Ozone and Fine Particulate Matter ($PM_{2.5}$) Conformity Analysis

For The Adoption of SEMCOG's 2050 Regional Transportation Plan

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Introduction

The federal Clean Air Act requires that federally funded highway and transit projects contained in regional long-range transportation plans (RTP) and Transportation Improvement Programs (TIP) be consistent with the air quality goals established in state air quality implementation plans (SIP). The process for demonstrating this consistency is called Air Quality Conformity. The purpose of Conformity is to ensure that projects in the plan will not cause new air quality violations, worsen any existing violations, or delay timely attainment of National Ambient Air Quality Standards (NAAQS).

The U.S. Environmental Protection Agency (EPA) has established NAAQS for six criteria air pollutants: carbon monoxide, lead, ground-level ozone, nitrogen dioxide, sulfur dioxide, and particulate matter. EPA designates an area as either "attainment" or "nonattainment" for each of these pollutants based on whether local air monitoring data shows it is meeting or not meeting these standards. Areas that were initially designated as "nonattainment" for a particular standard but later attain that standard are termed "maintenance" areas.

Pollutants Analyzed for Transportation Conformity in Southeast Michigan

Air quality transportation conformity analysis is required for the entire seven-county region of southeast Michigan due to its designated status of "maintenance" for particulate matter and ozone. Below is a summary of southeast Michigan's current air quality status for each of these two pollutants.

- Fine Particulate Matter ($PM_{2.5}$): The entire seven-county region was originally designated nonattainment for both the 1997 annual (15 $\mu g/m^3$) and 2006 24-hour (35 $\mu g/m^3$) $PM_{2.5}$ standards. However, since the implementation of Michigan's State Implementation Plan (SIP) for this pollutant, levels have declined significantly, and all air monitors have been measuring levels well below the standards since 2009. Consequently, the U.S. EPA has re-designated the region as a "maintenance area" for these two standards in 2013. In 2015, southeast Michigan was designated as "attainment" for the tougher 2012 annual standard (12 $\mu g/m^3$) and the 1997 annual standard was revoked by the EPA in 2016. Thus, conformity analysis for this pollutant is only required for the 24-hour standard for the region.
- Ozone: The entire region was originally designated nonattainment for the 1997 ozone NAAQS of 0.08 ppm. Following successful implementation of Michigan's SIP for this pollutant, the region was re-designated as "maintenance" in 2009. In 2012, Southeast Michigan was designated as "attainment" for the 2008 ozone NAAQS of 0.075 ppm. In 2018, the entire seven-county region was designated nonattainment for the new stricter 2015 ozone NAAQS of 0.070 ppm by the EPA. However, since the implementation of Michigan's SIP for this pollutant, all air monitors have been measuring levels below the standards. Therefore, on May 19, 2023, the EPA redesignated the region to "attainment/maintenance area" for the 2015 ozone NAAQS. At the same time, the EPA also approved the 2025 and 2035 VOC and NOx motor vehicle emissions budgets included in Michigan's plan for maintaining the 2015 ozone NAAQS through 2035 in the region. Thus, conformity analysis for this pollutant is required for the region.

Overview of Conformity Analysis Process

To analyze conformity, emissions generated by all vehicles on Southeast Michigan's roadway system are estimated using a complex set of computer models. The models estimate the expected change in these emissions due to the combination of:

- Anticipated growth in the region, and
- The implementation of regionally significant transportation projects that either increase or decrease roadway capacity (e.g., building of new roads, adding or reducing the number of traffic lanes on existing roads). The impact of major transit projects is also included.

1. MOVES Model Run Specifications

EPA's MOVES version MOVES4.0.1 was used to perform this transportation conformity analysis. MOVES' County level run was utilized, and Wayne County was chosen to represent the fuel characteristics used in all seven SEMCOG counties (Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne counties).

These seven counties comprise Southeast Michigan's maintenance area for both the 1997 ozone National Air Ambient Quality Standard (NAAQS) and the 2015 ozone NAAQS. As ozone conformity analysis involves generating emissions for a high-ozone summer weekday, only weekday emissions were specified in MOVES. The simulated ozone meteorological data was entered into the month of July to represent the typical summer day.

These seven counties also reflect the maintenance area for the 2006 24-hour $PM_{2.5}$ NAAQS. MOVES runs for this pollutant specify the weekdays of the three winter months: December, January and February since previous monitoring data has shown $PM_{2.5}$ emissions are highest during these months.

Although Wayne County was chosen to represent the whole region geographically in MOVES runs, all local inputs were developed to represent the transportation activities in all seven SEMCOG counties. More information on the development of these local inputs is provided in Section 7.

2. Results of Transportation Conformity Analysis

A. 24-Hour Fine Particulate Matter ($PM_{2.5}$)

Table 1 shows the results of the 24-hour fine particulate matter ($PM_{2.5}$) conformity analysis for the Southeast Michigan attainment/maintenance area. This area includes the entire seven-county SEMCOG region. In accordance with EPA conformity guidance on the 24-hour $PM_{2.5}$ standard, the analysis uses daily emissions inventories for the season in which most 24-hour $PM_{2.5}$ violations occur. Research by the Michigan Environment, Great Lakes, and Energy (EGLE) and SEMCOG's Air Quality Study (SEMAQS) group found that $PM_{2.5}$ concentrations in Southeast Michigan tend to be highest during the winter season. Thus, vehicle emissions for an average winter day are used for this conformity analysis.

On-road mobile source emission budgets for the 24-hour standard were approved by the EPA in 2013, when the region was re-designated as an attainment/maintenance area. Conformity is demonstrated if forecasted 24-hour $PM_{2.5}$ and nitrogen oxide (NO_x) emissions for specific future years do not exceed these budgets. The data in Table 1 show that forecasted emissions of both $PM_{2.5}$ and NO_x are well below the established budgets for all analysis years. Thus, conformity is demonstrated.

Table 1: Results of Daily PM2.5 Conformity Analysis -Budget Emissions Test

Analysis Year	Emissions (Tons per winter weekday)		Regional Winter Weekday VMT (millions)
	Primary $PM_{2.5}$	NO_x	
Conformity Budget	16	365	NA
2025	2.85	62.08	121.74
2030	2.34	39.39	124.02
2035	2.11	26.15	125.85
2040	1.99	21.27	127.19
2050	1.95	18.52	128.98

B. Ozone

Table 2 shows the results of the ozone conformity analysis for SEMCOG's 2015 ozone "attainment/maintenance" area. This area includes the entire seven-county SEMCOG region. Conformity is demonstrated if forecasted emissions for specific future years do not exceed the EPA-approved mobile source emission budgets set forth in Michigan's State Implementation Plan (SIP) for maintaining the 2015 ozone NAAQS through 2035 in the region.

The data in Table 2 show that forecasted emissions in the SEMCOG region for the two pollutants causing ozone formation - volatile organic compounds (VOC) and nitrogen oxides (NO_x) - are below the approved mobile source emissions budgets of 2015 ozone for all analysis years. Thus, conformity is demonstrated.

Table 2: Results of 8-Hour Ozone Conformity Analysis -Budget Emissions Test

Analysis Year	Emissions (Tons per summer weekday)		Regional Summer Weekday VMT (millions)
	VOC	NO_x	
Conformity Budget - 2025 Interim Year	**47.86**	**104.35**	NA
2025	41.52	61.94	145.72
2030	32.27	38.61	148.45
Conformity Budget -2035 Maintenance Year	**44.67**	**102.41**	NA
2035	27.86	24.18	150.65
2040	25.00	18.51	152.25
2050	21.51	15.27	154.39

3. Projects Included in the Conformity Analysis

This analysis included all capacity-related projects proposed for SEMCOG's 2050 RTP, plus those already in SEMCOG's 2045 RTP with their open-to-traffic dates set in future years. A complete list of the projects included in this analysis can be found in Appendix A.

4. Coordination With Interagency Workgroup

A. Coordination Process

On August 21, 2023, the Michigan Transportation Conformity Interagency Workgroup (MITC-IAWG) held a conference call to review proposed projects of SEMCOG's 2050 RTP. The group also made consensus on the modelling process and assumptions. A summary of this call is provided in Appendix B, along with the list of projects being reviewed during the call. The results of the conformity analysis are documented in Section 2 above. A copy of this conformity analysis documentation was sent to each member of the MITC-IAWG for review and comment.

B. MITC-IAWG Comments and Responses

No comments received to date.

5. Description of Public Participation Process

A. Public Involvement

A public comment period for the 2050 RTP was initiated on March 27, 2024, and concluded on April 26, 2024. SEMCOG's General Assembly on June 28, 2024, formally adopted both documents. Public notices were emailed to a broad cross section that included interested citizens, advocacy groups, community organizations, and municipal clerks. The notice was also sent to the media, public libraries, published in SEMCOG's biweekly electronic newsletter, and posted on its Web site and social media pages.

B. Public Comments and Responses

No comments received to date.

6. Formal MPO Action Supporting the Conformity Determination

SEMCOG committee action on the 2050 RTP:

- Transportation Coordinating Council (TCC), April 18, 2024
- Executive Committee, May 03, 2024
- General Assembly, June 28, 2024

7. Key Modeling Assumptions and Local Inputs for SEMCOG Area

A. Description of Local Travel Data Inputs

1) Demographic Data

Travel forecasts used to calculate on-road mobile source emissions for the conformity analysis were based on demographic data from SEMCOG's 2050 Regional Development Forecast (RDF). At the time the base year inputs were developed, 2020 Census had only released limited 2020 household and population summary results, which also included intentional errors known as differential privacy (DP). This introduced complexities in creating a robust database for forecasting. Consequently, several data sources were combined to finalize the base year 2020 demographic data development.

a) Census 2020 release: This contained block-level household and population counts, along with large-area age group and race composition. This data served as synthesis targets and marginal controls for adjusting ACS attributes.
b) 2020 5-year ACS: This constituted the primary source for household and person attributes like age, children, income, workers, cars, etc. Data was predominantly obtained at the block group level, with certain attributes, such as household income, available only at the Census tract level.
c) SEMCOG housing units: Locally collected data primarily used in the household placement process to allocate households across the region into individual buildings.

The household and population data development comprised two key steps:

a) Household synthesis: adjusted marginal controls for each Census block group or tract using the data from 2020 census and 5-year ACS; conducted a population synthesis process to generate individual household and person records at the block group level using 2020 5-year ACS PUMS samples as seed data.
b) Placement: allocated households into individual housing units using the synthesized data by the placement program; assembled traffic analysis zone (TAZ) data after addressing some conflicts between Census and local housing data.

The 2050 RDF forecast was adopted in March of 2023. A three-step process was used to develop this forecast.

a) Regional forecast totals of population, households and jobs were generated from the REMI (Regional Economic Models, Inc.) model. The model forecasts Southeast Michigan's ability to attract and retain population and jobs relative to all other parts of the United States. Regional totals are developed in five-year intervals from the 2020 base year to 2050.
b) The regional totals were then used to develop a small-area forecast that disaggregates regional population, households and jobs into 1.8 million land parcels using the UrbanSim model. UrbanSim is a computer simulation model for planning and analysis of urban development. It incorporates the interaction between land use, transportation, and public policy. In doing so, it puts future population and jobs into the most desirable land parcel and models residential and nonresidential developments as demand arises.

c) Land parcels from the small-area forecast were aggregated to traffic analysis zones (TAZs) for use in SEMCOG's travel demand forecasting model.

2) **SEMCOG's Travel Demand Forecasting Model (TDFM)**

Vehicle miles of travel (VMT) forecasts for the on-road emissions inventory were developed using version E8 of SEMCOG's Travel Demand Forecasting Model (TDFM) for both passenger travel and commercial vehicle travel.

E8 – passenger travel model components were inherited from E7, which was implemented in 2018 using SEMCOG's 2015 travel survey and recalibrated in 2022 with the transit ridership numbers from SEMCOG's 2019 onboard transit survey. It utilizes the standard trip-based modeling process (trip generation, trip distribution and mode choice) to model the passenger travel demand. The program is run on the platform of TransCAD.

E8 - commercial vehicle (CV) travel model components were implemented in 2021 using SEMCOG's 2017 commercial vehicle survey and other observed truck data. The CV model runs with the script language of R and includes three model components, described below at high-level.

a) The Firm Synthesis Model, which develops a list of business establishment locations and processes zonal land use data used to generate truck trip demand in later steps of the CV model.
b) The Long-Distance Truck Model, which estimates long-haul freight truck travel to and from the region, as well as external to external truck travel through the region.
c) The Commercial Vehicle Touring Model (CVTM), which estimates demand for local deliveries and the provision of services by non-freight carrying trucks. The tours and trips simulated to serve this demand, when combined with the travel from the long-distance truck model, means that the CV model simulates all truck movements within, to, from, and through the region.

The last step of SEMCOG's TDFM is traffic assignment, which runs in TransCAD and assigns zone-to-zone passenger and commercial vehicle trips to the E8 model road network by time period and vehicle type. The base year 2020 of E8 model used the 2020 household/population and the 2019 employment data as model inputs to validate the model output against the travel observed before Covid in the region. The travel behavior changes due to Covid were not reflected in this E8 model version. Regional travel was forecasted in five-year intervals from the base year 2020 to the last year of SEMCOG's 2050 Regional Transportation Plan (RTP).

Detailed documentation on the model is contained in a separate SEMCOG document that is available upon request.

3) **Mapping of Road Types between TDFM and MOVES**

To use TDFM data in MOVES, the road types used in SEMCOG's TDFM must be reconciled with those used in MOVES. The MOVES model uses four basic road types for on-road activities: Urban Restricted, Urban Unrestricted, Rural Restricted and Rural Unrestricted. The term, "restricted", refers to restricted or limited-access roadways. In the SEMCOG region, this includes all freeway facilities. All other roadways in the SEMCOG region are considered unrestricted facilities. The TDFM also includes several special functional classes that are not part of the regular roadway network (e.g. walk only, external zone connectors, transit-only links).

As TDFM functional classes do not distinguish between urban and rural facilities, another TDFM variable, Area Type, was used as a surrogate. The TDFM defines five area types (urban business, urban fringe, urban, suburban and rural) and assigns one to each roadway link based on the density of households, population and employment in the traffic analysis zone in which the link resides.

Table 3 shows how each area type and functional class in SEMCOG's TDFM is mapped to the four road types used in MOVES.

Table 3: Mapping of TDFM Functional Class and Area Type to MOVES Road Type

<table>
<tr><th rowspan="2">SEMCOG TDFM
Functional Class</th><th colspan="5">SEMCOG TDFM Area Type</th></tr>
<tr><th>Urban Business</th><th>Urban Fringe</th><th>Urban</th><th>Suburban</th><th>Rural</th></tr>
<tr><td>1 - Interstate Freeway</td><td colspan="4" rowspan="2">4 – MOVES Urban Restricted Road Type</td><td rowspan="2">2 – MOVES Rural Restricted Road Type</td></tr>
<tr><td>2 - Other Freeway</td></tr>
<tr><td>3 - Principal Arterial</td><td colspan="4" rowspan="6">5 – MOVES Urban Unrestricted Road Type</td><td rowspan="6">3 – MOVES Rural Unrestricted Road Type</td></tr>
<tr><td>4 - Minor Arterial</td></tr>
<tr><td>5/6 - Collector</td></tr>
<tr><td>7 - Local</td></tr>
<tr><td>9 - Uncertified Road</td></tr>
<tr><td>99 - Centroid connector (local road surrogate)</td></tr>
<tr><td>81 - 94 Transit Use Only</td><td colspan="5" rowspan="3">Non-road or outside region. Not used in MOVES</td></tr>
<tr><td>90 - External</td></tr>
<tr><td>96 - Walk Only</td></tr>
</table>

4) **Vehicle Miles of Travel (VMT)**

MOVES provides an option to input annual VMT by the six FHWA Highway Performance Monitoring System (HPMS) vehicle types with the passenger car (HPMS 20) and other 4-tire/2-axle vehicles (HPMS 30) combined as HPMS25.

- HPMS10 – Motorcycle;
- HPMS25 - Passenger car and Other 4-tire, 2-axle vehicles;
- HPMS40 – Bus;
- HPMS50 - Single unit truck;
- HPMS60 - Combination truck.

Local VMT data used in the MOVES model is derived from SEMCOG's Travel Demand Forecasting Model (TDFM). The model generates average weekday VMT forecasts and does not currently have the capability to allocate this VMT to different HPMS vehicle types. The remaining part of this section describes the adjustment factors required to convert the TDFM data into the format required for MOVES.

a) HPMS Normalization

In accordance with EPA and FHWA guidance, SEMCOG TDFM VMT was normalized to HPMS VMT by county and road type. Normalization factors were developed by dividing the 2019 HPMS VMT by the estimated 2019 VMT from the E8 base year model. Table 2 shows the resulting factors. These factors were applied to TDFM VMT in all analysis years.

Table 4: HPMS Normalization Factors

County	Road Type	
	Restricted	Unrestricted
Livingston	1.14164	0.98447
Macomb	0.86251	1.06446
Monroe	0.96648	1.06906
Oakland	0.88927	0.97795
St Clair	1.03914	1.39949
Washtenaw	1.05165	0.92587
Wayne	0.93895	1.23753

b) Distribution of VMT Among HPMS Vehicle Types

Two sets of distribution factors for restricted and unrestricted roadways were developed to allocate the total VMT of an analysis year among five vehicle classes as described at the beginning of this section. Due to the impact of Covid, the scheduled traffic counts collection in 2020 was not able to be conducted. Therefore, all the VMT distribution factors developed with the 2015 counts for SEMCOG's 2045 RTP continued to be used for SEMCOG's 2050 RTP.

Table 5: VMT Distribution Factors by HPMS Vehicle Type

HPMS Vehicle Type	Restricted	Unrestricted
H10 – Motorcycle	0.00276	0.00589
H25 - Passenger Car and Other 4-tire, 2-axle vehicles	0.89201	0.90783
H40 – Bus	0.00166	0.00442
H50 - Single-Unit Truck	0.01931	0.05772
H60 - Combination Truck	0.08426	0.02414

Every five years starting from 2005, SEMCOG has been collecting screen line counts, which are mostly non-freeway counts, throughout the seven-county SEMCOG region. The 2015 screen line traffic count was used to develop VMT distribution factors for unrestricted roadways.

Every year, MDOT collects permanent traffic recording (PTR) counts, which includes vehicle classification counts from 13 freeway stations through SEMCOG region. These 2015 PTR classification counts were used to develop the average distribution factors for restricted roadways.

Both counts collected from MDOT and SEMCOG were classified based on FHWA's standard 13 traffic bins. These bins were aggregated to five vehicle classes required by MOVES. The factors derived from these counts are shown in Table 5.

c) Conversion of Average Weekday VMT to Annual VMT

Monthly and weekend adjustment factors were developed using 2014-2016 count data from the 35 PTR stations in Southeast Michigan. Monthly adjustment factors for motorcycles were developed separately due to its significant difference from other vehicle types. Weekend adjustment factors were developed for each of the five vehicle types since significant variations were shown among each other. These adjustment factors (shown in Table 6), along with the HPMS-normalized weekday VMT by vehicle type, were then entered into EPA's AADVMT converter of "moves4-*aadvmt-conveter-tool-2023-08.xls"* to compute the annual VMT, monthly and daily VMT fractions needed for MOVES4.

Table 6: Monthly and Weekend Adjustment Factors

Month	Monthly Adjustment Factors		Weekend Adjustment Factors				
	Motorcycle	Others	H10	H25	H40	H50	H60
Jan	0.61591	0.84277	0.74004	0.76880	0.50814	0.31258	0.34568
Feb	0.64898	0.89507	0.72627	0.74810	0.53906	0.28693	0.32378
Mar	0.70943	0.97283	0.78072	0.80027	0.56487	0.28654	0.32074
Apr	0.86564	1.01831	1.06431	0.80995	0.56013	0.30115	0.30696
May	1.18817	1.03520	1.00755	0.82747	0.51042	0.31796	0.31331
Jun	1.39409	1.08036	1.09094	0.82842	0.53217	0.34252	0.32225
Jul	1.47548	1.06434	1.04333	0.83058	0.61693	0.34956	0.31060
Aug	1.42116	1.07990	1.07714	0.85262	0.61017	0.36666	0.32662
Sep	1.29399	1.04244	1.02136	0.85271	0.61270	0.36014	0.32851
Oct	0.95050	1.04384	0.84475	0.82973	0.63029	0.33629	0.33077
Nov	0.78996	0.98673	0.72377	0.79581	0.61643	0.32037	0.34036
Dec	0.64280	0.93822	0.77974	0.78883	0.52432	0.31239	0.34840

5) Hourly VMT Fractions

Two different data sources were used to develop hourly VMT fractions for MOVES:

- 2015 screen line traffic counts collected by SEMCOG - All screen line counts include classification data but were only collected on weekdays.
- 2015 PTR counts for locations within the SEMCOG region - This data includes both weekdays and weekends. All the count stations are on freeways and only a limited number of these stations collect classification data.

Using this data, SEMCOG was able to develop weekday hourly VMT fractions for each of five HPMS vehicle types by restricted (shown in Table 7) and unrestricted MOVES road types (shown in Table 8).

Table 7: Weekday Hourly Fractions for Restricted Road Types

HOUR	H10	H25	H40	H50	H60	Total
1	0.00901	0.00853	0.01300	0.00685	0.01929	0.00941
2	0.00506	0.00508	0.01077	0.00607	0.01775	0.00618
3	0.00495	0.00412	0.01079	0.00671	0.01748	0.00531
4	0.00572	0.00487	0.01220	0.00855	0.01974	0.00621
5	0.01331	0.01094	0.01839	0.01323	0.02500	0.01218
6	0.03873	0.02914	0.02854	0.02445	0.03304	0.02940
7	0.05610	0.05634	0.04263	0.05114	0.04400	0.05518
8	0.05897	0.07031	0.05985	0.06570	0.04968	0.06843
9	0.05187	0.06151	0.06112	0.07814	0.05658	0.06139
10	0.04527	0.04812	0.06610	0.07654	0.06325	0.04996
11	0.04491	0.04411	0.06347	0.07401	0.06555	0.04653
12	0.04792	0.04569	0.05739	0.07388	0.06606	0.04798
13	0.05076	0.04846	0.06006	0.07350	0.06413	0.05029
14	0.05422	0.05120	0.06267	0.07587	0.06291	0.05269
15	0.06414	0.06073	0.06700	0.07750	0.06062	0.06107
16	0.07425	0.07509	0.06726	0.07268	0.05566	0.07339
17	0.07592	0.08344	0.05918	0.06113	0.04929	0.08007
18	0.07156	0.08323	0.05087	0.04636	0.04353	0.07909
19	0.06320	0.06326	0.04795	0.03500	0.04076	0.06079
20	0.04912	0.04401	0.03725	0.02398	0.03570	0.04292
21	0.03837	0.03466	0.02944	0.01737	0.03160	0.03407
22	0.03307	0.02891	0.03085	0.01314	0.02904	0.02863
23	0.02533	0.02233	0.02336	0.01009	0.02620	0.02243
24	0.01823	0.01591	0.01989	0.00810	0.02316	0.01638

Table 8: Weekday Hourly Fractions for Unrestricted Road Types

Hour	H10	H25	H40	H50	H60	Total
1	0.00536	0.00794	0.00434	0.00529	0.01420	0.00791
2	0.00371	0.00543	0.00249	0.00395	0.01364	0.00552
3	0.00416	0.00527	0.00357	0.00407	0.01379	0.00539
4	0.00426	0.00685	0.00344	0.00528	0.01637	0.00696
5	0.00865	0.01299	0.00744	0.00917	0.02186	0.01294
6	0.01924	0.02808	0.01596	0.02223	0.03012	0.02769
7	0.03800	0.04830	0.06490	0.04586	0.04488	0.04809
8	0.06079	0.06905	0.09539	0.06604	0.06031	0.06873
9	0.05785	0.06046	0.09259	0.07022	0.06781	0.06133
10	0.04103	0.04541	0.06258	0.06268	0.06417	0.04691
11	0.04297	0.04380	0.05978	0.06083	0.06390	0.04533
12	0.04714	0.04747	0.06159	0.06332	0.06677	0.04891
13	0.05924	0.05097	0.05531	0.06543	0.06308	0.05216
14	0.06083	0.05242	0.06116	0.06275	0.06378	0.05338
15	0.07287	0.06154	0.08679	0.06809	0.06259	0.06213
16	0.08846	0.07415	0.09969	0.07556	0.06072	0.07411
17	0.10167	0.08174	0.08279	0.07774	0.05772	0.08105
18	0.09847	0.08327	0.04963	0.07190	0.05491	0.08187
19	0.07032	0.06446	0.03165	0.05387	0.04189	0.06319
20	0.04197	0.04739	0.01901	0.03639	0.03149	0.04621
21	0.03187	0.03906	0.01488	0.02833	0.02705	0.03800
22	0.01966	0.02956	0.01118	0.01918	0.02313	0.02866
23	0.01337	0.02062	0.00735	0.01304	0.01861	0.02003
24	0.00810	0.01378	0.00649	0.00879	0.01722	0.01351

However, for weekends, the count data was not robust enough to develop separate factors by road type, so only a single set of hourly VMT factors (shown in Table 9 below) was developed for both restricted and unrestricted road types.

Table 9: Weekend Hourly Fractions for Restricted/Unrestricted Road Types

HOUR	H10	H25	H40	H50	H60	Total
1	0.01635	0.01781	0.03310	0.01946	0.03316	0.01839
2	0.01066	0.01119	0.02323	0.01586	0.02873	0.01187
3	0.00790	0.00841	0.01984	0.01526	0.02595	0.00911
4	0.00579	0.00642	0.01708	0.01556	0.02498	0.00718
5	0.00749	0.00823	0.01755	0.01712	0.02806	0.00902
6	0.01279	0.01332	0.02291	0.02249	0.03179	0.01407
7	0.01867	0.02010	0.03379	0.03690	0.03798	0.02089
8	0.02291	0.02624	0.05137	0.05046	0.04349	0.02708
9	0.03282	0.03478	0.05412	0.06060	0.04905	0.03552
10	0.04456	0.04581	0.05471	0.06376	0.05285	0.04622
11	0.05503	0.05565	0.05689	0.06525	0.05602	0.05574
12	0.06466	0.06392	0.05137	0.06709	0.05710	0.06369
13	0.07084	0.06986	0.05404	0.06761	0.05578	0.06932
14	0.07520	0.07230	0.04839	0.06710	0.05434	0.07159
15	0.07703	0.07398	0.04786	0.06348	0.05153	0.07307
16	0.08072	0.07576	0.05201	0.06053	0.04996	0.07469
17	0.07736	0.07454	0.05285	0.05702	0.04782	0.07342
18	0.07136	0.07088	0.05550	0.05255	0.04620	0.06982
19	0.06338	0.06289	0.05654	0.04594	0.04549	0.06211
20	0.05482	0.05373	0.04961	0.03817	0.04285	0.05321
21	0.04560	0.04517	0.03900	0.03143	0.03990	0.04486
22	0.03578	0.03735	0.04079	0.02575	0.03628	0.03722
23	0.02814	0.02989	0.03471	0.02164	0.03196	0.02990
24	0.02016	0.02177	0.03273	0.01898	0.02874	0.02201

6) Road Type Distribution

Several steps were involved to produce the VMT road type distribution factors for each HPMS vehicle class. First, the 2019 HPMS VMT numbers were grouped into four MOVES road types (Urban Restricted, Urban Unrestricted, Rural Restricted and Rural Unrestricted). Then, the VMT value for each of the four MOVES road types was divided among five HPMS vehicle types based on the vehicle type distribution factors developed in Table 5. The final VMT road type distribution factors (Table 10) were developed by dividing the calculated VMT for each MOVES road type and each HPMS vehicle type with the total VMT of each HPMS vehicle class.

Table 10: Road Type Distribution Factors

HPMS Vehicle Type	MOVES Road Type			
	Rural Restricted	Rural Unrestricted	Urban Restricted	Urban Unrestricted
H10 - Motorcycle	0.020290	0.048728	0.193794	0.737189
H25 - Passenger Car or Other 4-tire, 2-axle vehicles	0.034454	0.039461	0.329089	0.596996
H40 - Bus	0.017007	0.050876	0.162438	0.769680
H50 - Single-Unit Truck	0.015430	0.051907	0.147378	0.785285
H60 - Combination Truck	0.063482	0.020471	0.606346	0.309700

7) Average Speed Distributions

MOVES uses the distribution of vehicle hours of travel (VHT) by average speed to determine an appropriate operating mode distribution. To develop the local average speed distribution for Southeast Michigan, SEMCOG used congested speed and VHT output from the TDFM to compute the VHT fraction in each MOVES speed bin. MOVES requires the user to input hourly speed distributions by road type and vehicle class. While SEMCOG's travel model does not provide hourly speed data, it calculates speeds by five different time periods:

- AM peak, simulating the hours of 6:30 - 9:00 a.m.;
- Mid-day, simulating the hours of 9:00 a.m. - 2:30 p.m.;
- PM peak, simulating the hours of 2:30 - 6:30 p.m.;
- Evening, simulating the hours of 6:30 p.m. - 10:00 p.m.
- Night, simulating the hours of 10 p.m. – 6:30 a.m.

For MOVES, separate speed distributions were developed for each of these time periods and applied to all hours within that period. This was done as follows:

- For each time period, the directional congested speed of each roadway link was assigned to one of MOVES 16 speed bins;
- The associated directional VHTs on the links were then aggregated by speed bin and MOVES road type;
- Then, for each road type, the VHT fraction in each speed bin was computed.

For each analysis year, the average speed distributions were developed. As no local data is currently available on speed differentiation between vehicle classes, the same distributions were applied to all vehicle types.

B. Description of Local Vehicle Data Inputs

Every year, SEMCOG receives a snapshot of July-01 active vehicle registration data from Michigan Department of State (*DOS*). The 2023 vehicle registration data was used as the primary data source in developing local vehicle population, age distribution, and alternate vehicle fuel and technology (AVFT) information. The following sections describe briefly how each was developed. Detailed documentation on their development is contained in a separate memo of "*Development of Local Inputs using Vehicle Registration Data*".

1) Vehicle Population

Year 2023 vehicle registration data was used to develop the base year vehicle population inputs for most MOVES source types. The body style, plate type and use type fields in the DOS database were used to determine the MOVES source type of each vehicle. Table 11 shows how each combination of DOS body style, plate type and use type was mapped to the MOVES source type. Where DOS data did not provide sufficient detail, it was supplemented with information from MOVES default distributions for Southeast Michigan counties. As noted in the table, the base year vehicle population for the transit bus (M42) and school bus (M43) was developed using the 2018/2019 bus fleet data obtained from the Michigan Department of Transportation (MDOT).

Table 11: Mapping between MOVES Vehicle Types and Michigan DOS Body Styles

MOVES Vehicle Type	Michigan DOS Body Style
M11 – Motorcycle	Motorcycle
M21 – Passenger Car	2-door, 4-door, Convertible
M31 – Passenger Truck	Non-Commercial Station Wagon/Pick-up/Van
M32 – Light Commercial Truck	Ambulance, Hearse, Panel, Commercial Station Wagon/Pick-up/Van
M41 – Other Bus	Bus population from DOS registration database
M42* – Transit Bus	DOS data not used. Instead, MDOT 2018/2019 transit bus fleet data of SEMCOG region was used.
M43* – School Bus	DOS data not used. Instead, MDOT 2018/2019 school bus fleet data of SEMCOG region was used.
M51 – Refuse Truck	Dump Truck, Mixer, utility, Wrecker, Stake, Tank (Apportioned this data to M51, M52 and M53 vehicle types using split factors from MOVES4 default run.)
M52 – Single-unit Short-haul Truck	
M53 – Single–unit Long-haul Truck	
M54 – Motor Home	Motor Home
M61* – Combination Short-haul Truck	DOS data not used. Instead, National default numbers of SEMCOG region was used.
M62* – Combination Long-haul Truck	

Future year vehicle population data was based on future growth of regional population, households, and jobs of that year from SEMCOG's 2050 regional development forecasts (RDF). The rate of growth between 2023 and each future analysis year was calculated. Table 12 shows the growth factors of regional vehicle population. This rate was then uniformly applied to the 2023 vehicle population to generate the future year population for all the vehicle source types other than M61 and M62. Due to lacking sufficient information of combination trucks in the recent vehicle registration database, MOVES4's default-scale run was used to obtain the combination short-haul (M61) and long-haul (M62) truck population of SEMCOG region for each analysis year.

Table 12 Regional Vehicle Population Growth Factors

Growth Index from 2023		Regional Growth Index Based on SEMCOG's 2050 RDF						
Forecasted Item	% of	2023	2025	2030	2035	2040	2045	2050
Population	30%	1.000000	0.999655	1.014418	1.035057	1.049615	1.058643	1.062214
Households	30%	1.000000	1.005571	1.025841	1.044242	1.055069	1.060096	1.063158
Jobs	40%	1.000000	1.006936	1.034116	1.048158	1.053197	1.062414	1.078203
Vehicle Population	100%	1.000000	1.004342	1.025724	1.043053	1.052684	1.060587	1.068893

2) Vehicle Age Distribution

Year 2023 DOS vehicle registration was used to develop the vehicle age distribution used in MOVES. The DOS body style field was used to assign each vehicle to one of six HPMS vehicle types (see Table 13 below). Once HPMS vehicle types had been assigned, the data was aggregated by model year and assigned to the appropriate age category. Model years 2023 and 2024 were considered age 0, 2022 was considered age 1 and so on. Model years 1993 and older were grouped into the age 30+ category. The age distribution for each HPMS vehicle type was then computed.

Table 13: Mapping between HPMS Vehicle Types and Michigan DOS Body Styles

HPMS Vehicle Type	Michigan DOS Body Style
H10 – Motorcycle	Motorcycle
H20 – Passenger Car	2-door; 4-door; Convertible
H30 – Other 4-tire, 2-axle vehicles	Station Wagon; Pick-up/Van; Ambulance; Hearse; Panel;
H40 – Bus	Bus
H50 – Single-unit Short Truck	Dump Truck; Mixer; Utility; Wrecker; Stake; Tank, Motor Home
H60* – Combination Truck	National default data for M61 and M62 was used

By using the base year 2023 data, future year age distribution was projected by applying EPA's age projection tool of "*moves4-age-distribution-projection-tool-2023-08*.xls". Instead of using local data, the default age distribution of combination trucks in MOVES4 was used for each analysis year.

3) Alternate Vehicle and Fuel Technology (AVFT)

The vehicle fuel engine fractions of AVFT table were developed by using the fuel code information included in the 2023 DOS vehicle *registration* data and the 2018/2019 school/transit bus fleet data. Based on its fuel code, each vehicle record was assigned with one of five MOVES fuel types (see Table 14 below). Then, the vehicles with the same MOVES fuel type were counted for each MOVES vehicle source type and each model year. The fuel engine fractions of vehicles were computed for the model years between 1993 and 2023, and for the following vehicle source type/group: 21, 31, 32, 41 & 42 & 43, 51 & 52 & 53, and 54.

Based on the data developed for the vehicle model years of 1993-2023, the fuel engine fractions of future model years can be projected by EPA's AVFT tool included in MOVES4.

Table 14: Mapping between MOVES Fuel Type and DOS Fuel Code

MOVES Fuel Type	DOS Fuel Code
1-Gasoline	Convertible
	Electric & Gas Hybrid
	Flexible
	Gas
	Gas & Oil Mix
2-Diesel Fuel	Diesel
	Electric & Diesel Hybrid
3-Compressed Natural Gas	Butane
	Comp Nat Gas
	Liq Nat Gas
	Propane
5-Ethanol (E85)	Alcohol
	Ethanol
9-Electricity	Electric
	FEV
	PHEV

C. Local Temperature Used for $PM_{2.5}$ and Ozone

Temperature and humidity data are required inputs for MOVES. For the PM2.5 conformity analysis, local temperature profiles were developed for each month of the year. To generate these profiles, the average minimum, and maximum daily temperatures of each month in Southeast Michigan were compiled using 2020-2022 National Weather Service (NWS) local climatological data reports. EPA's *MeteorologicalDataConverter_Mobile6.xls* tool was then used to convert the average minimum and maximum temperatures to the required hourly temperature inputs for MOVES. Table 14 shows the average min/max temperatures that were used to develop each month's hourly profile. Since PM 2.5 emissions are at their highest during winter months, only data from December, January and February are used in the conformity analysis for this pollutant.

Table 15: Monthly Average Min/Max Temperatures for $PM_{2.5}$

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	21.2	19.1	31.5	38.5	50.6	61.0	65.9	64.9	56.1	45.6	34.2	28.1
Max	33.5	34.1	50.8	57.2	70.0	82.0	84.9	84.2	75.3	63.5	51.4	40.5

For ozone analysis, different temperature inputs were used. The objective is to simulate the on-road emissions that are likely to occur on days when meteorological conditions are conducive to high ozone formation (i.e., hot summer days). The emission inventory data from 2019 to 2021 was used to develop the most resent ozone SIP for the ozone redesignation submittal of SEMCOG region. Thus, the maximum summer temperature used in MOVES was calculated by averaging the maximum local temperatures on the 10 highest ozone days of these three years. Similarly, the minimum summer temperature was calculated by averaging the minimum local temperatures on the same 10 highest ozone days. This yielded a maximum temperature of 88.7 degrees and a minimum of 63.7 degrees. These numbers were entered into the month of July to simulate a typical summer day for ozone conformity analysis.