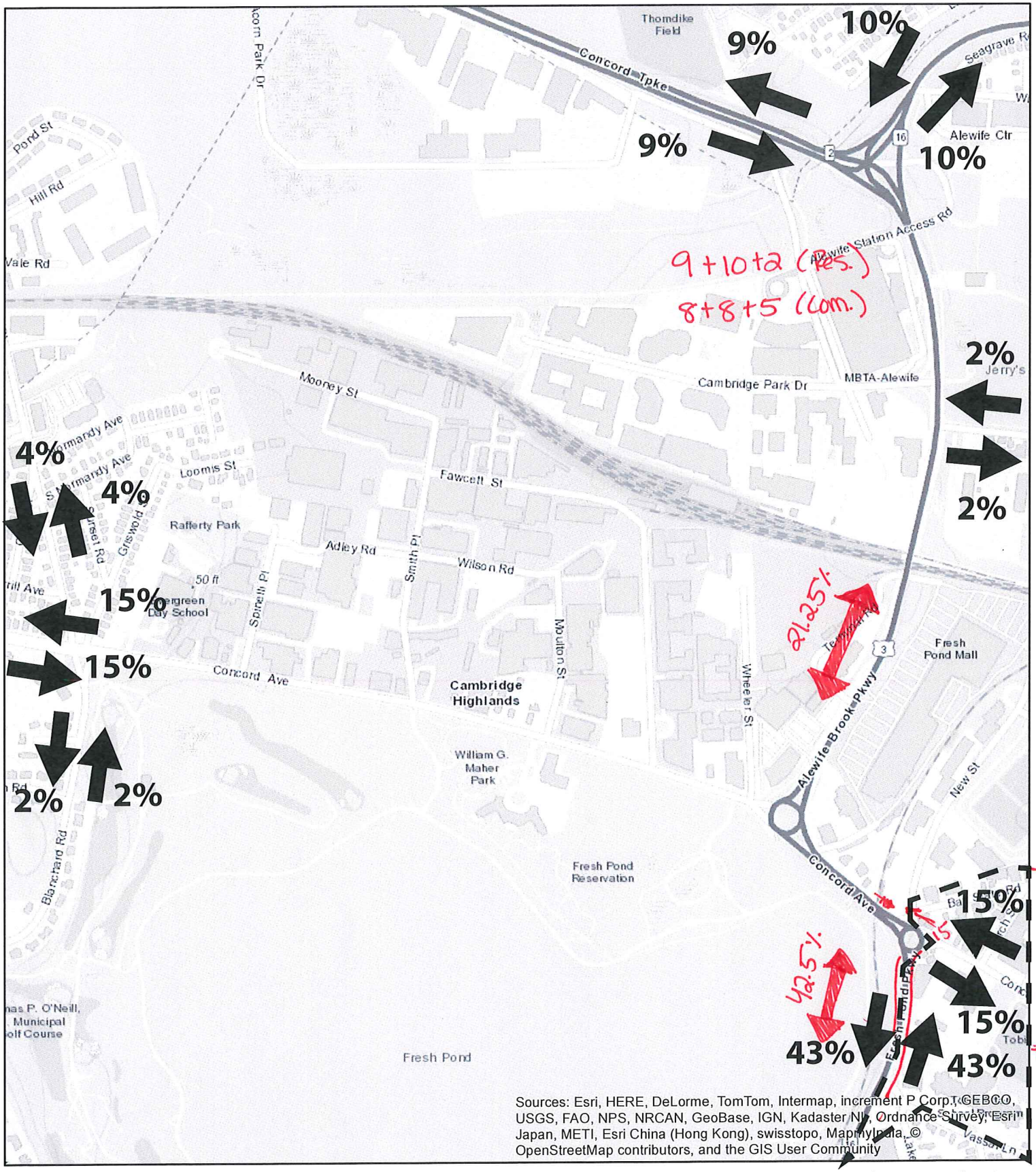

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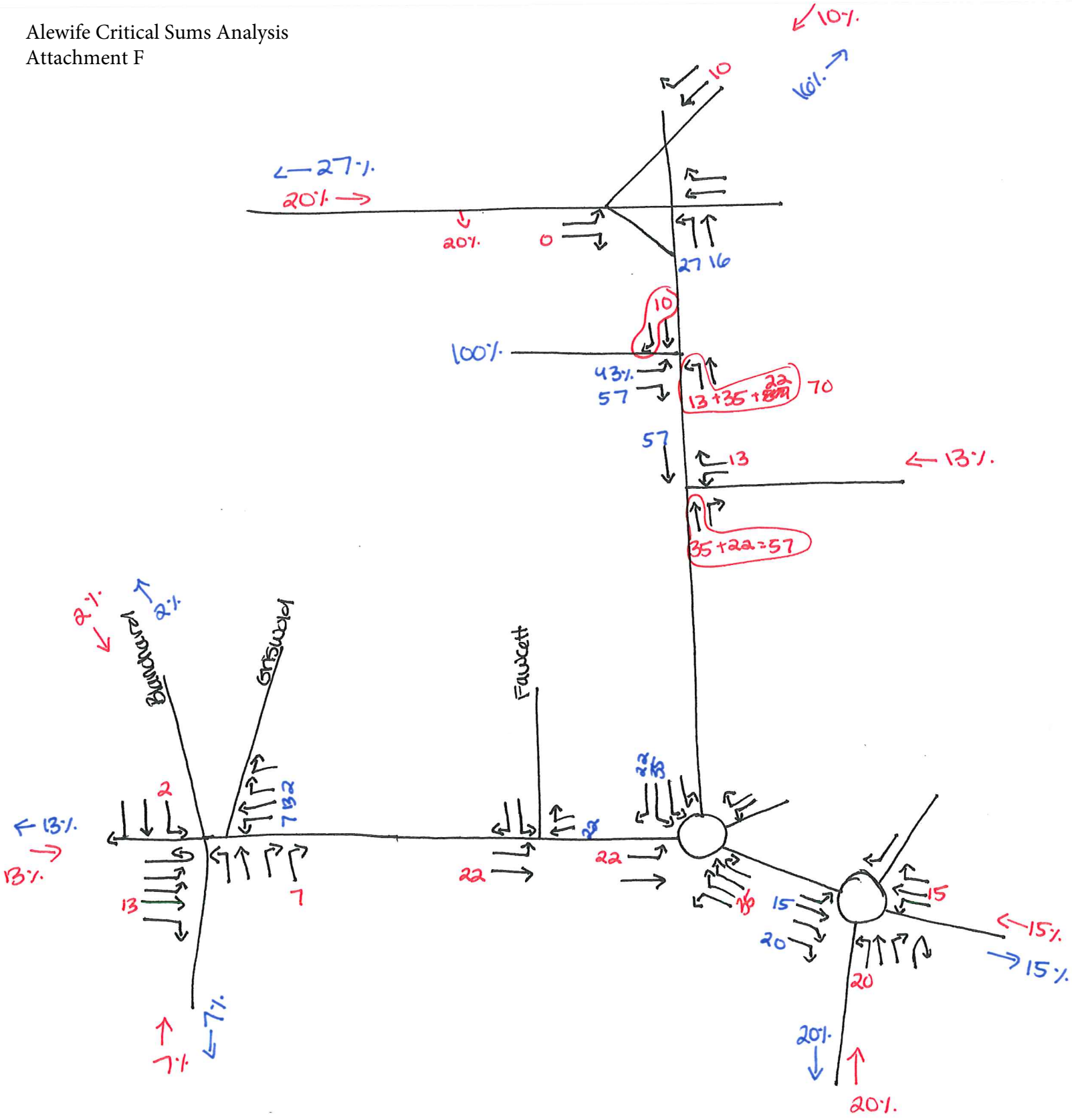

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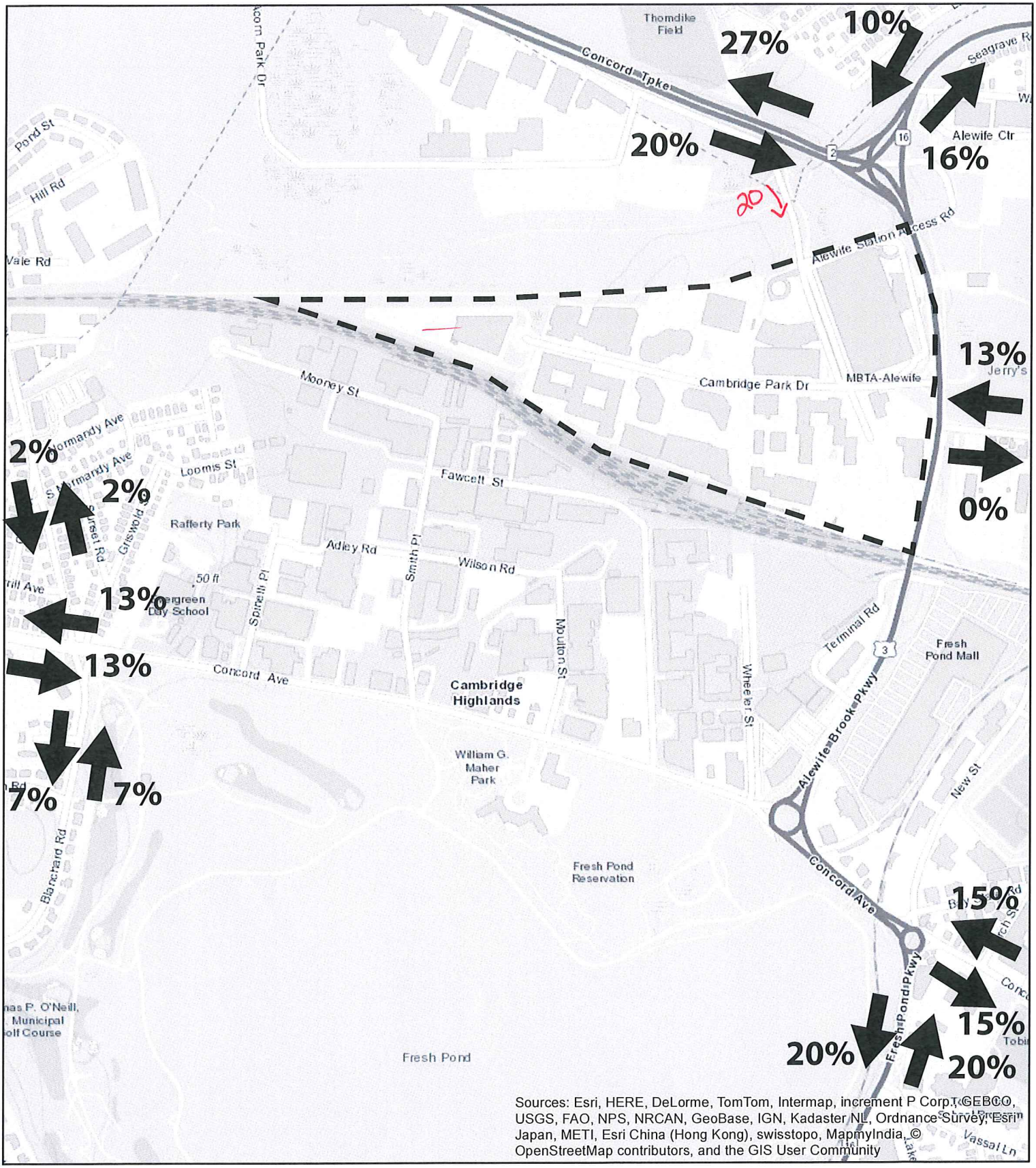
TRIANGLE COMMERCIAL



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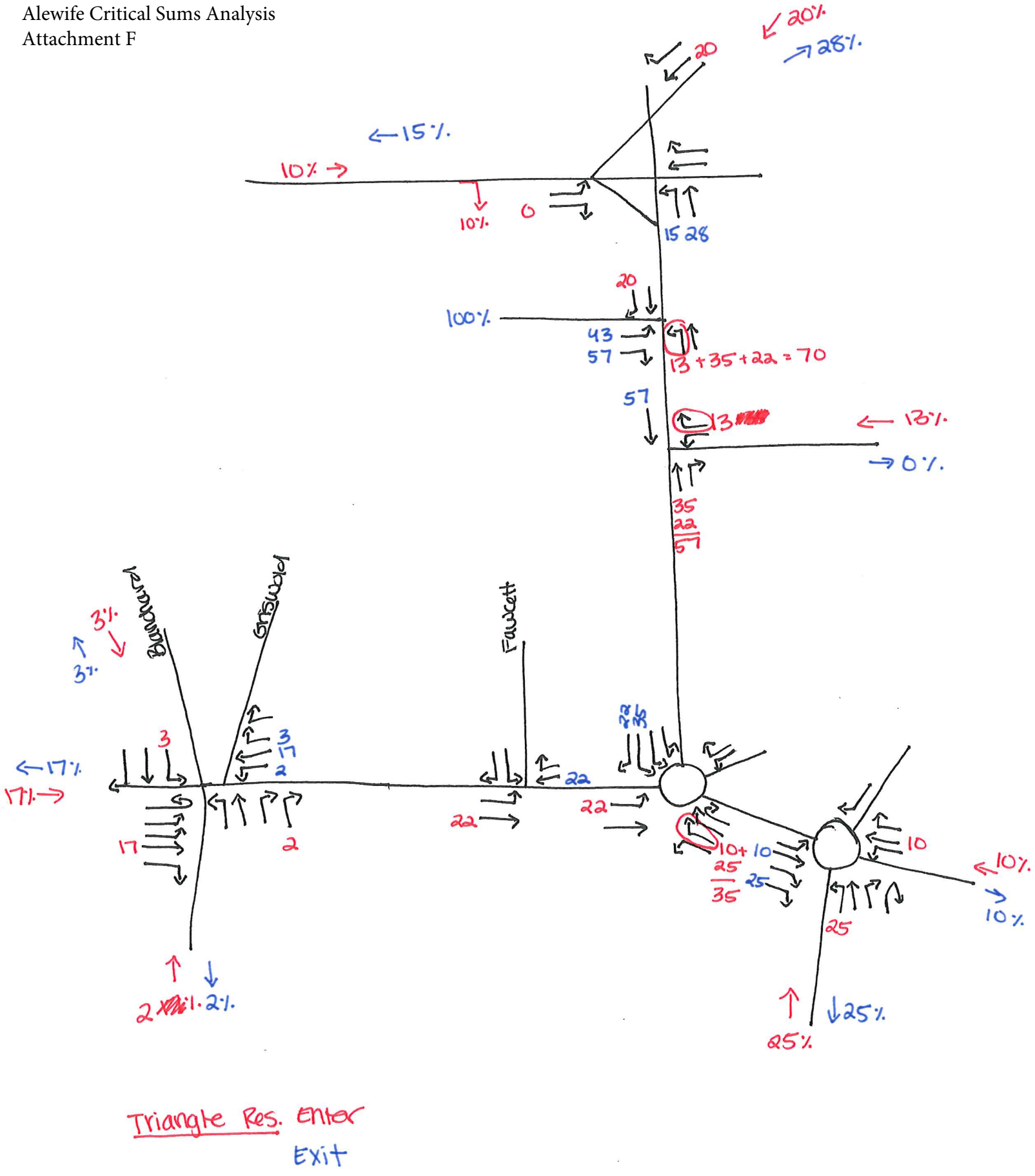

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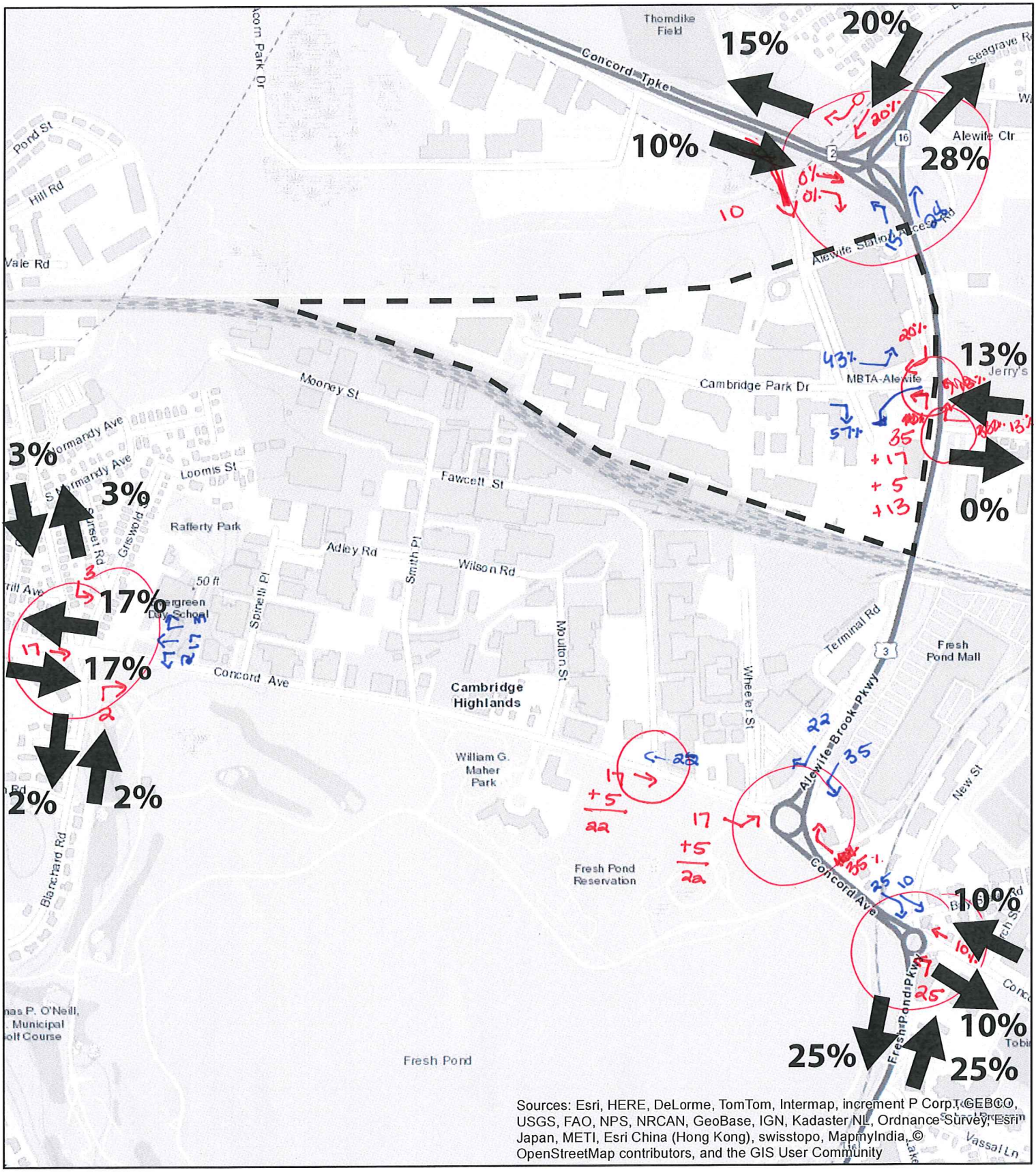

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Alewife Critical Sums Analysis
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Overview of Findings

- Adopting auto mode share goals consistent with the 2005 projections improves critical sums for 4/7 intersections in 2016 and improves 5/7 intersections as compared to 2005 projection in the Concord Alewife Study for proposed zoning in 2024. The Quad sub area remains the main driver of increased volumes along Concord Avenue due to it having the largest amount of new development.
- If a more aggressive reduction in auto mode share is adopted for the Quad, representing the same mode share goals used for the Triangle, the intersections of Fresh Pond Parkway & Concord Avenue and Concord Avenue & Fawcett are projected below the threshold, with Concord Avenue & Blanchard improved but still slightly above the threshold.
- Overall, both 2030 scenarios with further reductions to auto mode share (consistent with 2005 mode shares for the proposed zoning scenario) illustrate an improvement in critical sums from the 2024 projection and from the 2030 existing zoning build out.
    - Alewife Brook Parkway & Route 2 is the exception in the comparison to 2024 proposed zoning, which may be explained by increases in regional traffic.

Mode Share and Sensitivity Analysis
Alewife Critical Sums 2017

	Current Analysis		With 2005 Auto Mode Share Reduction		With Reduction and Triangle Auto Mode Share Applied to Quad	
	Proposed Zoning 2030 Build Out (60%)		Proposed Zoning 2030 Build Out (60%)		Proposed Zoning 2030 Build Out (60%)	
	Total Volume	Critical Sum	Total Volume	Critical Sum	Total Volume	Critical Sum
1. Alewife Brook Parkway & Route 2	5888	1868	5831	1852	5800	1845
2. Alewife Brook Parkway & Cambridge Park Drive	4477	1452	4418	1438	4385	1433
3. Alewife Brook Parkway & Rindge Ave.	4450	1437	4382	1426	4343	1422
4. Alewife Brook Parkway & Concord Ave Rotary	4815	2686	4656	2632	4529	2601
5. Concord Ave & Fresh Pond Parkway Rotary	8172	1852	3936	1807	3936	1774
6. Concord Ave & Fawcett St.	2718	1708	2554	1580	2405	1461
7. Concord Ave & Blanchard Rd.	3100	1651	2962	1587	2836	1532

Threshold for intersections is 1,500 vehicles and for rotaries is 1,800 vehicles in the peak hour. Intersections over the threshold are noted in red.

Methodology described on pages that follow

2005 Mode Share from Concord Alewife Study

- Auto mode share was determined for residential and commercial uses for each sub area
    - Residential based on 2002 PTDM Reports
    - Commercial based on 2000 Census Journey to Work data
- Auto mode share varied by sub area: Triangle, Quad East, Quad West, Fresh Pond Shopping Center (4 sub areas)
- Auto mode share applied to existing zoning scenario assumed some improvement (2.5-5% reduction to SOV share) through application of PTDM data.
- **Auto mode shares assumed for the scenario in 2005 applied to existing zoning in 2005 are greater than those used in 2016.**
- The auto mode share applied to proposed zoning **further reduced the mode shares by 1-8%** (8% in the Quad for commercial) to reflect the opportunity to realize greater mobility and transit accessibility than under existing zoning
    - This would account for the decrease in auto trips under2005 proposed zoning compared to 2005 existing zoning, even in the event of more development (we do not have the square footage of new development in either scenario)
- Vehicle occupancy of 1.1 assumed for all (consistent with 2016)

The following tables summarize the mode shares used in 2005 and 2016 for residential and commercial uses, as well as the reductions applied in 2005 and the resulting mode share if the same reductions are applied in 2016.

Applied Residential Auto Modes Shares in 2005 and 2016 [SOV + HOV]

Sub-area	2005 Res Existing Zoning	Res 2005 Proposed Zoning	2005 Difference	2016 Residential	Res 2016 [with 2005 Difference Applied]
Triangle	42.5%	41.5%	-1	28%	27%
Quad*	See below	See below	See below	30%	27%
Quad East	48.5%	46%	-2.5	N/A	N/A
Quad West	53.5%	50.5%	-3	N/A	N/A
Other**	46%	45%	-1	37%	36%

*Reductions for Quad East and Quad West applied

**Other for 2005 only applies to "Fresh Pond Shopping Center" and in 2016 applies to Jerry's Pond, Fresh Pond, and Shopping Center sub areas.

Applied Commercial Auto Modes Shares in 2005 and 2016 [SOV + HOV]

Sub-area	2005 Comm Existing Zoning	2005 Comm Proposed Zoning	2005 Difference	2016 Commercial	Comm 2016 with 2005 Difference Applied
Triangle	49%	46.5%	-2.5	46%	43.5%
Quad*	See below	See below	See below	58%	50.5%
Quad East	66.5%	59.5%	-7	N/A	N/A
Quad West	76%	68%	-8	N/A	N/A
Other**	57%	51%	-6	48%	42%

*Reductions for Quad East and Quad West applied

**Other for 2005 only applies to "Fresh Pond Shopping Center" and in 2016 applies to Jerry's Pond, Fresh Pond, and Shopping Center sub areas.

Sensitivity Analysis

1. Critical Sums with "2005 Difference" Auto Mode Share Reduction Applied to Scenarios

	Existing Zoning Build Out Comparison					**Proposed Zoning Build Out Comparison**			
	Existing Zoning 2024 Build out (2005 Concord-Alewife Study		Existing Zoning 2030 Build Out (60%)			Proposed Zoning 2024 Build Out (2005 Concord-Alewife Study)		Proposed Zoning 2030 Build Out (60%)	
Intersection	Total Volume	Critical Sum	Total Volume	Critical Sum		Total Volume	Critical Sum	Total Volume	Critical Sum
1. Alewife Brook Parkway & Route 2	4620	1820	5804	1850		4520	1780	5831	1852
2. Alewife Brook Parkway & Cambridge Park Drive	5740	1560	4370	1433		5500	1520	4418	1438*
3. Alewife Brook Parkway & Rindge Ave.	5680	1760	4339	1429		5400	1730	4382	1426*
4. Alewife Brook Parkway & Concord Ave Rotary	5640	2440	4409	2622		5140	2270	4656	2632
5. Concord Ave & Fresh Pond Parkway Rotary	4760	1870	3884	1766		4640	1850	3936	1807*
6. Concord Ave & Fawcett St.	N/A	N/A	2202	1283		N/A	N/A	2554	1580
7. Concord Ave & Blanchard Rd.	2920	1630	2661	1461		2860	1610	2962	1587*

Green = about the same (within 10 cars) or better than existing zoning build out red = above threshold

*2016 improvement in 2030 scenario compared to 2005 projection to 2024

2. Critical Sums with "2005 Difference" Auto Mode Share Reduction Applied to Scenarios – Plus lower Auto Mode Share of Triangle Sub Area Assumed for Quad Sub Area

	Existing Zoning Build Out Comparison					**Proposed Zoning Build Out Comparison**			
	Existing Zoning 2024 Build out (2005 Concord-Alewife Study)		Existing Zoning 2030 Build Out (60%)			Proposed Zoning 2024 Build out (2005 Concord-Alewife Study)		Proposed Zoning 2030 Build Out (60%)	
	Total Volume	Critical Sum	Total Volume	Critical Sum		Total Volume	Critical Sum	Total Volume	Critical Sum
1. Alewife Brook Parkway & Route 2	4620	1820	5804	1850		4520	1780	5800	1845
2. Alewife Brook Parkway & Cambridge Park Drive	5740	1560	4370	1433		5500	1520	4385	1433*
3. Alewife Brook Parkway & Rindge Ave.	5680	1760	4339	1429		5400	1730	4343	1422*
4. Alewife Brook Parkway & Concord Ave Rotary	5640	2440	4409	2622		5140	2270	4529	2601
5. Concord Ave & Fresh Pond Parkway Rotary	4760	1870	3884	1766		4640	1850	3936	1774*
6. Concord Ave & Fawcett St.	N/A	N/A	2202	1283		N/A	N/A	2405	1461
7. Concord Ave & Blanchard Rd.	2920	1630	2661	1461		2860	1610	2836	1532*

Green = the same (within 10 cars) or better than existing zoning build out red = above threshold

*2016 improvement in 2030 scenario compared to 2005 projection to 2024