IDENTIFICATION OF ELIGIBLE PROJECTS AND DEVELOPMENT OF STANDARDIZED METHODOLOGIES FOR ESTIMATING POTENTIAL EMISSION BENEFITS FOR THE CARBON REDUCTION PROGRAM (CRP) FUNDING

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1 BACKGROUND

The Carbon Reduction Program (CRP) established under the Infrastructure Investment and Jobs Act (IIJA) (Public Law 117-58) requires the State Department of Transportation (DOT) to reduce carbon dioxide (CO_2) emissions from the transportation sector by developing and implementing Carbon Reduction Strategies (CRS) aimed at reducing transportation emissions. To meet this requirement, the Texas Department of Transportation (TxDOT) developed a framework to be applied to infrastructure projects in the state from CRP and other federal program sources to address transportation emissions. Metropolitan planning organizations (MPOs), play an important role in identifying projects and strategies to reduce transportation emissions. The 2023 CRS identified the need to integrate carbon reduction projects and programs into the MPO planning process. In addition, MPOs indicated that the carbon reduction categories

'Advanced Technology' and 'Travel Demand Management' as the most implementable in terms of feasibility and potential carbon emissions reduction benefits.

As part of the technical assistance available through the Air Quality interagency contract (IAC), in FY2023 the Texas A&M Transportation Institute (TTI) study team supported the development of TxDOT's 2023 CRS. TxDOT is required to develop the 2027 CRS that will support statewide and regional efforts to reduce transportation emissions, identify projects and strategies to reduce transportation emissions, support the reduction of transportation emissions in Texas, and be appropriate to the population density and context of Texas. Within the 2023 CRS, there is a wide range of strategies and programs that have been identified as candidates for CRP funding. As projects and programs are implemented, it will be imperative for TxDOT to evaluate how effectively these projects and programs reduce carbon emissions. The 2023 CRS provided a successful effort for TxDOT and has identified many recommendations that could give us a head start for the development of the 2027 CRS.

The objectives of this task include the following:

- Review the most up-to-date Transportation Improvement Plans (TIP) for each of the 25 MPOs within the State of Texas.
- Investigate and document the best means of evaluating data-driven approaches to evaluating carbon reduction strategies.
- Quantify the estimated CO_2 emissions reduction for most of the categories identified in the 2023 CRS using data-driven methodologies that will support and justify carbon reduction strategies chosen for implementation.

2 METHODOLOGY

2.1 Documentation of CRS in Texas

The TTI study team downloaded and reviewed the latest available TIPs from all 25 MPOs in the state of Texas. Unfortunately, the TIPs do not classify the strategies employed in the projects (i.e., advanced technology, travel demand management, etc.). In addition, emission reduction is not a parameter that needs to be reported in the TIPs. To resolve this, the TTI study team developed methodologies to filter and reclassify projects by strategy type, which will be discussed in this section, and identified methods to quantify CO_2 emission reduction, which will be discussed in more detail in the following section.

The TIPs from all MPOs are combined to form the Statewide TIP (STIP), which TxDOT amends on a quarterly basis. The TTI study team was able to download a complete list of TIP projects from TxDOT's STIP Data Table dashboard[1], which was revised in November 2023.

Next, the TTI study team conducted a literature review to identify a list of keywords frequently used to describe certain strategies. In addition to Advanced Technology and Travel Demand Management, the TTI study team also included the Active Transportation category from the 2023 CRS and broke the strategy category down into individual strategies, as shown in Table 1. The individual keywords used to filter the STIP data and classify them are listed in Appendix A.

Table 1. CRS Strategy Categories and Strategies

Strategies Category	Strategy
Advance Technology	Traffic Signal Optimization
	Intelligent Transportation System (ITS)
	Real-Time Information and Communication
	Rail Crossing Traffic Management System
	Vehicle to Infrastructure (V2I) Communications
	Dynamic Freight Routing
	Traffic Management Center (TMC)
	Dynamic Parking Availability Signs and Systems
Travel Demand Management	Intersection Improvements
	Demand Shifting
	Interchange Improvements
	Increasing Vehicle Occupancy Rates
	Shifting Demand to Nonpeak Hours
	Congestion Pricing
	Roundabout
Active Transportation	Bike Lanes
	Visibility Improvement
	Americans with Disabilities Act (ADA) Improvements

[1] TxDOT's STIP Data Table dashboard, available here: https://tableau.txdot.gov/views/STIPDashboards/STIPDataTableDashboard, was accessed on June 20th, 2024.

	Bikeshare and Electric Bikes

2.2 Quantification of Emission Reduction

As previously discussed, the MPOs do not need to include emission reduction benefits of the individual projects in their MTP. Thus, the TTI study team needed to identify a methodology to assign estimated CO_2 emission benefits to each project in the STIP, based on limited available information. The TTI study team proposed two methodologies and compared their efficacy to real world examples:

- Using the Congestion Mitigation and Air Quality (CMAQ) projects reported benefits to estimate an average emission benefit baseline for the strategy type,
- Using the Federal Highway Administration's (FHWA's) CMAQ Toolkit or Texas' MObile Source Emission Reduction Strategies (MOSERS) tool to estimate an average CO_2 emission benefit for each strategy type.

The following sections describe each approach in more detail.

2.2.1 CMAQ Project Averages

The TTI study team downloaded the latest available CMAQ project list, containing information on awarded CMAQ projects from 1992 through 2023 for all 50 states. The spreadsheet included information on project type, title, description, and emission benefits for volatile organic compounds (VOC), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (both under 10 microns [PM_{10}] and under 2.5 microns [$PM_{2.5}$]), and CO_2 in kg per day (CO_2 was reported in metric tons per day).

First, the TTI study team filtered for strategy keywords (available in Appendix A) in the CMAQ project type, title, description, and additional description columns to categorize the projects into those listed in Table 1. Then, the CO_2 benefits for all projects filtered into each strategy in Table 1 were averaged. To ensure that the emission benefits were estimated using up-to-date methods, the TTI study team filtered out CMAQ projects awarded before 2021, unless they were continuing projects. These averages would then be used to calculate the total emission benefits of STIP projects. For example, if a project in the STIP were categorized into both the ITS and demand shifting categories, the average CO_2 benefits from ITS and demand shifting would be applied, and the total CO_2 benefits would be the sum of both values.

Upon closer inspection of the dataset, the TTI study team found an error in the units for CO_2 Emissions benefit field which is marked as MT/day (metric tons/day). This will make the values very extreme when compared to the emission benefits of other pollutants. For example, a 2022 congestion mitigation project in California's San Francisco Bay area was estimated to produce 1,821 metric tons of CO_2 emission reduction per day, while the other pollutants were around or less than 1 kg per day. While CO_2 emission rates are higher than these pollutants (e.g., based on the emission rate lookup table [ERLT] for an urban restricted access roadway in Dallas in 2022, if the average running speed is 35 mph, the CO_2 emission rate is around 665 grams/mile compared to NO_x's 1.3 grams/mile, yielding a 511 times difference), the San Francisco Bay project's difference between its CO_2 and NO_x emission benefits was about 607,000 times.

The TTI study team believes this may be an input error, as all other pollutants aside from CO_2 were reported in kg per day while CO_2 was reported in metric tons per day. Assuming the CO_2 emissions benefit as kg per day instead of metric tons per day yields a NOx to CO_2 ratio more in line with the ERLT. Upon looking at the individual project reports from the CMAQ website, the CO_2 emission benefits were indeed reported in kg/day. Hence, for determining the CO_2 emission benefits, the values were assumed to be reported in Kg/day.

There were many projects on the CMAQ list which did not report CO_2 emission benefits and many projects where the ratio of CO_2 to CO appears to be vastly out of expected range. CO_2 to CO ratio was chosen to filter the projects from CMAQ as it was the one which had least variance among all the pollutants ratio to CO_2 in ERLT table. The range selected for filtering CO_2 to CO ratio is from 25 to 600, which is in line with the range from ERLT rates. Table 2 summarizes the average emission benefits reported for each of the strategy types from CMAQ project reports.

Table 2 Average CO_2 Emission Benefits for Different Strategies from CMAQ Projects

Strategy Category	Strategy #	Strategy	Number of Projects	Average CO_2 Emission Benefits (kg/day)
Advance Technology	1A	Traffic Signal Optimization	2	721
	1B	ITS	3	16,468
	1D	Rail Crossing Traffic Management System	15	437
	1G	TMC	1	232
	2A	Intersection Improvements	5	728

Strategy Category	Strategy #	Strategy	Number of Projects	Average CO_2 Emission Benefits (kg/day)
Travel Demand Management	2B	Demand Shifting	39	2,201
	2C	Interchange Improvements	1	643
Active Transportation	3A	Bike Lanes	25	276
	3B	Visibility Improvement	1	83
	3C	ADA Improvements	5	305
	3D	Bikeshare and Electric Bikes	1	49,076

2.2.2 CMAQ Toolkit & MoSERS Method

Based on the average total project cost of the strategy, as reported for the STIP, the TTI study team conducted a literature review to identify projects of the same strategy type and with a similar project cost to use as a baseline for the MOSERS input. As not all projects listed in the MPOs' TIPs contain detailed information, the TTI study team also reviewed the CMAQ projects and toolkits to fill in the gaps, as well as relied on default values already in the MOSERS tool.

For all strategy types, the TTI study team used the 2023 Dallas area emission rates as the baseline. Also, here is the list of assumptions used to calculate the baseline CO_2 emission benefits. Most of the parameters were held at same level between strategies as much as possible.

- Length of corridor – 1 mile
- Number of signalized intersections along the corridor - 1
- Existing number of through lanes along the corridor (one direction) – 1
- Intersection number of lanes (one direction)
- Major Road:
    - Before - 1 Left, 1 right, 2- through
    - After - 2 Left, 1 right, 2- through
- Minor Road:
    - Before - 1 Left, 1 right 1 – through
    - After - 2 Left, 1 right, 1- through

- Annual average daily traffic (both directions) - 10000
- Posted speed limit (before) – 40 mph
- Posted Speed (after) – 50 mph
- Existing average corridor travel time during peak period (one direction) – 10 min
- Existing average cycle length along the corridor -40 s
- All-red time – 5 s
- Yellow time – 4s
- Average amount of time rail crossing is closed due to train crossing – 1 hr/day
- Freight VMT (before) - 1000
- Freight VMT (after) – 900
- Number of HOV Lanes added - 1
- Delay per vehicle
- Peak – 30s
- Off-Peak – 20s
- Population – 100000
- Percent of Cyclists – 10%
- Length of Bike Lane – 1 mile

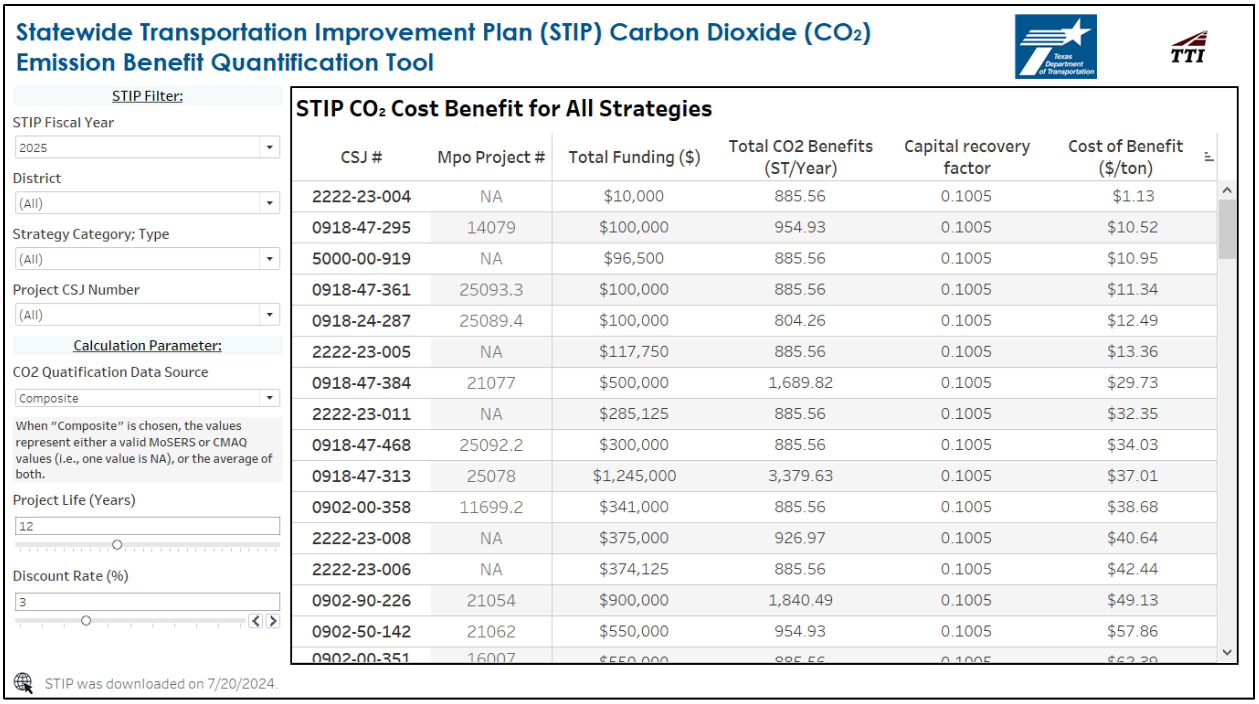
Table 3 presents the baseline CO_2 emission benefits (in kg/day) for different transportation strategies categorized under Advance Technology, Travel Demand Management, and Active Transportation. The calculations are based on consistent assumptions such as the CO_2 emission factor, daily traffic volume, reduction in delay, and other relevant data. The MoSERS strategies and the required data for each calculation are also listed for reference.

Table 3 Baseline CO_2 Emission Benefits for Various Strategies Using MoSERS Framework and the data needs for each strategy

Strategy	MoSERS Strategy	Required Data for Emission Benefits Calculation	CO_2 Emission Benefits (Kg/day)
Traffic Signal Optimization	5.1	Length, AADT, speed, cycle length, number of signals, travel time, number of lanes	9.150
ITS	5.4	Length, AADT, speed (before and after)	158.45
Real-Time Information and Communication	5.4	Length, AADT, speed (before and after)	158.45
Rail Crossing Traffic Management System	5.5	AADT, Time railway crossing is closed in a day	2.05
V2I Communications	5.4	Length, AADT, speed (before and after)	158.45
Dynamic Freight Routing	7.2	Freight VMT (Before and After) and Speed (Before and After)	627.17
TMC	5.4	Length, AADT, speed (before and after)	158.45
Intersection Improvements	5.3	Number of Lanes – Both roads of intersection (Left, Through, Right) & (Before and After), cycle length, all-red time, yellow time	20.957
Interchange Improvements	5.3	Number of Lanes – Both roads of intersection (Left, Through, Right) & (Before and After), cycle length, all-red time, yellow time	20.957
Increasing Vehicle Occupancy Rates	2.1	Number of HOV Lanes added, Number of General-Purpose Lanes (GPL), Hourly Volume (HOV and GPL) and Speed Limit	96.602
Roundabout	5.8	Intersection (all approaches)- Volume, Capacity, Delay, No of Lanes	339.481
Bike Lanes	3.2 (Option 2)	Number of cyclists, reduction in vehicle trips, Average trip length, Number of trips, Length of bike lanes,	3,721.874
Bikeshare and Electric Bikes	3.2 (Option 1)	Number of bikeshare/e-bike users, Reduction in vehicle trips, Average trip length, Number of trips	2,147.340

3 RESULT VISUALIZATION

Based on the results in Chapter 2, the TTI study team developed a visualization tool using Tableau software to assist in the quantification of STIP CO_2 benefits, as shown in Figure 1. The dashboard has toggles that allow users to filter by STIP fiscal year, TxDOT district, CRS strategy category and type, as well as project CSJ number. If a project CSJ number does not exist (coded “0- -0”), the dashboard assigns it a dummy number of “9999-99-“ followed by its MPO project number.



CSJ #	Mpo Project #	Total Funding ($)	Total CO2 Benefits (ST/Year)	Capital recovery factor	Cost of Benefit ($/ton)
2222-23-004	NA	$10,000	885.56	0.1005	$1.13
0918-47-295	14079	$100,000	954.93	0.1005	$10.52
5000-00-919	NA	$96,500	885.56	0.1005	$10.95
0918-47-361	25093.3	$100,000	885.56	0.1005	$11.34
0918-24-287	25089.4	$100,000	804.26	0.1005	$12.49
2222-23-005	NA	$117,750	885.56	0.1005	$13.36
0918-47-384	21077	$500,000	1,689.82	0.1005	$29.73
2222-23-011	NA	$285,125	885.56	0.1005	$32.35
0918-47-468	25092.2	$300,000	885.56	0.1005	$34.03
0918-47-313	25078	$1,245,000	3,379.63	0.1005	$37.01
0902-00-358	11699.2	$341,000	885.56	0.1005	$38.68
2222-23-008	NA	$375,000	926.97	0.1005	$40.64
2222-23-006	NA	$374,125	885.56	0.1005	$42.44
0902-90-226	21054	$900,000	1,840.49	0.1005	$49.13
0902-50-142	21062	$550,000	954.93	0.1005	$57.86
0902-00-351	16007	[illegible]	[illegible]	[illegible]	[illegible]

Figure 1. STIP CO_2 Emission Benefit Quantification Tool Dashboard

3.1 Emission Benefit Quantification

Before the data was inputted into the dashboard, the TTI study team first assigns CRS strategies in Table 1 to each of the STIP projects based on the description. Codes were written to filter each project’s description for keywords associated with the CRS strategy, available in Appendix A, which is then inputted into Tableau. Based on the CRS strategy, the emission benefits were assigned to the project. If the project consisted of multiple strategies, all instances of distinct CRS strategies were accounted for. Users can choose either to use emissions quantified through CMAQ (results from Chapter 2.2.1), MoSERS (results from Chapter 2.2.2), or a composite of both, which takes the average value if both have valid values or the valid value if the other is invalid.

The "Total Funding" column includes the sum of funding for each category, whereas the "Total CO_2 Benefits (ST/Year)" columns sum up the individual CO_2 benefits for each strategy and each category. When the user hovers over any of the values, a pop-up tooltip, as shown in Figure 2, will appear. This tooltip lists the project's CSJ and MPO numbers, the district where the project lies, the MPO, the highway number, its description, as well as a more detailed breakdown of the funding and CO_2 benefits by category and CRS strategies. For example, project CSJ: 0918-47-313 (Figure 2) is divided into two categories with different funding amounts. The funding from both categories was added to yield the total funding amount. Since each category has a different funding amount, the TTI study team assigned CRS strategies and CO_2 benefits to each category—in this case, two categories with two CRS strategies each. The total CO_2 benefits for the project will be the sum of all four benefits, totaling 3,380 tons per year as shown in Figure 1).

TIP Information:
CSJ #: **0918-47-313**
MPO #: **25078**
District: **DALLAS**
Stip-Mpo: **NCTCOG - Dallas**
Highway Number: **CS**
Description: **RECONSTRUCT FROM 2 TO 3 LANES WITH PEDESTRIAN IMPROVEMENTS, INCLUDING SIDEWALKS AND SHARED-USE PATH**

Carbon Reduction Program (CRP) Strategies:
Distinct count of Strategy: **2**
Total Funding ($): **$1,245,000**

Category	CRS Strategy	Funding per Category ($)	CO2_Benefits (ST/Yr)
3LC	Bike Lanes	$165,000	804.26
	Demand Shifting	$165,000	885.56
7	Bike Lanes	$1,080,000	804.26
	Demand Shifting	$1,080,000	885.56

Figure 2. STIP CO_2 Quantification Tool Pop-Up Tooltip

3.2 Cost Benefit Calculation

Capital recovery factor (CRF) is utilized to calculate the cost benefit, in terms of dollars per ton of CO_2 removed each year. CRF is calculated using the formula:

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where, i is the discount rate and n is the number of annuities.

The user can adjust the discount rate and number of annuities using a toggle on the dashboard, as seen in Figure 1. The dashboard automatically sorts the results by the cost of benefit in ascending order. The user can also sort this order by total funding or total quantified benefits. Any projects that did not have a CRS strategy assigned, were assigned a CRS strategy without quantification (i.e., congestion pricing, etc.), or had zero total funding were filtered out automatically.

4 FUTURE WORK

The dashboard discussed in this report is a prototype that the TTI study team developed based on minimal input from the TxDOT team. As discussed in Chapter 2.2.1, the TTI study team does not have full confidence in the CMAQ data and filtered out values that were above or below certain ranges to increase the confidence level. Conversely, the MoSERS values, as discussed in Chapter 2.2.2, were derived using a set of default values applied across all strategies and regions. While the TTI study team believes the current configuration is acceptable for the purpose of ranking strategies in terms of CO_2 benefits, it cannot be used as a replacement for specific CO_2 benefits modeling and analysis in its current capacity. The TTI study team will present the dashboard to TxDOT once finalized and will update the dashboard to better fit the TxDOT team's needs based on review and discussion.

APPENDIX A: KEYWORDS FOR CRS STRATEGIES

This appendix includes the keywords used by the TTI study team to filter and categorize strategies, as discussed previously in Chapter 2.1.

Strategies Category	Strategy	Strategy ID	Keywords
Advance Technology	Traffic Signal Optimization	1A	Traffic Signal Optimization
			Signal Detection
			Upgrade Signals
			Traffic Signal Improvement
			Traffic Signal Upgrade
			Traffic Signal Upgrades
			Traffic Signal
			Traffic Signals
			Signal Timing
			Synchronization
			Traffic Signal Coordination
	ITS	1B	ITS
			Intelligent Transportation System
			Its Deployment
			Traffic Control Device Installation
			Traffic Control Device Upgrades
			Traffic Control Device
			Traffic Control Devices
			Traffic Control
			Adaptive Traffic Signal Control
			Smart City
			Advanced Traffic Management Systems
			Traffic Control Management
	Real-Time Information and Communication	1C	Real-Time Information
			Real-Time Communications
			Communications Device
			Closed-Circuit Television
			Dynamic Message Sign
			Dynamic Message Signs
			DMS
			CCTV
			Automated Traffic Monitoring
			Traffic Monitoring

Strategies Category	Strategy	Strategy ID	Keywords
			Variable Message Signs
			Changeable Message Signs
			Traffic Surveillance
			IVHS
			Surveillance
			Communication
	Rail Crossing Traffic Management System	1D	Rail Crossing
			Rail Crossing Traffic Management System
			Rail Crossing Improvement
			Railway Crossing Control Systems
			Railroad Crossing
			Rail Crossing Barrier Installation
			Barrier
	V2I Communications	1E	Vehicle To Infrastructure
			Vehicle To Infrastructure Communications Technology
			V2I
			Communications Technology
			Connected Vehicles
	Dynamic Freight Routing	1F	Freight Routing System
			Dynamic Freight Routing System
			Dynamic Freight
			Freight Routing
			Freight Route
	TMC	1G	Traffic Management Center
			Traffic Management and Operations Center
			TMC
			Incident Management
	Dynamic Parking Availability Signs and Systems	1H	Dynamic Parking
			Dynamic Parking Signs
			Dynamic Parking Availability Signs
			DPAS
			Truck Parking System
			Truck Parking Availability System
			TPAS
			Smart Parking
			Intelligent Parking
			Real-Time Parking

Strategies Category	Strategy	Strategy ID	Keywords
			Parking Information System
			Electronic Parking
			Parking Occupancy
			Adaptive Parking
Travel Demand Management	Intersection Improvements	2A	Intersection Improvement
			Intersection Upgrade
			Intersection Improvements
			Roundabout Installation
			Roundabout
			Convert Intersection
			Pedestrian Crossing
			Turn Lane Addition
			Turn Lane
			Traffic Congestion Mitigation
			Traffic Control Measures
			Traffic Calming
	Demand Shifting	2B	Demand Shift
			Shift Demand
			Carpool
			Carpooling
			Vanpool
			Vanpooling
			Telecommute
			Telecommuting
			Transit
			Bus
			Public Transit
			Public Transportation
			Bike
			Biking
			Walking
			Bike Lanes
			Bike Share
			Bike Sharing
			Pedestrian
			Pedestrian Infrastructure
			Education

Strategies Category	Strategy	Strategy ID	Keywords
			Educational Campaigns
			MAAS
			Park-And-Ride
			Rideshare
			Ride-Sharing
			Transit Vehicles
			Transit Fare
	Interchange Improvements	2C	Interchange Improvement
			Interchange Reconstruction
			Convert Interchange
			Interchange Reconfiguration
			Interchange Access Improvement
			Interchange Design Upgrades
			Interchange Capacity
	Increasing Vehicle Occupancy Rates	2D	Vehicle Occupancy Rate
			Vehicle Occupancy
			Increase Vehicle Occupancy
			HOV
			HOT
			High Occupancy Vehicle
			High-Occupancy Vehicle
			High Occupancy Toll
			High-Occupancy Toll
	Shifting Demand to Nonpeak Hours	2E	Shift Demand
			Shifting Demand
			Demand Shift
			Nonpeak
			Non-Peak
			Remote Work
			Remote Working
			Flexible Work Hours
			Peak Hour Traffic Mitigation
			Off-Peak Travel Incentives
	Congestion Pricing	2F	Congestion Pricing
			Express Lane
			Express Lanes
			Managed Lane

Strategies Category	Strategy	Strategy ID	Keywords
			Managed Lanes
			Tolling
			Dynamic Tolling
			Toll Plaza
			Electronic Road Pricing
			Transportation Pricing
			Pricing Policies
	Roundabout	2G	Roundabout
			Round About
Active Transportation	Bike Lanes	3A	Bicycle Lane
			Bicyclist
			Bicyclist Separation
			Bike Lane
			Motor Vehicle-Pedestrian
			Pedestrian
			Pedestrian Bridge
			Shared Use Path
	Visibility Improvement	3B	Streetlight
			Street Light
			Visibility
	ADA Improvements	3C	Americans with Disabilities Act
			ADA
			Disability
			Disabilities
	Bikeshare and Electric Bikes	3D	Bikeshare
			Bike Share
			Bicycle Sharing
			Electric Bike
			Electric Bicycle