CHARLOTTESVILLE-ALBEMARLE MPO PERFORMANCE-BASED PLANNING PROCESS

Logo of recipient or name of recipient in reverse (white) text

Prepared for Charlottesville-Albemarle MPO

DRAFT JANUARY 2023

CHARLOTTESVILLE-ALBEMARLE MPO PERFORMANCE-BASED PLANNING PROCESS

Process for Identification of Needs and Process for Project Prioritization

ACKNOWLEDGMENTS

Sandy Shackleford, Director of Planning and Transportation, Thomas Jefferson PDC
Christine Jacobs, Executive Director, Thomas Jefferson PDC

ABOUT GAP-TA

Visit vtrans.org/about/GAP-TA for information about the Growth and Accessibility Planning Technical Assistance program.
OIPI will provide a blurb describing the GAP-TA program

CONTACT INFORMATION

Sandy Shackleford, Thomas Jefferson PDC Director of Planning and Transportation
(434) 422-4823
sshackelford@tjpdc.org
401 East Water Street
Charlottesville, VA 22902

CONTENTS

LIST OF FIGURES, TABLES, ETC.

GLOSSARY OR LIST OF ACRONYMS

CTB	Glossary item or acronym
DRPT	
EEA	Equity Emphasis Area
FIPS	Federal Information Processing Standards
GAP	Growth and Accessibility Program
GIS	Geographic Information System
ITRM	
LRTP	Long Range Transportation Plan
MPO	Metropolitan Planning Organization
NPMRDS	National Performange Management Research Data Set
OIPI	Office of Intermodal Planning and Investment
PDC	Planning District Commission
SDE	
SYIP	Six-Year Improvement Program
TDM	Travel Demand Management
UDA	
UPC	
VDOT	Virginia Department of Transportation
VEDP	Virginia Economic Development Partnership

1 - INTRODUCTION

In 2021, the Charlottesville-Albemarle Metropolitan Planning Organization (CAMPO) was awarded a grant through the Virginia Office of Intermodal Planning and Investment (OIPI) Growth and Accessibility Planning (GAP) Technical Assistance program to develop a performance-based planning process that identifies transportation needs and prioritizes transportation projects for its Long Range Transportation Plan. Additionally, this process is intended to be managed and maintained over time within the constraints of CAMPO's limited staffing resources. The process resulting from this study is transparent, repeatable, and flexible to accommodate additional measures, new or updated data sources, and alternative analysis parameters, such as needs thresholds and weighting schemes. This data-driven performance-based planning process includes two parts:

1. Process for the Identification of Transportation Needs – This process involves a system evaluation of needs based on performance measures that address goals and objectives in the CAMPO's long range plan including safety, access and equity, mobility and system efficiency, and economic development.

2. Process for the Prioritization of Transportation Projects – This process involves a project-level evaluation of the benefits and costs associated with projects. Project benefits are evaluated based on each project's expected improvements related to safety, accessibility, congestion mitigation, environmental impacts, and economic development. While the prioritization of transportation projects is closely related to the identification of needs and there is a common set of metrics used by both, the analytical processes and combinations of metrics may differ between project prioritization and needs analyses. For example, an important difference is that while needs analysis focuses on existing or forecasted system-level conditions, project prioritization considers a particular project's impacts in its specific location.

This report is divided into four chapters, including this introduction explaining the purpose and organization of the report. Chapter 2 starts by outlining the dimensions of transportation needs indicated in CAMPO's policies and ongoing planning activities. These inform the metrics included in the needs analysis and project prioritization processes. As CAMPO's policies evolve, the performance-based planning process can be updated, extended, or modified accordingly. In addition to presenting the overall process for identifying transportation needs, Chapter 3 discusses the methodologies applied to evaluating needs for each performance measure and the steps for weighting and aggregating across need categories. Chapter 4 presents the process for the prioritization of transportation projects, including the methodologies for evaluating the benefits of all surface transportation improvements, including highway and roadway, transit, active transportation, and transportation demand management (TDM) projects. Chapter 4 also presents the methodology for normalizing benefit scores across measures, assessing the costs of projects, and developing a single project score that can be used to rank projects across project types. These methodologies were tested on a variety of project types including roadway widenings, bicycle and pedestrian improvements, and transit projects.

2 - CAMPO'S PLANNING PRIORITIES

Through coordination with CAMPO staff and the CAMPO Technical Committee, the technical work group developed metrics that focus on five need categories: Safety, Accessibility and Equity, Mobility and System Efficiency, Environment, and Economic Development. These five need categories align with CAMPO's 2045 Long Range Transportation Plan (LRTP) vision, goals, and objectives while providing sufficient nuance in supportive measures to evaluate a project's competitiveness for a variety of funding opportunities including SMART SCALE, Congestion Mitigation and Air Quality (CMAQ), and the Regional Surface Transportation Program (RSTP).

The five need categories include:

Safety –the aim of the safety category is to identify intersections and segments where safety improvements are needed and prioritize projects that can reduce crashes and/or exposure to risk.

Accessibility and Equity – the aim of the accessibility and equity category is to identify areas where the design and/or performance of the transportation system degrades travelers' ability to reach key destinations, like jobs, especially for disadvantaged users; and prioritize projects that are likely to enhance accessibility through improved connectivity, reduction in delay, more frequent transit services, and/or improved bicycle and pedestrian facilities.

Mobility and System Efficiency – the aim of the mobility and system efficiency category is to identify segments where congestion-related delay degrades travel time and travel time reliability for automobiles and transit vehicles and to prioritize projects that will alleviate delay and/or enhance person throughput throughout the region. This category also includes a measure which considers the on-time performance of the bus system.

Environmental – the aim of the environmental category is to identify resiliency needs, especially where infrastructure is exposed to inland flooding and to prioritize projects that pose no environmental impacts, mitigate impacts, or offer environmental services.

Land Use and Economic Development – the aim of the land use and economic development category is to identify areas where there is access to non-work destinations to stimulate local economic activity or to create transportation choices for disadvantaged people and to prioritize projects that connect to areas of local economic development activity.

The technical team for the study conducted an internal capacity assessment to establish the technologies and staff capabilities available to CAMPO for the implementation and maintenance of this process in diverse planning applications. That assessment is summarized in detail in Appendix A. It informed the development of the needs analysis and project prioritization processes by focusing on measures that are supported by readily available data and implementable in commonly used software, like Microsoft Excel or ArcMap, with no specialized expertise required. The measures described in the remaining chapters of this report are, therefore, accompanied by step-by-step instructions for their production in the appropriate software.

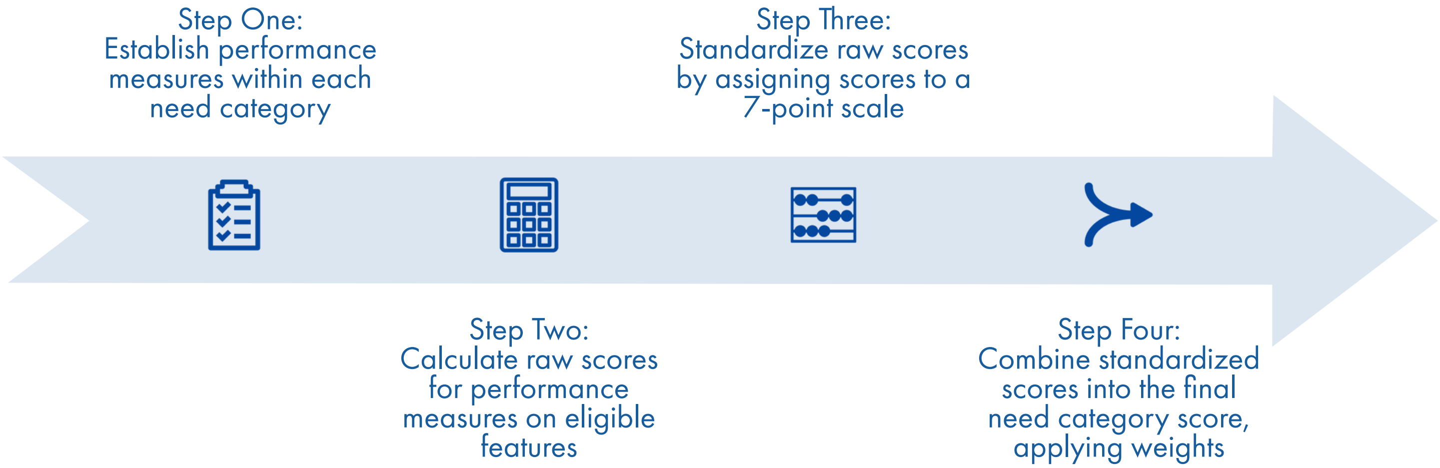
3 – PROCESS FOR THE IDENTIFICATION OF TRANSPORTATION NEEDS

A critical component of the transportation planning process is the identification of needs for future transportation improvements. Traditional needs assessments have focused on evaluating highway system performance including standard infrastructure condition deficiencies, crash hot spots, and network operational performance. Needs analysis methods have relied on these performance measures due to inadequate data for transit and active transportation modes. This process expands the needs analysis to consider transit and active transportation as part of a holistic multimodal needs assessment.

Figure 1 illustrates the general process for the identification of needs. The first step of this process is establishing the need categories and performance measures that align the scoring factors with the MPO's goals and objectives. The needs addressed in the process developed for this study are organized into the planning priorities described above. A total of 11 performance measures are defined with each measure assigned to one of the four factors, meaning some factors are defined by combinations of several metrics. For example, safety needs are identified through three metrics: PSI ranking, EPDO crash frequency, and pedestrian safety. The confluence of PSI segments and segments with high crash density and segments with high pedestrian safety priorities will have the highest overall safety need.

The first part of step two is the identification of needs. This step screens the full street network to determine segments that are eligible for scoring. Eligibility is determined by using one of the two threshold options discussed in the following sections within each need category. After eligibility is determined, raw scores are calculated for all performance measures within each need category. The specific steps in calculating metrics are often complex, involving multiple input datasets, spatial analysis, computation, summarization, etc. When describing the metrics used in the needs analysis and project prioritization processes, follow the step-by-step instructions for transparency and replicability. However, most metrics can also be processed using automated procedures developed for this study, usually in custom geoprocessors that can be run in ArcGIS or Microsoft Excel spreadsheet tools.

Figure 1 *Process for the identification of needs*



3 – PROCESS FOR THE IDENTIFICATION OF TRANSPORTATION NEEDS

Since each factor is composed of several performance measures, the measures need to be standardized and combined. In Step 3, all measures are expressed on a consistent seven-point scale, with a value of 1 indicating "Very Low" relative need and a value of 7 indicating "Very High" relative need. As shown by Table 1, raw metric values are translated into the seven-point scale based on thresholds that organize similar values into bins reflecting similar levels of need.

Table 1 Process for the identification of needs

Need Category	Need Score
Very Low	1
Low	2
Medium Low	3
Medium	4
Medium High	5
High	6
Very High	7

need score for the need category they support (Step 4). In the combination step, all standardized values are summarized into a single score through a weighted-average score. For example, roadway safety needs may be given greater or lower weight than pedestrian safety needs in the safety analysis. This process allows different weights to be assigned to each metric in the scoring process for each factor. The result is that need category scores are combined into an aggregate needs score that reflects total need based on all five need categories. An example of how scores are combined across all needs categories is provided in Table 2.

Since project location is a critical component of environmental impacts, the Environment and Sustainability need category is applied after aggregating need scores. An environmental factor is applied to the overall score as an adjustment to roadway segments that are exposed to projected sea level rise, storm surge, or inland/riverine flooding and whether the segment is within an economically distressed community.

Table 2 - Example of aggregate needs score based on combinedcategory scores

Need Category	Performance Measure	Weight	Need Score	Weighted Need Score
Safety (30%)	Roadway Safety	15%	4	0.6
	Pedestrian Safety	15%	6	0.9
Accessibility and Equity (30%)	Bicycle Access to Jobs	8%	6	0.48
	Transit Access to Jobs	8%	4	0.32
	Automobile Access to Jobs	6%	6	0.36
	Access to Jobs by Disadvantaged Populations	8%	5	0.4
Mobility and System Efficiency (20%)	Congestion Mitigation	5%	0	0
	Travel Time Reliability	5%	0	0
	Bus Transit On-Time Performance	10%	1	0.1
Land Use & Economic Development (20%)	Access to Non-Work Destinations	10%	5	0.5
	Access to Non-Work Destinations by Disadvantaged Populations	10%	5	0.5
Overall		100%	-	4.16 (Medium)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Details of each need category and supporting measures are provided in the sections the follow. The measures presented are applicable to all roadway segments. This process does not identify priorities for recreational trails that are not aligned with a public street, although the impacts of these facilities are accounted for in the bicycle access to jobs metric supporting the Accessibility and Equity need category. Similarly, segments where bicycles and pedestrians are not permitted, such as Interstates and other limited access facilities, are excluded from the bicycle access to jobs and pedestrian safety needs measures.

Need Category: Safety

The aim of the safety category is to identify intersections and segments where safety improvements are needed and prioritize projects that can reduce crashes and/or exposure to risk. Safety needs are assessed based on three supporting measures. Two measures: Potential for Safety Improvement (PSI) ranking, and equivalent property damage only (EPDO) crash frequency are blended into a roadway safety score. This is complemented by a pedestrian safety score based on VDOT's current Pedestrian Safety Action Plan.

Roadway Safety

Roadway safety needs are evaluated based on the combination of two separate performance measures: Potential for Safety Improvement (PSI) ranking and equivalent property damage only (EPDO) crash frequency. The analysis of EPDO crash frequency is limited to segments that are eligible for scoring based on PSI ranking criteria.

PSI is identified by a data-driven safety analysis by VDOT for its Highway Safety Improve Plan (HSIP) that ranks locations by their potential for safety improvement. Locations are ranked within VDOT Construction Districts and statewide. A location's PSI ranking is an estimate of the extent to which the number of crashes observed at an intersection or along a segment is higher than would be expected based on the facility type, traffic volume, and other factors. The PSI ranking is determined by its excess expected crash frequency, which is the number of observed or "expected" crashes modified by the Empirical Bayes (EB) adjustment method minus the number of typical or "predicted" crashes for the location based on state-specific safety performance functions (SPF). EB accounts for yearly variations and regression to the mean (RTM). SPFs are a mathematical relationship between the frequency of crashes and causal characteristics for a specific highway, including roadway facility type and traffic volume. A positive PSI value indicates a segment or intersection where the number of expected crashes exceeds the number of predicted crashes. Locations with a greater number of excess expected crashes receive a higher ranking.

The PSI ranking is used to determine segments that are eligible for roadway safety scoring, including the EPDO crash frequency analysis. Segments that do not meet the PSI-based criteria are deemed to have no safety needs, while those that do qualify are differentiated based on their PSI ranking and/or their EPDO crash frequency. The following threshold options were tested to determine scoring eligibility:

- All PSI Intersections and PSI Segments with three or more crashes in a five-year analysis period.
- Top ten miles of PSI Segments and top twenty PSI intersections within CAMPO boundaries.

If the first threshold is selected, any feature that has a potential for safety improvement according to VDOT's PSI analysis is eligible for *roadway safety* scoring. Alternatively, if the second option is selected, features eligible for scoring are limited to the top ranked segments PSI locations in the study area.

The EPDO crash frequency performance measure identifies locations that have a combined greater severity and frequency of crashes than other locations. It assigns weighting factors to fatal and injury crashes relative to PDO crashes, giving more weight to locations where more severe crashes have occurred. The weighting factors in Table 3 are used for the identification of roadway safety needs. These values are based on VDOT's crash costs by severity used for SMART SCALE.

Table 3 *Crash value conversion table*

Crash Severity	Rounded Value	Weight
Fatal (F) + Severe Injury (A)	$2,200,000	160
Moderate Injury	$260,000	20
Minor Injury	$140,000	10

Source: VDOT EPDO Crash Value Conversion Table (SMART SCALE Technical Guide, 2022)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for evaluating the level of roadway safety needs by segments:

1. Assign District-level PSI rankings to segments that are eligible for roadway safety scoring.
   - Create route events for PSI segments based on the direction indicated in the PSI segment tabular data. If the direction of the PSI segment applies to both sides of a divided roadway, ensure that route events are created for the opposite route name (WB and SB) in addition the route events created for the prime direction (NB and EB). Use the stated direction only for PSI segments where directionality is limited to eastbound, northbound, southbound, or westbound.
   - Convert PSI Intersections to segments using tabular data to identify the routes that approach PSI intersections. Assign node-based district PSI rankings to segments within a 250 feet influence area around the intersections.
   - Merge segments identified in steps 1a and 1b above into a single collection of segment features with PSI ranking values. If the merged segments needs layer contains both segment-based and intersection-based rankings, retain the higher of the two district PSI rankings.

2. Calculate EPDO crash frequency for segments that are eligible for roadway safety scoring.
   - Assign EPDO weighting factors (Table 2) to all crashes for the most recent five-year analysis period.
   - Assign crash events to segments using a spatial join and sum EPDO-weighted crashes along each segment.

Scoring of Roadway Safety Needs

Roadway safety is assessed as each segment's average standardized score from the PSI ranking and EPDO crash frequency analyses described above. District PSI ranking standardization thresholds are shown in Table 4. EPDO crash frequency standardization is based on the distribution of raw results over the entire collection of segments scored, as shown in Table 5. This requires sorting segments based on their EPDO crash frequency in descending order, then assigning the need score based on the percentile ranking (in terms of total scored mileage) of each segment. For example, the segments representing the top five percent of scored mileage have "very high" need, while segments representing the bottom fifty percent of scored mileage have "very low" need.

***Table 4** Roadway safety need scores applied to District PSI ranks*

Need Category	Need Score	District PSI Rank
Very High	7	Rank <= 20
High	6	40 >= Rank > 20
Medium High	5	60 >= Rank > 40
Medium	4	80 >= Rank > 60
Medium Low	3	100 >= Rank > 80
Low	2	150 >= Rank > 100
Very Low	1	Rank > 150

***Table 5** Roadway safety need scores applied to District PSI ranks*

Need Category	Need Score	Percent of Total Mileage
Very High	7	0% to 5%
High	6	5.001% to 10%
Medium High	5	10.001% to 15%
Medium	4	15.001% to 20%
Medium Low	3	20.001% to 25%
Low	2	25.001% to 50%
Very Low	1	50.001% to 100%

Finally, calculate the overall roadway safety need score by averaging the PSI ranking and the EPDO crash frequency standardized scores. Recall that segments that are not ranked in terms of PSI are assumed not to be roadway safety needs, regardless of underlying EPDO crash frequency. Therefore, they are not part of the target layer that is joined with crashes for calculating EPDO crash frequency. Accordingly, although certain segments may have recorded crashes during a five-year period, the overall score may be zero because they are unranked in terms of district PSI ranking.

Data Requirements

- PSI Locations (source: 2016-2020 Top Potential Safety Improvement Segments and Intersections Web Map)
- 5 year crash data (source: InteractVTrans Map Explorer)
- VDOT Linear Reference System (LRS) Overlap Routes (source: VDOT)
- ArcGIS Geoprocessing Tools

Geoprocessing Tool Overview

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Pedestrian Safety

Pedestrian safety needs are evaluated based on VDOT's Pedestrian Safety Action Plan (PSAP) priority corridors. The PSAP corridors indicate locations where facility design, operations, context, performance, or other issues are likely to lead to pedestrian crashes. Priority corridors are identified through a systematic analysis of statewide data that includes crash history, design speed, number of lanes, traffic volume, demographics and land uses in the vicinity, and other factors. The PSAP process relies on these factors because pedestrian crash events are relatively rare, and the conditions that elevate pedestrian crash risk may be present on numerous facilities even if pedestrian crashes have not been observed in recent years. The PSAP process generates a score for highway segments across the state. The top scoring segments are mapped and made available for download via a web map (source: https://vdot.maps.arcgis.com/apps/webappviewer/index.html?id=02a155fedefa4e71bdb8c0cf524b636f)

Eligibility for pedestrian safety scoring may be determined by one of the following threshold options, based on a segment's PSAP score relative to other segments in the region:

1. Regional (District) Top 1% Corridors

2. Regional (District) Top 5% Corridor

The above threshold options reflect the available collections of segments generated by the PSAP process (i.e., scores for all segments are not available for download, and other percentile thresholds would require coordination with VDOT to obtain). The top 1% of corridors tend to emphasize major highways, while the top 5% also includes more local roads and may be more appropriate for MPO-scale applications.

Calculation Steps

The following steps outline the process for prioritization within the pedestrian safety need category.

1. Download the most recent PSAP Priority Corridors to identify segments eligible for pedestrian safety scoring, selecting the top 1% or top 5%. The PSAP analysis is conducted approximately every three years.

2. Identify the PSAP Score in the PSAP Priority Corridors. In VDOT's Pedestrian Safety Action Plan 3.0, segments' PSAP Scores are in the "MAX_TOT_SCORE" field.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Scoring of Pedestrian Safety Needs

Sort the raw pedestrian safety need score (i.e., PSAP Score) in descending order. Then, using Table 6, assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for pedestrian safety.

Table 6 *Pedestrian safety need scores applied to segments by pedestrian crash rate*

Need Category	Need Score	Percent of Total Mileage
Very High	7	0% to 5%
High	6	5.001% to 10%
Medium High	5	10.001% to 15%
Medium	4	15.001% to 20%
Medium Low	3	20.001% to 25%
Low	2	25.001% to 50%
Very Low	1	50.001% to 100%

Data Requirements

The following steps outline the process for prioritization within the *pedestrian safety* need category.

- PSAP 3.0 Regional Priorities (source: VDOT Pedestrian Safety Action Plan Map Viewer)
- ArcGIS Geoprocessing Tools

Geoprocessing Tool Overview

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

The aim of the accessibility and equity category is to identify areas where the design and/or performance of the transportation system degrades travelers' ability to reach key destinations, like jobs, especially for disadvantaged users; and prioritize projects that are likely to enhance accessibility through improved connectivity, reduction in delay, more frequent transit services, and/or improved bicycle and pedestrian facilities. Accessibility and equity needs are assessed based on four supporting measures: bicycle access to jobs, transit access to jobs, automobile access to jobs, and access to jobs by disadvantaged populations. These measures combine to provide a holistic, multimodal assessment of needs that accounts for different needs and abilities among travelers throughout the region.

Many of these supporting measures rely on several key concepts, described in general terms here and applied with specific parameters for each measure. Broadly, accessibility is analyzed on a zone basis and describes the ease with which destinations in other zones can be reached from each origin zone. Accessibility scores can be sensitive to the connectivity provided by the current network, its design and performance, traveler characteristics/preferences, and the number of activities (jobs, e.g.) in destination zones. Maps of accessibility scores show which zones can get to the higher or lower levels of activity in other zones. Since the scores derive from activities in other zones, projects to enhance accessibility may be displaced from the zone where need is indicated, as long as the project enhances the connectivity from the zone having the need to one or more other zones where activities are concentrated.

In this process, the identification of accessibility needs by mode is based on the "potential for accessibility improvement" (PAI), which is estimated as the difference between the "current" accessibility offered and a "reference" condition. The "current" condition refers to the cumulative number of activities (jobs in the case of all metrics generated in this process) accessible from a given location applying parameters, such as level of traffic stress (LTS) or average travel speed, that influence the estimated travel times among zones. The "reference" condition refers to the cumulative number of jobs accessible from the same location but with hypothetical parameters that yield an estimated maximum level of job accessibility. Details regarding the current and reference conditions for each mode are discussed in the subsequent sections on mode-specific accessibility performance measures.

The concepts of "maximum travel time" and "decay function" also determine the cumulative number of jobs that are accessible from a given location. In this analysis, maximum travel time defines the maximum amount of time for traveling from an origin census block to a destination census block. This maximum travel time parameter may reflect, for example, the idea that walking trips longer than 30 minutes are uncommon. Under this assumption, activities in blocks beyond a 30-minute walk would be ignored in a pedestrian accessibility analysis. Decay functions are commonly used in accessibility analyses to provide more weight to jobs that are closer to origin census blocks than jobs that are located further away. Decay functions are applied in the Access Across America data used in the accessibility metrics described below to reflect the tendency for travelers to choose destinations that are nearby, all else being equal.

The accessibility measures described below also employ the concept of a "catchment area." This refers to the area around a zone that is likely to contribute most substantially to its accessibility score, based on the maximum travel time associated with the mode of travel being analyzed. Catchment areas are included in this analysis primarily because project opportunities to enhance accessibility can be displaced from the zone of need and because the Access Across America data that support the analysis do not include underlying data (such as block-to-block travel time estimates) but only the current and reference accessibility conditions. Thus, the catchment area is used to calculate areawide PAI averages around street segments to rank segments according to the PAI in its surrounding travel shed.

Lastly, functional classification is used to scale the weighted average PAI for each segment by the volume of trips the street is expected to carry. Functional classification refers to the grouping of streets and highways into various classes based on the services they provide. This analysis assumes higher classified streets are more heavily utilized than lower classified streets. Therefore, road segments with a higher functional classification are weighted higher than road segments with a lower function classification as opportunities to provide accessibility enhancements.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Bicycle Access to Jobs

Bicycle access to jobs needs are based on the Access Across America study by the Accessibility Observatory at the University of Minnesota Center for Transportation Studies. This study estimates the number of destinations reachable by bicycle within a given travel time for all census blocks in the United States. In brief, the accessibility calculations performed in the Access Across America study are as follows:

- Calculate travel times by biking from each census block to all other blocks within 20 km using detailed bicycling and walking networks based on OpenStreetMap (OSM) data.
- Calculate cumulative opportunity accessibility to jobs for each block and Level of Traffic Stress score using travel time thresholds of five minutes to one hour. A destination decay function is used to weight the number of jobs reachable such that nearby jobs contribute more to the access score than jobs that are farther away.

Level of Traffic Stress (LTS) is a metric used to evaluate the perception of safety by quantifying the level of discomfort people feel when they bicycle next to traffic. The LTS process assigns numerical values to segments based on OSM tags that indicate the presence or absence of bicycle facilities, number of lanes, and posted roadway posted, and assigns a numerical value of 1 (lowest stress) to 4 (highest stress) to street segments based on these characteristics. For the purposes of applying LTS parameters to the estimation of travel times by biking, LTS values determine segments' traversability. In this case, the tolerance is set to the maximal LTS value. For example, the LTS 3 analysis allows bike trips along facilities classified as LTS 1, 2, or 3, while the LTS 1 analysis only allows bike trips along the LTS 1 facilities. These tolerances reflect the preferences and abilities of different types of users, where LTS 1 is the most inclusive of all users while LTS 4 represents avid cyclists who may tolerate conditions (heavy mixed traffic, e.g.) that are deemed intolerable by other cyclists.

The Access Across America analysis calculates bicycle travel times using an assumed travel speed of 18 kph (approximately 11 mph), while travel times associated with walking portions of trip, including initial access time to reach the nearest network link by foot, barrier-crossing time for segments with a higher stress level than the trip's maximal LRS tolerance, and destination access time, take place at a speed of 5 kph (approximately 3 mph). While bicycle travel time on a network without bicycle infrastructure would be negatively impacted by automobile congestion, this analysis is not sensitive to congestion effects at certain times of the day. The data generated by the study are estimates for each census block of the number of jobs reachable by cycling.

In this analysis, the "current condition" is access to jobs by bicycle along low stress (LTS1) segments and the "reference condition" is access to jobs by bicycling along high stress (LTS4) segments. The reference condition approximates the jobs accessible by cycling assuming all facilities were comfortable for all users rather than only the most avid and experienced cyclists (i.e., how many jobs could be reached by cycling if all facilities were LTS1 facilities?). The deficit that results from subtracting the current condition from the reference condition is the potential accessibility increase (PAI).

The zone (block) data from Access Across America are intersected with 3-mile buffers defining each segment's catchment area. Within each catchment area, the population weighted average PAI is calculated, and the result is multiplied by the segment's functional classification weight. This elevates facilities that are likely to carry relatively high volumes of person trips and that are in areas where bicycle access to jobs could be improved. The segments identified in this process do not necessarily lack suitable facilities for cyclists, so the results should be compared with available inventories of bicycle facilities to determine what projects or investments may be appropriate to enhance bicycle accessibility.

Eligibility for bicycle access to jobs scoring is determined by population weighted PAI for each segment and may be determined by one of the following optional thresholds:

1. All segments where population weighted PAI is greater than zero.

2. All segments where population weighted PAI is greater than the region's median population weighted PAI.

The first option acknowledges all opportunities for potential accessibility enhancements while the second option focuses on the most acute needs. Note that functional class weightings apply after eligibility is determined.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for prioritization within the *access to jobs by bicycle need* category.

1. Obtain the Access Across America datasets given the following parameters:
   - Current Condition: Bicycle LTS 1 (Lowest Stress)
   - Reference Condition: Bicycle LTS 4 (Highest Stress)
   - Maximum Travel Time: 20 minutes
   - Maximum Travel Distanace: 3 miles

2. For each census block, calculate PAI as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$PAI_{Bike} = Reference - Current$$

3. Calculate the population weighted PAI for each census block by multiplying PAI by the population of the census block in which the segment is located.

$$Population\ Weighted\ PAI = Population \times PAI$$

4. Sum the population weighted PAI and total population in the catchment area around each segment. Next, divide the summed population-weighted PAI by the total population in the catchment area to yield the population-weighted average PAI.

$$Weighted\ Average\ PAI = \frac{\sum_{i=1}^{n} Population\ Weighted\ PAI_i}{\sum_{i=1}^{n} Population_i}$$

5. Calculate the *bicycle access to jobs* performance measure
   - Assign a functional class (FC) score to all road segments. Segments where cyclists are not permitted such as Interstates and other limited-access facilities are ignored (receive a score of zero) since they are not relevant to bicycle accessibility.
   - Calculate the raw score for bicycle access to jobs performance measure by multiplying segments' weighted average accessibility improvement by its FC score (see **Table 7**).

$$Raw\ Need\ Score = Weighted\ Average\ PAI\ x\ FC\ Score$$

Table 7 Bicycle access to jobs functional class score standardization

Functional Class	FC Score
Other Principal Arterial	7
Minor Arterial	5
Major Collector	3
Minor Collector	1
Local	0.25
Interstates, Other Freeways & Expressways	0

Scoring of Bicycle Access to Jobs Needs

Sort the raw bicycle need score in descending order for all eligible segments. Then, using **Table 8** assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for *bicycle access to jobs.*

Table 8 Bicycle access to jobs need scores applied to segments by average PAI

Need Category	Need Score	Percent of Total Mileage
Very High	7	0% to 5%
High	6	5.001% to 10%
Medium High	5	10.001% to 15%
Medium	4	15.001% to 20%
Medium Low	3	20.001% to 25%
Low	2	25.001% to 50%
Very Low	1	50.001% to 100%

Data Requirements

- Block-Level Access to Jobs (source: Access Across America analysis by the Accessibility Observatory)
- Roadway Functional Classification (source: InteractVTrans Map Explorer)
- ArcGIS Geoprocessing Tools

Geoprocessing Tool Overview

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Transit Access to Jobs

Transit access to jobs needs are based on the Access Across America study by the Accessibility Observatory at the University of Minnesota Center for Transportation Studies. This study estimates the number of destinations reachable by transit and by automobile (see Automobile Access to Jobs) within a given travel time for all census blocks in the United States. In brief, the accessibility calculations performed in the Access Across America study are as follows:

- Calculate travel times by transit from each census block to all other blocks within 60km using transit schedules for the 7:00 – 9:00 AM period and detailed walking networks based on OpenStreetMap (OSM) data.
- Calculate cumulative opportunity accessibility to jobs for each block and departure time using travel time thresholds of five minutes to one hour. A destination decay function is used to weight the number of jobs reachable such that nearby jobs contribute more to the access score than jobs that are farther away

In the Access Across America data, the time cost of travel by transit includes all components of a transit journey, including initial access time, initial wait time, on-vehicle time, transfer access time, transfer wait time, and destination access time. On-vehicle travel time, which is derived from GTFS transit schedules, accounts for variations in service frequency by time of day. Access and egress components of trips (i.e., initial, transfer, and access) are assumed to be made by walking at a speed of 5 kph (3 mph). There is no constraint on the number of transfers required, and it is possible for a block-to-block path to be found that does not use a transit vehicle (i.e., the shortest path from an origin block to a destination block requires walking only).

In the Access Across America data, the time cost of travel by transit includes all components of a transit journey, including initial access time, initial wait time, on-vehicle time, transfer access time, transfer wait time, and destination access time. On-vehicle travel time, which is derived from GTFS transit schedules, accounts for variations in service frequency by time of day. Access and egress components of trips (i.e., initial, transfer, and access) are assumed to be made by walking at a speed of 5 kph (3 mph). There is no constraint on the number of transfers required, and it is possible for a block-to-block path to be found that does not use a transit vehicle (i.e., the shortest path from an origin block to a destination block requires walking only).

In the CAMPO needs analysis, the magnitude of need arising from transit access to jobs performance is determined by the difference in block-level access to jobs between the current condition and the reference condition. The current condition is access to jobs by transit during the 7:00 – 9:00 AM period and the reference condition is access to jobs by automobile during 8:00 – 9:00 AM period. This elevates areas where jobs access by car is significantly higher than by transit, suggesting an opportunity to enhance transit service to make it more competitive with driving. The deficit that results from subtracting the current condition from the reference condition is the potential accessibility increase (PAI).

The zone (block) data from Access Across America are intersected with 5-mile buffers defining each segment's catchment area. Within each catchment area, the population weighted average PAI is calculated, and the result is multiplied by the segment's functional classification weight. This elevates facilities that are likely to carry relatively high volumes of person trips and that are in areas where transit access to jobs could be improved. The segments identified in this process do not necessarily lack existing transit service, so the results should be compared with current transit routes and schedules to determine what projects or investments may be appropriate to enhance transit accessibility.

Eligibility for transit access to jobs scoring is determined by population weighted PAI for each segment and may be determined by one of the following optional thresholds:

1. All segments where population weighted PAI is greater than zero.

2. All segments where population weighted PAI is greater than the region's median population weighted PAI.

The first option acknowledges all opportunities for potential accessibility enhancements while the second option focuses on the most acute needs. Note that functional class weightings apply after eligibility is determined.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for estimating the magnitude of need under the *access to jobs by transit score*:

1. Obtain the Access Across America datasets given the following parameters:
   - Current Condition: Transit
   - Reference Condition: Automobile (8 AM)
   - Maximum Travel Time: 45 minutes
   - Maximum Travel Distanace: 5 miles

2. For each census block, calculate PAI as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$PAI_{Transit} = Reference - Current$$

3. Calculate the population weighted PAI for each census block by multiplying PAI by the population of the census block in which the segment is located.

$$Population\ Weighted\ PAI = Population \bullet PAI$$

4. Sum the population weighted PAI and total population in the catchment area around each segment. Next, divide the summed population-weighted PAI by the total population in the catchment area to yield the population-weighted average PAI.

$$Weighted\ Average\ PAI = \frac{\sum_{i=1}^{n} Population\ Weighted\ PAI_i}{\sum_{i=1}^{n} Population_i}$$

5. Calculate the *transit access to jobs* performance measure
   - Assign a functional class (FC) score to all road segments.
   - Calculate the raw score for *transit access to jobs* performance measure by multiplying segments' weighted average accessibility improvement by its FC score (see **Table 9**).

$$Raw\ Need\ Score = Weighted\ Average\ PAI \times FC\ Score$$

Table 9 Transit access to jobs functional class score standardization

Functional Class	FC Score
Interstates, Other Freeways & Express, and Other Principal Arterial	7
Minor Arterial	5
Major Collector	3
Minor Collector	1
Local	0.25

Scoring of Transit Access to Jobs Needs

Sort the raw transit need score in descending order. Then, using **Table 10**, assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for *transit access to jobs.*

Table 10 Transit access to jobs need scores applied to segments by average PAI

Need Category	Need Score	Percent of Total Mileage
Very High	7	0% to 5%
High	6	5.001% to 10%
Medium High	5	10.001% to 15%
Medium	4	15.001% to 20%
Medium Low	3	20.001% to 25%
Low	2	25.001% to 50%
Very Low	1	50.001% to 100%

Data Requirements

- Block-Level Access to Jobs (source: Access Across America analysis by the Accessibility Observatory)
- Roadway Functional Classification (source: InteractVTrans Map Explorer)
- ArcGIS Geoprocessing Tools

Geoprocessing Tool Overview

(forthcoming)

Automobile Access to Jobs

Automobile access to jobs needs are based on the Access Across America study by the Accessibility Observatory at the University of Minnesota Center for Transportation Studies. This study estimates the number of destinations reachable by automobile within a given travel time for all census blocks in the United States. In brief, the accessibility calculations performed in the Access Across America study are as follows:

- Calculate travel times by car from each census block to all other blocks within 120km for each departure time at 1-hour intervals over the 24-hour period. Block-Level Access to Jobs (source: Access Across America
- Calculate cumulative opportunity accessibility to jobs for each block and departure time using travel time thresholds of five minutes to one hour. A destination decay function is used to weight the number of jobs reachable such that nearby jobs contribute more to the access score than jobs that are farther away.

In the Access Across America data, the time cost of travel by automobile is evaluated by time of day with average link speeds estimated from TomTom, which reports typical speeds based on data collected from GPS devices. Average speed data reflect conditions on Wednesdays (representing a typical weekday) during the June 2017 to June 2019 period.

In the CAMPO needs analysis, the magnitude of need arising from automobile access to jobs performance is determined by the difference in block-level access to jobs between the current condition and the reference condition. The current condition is access to jobs by automobile during the 8:00 – 9:00 AM period and the reference condition is access to jobs by automobile during the 12:00 – 1:00 AM period. This elevates areas where jobs access by car is significantly lower during the morning commute period than it would be under a free flow condition, suggesting an opportunity to enhance highway operations and/or capacity to offer greater access to destinations when highway demand is highest. The deficit that results from subtracting the current condition from the reference condition is the potential accessibility increase (PAI).

The zone (block) data from Access Across America are intersected with 10-mile buffers defining each segment's catchment area. Within each catchment area, the population weighted average PAI is calculated, and the result is multiplied by the segment's functional classification weight. This elevates facilities that are likely to carry relatively high volumes of person trips and that are in areas where automobile access to jobs could be improved. The segments identified in this process do not necessarily experience acute congestion-related delays, so the results should be compared with measures of delay and reliability to determine what projects or investments may be appropriate to enhance automobile accessibility.

Eligibility for automobile access to jobs scoring is determined by population weighted PAI for each segment and may be determined by one of the following optional thresholds:

1. All segments where PAI deficit is greater than zero

2. All segments where PAI deficit is greater than the region's median PAI deficit

The first option acknowledges all opportunities for potential accessibility enhancements while the second option focuses on the most acute needs. Note that functional class weightings apply after eligibility is determined.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for estimating the magnitude of need under the *access to jobs by automobile* score:

1. Obtain the Access Across America datasets given the following parameters:
   - Current Condition: Auto (8 AM - 9AM, Peak Period)
   - Reference Condition: Automobile (12 AM - 1 AM, Off Peak Period)
   - Maximum Travel Time: 45 minutesMaximum Travel Distanace: 10 miles

2. For each census block, calculate PAI as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$PAI_{Auto} = Reference - Current$$

3. Calculate the population weighted PAI for each census block by multiplying PAI by the population of the census block in which the segment is located.

$$Population\ Weighted\ PAI = Population \bullet PAI$$

4. Sum the population weighted PAI and total population in the catchment area around each segment. Next, divide the summed population-weighted PAI by the total population in the catchment area to yield the population-weighted average PAI.

$$Weighted\ Average\ PAI = \frac{\sum_{i=1}^{n} Population\ Weighted\ PAI_i}{\sum_{i=1}^{n} Population_i}$$

5. Calculate the *automobile access to jobs* performance measure
   - Assign a functional class (FC) score to all road segments.
   - Calculate the raw score for automobile access to jobs performance measure by multiplying segments' weighted average accessibility improvement by its FC score (see **Table 11**).

Table 11 Automobile access to jobs functional class score standardization

Functional Class	FC Score
Interstates, Other Freeways & Express, and Other Principal Arterial	7
Minor Arterial	5
Major Collector	3
Minor Collector	1
Local	0.25

Scoring of Automobile Access to Jobs Needs

Sort the raw automobile need score in descending order. Then, using **Table 12**, assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for *automobile access to jobs.*

Table 12 Transit access to jobs need scores applied to segments by average PAI

Need Category	Need Score	Percent of Total Mileage
Very High	7	0% to 5%
High	6	5.001% to 10%
Medium High	5	10.001% to 15%
Medium	4	15.001% to 20%
Medium Low	3	20.001% to 25%
Low	2	25.001% to 50%
Very Low	1	50.001% to 100%

Data Requirements

- Block-Level Access to Jobs (source: datasets from the Access Across America analysis by the Accessibility Observatory. Obtained via VTRC through pooled fund study)
- Roadway Functional Classification (source: VDOT via InteractVTrans Map Explorer)
- ArcGIS Geoprocessing Tools

Geoprocessing Tool Overview

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Access to Jobs by Disadvantaged Populations

Access to jobs by disadvantaged populations needs are based on the analysis of transit access to jobs. However, *transit access to jobs* results are filtered to segments within areas that are identified as Equity Emphasis Areas (EEA) that are considered transit-viable. EEA is an existing dataset provided by OIPI, so no additional calculations are necessary. While an outline of the process is discussed below, the full process and data needs are discussed in the Technical Guide for the Identification and Prioritization of the VTrans Mid-Term Needs.

OIPI defines EEA as block groups with high concentrations of low-income individuals, disadvantaged racial and ethnic groups, elderly, disabled, and limited-English proficiency population. Since disability data is not available at the census block group level, the share of residents with a disability is determined by multiplying the share of residents with a disability in the census tract by the block group's populations. Next, convert the count of residents in each category to population shares by dividing by the block group population. Then, calculate the regional average concentration for each category. Once the block group level data has been assembled, calculate the ratios of concentration (ROC) for each category by dividing the block group's share by the regional concentration. Finally, sum the six individual ROC are into an index by converting all ROCs above 3 to 3, low-income ROCs below 1 to 0, and ROCs for the other categories below 1.5 to 0. A block group is flagged as an EEA if the index is greater than 2or the ROC for low-income or disability is greater than or equal to 1. An EEA is considered transit viable if the population density of the block group is greater than the 10th percentile density of areas in the region that are currently served by transit. The latter is defined by block groups centroids within ¼ mile of an existing transit stop.

In the CAMPO needs analysis, the magnitude of need arising from access to job for disadvantaged populations is assessed in the same way that transit access to jobs needs are assessed, except that the population weighting is based on populations in EEAs only.

Eligibility for access to jobs for disadvantaged populations scoring is limited to segments within EEAs and determined by population weighted PAI for each segment and may be determined by one of the following optional thresholds:

- All segments in transit viable EEAs where PAI is greater than zero.
- All segments in EEAs where population weighted PAI is greater than the region's median population weighted PAI. of five minutes to one hour. A destination decay function is used to weight the number of jobs reachable such that nearby jobs contribute more to the access score than jobs that are farther away.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for prioritization within the *Access to Jobs by Disadvantaged Populations* need category:

1. Obtain the NAE datasets given the following parameters:
   - Current Condition: Transit
   - Reference Condition: Automobile (8 AM)
   - Maximum Travel Time: 45 minutes
   - Maximum Travel Distance: 5 miles
2. For each census block, calculate PAI as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$PAI_{Transit} = Reference - Current$$

3. Calculate the population weighted PAI for each census block by multiplying PAI by the disadvantaged population of the census block in which the segment is located.

$$Population\ Weighted\ PAI = Disagvantatged\ Population \bullet PAI$$

4. Sum the population weighted PAI and total disadvantaged population in the catchment area around each segment. Next, divide the summed population-weighted PAI by the total population in the catchment area to yield the population-weighted average PAI.Assign a functional class (FC) score to all road segments.

$$Weighted\ Average\ PAI = \frac{\sum_{i=1}^{n} Population\ Weighted\ PAI_i}{\sum_{i=1}^{n} Population_i}$$

5. Calculate the *transit access to jobs* performance measure
   - Assign a functional class (FC) score to all road segments.
   - Calculate the raw score for transit access to jobs performance measure by multiplying segments' weighted average accessibility improvement by its FC score (see **Table 13**).

$$Raw\ Need\ Score = Weighted\ Average\ PAI \times FC\ Score$$

Table 13 *Access to jobs for disadvantaged populations functional class score standardization*

Functional Class	FC Score
Interstates, Other Freeways & Express, and Other Principal Arterial	7
Minor Arterial	5
Major Collector	3
Minor Collector	1
Local	0.25

Scoring of Access to Jobs by Disadvantaged Populations Needs

Sort the raw automobile need score in descending order. Then, using **Table 14**, assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for *Access to Jobs by Disadvantaged Populations.*

Table 14 *Access to jobs by disadvantaged populations need scores applied to segments by average PAI*

Need Category	Need Score	Percent of Total Mileage
Very High	7	0% to 5%
High	6	5.001% to 10%
Medium High	5	10.001% to 15%
Medium	4	15.001% to 20%
Medium Low	3	20.001% to 25%
Low	2	25.001% to 50%
Very Low	1	50.001% to 100%

Data Requirements

- Block-Level Access to Jobs (source: datasets from the Access Across America analysis by the Accessibility Observatory. Obtained via VTRC through pooled fund study)
- Equity Emphasis Areas (source: OIPI via InteractVTrans Map Explorer)
- Roadway Functional Classification (source: VDOT via InteractVTrans Map Explorer)
- ArcGIS Geoprocessing Tools

Geoprocessing Tool Overview

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Need Category: Mobility and System Efficiency

The aim of the mobility and system efficiency category is to identify segments where congestion-related delay degrades travel time and travel time reliability for automobiles and transit vehicles and to prioritize projects that will alleviate delay and/or enhance person throughput throughout the region. Mobility needs are assessed using two measures: *congestion mitigation* and *travel time reliability*. Both measures compare congested travel conditions to free flow conditions, assessing the severity of congestion under typical and extreme conditions, respectively.

Congestion Mitigation

Congestion mitigation needs are identified through Travel Time Index (TTI), which is the ratio of a segment's typical travel time during an observed period (such as the morning or evening peak commuting period) to the time required to travel the same distance in a reference period (under free-flow conditions, e.g.). A TTI value greater than one indicates there is delay during the observation period, and higher numbers indicate increasingly severe delay due to congestion. TTI is usually measured at a segment level. For example, a TTI of 1.3 indicates typical travel times along a particular segment are 30% longer. If it would take 2 minutes to traverse the segment under free-flow conditions, the TTI of 1.3 would imply it typically takes 2 minutes and 40 seconds during congested conditions.

The dataset used for this analysis contains TTI measures by segment that cover a 14-hour period from 6 AM to 8 PM on weekdays and weekends for multiple years (i.e., TTI for weekdays and weekends in 2018, 2019, 2020, and 2021 for each hour from 6 AM to 8 PM). The TTI measures, which are calculated by OIPI using INRIX TMC data from the Regional Integrated Transportation System (RITIS), can be obtained from the InteractVTrans Map Explorer, and reflect the ratio of the 50th percentile travel time to the estimated free flow time.

The identification of qualifying segments requires that a given segment at any time in the previous four years exceeds the congestion mitigation need threshold discussed in the following sections.

The following steps outline the process for identifying congestion mitigation needs. In this process the focus is on weekday and weekend TTI from 6 AM to 8 PM analysis periods.

1. For each segment and each year, calculate the weeklong average TTI for each hour in the analysis period by combining the separate estimates of weekday TTI and weekend TTI as follows:
   - Multiply weekday TTI values by 5/7 (five of seven days)
   - Multiply weekend TTI values by 2/7 (two of seven days)
   - Sum the results of 1a and 1b to obtain weeklong average TTI
2. For each segment, tally the number of hours in the analysis period where the weeklong average TTI in any year is above the eligibility threshold. Select eligible segments where the thresholds are satisfied.

Eligibility for congestion mitigation scoring may be determined by one of the following alternative thresholds:

- Average weeklong TTI in any year is greater than 1.3 for three or more hours or average weeklong TTI is greater than 1.5 for one or more hours.
- Average weeklong TTI in any year is greater than 1.5 for three or more hours or average weeklong TTI is greater than 1.7 for one more hours.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for assessing the magnitude of the *congestion mitigation* need:

1. Calculate the daily cumulative TTI values from 6 AM to 8 PM. This step accumulates over all qualifying hours in a single year to a calculate a "daily cumulative TTI" value.

$$\text{Daily cumulative TTI} = \frac{5}{7}\left(\sum_{\text{Weekday TTI} \geq T} \text{Weekday TTI}\right) + \frac{2}{7}\left(\sum \text{Weekend TTI}\right)$$

Where:
T = TTI threshold (1.3, 1.5, 1.7, e.g.)

2. Adjust for magnitude of congestion by multiplying cumulative congested hours by traffic volume using length weighted Annual Average Daily Traffic (AADT)

$$\text{Normalized TTI\_AADT} = \frac{\text{TTI\_AADT}_i - \text{TTI\_AADT}_{min}}{\text{TTI\_AADT}_{max} - \text{TTI\_AADT}_{min}}$$

Where:
TTI_AADTi = Cumulative TTI × AADT for segment i
TTI_AADT_{min} = Minimum Cumulative TTI × AADT for all segments
TTI_AADT_{max} = Maximum Cumulative TTI × AADT for all segments

Scoring of Congestion Mitigation Needs

Using **Table 15**, assign need scores based on segments' normalized volume adjusted weekly average TTI.

Table 15 *Congestion mitigation need scores by the normalized volume adjusted weekly average TTI*

Need Category	Need Score	Normalized Congestion Need Score
Very High	7	0.95 to 1
High	6	0.9 to 0.95
Medium High	5	0.85 to 0.9
Medium	4	0.8 to 0.85
Medium Low	3	0.75 to 0.8
Low	2	0.5 to 0.75
Very Low	1	0 to 0.5

Data Requirements

- Travel Time Index (source: INRIX provided by RITIS via InteractVTrans Map Explorer)
- AADT (source: InteractVTrans Map Explorer)

Geoprocessing Tool Overview

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Travel Time Reliability

Travel time reliability needs are identified through Planning Time Index (PTI), which is the ratio of a segment's 95th percentile travel time compared to the time needed to travel the same distance in a reference period (free-flow traffic, e.g.). PTI refers to the total planned duration of travel (expected delay plus unexpected delay) that is required for an on-time arrival for 95% of trips on a given segment. For example, a PTI of 1.5 at a given time indicates that a trip that normally takes 10 minutes in uncongested conditions should be planned to take 15 minutes to ensure that 95% of trips arrive on time. PTI is a measure of travel time reliability because it measures the extent of unexpected delay against free flow traffic and measures the consistency or dependability in travel times across different times of day.

The dataset used for this analysis contains PTI measures that cover a 14-hour period from 6 AM to 8 PM on weekdays and weekends for multiple years (i.e., PTI for weekdays and weekends in 2018, 2019, 2020, and 2021 for each hour from 6 AM to 8 PM). The PTI measures, which are calculated by OIPI using INRIX TMC data from the Regional Integrated Transportation System (RITIS), can be obtained from the InteractVTrans Map Explorer and reflect the ratio of the 95th percentile travel time to the estimated free flow time.

The identification of qualifying segments requires that a given segment at any time in the previous four years exceeds the congestion mitigation need threshold discussed in the following sections.

The following steps outline the process for identifying *travel time reliability* needs. In this process the focus is on weekday and weekend PTI from 6 AM to 8 PM analysis periods.

1. For each segment and each year, calculate the PTI for each hour in the analysis period by combining the separate estimates of weekday PTI and weekend PTI as follows:
   - Multiply weekday PTI values by 5/7 (five of seven days)
   - Multiply weekend PTI values by 2/7 (two of seven days)
   - Sum the results of 1a and 1b to obtain weeklong average PTI
2. For each segment, tally the number of hours in the analysis period where the weeklong average PTI in any year is above the eligibility threshold. Select eligible segments where the thresholds are satisfied.

Eligibility for *travel time reliability* scoring may be determined by one of the following alternative thresholds::

- Average weekday and weekend PTI is greater than 1.3 for three hours or greater than 1.5 for one hour.
- Average weekday and weekend PTI is greater than 1.5 for three hours or greater than 1.7 for one hour.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for assessing the magnitude of the congestion mitigation need:

1. Calculate the daily cumulative PTI values from 6 AM to 8 PM. This step accumulates over all qualifying hours in a single year to a calculate a "daily cumulative PTI" value.

$$\textit{Daily cumulative PTI} = \frac{5}{7}\left(\sum_{\textit{Weekday PTI} \geq T} \textit{Weekday PTI}\right) + \frac{2}{7}\left(\sum_{\textit{Weekday PTI} \geq T} \textit{Weekend PTI}\right)$$

Where:
T = TTI threshold (1.3, 1.5, 1.7, e.g.)

2. Adjust for magnitude of congestion by multiplying cumulative congested hours by traffic volume using length weighted Annual Average Daily Traffic (AADT)

3. Repeat steps 1 and 2 for all years available in the PTI dataset to calculate AADT-weighted daily cumulative PTI for each year. Retain the maximum result across all years for each segment.

4. Normalize the AADT adjusted PTI for all years available in the dataset using the following equation. Normalization results in values ranging from 0.0 to 1.0, with the segment that has the lowest volume adjusted PTI receiving a score of 0.0 and the segment that has the highest volume adjusted PTI receiving a score of 1.0.

$$\textit{Normalized PTI\_AADT} = \frac{PTI\_AADT_i - PTI\_AADT_{min}}{PTI\_AADT_{max} - PTI\_AADT_{min}}$$

Where:
PTI_AADT_i = Cumulative PTI × AADT for segment i
PTI_AADT_{min} = Minimum Cumulative PTI × AADT for all segments
PTI_AADT_{max} = Maximum Cumulative PTI × AADT for all segments

Scoring of Travel Time Reliability Needs

Using **Table 16**, assign need scores based on segments' normalized volume adjusted weekly average PTI.

Table 16 *Travel time reliability need scores by normalized volume adjusted weekly average PTI*

Need Category	Need Score	Normalized Congestion Need Score
Very High	7	0.95 to 1
High	6	0.9 to 0.95
Medium High	5	0.85 to 0.9
Medium	4	0.8 to 0.85
Medium Low	3	0.75 to 0.8
Low	2	0.5 to 0.75
Very Low	1	0 to 0.5

Data Requirements

- Planning Time Index (source: INRIX provided by RITIS via InteractVTrans Map Explorer)
- AADT (source: InteractVTrans Map Explorer)

Geoprocessing Tool Overview

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF TRANSPORTATION NEEDS

Bus Transit On-Time Performance

While there are multiple factors that influence people's decisions to use public transportation, one of the most important decision-making factors in low-frequency bus systems such as Charlottesville Area Transit (CAT) is passenger waiting time, which is influenced by the reliability of the transit service and adherence to published schedules. When buses regularly depart from stops at the scheduled time, passengers can time their arrival at the stop to minimize wait time. However, if the bus is not usually on time, passengers can face unpredictable wait times. Accordingly, one of the most common measures of the effectiveness of the bus transportation system is on-time performance (OTP).

For the purpose of this analysis, OTP measures how well transit vehicles adhere to the published schedule within an acceptable level of deviation measured in time and serves as an indicator of the attractiveness of bus transit as a travel option. OTP is expressed as a percentage and is calculated by the count of bus timepoint departures that are on time divided by the count of total departures multiplied by 100. Buses are considered "on-time" if they are no more than 30 seconds early and no more than 5 minutes late to the major stops on the route schedule.

Since OTP data is only collected at stops where departure times are scheduled (i.e., timepoints), this analysis does not include intermediate stops with scheduled departure times. Since stop locations may include bus stops for more than one route, the term "timepoint" refers to bus stops associated with a specific route (i.e., there may be multiple timepoint features at a single stop location). Additionally, this analysis does not consider reliability in terms of service consistency or the change in reliability over time. For example, a bus that is consistently six minutes late is not on time but is reliable. Furthermore, the analysis of OTP does not provide reasons for poor performance including predictable events such as traffic congestion, passenger loads, and delays due to at-grade railroad crossings or unexpected events like crashes, disabled buses, temporary detours, weather, and issues related to labor.

The following threshold options were tested to determine scoring eligibility:

- Stops where OTP is less than the systemwide weekly average OTP from the previous year.
- Stops where OTP is less than 85% or an alternative target value in accordance with CAMPO's transit performance goals.

Calculate OTP for all timepoints in the analysis period for weekdays and weekends separately.

1. Calculate OTP in two steps:

   - Find the percentage of on-time departures by dividing the sum of on-time departures by the sum of total departures, then multiply by 100.
   - Subtract the result from 100 to obtain the share of departures that are not on time.

2. Multiply timepoints' weekday OTP values by 5/7 (five of seven days)
3. Multiply timepoints' weekend OTP values by 2/7 (two of seven days)
4. Sum the results of step 2 and step 3 to obtain weeklong average OTP by timepoint

OTP is used in the identification of needs to determine if stops are eligible for bus transit on-time performance scoring. The first threshold option determines eligibility if OTP at a timepoint is worse than the systemwide weekly average OTP from the previous year or analysis period. Alternatively, if the second threshold option is selected, timepoints are eligible for scoring if OTP is less than a target value set by CAMPO (e.g., 85%). The second threshold option does not require computation of an average weeklong average OTP.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for assessing the magnitude of the *congestion mitigation* need:

1. Calculate the daily cumulative PTI values from 6 AM to 8 PM. This step accumulates over all qualifying hours in a single year to a calculate a "daily cumulative PTI" value.

$$\text{Weeklong OTP} = \frac{5}{7}\left(\sum_{\text{Weekday OTP} > T} \text{Weekday OTP}\right) + \frac{2}{7}\left(\sum_{\text{Weekend OTP} > T} \text{Weekend OTP}\right)$$

Where:
Weeklong OTP = Average OTP for each stop by route
T = OTP threshold (83%, 85%, 90%, e.g.)

2. Adjust Weeklong OTP by subtracting the on-time rate from 100%. This will ensure that the timepoints with greater needs receive a higher value. For example, a timepoint with an OTP of 80% will become 20%, while a timepoint with an OTP of 60% will become 40%.

3. Account for the magnitude of needs by multiplying the adjusted weeklong OTP by the number of daily boardings and alightings at each timepoint (boardings and alightings are treated as a proxy for ridership in this analysis).

$$OTP\_Ridership_i = Ridership_i \times \text{Adjusted Weeklong OTP}_i$$

Where,
$OTP\_Ridership_i$ = Ridership Adjusted OTP at timepoint i
$Ridership_i$ = Daily Ridership at timepoint i
Weeklong OTP_i = Adjusted Weeklong OTP at timepoint i

4. Normalize ridership adjusted OTP.

$$\text{Normalized } OTP\_Ridership_i = \frac{OTP\_Ridership_i - OTP\_Ridership_{min}}{OTP\_Ridership_i - OTP\_Ridership_{max}}$$

Where:
$OTP\_Ridership_{min}$ = Minimum ridership adjusted OTP across all timepoints
$OTP\_Ridership_{max}$ = Maximum ridership adjusted OTP across all timepoints

Scoring of Bus On Time Performance Needs

Using **Table 17**, assign need scores based on segments' normalized volume adjusted weekly average PTI.

Table 17 Bus Transit On-Time Performance need scores by normalized ridership adjusted weekly average OTP

Need Category	Need Score	Normalized Reliability Need Score
Very High	7	0.95 to 1
High	6	0.9 to 0.95
Medium High	5	0.85 to 0.9
Medium	4	0.8 to 0.85
Medium Low	3	0.75 to 0.8
Low	2	0.5 to 0.75
Very Low	1	0 to 0.5

Data Requirements

- Charlottesville Area Transit On-Time Performance (source: CAT)
- Charlottesville Area Transit Daily Ridership (source: CAT)

Geoprocessing Tool Overview

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF TRANSPORTATION NEEDS

Need Category: Land Use and Economic Development

The aim of the land use and economic development category is to identify areas where there is access to non-work destinations to stimulate local economic activity or to create transportation choices for disadvantaged people and to prioritize projects that connect to areas of local economic development activity. Land use needs are assessed using two measures: walk access to *non-work destinations* and *walk access to non-work destinations by disadvantaged populations*. Both measures rely on WalkScore and BikeScore indices, focusing on the general population and disadvantaged populations, respectively.

Walk Access to Non-Work Destinations

The *need for walk access to non-work destinations* is determined by a segment's maximum of WalkScore and BikeScore and its future population and employment level (i.e., activity level). WalkScore3 measures walkability through measures of access to non-work destinations (cultural, restaurants, groceries, parks, errands) and roadway connectivity such as intersection density and average block length. In this needs assessment process, the maximum WalkScore or BikeScore is weighted by future activity level from the regional travel demand model. This performance measure shows locations that are in close proximity to non-work destinations, population and employment. Through the WalkScore component, the performance measures indicates where there is high network connectivity. However, these locations may have barriers to walking not accounted for in the WalkScore methodology including lack of sidewalks or crosswalks along existing facilities. Therefore, the walk *access to non-work destinations* performance measures indicates where investments in pedestrian improvements would likely yield the greatest benefits.

Segment eligibility for walk access to non-work destinations scoring may be determined by one of the following optional thresholds:

- All segments in the City of Charlottesville and in Albemarle County Development Areas
- All segments in "somewhat walkable" census tracts (i.e., WalkScores greater than 49)

If the first threshold option is selected, all segments in the City of Charlottesville or in one of Albemarle County's five Development Areas are eligible for *walk access to non-work destinations* scoring. Development areas, which are defined by the County's Comprehensive Plan, are intended "to focus development into the urban areas to create quality living areas, avoid sprawl, improve access to services, and protect the natural and agricultural resources and uses of the rural areas." Development areas include Crozet, Pantops, the US-29 corridor from Hydraulic Road to north of the airport, the Southern and Western neighborhoods adjacent to Charlottesville, and the Village of Rivanna. The effect of selecting this threshold option is that needs will be considered for all areas regardless of the current WalkScore.

Alternatively, if the second threshold option is selected, segments are eligible for *walk access to non-work destinations* scoring if they are in "somewhat walkable" census tracts which is defined by WalkScores that are greater than 49. The result of selecting this threshold option is that needs will be considered for all areas regardless of its designation as a Development Area (for Albemarle County only). However, given that WalkScores are higher in more urban areas due to better network connectivity and shorter distances to amenities, the more realistic outcome is that needs will be identified in areas within Development Areas where there is the greatest potential for improving access to non-work destinations.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for assessing the magnitude of the *walk access to non-work destinations* need:

1. Calculate segments' average WalkScore by performing a spatial join of segments that intersect the WalkScore feature layer.
2. Calculate segments' average activity level by performing a spatial join of segments that intersect the regional travel demand model's Traffic Analysis Zones (TAZ) layer that contains total population and all employment. Summarize the average activity level for segments that span two or more TAZs.
3. Calculate segments' activity weighted WalkScore by multiplying average WalkScore by average future activity level.

$$\text{Weighted Walk Score} = \text{Walk Score} \bullet (\text{Average Population} + \text{Average Jobs})$$

Normalize the weighted WalkScore using the following equation:

$$\text{Normalized WalkScore} = \frac{\text{Weighted WalkScore}_i - \text{Weighted WalkScore}_{min}}{\text{Weighted WalkScore}_{max} - \text{Weighted WalkScore}_{min}}$$

Where:
Weighted WalkScore$_i$ = WalkScore • Activity level for Segment i
Weighted WalkScore$_{min}$ = Minimum (WalkScore • Activity level) for all segments
Weighted WalkScore$_{max}$ = Maximum (WalkScore • Activity level) for all segments

Scoring of Walk Access to Non-Work Destinations Needs

Sort the normalized average WalkScore weighted by average activity level. Then, using **Table 18**, assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for *walk access to non-work destinations.*

***Table 18** Walk access to non-work destinations need scores applied to segments by population weighted WalkScore*

Need Category	Need Score	Percent of Total Mileage
Very High	7	0% to 5%
High	6	5.001% to 10%
Medium High	5	10.001% to 15%
Medium	4	15.001% to 20%
Medium Low	3	20.001% to 25%
Low	2	25.001% to 50%
Very Low	1	50.001% to 100%

Data Requirements

- WalkScore and BikeScore (source: InteractVTrans Map Explorer)
- Future population and employment (source: Charlottesville-Albemarle Regional Model)

Geoprocessing Tool Overview

(forthcoming)

Walk Access to Non-Work Destinations by Disadvantaged Populations

The need for *walk access to non-work destinations by disadvantaged populations is* similar to the performance measure described in the previous section but the combined WalkScore and BikeScore is weighted by disadvantaged population from Equity Emphasis Areas in the InteractVTrans Map Explorer instead of future activity level. Like *walk access to non-work destinations,* this performance measure shows locations that are in close proximity to non-work destinations and disadvantaged populations and where there is high network connectivity. However, these locations may still have barriers to walking not accounted for in the WalkScore methodology including lack of sidewalks or crosswalks along existing facilities. Therefore, the *walk access to non-work destinations by disadvantaged populations* performance measure indicates where investments in pedestrian improvements would likely yield the greatest benefits for disadvantaged residents.

Segment eligibility for *walk access to non-work destinations for disadvantaged populations* scoring may be determined by one of the following optional thresholds:

- All segments in transit viable EEAs
- All segments in transit viable EEA that are also in "somewhat walkable" census tracts (i.e., WalkScores of 50 or higher)

The implication of selecting all segments in transit EEAs for walk access to non-work destinations scoring is that the current WalkScore does not affect which segments are scored for walk access to jobs by disadvantaged populations. Conversely, the effect of choosing the threshold option that limits scoring to segments in "somewhat walkable" locations is that "car-dependent" EEAs which have a combined WalkScore and BikeScore of less than 50 will not be considered for scoring.

Calculation Steps

The following steps outline the process for assessing the magnitude of the *walk access to non-work destinations* need:

1. Calculate segments' average WalkScore by performing a spatial join of segments that intersect the WalkScore feature layer.

2. Calculate segments' disadvantaged population by performing a spatial join of segments that intersect the Equity Emphasis Areas (EEA) Census tract layer. Sum the low-income population, age 75-plus population, disabled population, limited English proficiency population, minority population, and Hispanic population for each segment.

3. Calculate segments' weighted WalkScore by multiplying average WalkScore by average disadvantaged populations in intersecting zones.

$$\textit{Weighted Walk Score} = \textit{Walk Score} \bullet \textit{Segment disadvantaged population}$$

4. Normalize the weighted WalkScore using the following equation:

$$\textit{Normalized WalkScore} = \frac{\textit{Weighted WalkScore}_i - \textit{Weighted WalkScore}_{min}}{\textit{Weighted WalkScore}_{max} - \textit{Weighted WalkScore}_{min}}$$

Where:

Weighted WalkScore*i* = WalkScore • Activity level for Segment i

Weighted WalkScoremin = Minimum (WalkScore • Activity level) for all segments

Weighted WalkScoremax = Maximum (WalkScore • Activity level) for all segments

Scoring of Walk Access to Non-Work Destinations Needs

Sort the normalized average WalkScore weighted by disadvantaged population. Then, using **Table 19**, assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for walk access to non-work destinations.

Table 19 *Walk access to non-work destinations need scores applied to segments by disadvantaged population weighted WalkScore*

Need Category	Need Score	Percent of Total Mileage
Very High	7	0% to 5%
High	6	5.001% to 10%
Medium High	5	10.001% to 15%
Medium	4	15.001% to 20%
Medium Low	3	20.001% to 25%
Low	2	25.001% to 50%
Very Low	1	50.001% to 100%

Data Requirements

- WalkScore and BikeScore
- (source: InteractVTrans Map Explorer)
- Equity Emphasis Areas (source: OIPI via InteractVTrans Map Explorer)

Geoprocessing Tool Overview (forthcoming)

(forthcoming)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Need Category: Environment and Resiliency

The aim of the environmental category is to identify resiliency needs, especially where infrastructure is exposed to inland flooding and to prioritize projects that pose no environmental impacts, mitigate impacts, or offer environmental services.

Exposure to Projected Sea Level Rise, Storm Surge, or Historical Inland/Riverine Flooding

Environmental and Resiliency needs are accounted for as an adjustment to combined needs scores for segments that are exposed to sea level rise, storm surge, or historical flooding and are within an Economically Distressed Community. This metric adjusts the aggregate scores of all roadway segments with a need based on Flooding Risk Assessment and the Distressed Communities Index (DCI).

OIPI's Flooding Risk Assessment is a system level analysis of the system's assets' (i.e., roads and bridges) vulnerability to climate change, including sea level rise, storm surge, and inland flooding. The components of vulnerability as defined by the Federal Highway Administration (FHWA) include exposure, sensitivity, and adaptive capacity. For the purposes of CAMPO's environmental needs analysis, only system exposure to inland flooding is considered. The following definitions, which are taken from the VTrans Vulnerability Assessment Tech Memo, reflect the components of vulnerability as defined by FHWA.

- *Exposure* determines whether the asset is experiencing the direct effects of climate change
- *Sensitivity* determines how well the system fares when exposed to climatic events
- *Adaptive Capacity* determines the system's ability to adjust with future climate impacts

The Distressed Communities Index (DCI), which derives data from the American Community Survey (ACS), sorts zip codes into quintiles of economic well-being: prosperous, comfortable, mid-tier, at risk, and distressed. The seven components of DCI is the share of residents who are 25 or older who do not have a high school diploma or equivalent, housing vacancy rate, unemployment rate for working-age adults (25-54), the share of the population living under the poverty line, median household income as a percent of metro area/state median household income, the percent change in employment from 2016 to 2020, and the percent change in the number of business establishments from 2016 to 2020. **Table 20** lists zip codes in the Charlottesville-Albemarle MPO area by DCI.

Table 20 *Distressed Communities Index for Zip Codes in the Charlottesville-Albemarle Area*

Zip Code	Post Office	Distressed Communities Index	Population (2021)
22901	Charlottesville	35.6 (Comfortable)	36,964
22902	Charlottesville	38.5 (Comfortable)	24,018
22903	Charlottesville	62.9 (At Risk)	44,101
22904[4]	Charlottesville	n/a	3,119
22911	Charlottesville	7.4 (Prosperous)	18,627
22923	Barboursville	9.4 (Prosperous)	6,004
22932	Crozet	15.3 (Prosperous)	10,102
22936	Earlysville	15.4 (Prosperous)	5,186
22947	Keswick	47.4 (Mid-Tier)	5,150
22959	North Garden	60.7 (At Risk)	1,932
22968	Ruckersville	21.9 (Comfortable)	11,239
22974	22974	34.5 (Comfortable)	5,441

Calculation Steps

Since project location is a critical component of environmental impacts, the *Environment and Sustainability* need category is applied after aggregating need scores across the other metrics described in previous sections. The adjustment factors apply to aggregate scores for road segments that are exposed to projected sea level rise, storm surge, or inland/riverine flooding and to segments in economically distressed communities.

- 5% adjustment for segments exposed to historical flooding in a 100-year flood zone
- Adjustments for economically distressed communities
  - 5.0% adjustment applied to aggregate score of road segments in a zip code that has a DCI index of 80 to 100 (i.e., distressed)
  - 3.5% adjustment applied to aggregate score of road segment in a zip code that has a DCI rating of 60 to 80 (i.e., at risk)
  - Additional 2.0% if a roadway segment falls within a zip code that has a DCI rating of 40 to 60 (i.e., mid-tier)

Data Requirements

- VTrans Flood Risk Assessment (source: OIPI via InteractVTrans Map Explorer)
- Distressed Communities Index (source: Economic Innovation Group)[5]