# Appendix 3 Supplemental Indicator Methodology

Conflating NPMRDS Speed Data to Project Lines

As Figure 1 shows, the NPMRDS traffic speed data are provided on segments, called TMCs (traffic message channels) whose end points generally will not line up with a project's extents. Some shorter projects will be contained entirely within a TMC, but in most cases a project will span multiple TMCs. To reconcile these geometry differences, the PPA tool does the following:

1. Identify which TMCs overlap the project extent, represented by the blue segments in Figure 1

Figure 1 TMC Lines Vs. Sample Project Line
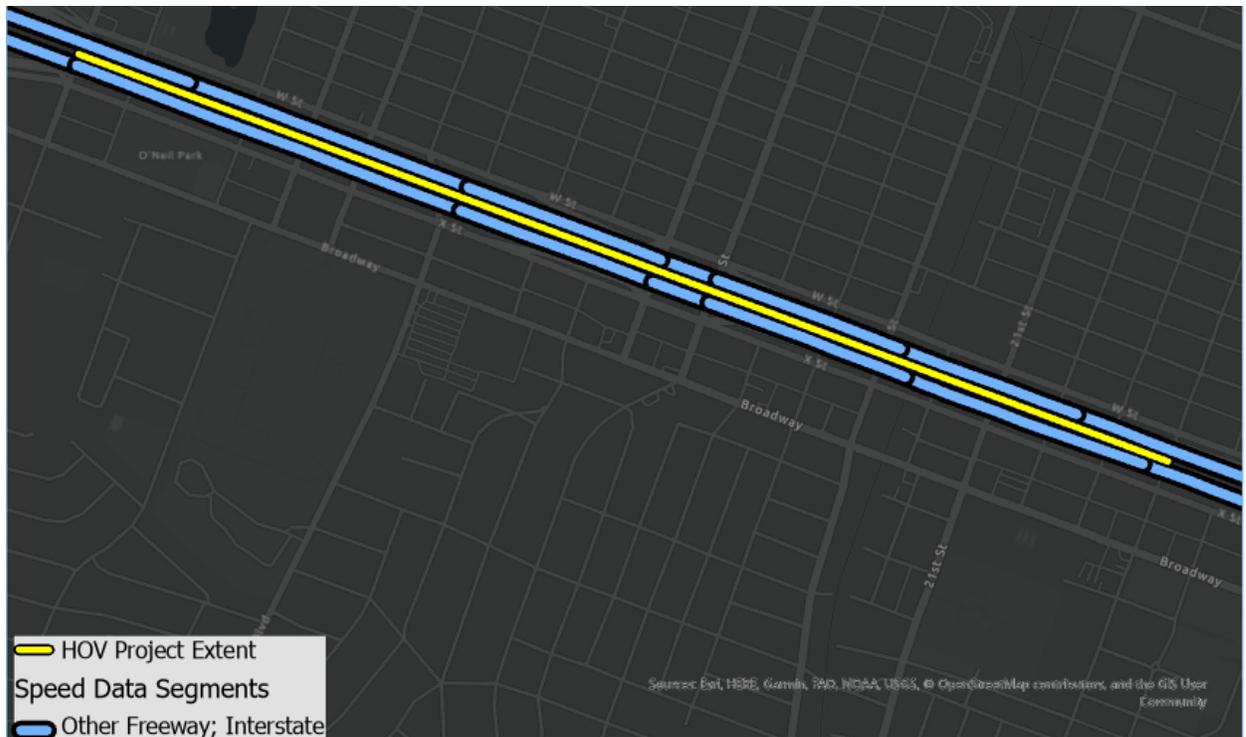
2. For each direction of the project (e.g. east and west), the tool breaks up the project line into pieces whose extents either match up with the TMCs or are contained within a TMC. If a project line is short and within a single TMC, the project line is not split up. This splitting allows a GIS spatial join to occur, in which each TMC's data gets copied over to the piece of the project line that overlaps it. Figure XX shows the result of this splitting and spatial join, with the westbound speed being copied over from the blue project line onto the corresponding project piece, and the distance representing the length of that project piece.

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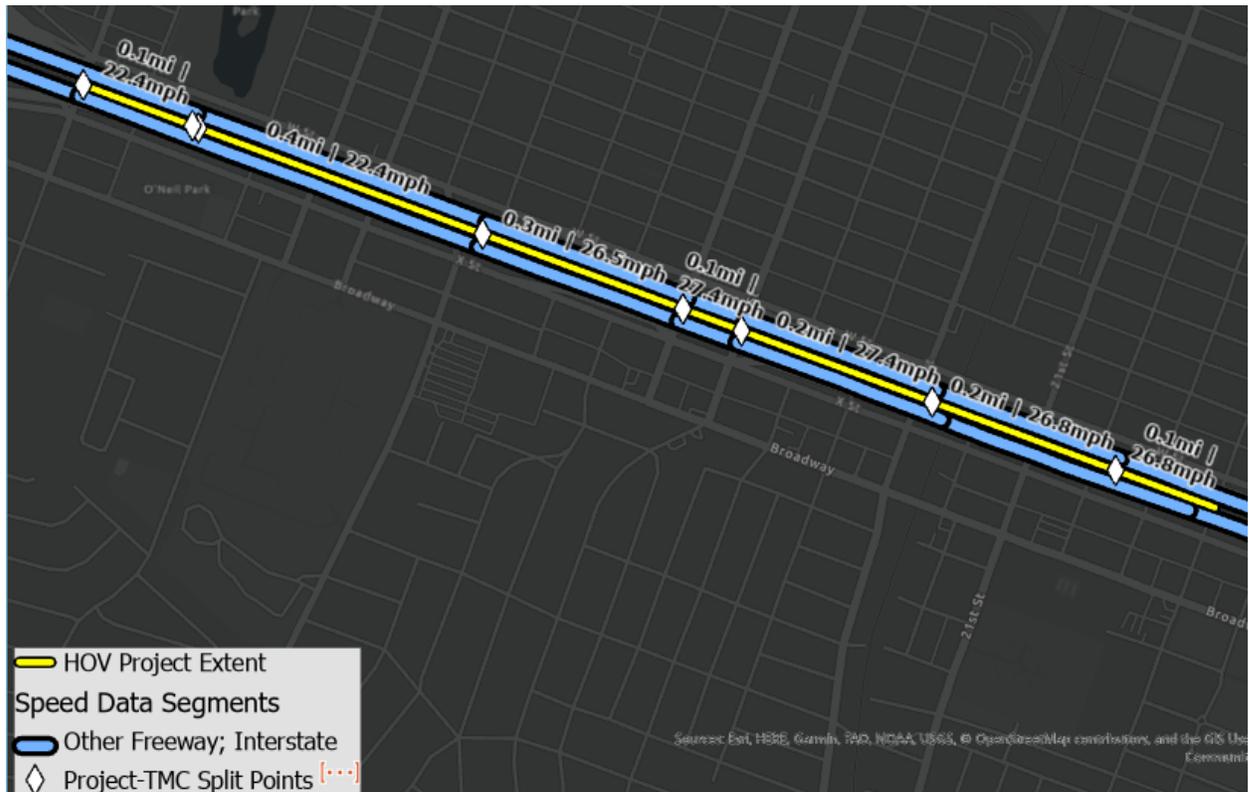
3. After this splitting and spatial joining process, each project piece has the following data:
    a. Free-flow and congested speeds, from the TMC
    b. Level of travel time reliability (LOTTR) also from the TMC
    c. Length of the project piece, in miles

The next step is to aggregate these values into a single number that represents, for example, the average representative speed for the entire project extent, or its overall level of travel time reliability.

The tool calculates the project's average speeds (both the free-flow and congested speeds) through the following steps, which are summarized in the equation below

1. For each piece, get the inverse of its speed, or "hours per mile", and multiply this hours-per-mile rate by the piece's distance in miles. This returns the travel time, in hours, to traverse the piece.
2. Sum the results from step 1 for all pieces, which will give you the total travel time, in hours, to traverse the entire project segment.
3. Divide the total project length, in miles, by the total travel time, in hours, which returns the average project speed, in miles per hour.

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$$S_P = \frac{\sum D_i}{\sum \left(\frac{1}{S_i}\right) * D_i}$$

Where:

- S_P = Average speed, in miles per hour, for entire project extent
- S_i = Speed, in miles per hour, of project piece i
- D_i = Distance, in miles, of project piece i

To calculate the average LOTTR, the tool takes a simpler distance-weighted average:

$$R_P = \frac{\sum R_i * D_i}{\sum D_i}$$

Where:

- R_P = Distance-weighted travel time reliability for entire project extent
- R_i = travel time reliability on project piece i
- D_i = Distance, in miles, of project piece i

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Calculating Project-Level Accessibility

Accessibility data come from Sugar Access and are provided in census block geographies, which you can view in the map layers of the tool interface. Given that projects are lines, and most projects span multiple census blocks, the tool must get an "average" level of accessibility for the project line.

To calculate the average accessibility, the tool does the following, for each accessibility metric (e.g. walk distance to schools, bike distance to jobs, etc.):

1. Select all census blocks within 300 feet of the project line, or all census blocks that are within roughly half a physical, street block of the project line.
2. Get the population-weighted average accessibility of all of the selected census blocks, using the formula below:

$$A_{dm} = \frac{\sum A_{idm} * P_i}{\sum P_i}$$

Where:

- A_{dm} = Population-weighted accessibility to destination type "d" using mode "m"
- A_{idm} = Accessibility to destination type "d" from census block "i" using mode "m"
- P_i = Population of census block "i"

The population-weighted accessibility gives a sense of how accessible something is for an average person living in a census block within 300 feet of the project line, e.g., if a PPA report says accessibility to schools in a 30-minute bicycle ride is 7.5, it means the average person living near the project line can access 7.5 schools within a 30-minute bicycle ride.

Accessibility for People Environmental Justice Areas

Within census blocks near the project line, designated Environmental Justice (EJ) areas may be concentrated within one part of the project, and therefore the average accessibility for the entire project may be different than the accessibility for the parts of the project that are within EJ areas. To account for this, the tool has a separate indicator, under the Social Equity performance outcome, for EJ-population weighted accessibility.

The formula to calculate EJ-population-weighted accessibility is essentially the same as the formula above used for all-project accessibility, except instead of population P_i representing the whole population, it only includes populations within EJ areas.

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Complete Streets Index Methodology

The complete streets index (CSI) aims to evaluate a street's potential for being a "complete street" that provides a comfortable environment and effective means of mobility for users of all modes. The CSI formula, provided below, is based on the following assumptions:

The following factors *increase* the CSI:
- A higher density of school students, since students are more likely to walk to school, younger children are more vulnerable to safety risks posed by auto-oriented streets, and schools tend to generate large amounts of foot traffic on school days.
- More transit service, which results in more pedestrians since most transit trips include a walking trip to access the stop.
- Higher density of jobs and/or housing, which means a higher number of origins and destinations nearby and thus a higher potential for investments in bike and pedestrian infrastructure to shift short driving trips to being made by biking or walking
- Slower posted speed limits, since slower speeds reduce the incidence of fatal collisions and create a more comfortable biking and walking environment.

In contrast, once a project's posted speed limit rises above 40mph, higher speeds will *decrease* a project's CSI. The policy assumption behind this is that high-speed roads are inherently less compatible with having non-auto modes nearby or sharing the same space due to a less comfortable walking/biking environment and higher risk of fatal collisions at high speeds.

$$CSI = (D_S + D_T + D_J + D_D) * (1 - (S_P - S_T)*P)$$

Where:
- CSI = Complete Street Index
- D_S = students per acre (at school location, not home location)
- D_T = transit vehicle stops per acre per day
- D_J = jobs per acre
- D_D = dwelling units per acre
- S_P = Posted speed limit
- S_T = Threshold speed at which the speed penalty factor begins affecting the index value. For PPA2 this is 40mph.
- P = Speed penalty factor, set to 0.04 for PPA2

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SACOG Land Use Diversity Index

The land use diversity index measures an area's ratio of households compared to neighborhood amenities including K-12 enrollment, park acreage, and employment in the retail, service and food sectors, which are presented in the "land use factor" column of Table 1. A score of 1 indicates an 'ideal' ratio of households to amenities that people use on a daily basis like shopping, restaurants, schools, etc. Areas with a mix of land uses increase the likelihood that vehicle trips are shorter per capita and can also be served by active transportation modes. The land use diversity uses a buffer of 1 mile, instead of the shorter 0.5 mile buffer used in other buffer metrics.

The "ideal" ratio of households to amenities is based on the ratio of households to amenities for the entire SACOG region, shown in the "regional ratio" column of Table 1. The assumption is that if the ratio of households to amenities within a one-mile buffer of a project matched that of the region as a whole, then those households would live within an easily walkable or bikeable distance to those amenities and therefore drive less to access them, or at least drive a shorter distance. Conversely, it also means that those amenities' users are more likely to access the amenities by either walking, biking, or driving a shorter distance.

The "weight" column captures which, in professional judgement, are the land use factors that have the most potential to reduce trip lengths if people live near them. For example, people will tend to go to the schools and retail stores closest to their homes, so if they have schools and retail within an easily bikeable or walkable distance from their homes, they are likely to patronize those facilities and thus be more likely to walk, bike, or at least have a shorter driving distance. Conversely, jobs are given a relatively low weight because people have far less choice over where they work than where they shop and are not as likely to choose a job just because it's the closest to their homes.

Table 1 – Land Use Diversity Index input factors

Land Use Factor	Regional ratio (hh/factor)	Weight
K-12 School Enrollment	0.39	0.2
Total Jobs	1.09	0.05
Retail Jobs	0.15	0.4
Service Jobs	0.13	0.1
Food/Restaurant Jobs	0.10	0.2
Acres of Parks	0.27	0.05

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The steps to calculate the land use diversity index for a project are the following:

1. From parcel-level data within one mile of the project line, get the total number of households and total numbers for each of the land use factors listed in Table 1
2. For each land use factor, calculate the ratio of households to that factor (e.g. households per job, households per k-12 student, etc.)
3. For each of these ratios:
   a. If the ratio value is less than the regional factor, divide the ratio value by the regional factor. If the ratio value is greater than or equal to the regional factor value, divide the regional factor value by the ratio.
   b. Example: if regionally there are 0.39 households per student but the project has 0.24 households per student, divide 0.24/0.39; if the project had 0.56 households per student, divide 0.39/0.56
   c. The resulting number for each factor is called the "balance ratio", i.e., how well the project's ratio compares to the ideal, regional ratio.
4. Multiply each of the balance ratios by the weights specified in Table 1. The result from each multiplication is the "weighted balance ratio".
5. Sum up the weighted balance ratios. This is the land use diversity index value.

An important aspect of the land use diversity index is that it works both ways, i.e., a project that has mostly homes around it and few nearby amenities will score as low as a project that has many jobs and/or services around it but few households. In both of these scenarios, the land use mix implies that there are not many households living near destinations the people use on a regular basis, and therefore the people or facilities occupying the land will generate more and longer driving trips due to greater travel distances.

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