Red Sticker Appendix C
Update to Inventory of Off-Highway Motorcycles & RV2018 Model

March 5, 2019

CALIFORNIA AIR RESOURCES BOARD

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1. Executive Summary

Off-highway recreational vehicles (OHRVs) include off-highway motorcycles (OHMC), all-terrain vehicles (ATV), off-road sport vehicles, off-road utility vehicles, sand cars, and golf carts, as defined in California Code of Regulations, title 13,§ 2411(a). In support of the Proposed Amendments to the Red Sticker Program for Off-Highway Recreational Vehicles, this document details the updated emissions inventory as utilized in the California Air Resources Board's (CARB) Recreational Vehicle 2018 Emissions Model (RV2018).

To support the proposed rule, CARB staff has updated the previous emissions inventory model, RV2013, to reflect the most current data available for OHMCs in each region of the state. The newly revised model, RV2018, contains updates to base year population, activity (miles/year), activity growth, spatial allocation, and emission factors. Adjustments reflect the recovering California economy and incorporate results from recent CARB in-house testing and survey data from the University of California, Davis (UCD)[1].

California's current OHRV regulation allows for the certification of vehicles with no emissions controls. These vehicles, referred to as "red sticker" vehicles because they are issued a red colored sticker from the Department of Motor Vehicles (DMV), can be used recreationally throughout the state during much of the year, but their use is restricted during summertime on public lands in portions of the state that are not in attainment with federal ozone standards. The red sticker program is specific to California, and is not utilized anywhere else in the United States. The original intent of the red sticker program was to provide manufacturers additional time to design a full range of OHRV that comply with applicable emissions standards. By eliminating the red sticker program, all new OHRV sold in California for recreational riding would be subject to emission standards, while non-compliant vehicles would be competition-only vehicles for use on private tracks. The adoption of these amendments would be consistent with federal regulations that do not allow uncontrolled vehicles to be ridden recreationally on public lands.

Figure 1 compares the baseline emissions from OHRVs under current regulations as compared to emissions with the proposed amendments, based on RV2018. As shown in Figure 1, the baseline statewide summer reactive organic gas (ROG) emissions, from OHRV operating in California in calendar year (CY) 2040, is approximately 11.2 tons per day (tpd). Accounting for the benefits of the proposed amendments, statewide summer ROG emissions are reduced to 5.2 tpd or a 54% reduction. Because of the relatively long useful life of OHRVs and the near-term flatline in sales of new OHRVs, emissions benefits

[1] UCD, 2016. California Registered Off-Highway Motorcycles Usage and Activity Survey 2016. University of California, Davis. December 2016.

from the proposed amendments will increase further into the future as a larger fraction of the existing, higher-emitting OHRV population operating in California turns over to newer vehicles that meet the more stringent emissions requirements.

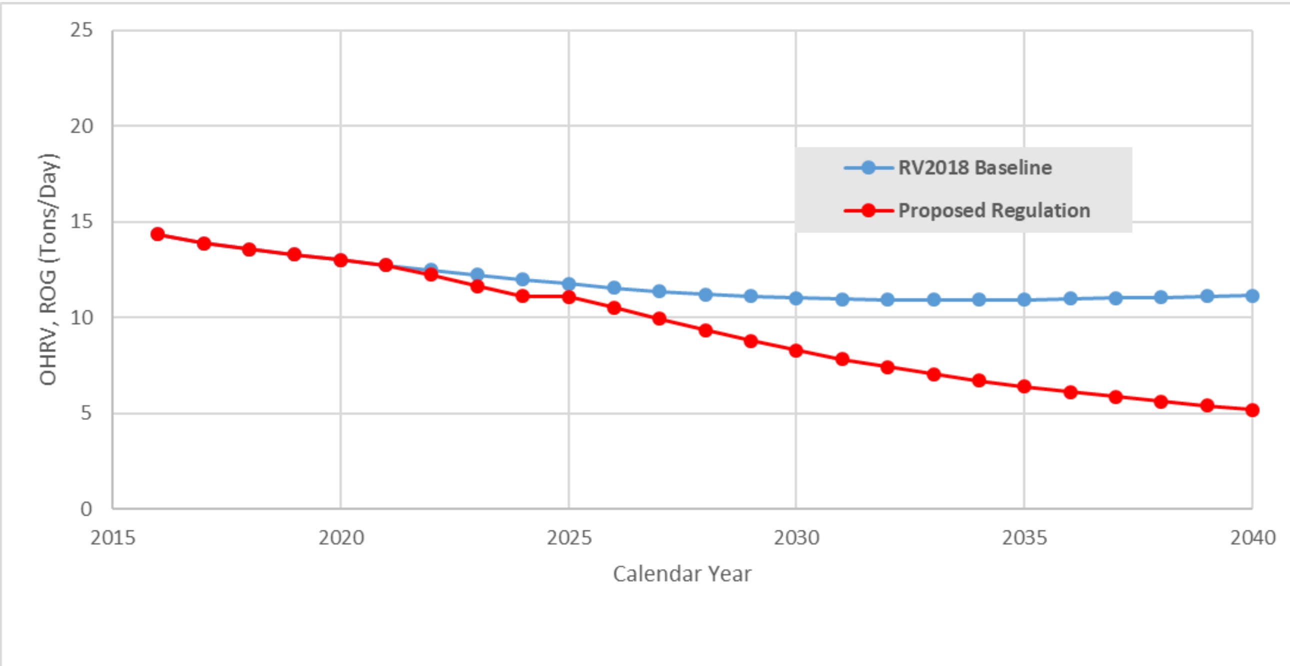

Figure 1: OHRV Statewide Summer-time Emissions (Proposed Regulation vs Baseline)

2. Background

Since 1972, the California Vehicle Code has required OHRV to be registered with the Department of Motor Vehicles (DMV). Registration is necessary for OHRVs to operate legally on California's public lands designated for OHRV use. The Board approved regulations establishing emissions standards for OHRV starting with the 1997 model year. Only OHRVs that meet California's emission standards are eligible for green sticker registration. In response to concerns about a lack of emissions-comlpiant models, the Board adopted regulations that allowed OHMCs and ATVs that do not comply with California's exhaust emission standards to receive a red registration sticker instead. The majority of these noncomplying OHRVs were powered by two-stroke engines, and a small percentage (less than 10%) were four-stroke OHRVs. According to DMV data, red sticker ATV sales comprise a small percentage of total sales in California, and new red sticker ATV sales declined to almost zero from 2008-2017. Because the vast majority of red sticker vehicles are OHMC, updates the emissions inventory focus primarily on OHMC green and red sticker vehicles.

In ozone nonattainment areas, OHMCs with red sticker registration are subject to a usage restriction, which prohibits operation when ambient ozone levels exceed federal 2008 8-hour ozone standards. This restriction is in effect typically during the months of May through October, though specific dates vary by region. The Board approved new, more stringent evaporative emissions controls measure in 2013, which went into effect starting withmodel year 2018. These new evaporative standards apply only to green sticker vehicles, and CARB staff was directed to conduct an assessment of the red sticker program to see whether emissions from those vehicles could be reduced. The assessment investigated evaporative and exhaust emissions impact of red sticker OHMCs and includes three elements:

- Population evaluation (Section 3.1)
- Emissions testing (Section 3.2)
- Activity analysis (Section 3.4)

The estimate was calculated based on assumptions of what limited federal riding areas and private tracks were available to ride during the summer months for red sticker OHMCs. Following the 2016 OHMC survey by the University of California Davis[1], the red sticker impact was further refined since the survey revealed an 18% reduction in red sticker OHMC riding during the summer. The survey showed a reduction of activity at state parks during the summertime months when the red sticker riding restrictions are in effect, but a corresponding increase of activity at other riding areas.

This document details the updates to the emissions inventory in CARB's RV2018 emissions model, which is an update on the most recent OHRV emissions model (RV2013). Additional background information or methodologies that remained unchanged from RV2013 are referenced in the document Attachment C: Emissions Estimation Methodology for Off-Highway Recreational Vehicles[2].

3. Emissions Inventory (OHMC)

The emissions inventory of OHMCs is detailed in this section and includes the methodologies, assumptions and algorithms used in updating the RV2018 model. The revised emissions inventory reflects updates to base year population, activity (miles/year), activity growth, spatial allocation, and emission factors. Adjustments reflect the recovering

[2] CARB, 2013. Attachment C: Emissions Estimation Methodology for Off-Highway Recreational Vehicles. Final Regulation Order. Off-Highway Recreational Vehicles: Evaporative Emission Control. Title 13, California Code of Regulations (2013)
https://www.arb.ca.gov/regact/2013/ohrv2013/ohrvattachc.pdf

California economy and incorporate results from recent CARB in-house emissions testing and survey data from the University of California, Davis (UCD)[1].

The emissions inventory for the other OHRVs (ATVs, snowmobiles, golf carts, and specialty vehicles) contained in the RV2018 model is summarized in Section 5.

3.1. OHMC Population

DMV vehicle registration data, for calendar years 2000-2017, was utilized to update the OHMC population, which is a combination of “active” and “inactive” vehicles.[3] In addition to OHMC, the population of other OHRV categories were also updated.

As shown in Table 1, DMV has designated different codes to reflect the current registration status of the vehicle. Based on the DMV’s definition, staff has divided the OHRV population into two groups: “active” and “inactive.” Active vehicles are defined as vehicles with a DMV code of C, E, or S in the registration database. For active vehicles, both exhaust and some evaporative emissions associated with operation (hot soak and running loss) occur where the vehicles are operated, at OHRV riding areas such as state parks. Inactive vehicles are defined as vehicles with a DMV code of N, P, or R in the registration database. Inactive vehicles are stored at their registered address and assumed that there will be no usage during the calendar year. All vehicles, whether active or inactive, generate daily evaporative emissions where they are stored, based on each vehicle’s registered address.

Table 1: Definition of Active & Inactive Status

DMV code	Definition	Status
C	Currently registered	Active
E	Evidence of use	Active
S	Pending	Active
N	Not currently registered	Inactive
P	Planned non-operational	Inactive
R	Prior history	Inactive

The following equation is used to forecast the population of OHMCs in future years:

Total Population = Base population + Annual sales – Vehicle scrappage (1)

- Section 3.1.1 describes how annual sales are determined from DMV data.
- Likewise, Section 3.1.2 describes the vehicle scrappage figure that is calculated from DMV data.

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[3] The aggregate information regarding the OHRV population provided in this appendix is sufficient to describe the emissions inventory while balancing the privacy interests of DMV data, which can be sensitive.

Figure 2 illustrates the updated population of OHMCs in RV2018 as compared to what was previously assumed in the RV2013 model. Resulting from a combination of improvements in processing vehicle registration data and an updated survival rate (Figure 6), the RV2018 OHMC population for CY 2004-2014 is slightly higher than the RV2013 value. CARB's in-house VIN decoders, based on latest certification database, captured more OHMCs versus the previous decoders utilized by Polk/IHS. In 2017, OHMC population decreased from 520,792 to 458,189 vehicles or almost a 14% decrease, as supported by the most current DMV data (i.e., DMV 2017).

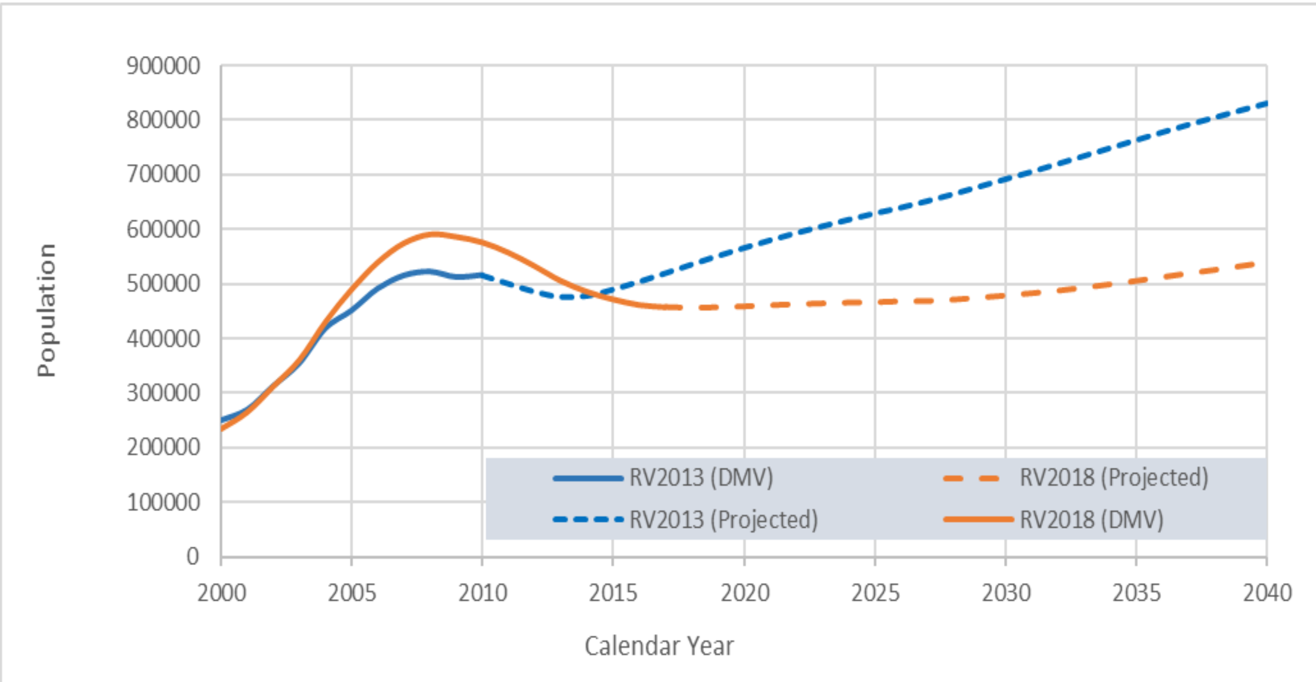

Figure 2: Updated OHMC Population (RV2013 vs RV2018)

As shown in Figure 2, the population of OHMCs from RV2018 grows at much slower rates than what was assumed in RV2013. This is mainly due to the slower rebound in economic factors (nationwide housing starts) from the 2008 recession than previously projected. Another factor could be the decreased enthusiasm of the younger generation in recreational vehicle riding.

3.1.1. Forecasting Annual Sales of OHMCs

OHMC population growth is determined from two factors: incoming population as estimated by future annual sales and the scrapped vehicle population as estimated by the survival rate. To estimate future sales, OHRV purchases generally correlated well with socioeconomic indicators such as number of housing units built. Specifically, there has been a good correlation between building permits issued in California[4] and historical annual vehicle sales data based on 2000 to 2017 DMV data as shown in Figure 3. The forecasted nationwide new housing starts (2018 UCLA economic forecast[5]) was used as a surrogate to forecast the future California building permits to 2021. From 2018 to 2021, OHMC annual sales were estimated using the California building permits as surrogates as shown in Figure 3.

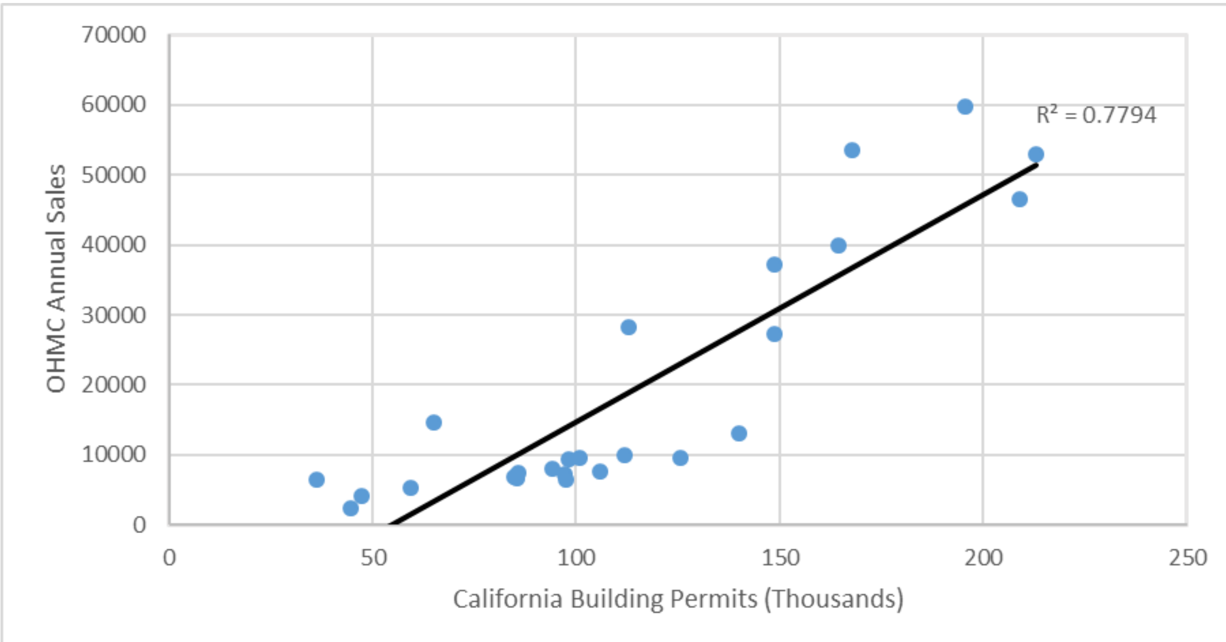

Figure 3: Annual Sales of OHMCs vs CA Building Permits

Figure 4 shows the historic and projected trend of OHMC annual sales in California between 2000 and 2025, which incorporates the actual and estimated future vehicle sales, and are based on forecasts of California's future economic and human population growth[6]. Note that the OHMC population from 2000 to 2017 is based on actual DMV vehicle registration data. As represented below in Figure 4, the annual sales of OHMCs peaked around 2004 and with the economic recession, annual sales dropped sharply.

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[4] California Department of Finance Building Permits Issued. http://www.dof.ca.gov/Forecasting/Economics/Indicators/Construction_Permits/

5 UCLA, 2017. The UCLA Anderson Forecast for the Nation and California (2017)

[6] California Human Population Growth www.dof.ca.gov/Forecasting/Demographics/Estimates/e-1/.../E-1_2018PressRelease.pdf

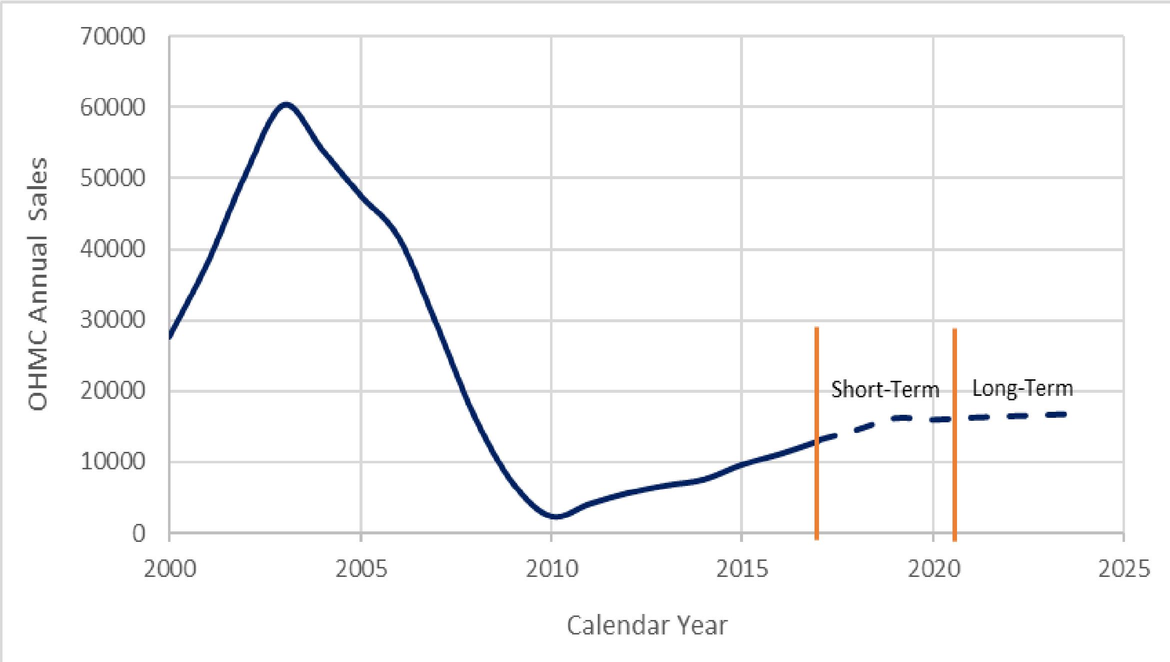

Figure 4: Projected Trend of OHMC Annual Sales in California

The short-term OHMC annual sales projection, 2018 to 2021, is based on 2018 UCLA projected nationwide housing starts. Staff used only a four year forecast because any short-term economic indicators may be reasonable for two to four years. For long-term annual sales projection after 2021, OHMC annual sales were estimated using the historical California human population growth of 1.2% annually. As California's economy recovers from the 2008 recession and individuals have more disposable income, OHRV sales are increasing as compared to the low values in 2010. The OHMC annual sales values, based on data from the Motorcycle Industry Council (MIC), was comparable with the output from RV2018, as shown in Figure 5. Note that the DMV data included only age 0 OHMCs sold in California, whereas the annual sales data obtained from MIC included all ages of OHMCs sold, which leads to MIC annual sales numbers being slightly higher than DMV registration data in each calendar year.

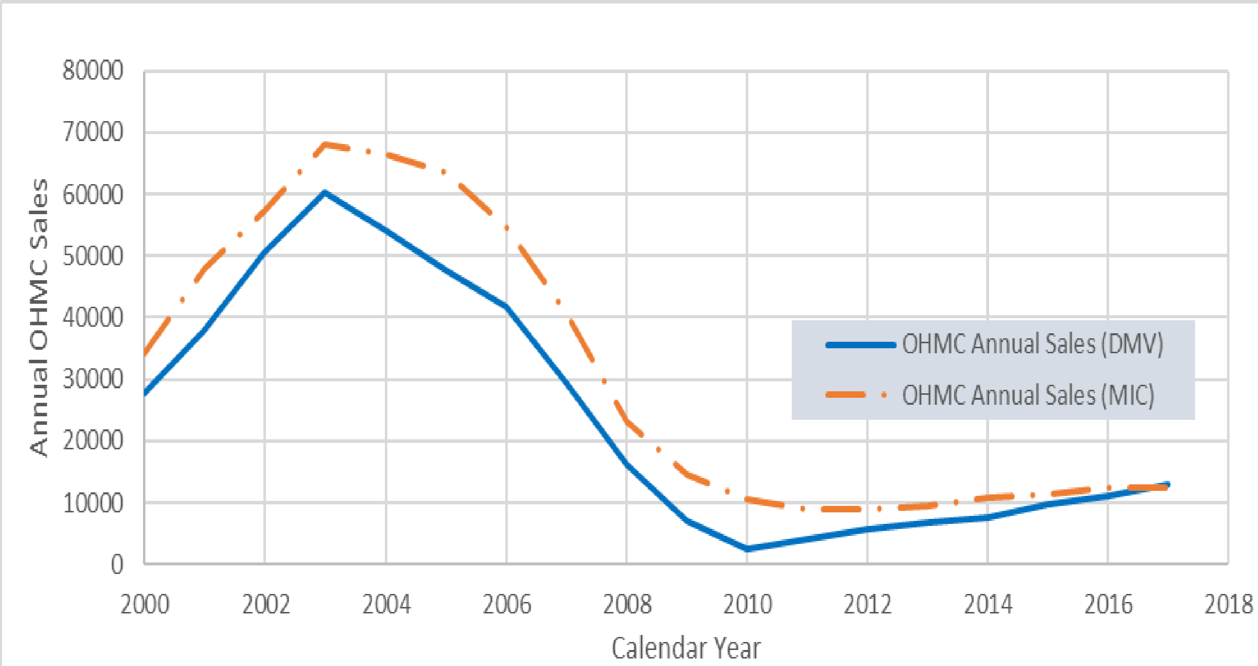

Figure 5: California OHMC Annual Sales (RV2018 vs MIC)

3.1.2. Survival Rate

A survival rate, or survival curve, is used to model the rate at which a population of vehicles is scrapped over time. To update the survival rate in RV2018, staff evaluated year-to-year changes in 18 years of DMV vehicle registration data from 2000 to 2017.

In theory, the survival ratio should decline starting from the first year the vehicle is sold. In practice, the trend is such that the vehicle population initially increases before it begins to decrease due to attrition/scrappage of vehicles. In the case of OHMCs, based on the analysis of 18 years of DMV registration data, newly manufactured vehicles may be sold over the course of several years rather than just in the year manufactured. For example, most model year 2016 OHRVs are sold in 2016, but some may be sold in 2017 or even 2018. This results in a small increase in population of vehicles over the first couple of years. This is now reflected in the survival rate estimates for the revised inventory.

Figure 6 illustrates the typical trend staff observed for OHRV survival rates in the DMV registration data, where in practice the survival rate increases until approximately age 4 and then starts decreasing afterwards.

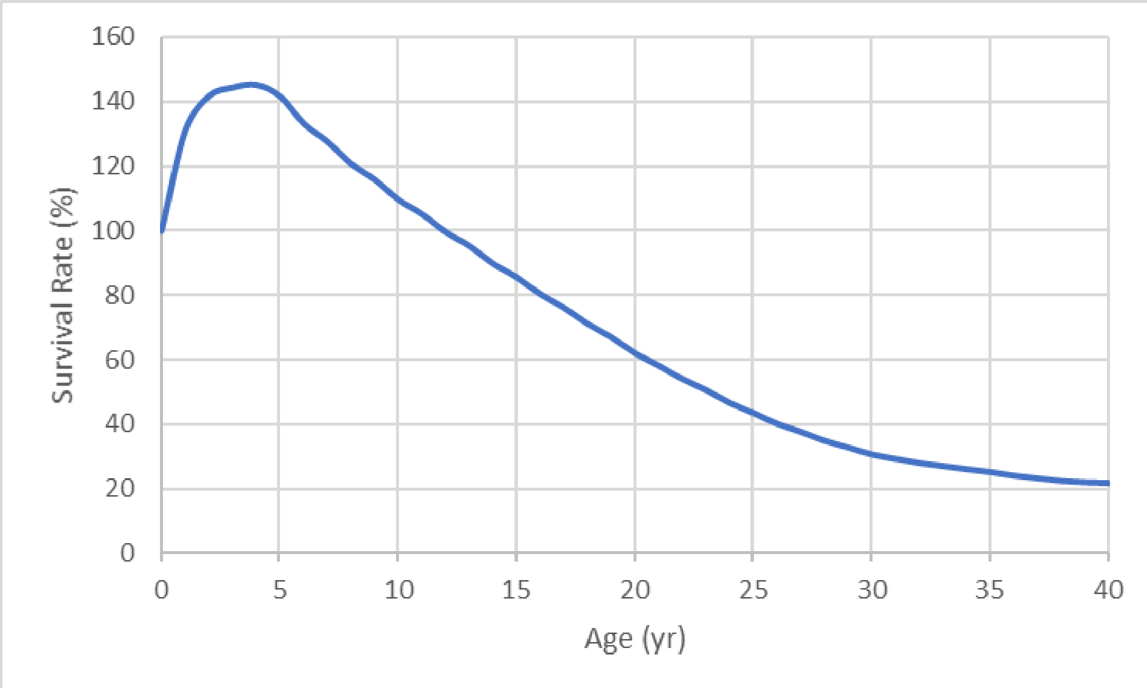

Figure 6: Survival Rate of OHMCs

3.2. Exhaust Emission Factors

Exhaust emission factors used in RV2018 are based on exhaust emission certification data, adopted exhaust emissions standards, and limited available test data[7]. Although OHMCs and ATVs were tested on the Urban Dynamometer Driving Schedule (UDDS), which was designed primarily for passenger vehicles and light duty trucks, the exhaust emission factors did not represent the typical trail driving conditions experienced by OHMCs and ATVs. One study, conducted by the College of Engineering – Center of Environmental Research and Technology (CE-CERT) at the University of California at Riverside (UCR), focused on real-world driving conditions for OHMCs, ATVs, and mini-bikes[8]. This provided the average speed, miles driven per day, hours of operation per day, and fuel economy reported by a group of OHMC and ATV users. After analyzing the results of the CE-CERT study, CARB staff determined that the average fuel use reported in the CE-CERT study was about three times higher than fuel use measured for comparable vehicles tested on the UDDS. An external adjustment factor was applied to revise the baseline for the CO_2 emission factors only.

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[7] U.S. EPA and 2015 CARB in-house test data

[8] Durbin, T.D., Smith, M.R., Wilson, R., Rhee, S. (2004). In-Use Activity Measurements for Off-Road Motorcycles and All-Terrain Vehicles. Transportation Research Part D 9. (2004) 209–219. 2004. http://cichlid.cert.ucr.edu/research/pubs/durbin-9.pdf

The impact of real-world driving conditions on OHMCs and other OHRVs is currently an issue that requires further investigation. The exhaust emission factors currently used in RV2018 are shown in Table 2 below.

Table 2: Exhaust Emission Factors in RV2018

Vehicle Type	HP Group	Engine	MY Group	HC (g/mi)	NOx (g/mi)
OHMC - Green	0 – 5	G2-CARBU	1997 and older	34.20	0.01
			1998+	34.20	0.01
		G2-FI	1997 and older	21.30	0.01
			1998+	21.30	0.01
		G4-CARBU	1997 and older	3.59	0.49
			1998+	1.00	0.21
		G4-FI	1997 and older	3.59	0.49
			1998+	0.50	0.27
	5+	G2-CARBU	1997 and older	34.20	0.01
			1998+	34.20	0.01
		G2-FI	1997 and older	21.30	0.01
			1998+	21.30	0.01
		G4-CARBU	1997 and older	3.59	0.49
			1998+	0.77	0.33
		G4-FI	1997 and older	3.59	0.49
			1998+	0.50	0.27
OHMC - Red	0 - 5	G2-CARBU	1997 and older	12.38	0.01
			1998+	12.38	0.01
		G2-FI	1997 and older	12.38	0.01
			1998+	12.38	0.01
		G4-CARBU	1997 and older	3.59	0.49
			1998+	1.62	0.16
		G4-FI	1997 and older	3.59	0.49
			1998+	1.62	0.16
	5+	G2-CARBU	1997 and older	34.20	0.01
			1998+	34.20	0.01
		G2-FI	1997 and older	21.30	0.01
			1998+	21.30	0.01
		G4-CARBU	1997 and older	3.59	0.49
			1998+	1.62	0.16
		G4-FI	1997 and older	3.59	0.49
			1998+	1.62	0.16

G2 – Gasoline 2-Stroke | G4 – Gasoline 4-Stroke | CARBU – Carbureted | FI – Fuel Injected

3.3. Evaporative Emission Factors

In addition to the testing performed by the Automotive Testing Laboratory (ATL)[9] for evaporative emissions from OHRVs using a Sealed Housing for Evaporative Determination (SHED) in 2003, CARB has continued to test OHRVs at Hagen-Smit Laboratory (HSL) in El Monte, California. The goal of the testing was to determine baseline evaporative emissions for a wide range of OHRV equipment and obtain data for hot soak, running loss, diurnal, and resting loss processes. Note that the definition of diurnal in a regulatory context represents the sum of the diurnal and resting loss processes.

- Diurnal emissions occur in equipment that is not being used, when rising ambient temperature causes fuel evaporation from engines and gas tanks throughout the day.

- Resting loss emissions occur while the equipment is not being used and generated when the ambient temperature is either stable or declining during the day and evening.

- Hot soak emissions occur after an engine is shut off, as the temperature of equipment and fuel delivery systems gradually return to ambient temperatures.

- Running loss emissions occur while the equipment is operating and the temperature of the equipment and fuel delivery systems is above ambient temperature.

While analyzing the data from evaporative tests, some sources of uncertainty in estimating the evaporative emission factors were noted and are listed below:

- Carbureted (CARBU) and fuel injected (FI) engines used in OHRV applications are assumed to have the same evaporative emission rates (hot soak and running loss) due to the lack of emissions data currently available for FI vehicles. From a practical perspective, FI engines should have lower evaporative emission rates than CARBU engines because FI systems are sealed, whereas carbureted engines have an air intake open to the atmosphere. For diurnal and resting loss emission rates, the model is assuming different evaporative emissions rates for CARBU vs. FI.

- Evaporative testing is generally more difficult to conduct than exhaust testing since vehicle fuel systems can have many sources/processes for hydrocarbon emissions,

[9] https://www.arb.ca.gov/msprog/offroad/recmarine/meetings/atlfinalreport.pdf

including the fuel system hoses, hose fittings, fuel tank, carburetor opening, and liquid leaks. Subsequently, there will typically be a higher test to test variability when measuring evaporative emissions as compared to exhaust.

- Based on observations of on-road passenger vehicles, it is reasonable to assume that a small percentage of the OHRV population have leaks in their fuel systems (known as "liquid leakers"). This results in a disproportionate fraction of the overall evaporative emissions coming from those particular vehicles. However, RV2018 model assumes there are no "liquid leakers" in the OHRV inventory. Since all emissions tests were conducted on OHMCs that were in good operating condition, there was no information available on the contribution of "liquid leakers" to the overall OHRV emissions inventory. As a result, RV2018 model also does not take into account of tampering or malfunctioning components for vehicles. Further testing will be needed to estimate the impact of liquid leakers.

As a result of the combined testing, evaporative emission factors were updated as shown in Table 3.

Table 3: Evaporative Emission Factors for RV2018

Vehicle Type	MY Group	Engine	Hot Start (g/event)	Diurnal (g/day)	Resting (g/day)	Running (g/hr)
OHMC - Green	2007 and older	CARBU	3.12	12.23	6.59	1.07
	2008-2017		2.37	9.29	5.01	0.81
	2018		1.29	4.94	2.66	0.41
	2019		0.75	2.76	1.49	0.22
	2020		0.75	2.76	1.49	0.22
	2021+		0.21	0.58	0.31	0.02
OHMC - Red	all years	CARBU	3.12	12.23	6.59	1.07
OHMC - Green	2007 and older	FI	3.12	0.86	0.46	1.07
	2008-2017		2.37	0.86	0.46	0.81
	2018		1.29	0.58	0.31	0.41
	2019		0.75	0.58	0.31	0.22
	2020		0.75	0.58	0.31	0.22
	2021+		0.21	0.58	0.31	0.02
OHMC - Red	all years	FI	0.56	1.72	0.92	1.07

3.4. Activity

Assumptions about vehicle activity or usage (e.g. miles driven per year) are an essential component in estimating the OHRV emissions inventory. Previously, in RV2013, the annual activity of OHRVs was based on 1,123 responses from a 2009 phone survey conducted by

California State University, Sacramento (CSUS)[10], in combination with sales information, reported mileage and hours of use from second-hand OHRVs.

In the RV2018 model, the activity for OHMCs was updated based on 2,300 responses from the 2016 online survey of OHMC owners conducted by University of California, Davis (UCD)[1]. To further validate the responses obtained from Round 1 (R1) of the survey, a supplemental survey (R2) was conducted approximately 6 months later by UCD. Of the R1 respondents, 310 answered the R2 survey. A scaling factor was developed by comparing the R1 and R2 annual activity responses from the same respondent. This scaling factor was applied to the R1 activity responses. The updated OHMC annual activity by age in the RV2018 model is shown in Figure 7 below. Appendix A contains a description of the analyses and methodology used.

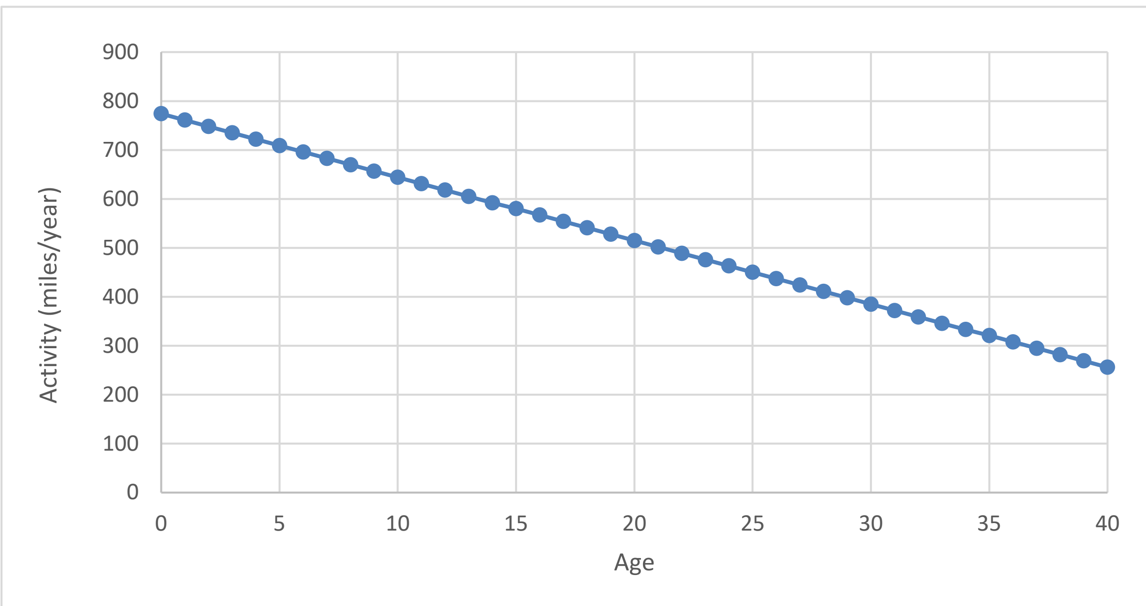

Figure 7: OHMC Annual Activity by Age

3.5. Spatial Allocation

Allocating emissions spatially throughout the state is an important part of an emissions inventory. OHMC emissions associated with operation and storage may not take place in the same location. Operation related emissions, applicable to active population, refer to exhaust emissions and some evaporative emissions (hot soak and running loss) that are allocated to the areas of operation (riding trails and parks from the survey). Storage related

[10] CSUS, 2009. Final Analysis of the 2008 California Survey of Registered Off-Highway Vehicle Owners: Usage and Storage. Final Report. California State University, Sacramento. June 2009.

emissions refers to daily evaporative emissions occurring where the vehicles are stored, including both active and inactive population. DMV registration data are used to determine where the vehicles are stored. Figure 8 shows how the spatial allocation of storage and operating emissions varies for OHMCs in California as updated with the 2016 UCD survey data (surrogate for operating emissions) and the 2017 DMV registration data (surrogate for storage).

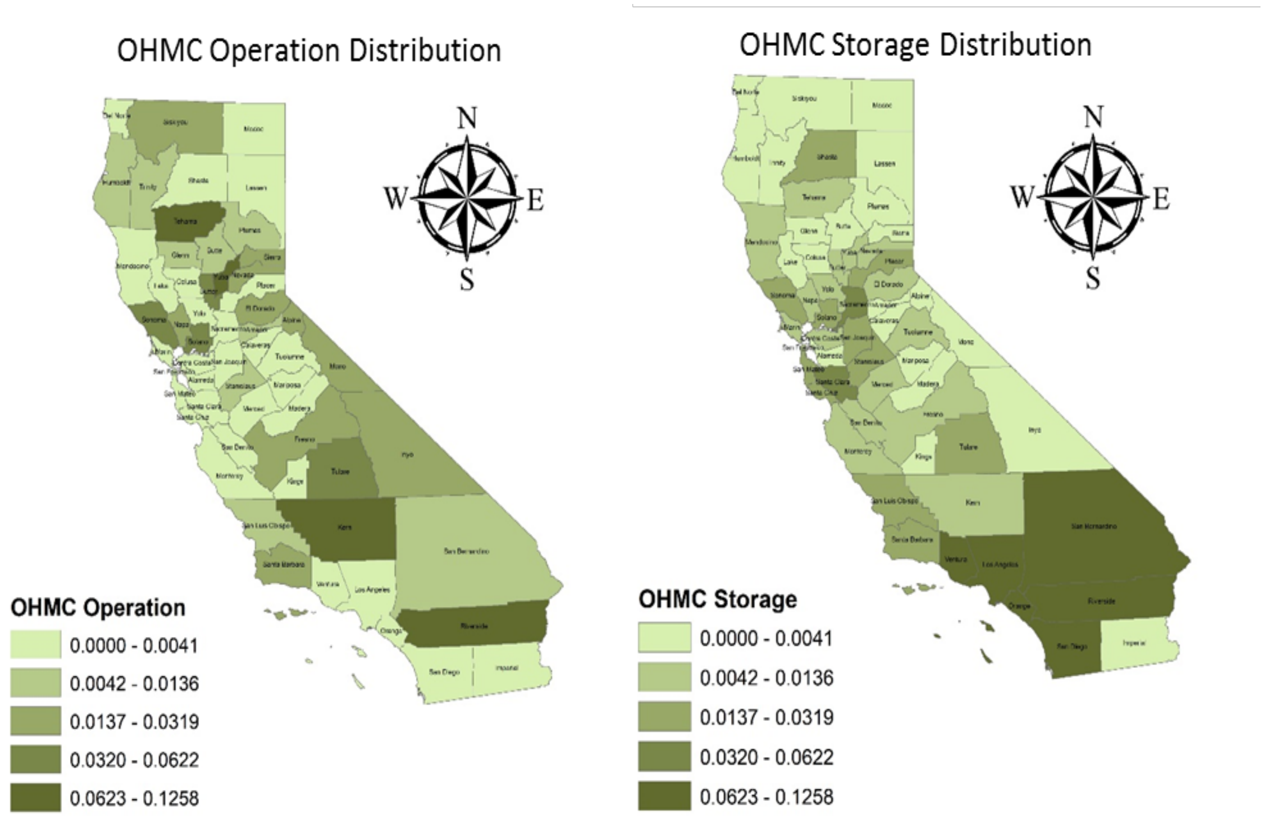

Figure 8: Spatial Allocation for OHMCs

3.6. Seasonality

The seasonality factor is used to compare the average summer or average winter activity relative to the annual average activity. To model seasonal variability in OHRV usage in California, staff analyzed the activity survey data collected by UCD[1] in 2016 and updated the seasonal usage in RV2018. The total hours of use per year was calculated by multiplying the reported days of use per year by the reported hours of use per day.

The monthly usage was developed for each of the four seasons: winter (December to February), spring (March to May), summer (June to August), and fall (September to November). The monthly usage was calculated using the following equation:

$$\mathbf{MUF_i = (THU * UF_i)/3} \qquad \mathbf{(2)}$$

Where,

MUF_i = monthly usage frequency for season i

THU = Total hours of usage per year

UF_i = Usage frequency for a given season i

Since the seasonal definition in the RV2018 model is different from what was defined in the survey, the seasonal usage frequency is calculated by summing the monthly usage frequency over the specified season. In the model, the summer season refers to the six months from May to October while the winter season refers to the remaining six months from November to April.

$$\mathbf{SUF_i = \sum MUF_{j,i}} \qquad \mathbf{(3)}$$

Where,

SUF_i = Seasonal Usage Frequency for a given season i

$MUF_{j,i}$ = j month usage frequency within a given season i

The RV2018 model assumes summer months to include May through October and winter months to include November through April. Therefore, the seasonality adjustment will be:

$$\boldsymbol{SA_i} = \mathbf{4 * \frac{SUF_i}{\sum SUF_i}} \qquad \mathbf{(4)}$$

Where,

SA_i = Seasonal adjustment factor for season i

The seasonal adjustment factor is designed to compare the average summer activity or average winter activity versus the annual activity. Using the methodology described above, the seasonal adjustment factor for OHRVs is 0.95 for summer months and 1.05 for winter months. To calculate summer average emissions, final emission tons per day are multiplied by the seasonality adjustment factor of 0.95. Likewise, the final emission are multiplied by 1.05 to calculate winter average emissions.

3.7. Other Input Factors

The RV2018 model contains additional input factors that have been carried over from the previous RV2013 model, with the addition of a weathering correction factor for active carburetor vehicles. The description of these inputs are summarized below.

3.7.1. Lifespan (Total Life)

The total life is defined as the time a population of vehicles is manufactured in a given year to the time all of those vehicles have been scrapped. This assessment is conducted on a vehicle type-specific basis, based on DMV registration data for active and inactive vehicles. It is assumed that the vehicle lifespans, as derived from DMV registration data, also represent the total life of each engine in each vehicle. As a result, engines are not assumed to be rebuilt or replaced during a vehicle's life span. The total life for OHRVs in RV2018 is 40 years.

3.7.2. Technology & Horsepower Split

Engine technology has an impact on exhaust and evaporative emissions. Typically, a two-stroke gasoline engine (G2) produces significantly higher amount of hydrocarbon (HC) exhaust emissions as compared to a four-stroke gasoline engine (G4). In RV2018, all vehicles are categorized as either two-stroke gasoline (G2) or four-stroke gasoline (G4) engines. These categories are further split into carbureted and fuel injected vehicles, and various horsepower groupings. As shown in Tables 4 and 5, the RV2018 model bins OHRVs into different technology and horsepower groups for the purpose of assigning emission factors.

Table 4: Technology Types

Technology
2-Stroke Carbureted (G2 CARBU)
2-Stroke Fuel Injected (G2 FI)
4-stroke Carbureted (G4 CARBU)
4-Stroke Fuel Injected (G4 FI)

Table 5: Horsepower Groups

Horsepower (hp)
0 to 5
5 to 15
16 to 25
26 to 50
51 to 120

3.8. Correction Factors

Evaporative emissions testing is conducted under controlled temperature and humidity conditions. Since OHRVs may experience different temperature and humidity conditions depending on where the vehicle is actually operated and stored, corrections are developed and applied to the baseline emission factors, which reflect controlled laboratory conditions, to better account for the emissions produced under real-world operating conditions.

For regulatory purposes, California is divided into 58 counties, 35 local air districts, and 15 air basins. To estimate emissions for each unique combinations of air basin, local air district, and county, emissions are developed for a smaller unit of area called a geographical area index (GAI). A total of 69 GAIs were developed and formed the basis for spatially allocating the statewide OHRV emissions inventory. The correction factors applied in RV2018, to reflect the local temperature and humidity conditions that OHRVs experience during operation and storage in different regions of California, are detailed below.

3.8.1. Temperature/RVP Correction for Evaporative Emissions

3.8.1.1. Temperature/RVP Correction (Diurnal & Resting Loss)

Evaporative emissions are a function of temperature and fuel volatility, which is expressed as Reid Vapor Pressure (RVP). Temperature/RVP correction factors are primarily used to correct the diurnal and resting loss emissions measurements made under laboratory conditions of 65ºF to 105ºF and standard RVP of 7 pounds per square inch (psi) to local ambient temperature and dispensed fuel properties that OHRVs actually experience under real-world conditions. The Temperature/RVP correction was estimated based on two main processes as described below.

Vapor Generation: For this analysis, we used the Reddy equation[11] for estimating grams of gasoline vapor generated per gallon of fuel tank vapor space, using coefficients for sea level and E10, as these are most reflective of California conditions:

$$\textbf{Vapor generated (g/gal vapor space)} = A^* \, e^{B^*(RVP)} \left(e^{C^*T2} - e^{C^*T1}\right) \qquad \textbf{(5)}$$

Where RVP, starting temperature (T1) and ending temperature (T2) are inputs, and A, B and C are coefficients for E10 and sea level (A=0.00875, B = 0.2056, C=0.0430).

$$\textbf{Vapor generated (grams) = Vapor (g/gallon vapor space) * Fuel Capacity (gal) * (1- Fill \%)} \qquad \textbf{(6)}$$

Permeation: The permeation process is assumed to include both tank permeation and hose permeation. The base permeation emission factors are 10.7 g/m^2/day for tanks, and 222 g/m^2/day for hoses based on the MOVES2014 model (E10 fuel). Generally speaking, temperature corrections for permeation are based on engineering judgement that

[11] Reddy, S. Raguma. Prediction of Fuel Vapor Generation from a Vehicle Fuel Tank as a Function of Fuel RVP and Temperature. SAE Technical Paper 1989-09-01. 1989. DOI: 10.4271/892089.

permeation emissions double with every increase of 18ºF (10ºC) from its reference temperature. As a result, a temperature adjustment is applied to the reference temperature when estimating the permeation emission factor at a different temperature.

<u>Hose Permeation Temperature Adjustment:</u> Temperature adjustment is applied to the hose permeation calculation. The hose permeation doubles with each 18ºF increase from the reference temperature of 73°F.

$$\mathbf{TCF = 0.06013899*exp(0.03850818*T)} \tag{7}$$

<u>Tank Permeation Temperature Adjustment:</u> Temperature adjustment is applied to the tank permeation calculation. The tank permeation doubles with each 18ºF increase from the temperature of 85°F.

$$\mathbf{TCF = 0.03788519*exp(0.03850818*T)} \tag{8}$$

$$\mathbf{Diurnal = Vapor\ Generation + 0.5*(Tank\ Permeation + Hose\ Permeation)} \tag{9}$$

$$\mathbf{Resting\ Loss = 0.5*(Tank\ Permeation + Hose\ Permeation)} \tag{10}$$

By calculating the absolute values of diurnal and resting loss at 65°F to 105°F and other local temperature conditions and fuel RVP, staff is able to normalize all calculated values, based on the value from 65°F to 105°F as 100%. These normalized values are used as the Temperature/RVP correction to adjust diurnal and resting loss emission factors to the local temperature and fuel RVP conditions. The tank size or hose diameter that is assumed represents the typical fleet average and is not important in the final calculation as staff is only interested in the normalized values from different temperature and RVP conditions. Appendix D provides a sample calculation of how the Temperature/RVP correction can be applied to diurnal and resting loss emissions conducted at different temperature profiles and fuel RVP.

3.8.1.2. RVP Correction (Hot Soak and Running Loss)

The RVP correction is applied to the hot soak and running loss of the evaporative emissions that are conducted with fuel RVP of 7 psi, which is the standard RVP in California during summertime. When the winter fuel with RVP of 9 psi is used, the following formula is utilized:

$$\mathbf{CFRVP = 0.3*RVP-1.1} \tag{11}$$

Applying RVP = 9 psi, the above equation becomes 0.3*9-1.1 = 1.6 which is used for all GAI when winter fuel is used. For summer fuel (RVP = 7 psi), the CFRVP is 1.0.[12]

3.8.2. Fuel Correction Factor for Exhaust Emissions

The fuel correction factors[13] (FCFs) are dimensionless multipliers applied to the basic exhaust emissions rates that account for differences in the properties of certification fuels compared to those of commercially dispensed fuels. California went through three phases of reformulated gasoline in the past two decades: California Reformulated Phase 1 Fuel (1992 to 1995), California Reformulated Phase 2 Fuel (1996 to 2003), and California Reformulated Phase 3 Fuel (2004+) including 6% ethanol gasoline (E6) and 10% ethanol gasoline (E10). In those instances where engines or vehicles are not required to certify, the FCFs intend to reflect the impact of changes in dispensed fuel over time as refiners respond to changes in fuel specific regulations compared to the fuel used to obtain the test data.

E10 is the reference fuel assumed in RV2013 and maintained in the RV2018 model for estimating the future emissions inventory since most OHRVs were tested using E10 fuel and it is the current commercially available gasoline throughout California.

3.8.3. Temperature and Humidity Correction

The temperature and humidity correction for exhaust emissions were developed as follows:

3.8.3.1. Temperature Correction

For hydrocarbons and nitrogen oxide (NOx), the temperature correction[2] is:

$$\mathbf{CF_{Temp} = 10^{(T-75)a}} \tag{12}$$

Where,

T = ambient temperature (°F)

a = coefficient which depends on engine type and whether the ambient temperature is above or below 75°F as shown in Table 6 below.

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[12] https://www.arb.ca.gov/msei/offroad/techmemo/SORE_Evaporative1.doc

[13] SICAT, 2007. Sicat, T. OFFROAD Modeling Change Technical Memo. F-Road Exhaust Emissions Inventory Fuel Correction Factors. 7/25/05

Table 6: Coefficients for Temperature Correction

	Low Temp (<75F)		High Temp(>75F)	
Pollutants	**G2**	**G4**	**G2**	**G4**
CO	0	0	0.01494	-0.0146
HC	0	0	0.00484	-0.0113
NOx	0	0	0	-0.0059

To simplify the calculation methods used in developing the OHRV emissions inventory, we have applied the temperature correction on a daily basis to the average daily temperature. Using this approach captures the general trend of the correction factor without requiring calculations on an hourly basis.

3.8.3.2. Humidity Correction

For humidity correction for NOx, the correction factor is:

$$\mathbf{CFHumd = 1 - 0.0038*(A - 75)} \qquad \mathbf{(13)}$$

Where,

A = absolute humidity

The absolute humidity is derived from the relative humidity and ambient temperature based on the following equation:

$$\mathbf{ABH = RH *(- 0.09132 + 0.01594 * T - 0.00029*T^{2} + 0.00000437*T^{3})} \qquad \mathbf{(14)}$$

Where,

ABH = scenario humidity (grains/pound)

T = scenario temperature (°F)

RH = relative humidity (%)

This equation is valid for ambient temperatures between 40°F and 120°F, and to predict absolute humidity values less than or equal to 200 grains/pound. If the ambient temperature is less than 40°F, then 40°F is used for the calculation. Similarly, if the ambient temperature is higher than 120°F, then 120°F is used for calculation. Finally, if the calculated absolute humidity is greater than 200 grains/pound, then only 200 grains/pound is used.

3.8.4. Speciation Factor for ROG, TOG and CH_4

3.8.4.1. ROG & TOG Speciation

The speciation factor refers to the conversion of total hydrocarbons (THC) to total organic gases (TOG), reactive organic gases (ROG), and other pollutants. These conversion factors vary by calendar year (due to phase-in schedule of reformulated gasoline), engine type and emission process such as evaporative and exhaust which are listed in Table 7.

Table 7: Conversion Factors for THC, TOG and ROG

Calendar Year	Engine	Process	TOG	ROG
Pre-1996	Gasoline	Exhaust (G2)	THC*1.01	THC*0.92
		Exhaust (G4)	THC*1.04	THC*0.89
		Evaporative (All)	THC*1.04	THC*1.04
1996 - 2003	Gasoline	Exhaust (All)	THC*1.09	THC*1.00
		Evaporative (All)	THC*1.12	THC*1.12
2004+	Gasoline	Exhaust (All)	THC*1.10	THC*1.01
		Evaporative (All)	THC*1.14	THC*1.14

3.8.4.2. Methane Conversion (CH_4)

Methane (CH_4) is derived as a fraction of TOG as shown in equation (15).

$$CH_4 = TOG * Coefficients \tag{15}$$

Where the coefficients are provided in Table 8 below:

Table 8: Coefficients Used for CH_4 Conversion from TOG

Fuel Type	CY	Coefficients
G2	Pre-1996	0.0774
	1996 - 2003	0.0558
	2004+	0.0572
G4	Pre-1996	0.1132
	1996 - 2003	0.0558
	2004+	0.0572

3.8.5. Fuel Consumption and Sulfur Dioxide (SO_2) Calculation

3.8.5.1. Fuel Consumption

The fuel consumption correction factor is derived from mass balance using CO, CO_2 and TOG or ROG. The formulas are shown below and the fuel consumption coefficients are shown in Table 9 below.

For hydrocarbon reported in ROG:

$$\text{Fuel consumption} = [(12.011/(12.011+\text{Alpha}*1.008))*\text{TOG}/\text{ROG}_{adj}+0.429*\text{CO}+0.273*\text{CO2}] /(0.854*453.59237*\text{Fuel Density}) \quad (16)$$

For hydrocarbon reported in TOG:

$$\text{Fuel consumption} = [(12.011/(12.011+\text{Alpha}*1.008))*\text{TOG}+0.429*\text{CO}+0.273*\text{CO2}] /(0.854*453.59237*\text{Fuel Density}) \quad (17)$$

Table 9: Coefficients Used for Fuel Consumption Calculations

Fuel Type	CY	Alpha	TOG_Adj	ROG_Adj	Fuel Density (lb/gal)
G2	Pre- 1996	0.54	1.0155	0.9079	6.17
	1996-2003	0.54	1.0949	0.9219	6.17
	2004+	0.54	1.1004	0.9198	6.17
G4	Pre- 1996	0.54	1.0379	0.8648	6.17
	1996-2003	0.54	1.0949	0.9219	6.17
	2004+	0.54	1.1004	0.9198	6.17

3.8.5.2. Sulfur Dioxide (SO_2)

The SO_2 conversion factor is calculated based on sulfur content in the fuel which differs by fuel type.

$$SO_2\ (\text{g/hp-hr})=(\text{ppm}\ /106) * 2 * \text{BSFC} * 453.5 \quad (18)$$

Where,

ppm = sulfur content in the fuel (weight basis)
BSFC = brake-specific fuel consumption (lb/hp-hr) conversion factor from pound to gram is 453.5

3.8.6. Garage Temperature Correction

Since temperature has a significant effect on evaporative emissions from OHRVs, especially the diurnal and resting loss processes, it is critical that the emissions modeling reflects the temperatures experienced by OHRVs under real-world storage conditions. The garage temperature correction factor adjusts the ambient temperature profiles assumed in the modeling to better reflect the temperatures OHRVs experience when stored inside a garage in California, as referenced in Attachment C: Emissions Estimation Methodology for Off-Highway Recreational Vehicles (2013)[14].

3.8.7. Carburetor Vehicles Corrections (Weathering and Fuel Line)

Diurnal emission factors are developed using one-day diurnal test procedures. OHRVs are not used every day and diurnal emissions vary over the course of an extended vehicle storage period. From multiple day diurnal testing of OHMC carburetor vehicles, there is some evidence of fuel weathering as illustrated in Figure 9.

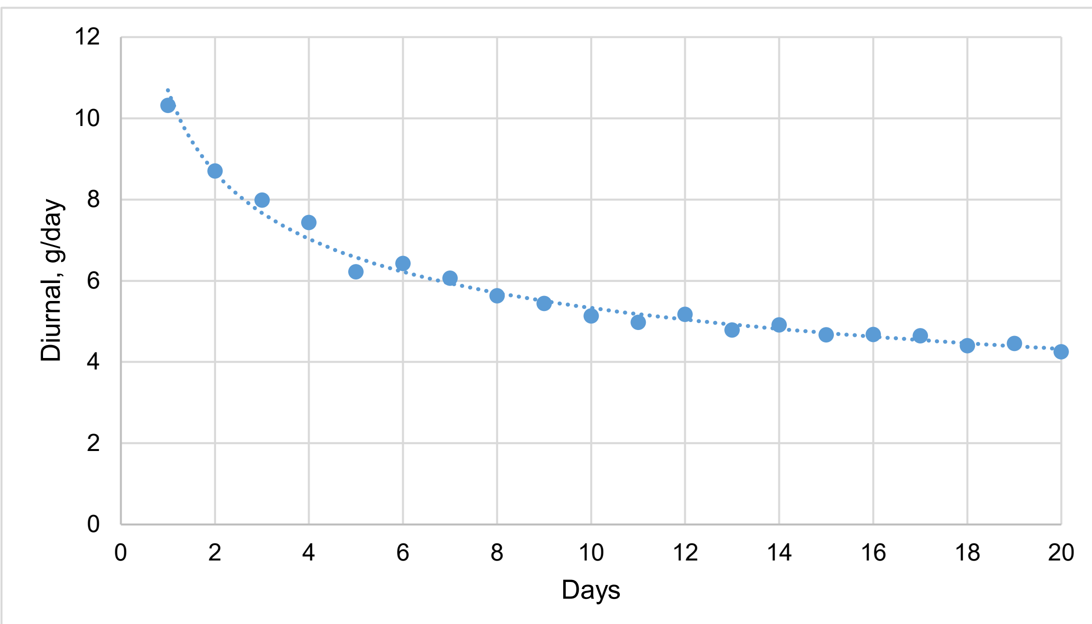

Figure 9: Carbureted Vehicle Multiple Day Diurnal Test

[14] CARB, 2013. Attachment C: Emissions Estimation Methodology for Off-Highway Recreational Vehicles. Final Regulation Order. Off-Highway Recreational Vehicles: Evaporative Emission Control. Title 13, California Code of Regulations (2013)

Carbureted OHMCs also have a manual fuel shutoff valve. Turning off the fuel shutoff valve during storage can cause diurnal emission rates to differ from day to day. For OHMC, the average day between uses is 26 days.This is derived from the 2016 UC Davis survey where survey indicates OHMC vehicle are used about 14 days per year (365/14 equals 26). Therefore, diurnal emission correction factor is 26 day average diurnal to one day diurnal ratio. Table 10 lists the correction factor for OHMC carburetor vehicle with fuel shutoff valve on or off.

Table 10: Weathering Correction Factors (Carbureted, Active)

Condition	Uncontrolled (Vehicle with no carbon canister)	Controlled (with carbon canister)
Fuel line is closed	0.49	0.67
Fuel line is open	0.55	0.75

Uncontrolled carbureted OHMCs with manual fuel shutoff valves that remain open have higher diurnal evaporative rates than when the valve is closed. When the valve is closed, the fuel in the carburetor dries out during storage. When the fuel valve is left open, the carburetor refills periodically with tiny amounts of fuel to replace the evaporated fuel and keep the carburetor filled with fuel at all times. Table 11 shows the composite fuel line correction factor for carbureted OHMC. Since the percentage of time the fuel line is closed or open is unknown, staff assumes 50 percent of the time, it is left open while the rest of time it is closed to arrive at a weighted average number. Evaporative emission factors for carbureted vehicles are based on tests conducted with fuel valve closed.

Table 11: Carbureted Vehicle Fuel Line Correction Factor

Condition	Fuel Line Correction Factor	Composite Fuel Line Correction Factor
Fuel line is closed	1	1.15
Fuel line is open	1.3	

Appendix B contains the description on the analyses and methodology used to develop the weathering correction factors.

3.8.8. Long Term Weathering Correction for Inactive Vehicles

The evaporative emissions[2] (diurnal and resting loss) are based on the assumption that the emission rate remains constant throughout all 365 days of the year for inactive vehicles. This is under the assumption that the liquid-phase composition of the fuel was constant with no depletion of volatile components over time. This assumption may be reasonable for active vehicles, but it may not be applicable for inactive vehicles which are likely to sit many months without any activity or refueling. The long-term weathering correction factors used to reduce the evaporative emissions for inactive vehicles are shown in Table 12 below.

Table 12: Weather Correction Factors (Inactive)

Temp Profile	Method	gram/yr.	gal/yr.	% of 5 gal tank	Adjustment Factor
LA County (12 months)	Weathered (VLE mass balance)	385	0.14	2.70%	0.53
	Un-weathered	737	0.26	5.20%	
65º -105º F	Weathered (VLE mass balance)	1870	0.66	13.00%	0.64
	Un-weathered	2900	1.03	20.60%	

4. Emission Benefits of Proposed Rule

4.1. Methodology for Estimating the Rule Inventory

The proposed regulation intends to amend the existing regulation that sets exhaust and evaporative emissions standards for OHRVs. Specifically, CARB is proposing to end the red sticker program that allows for CARB certification of OHRV that do not meet exhaust and evaporative emissions standards. Under the proposal, beginning in model year 2022, all OHRVs must either be certified as meeting emissions standards or sold exclusively for competition use. In summary, CARB proposes the following:

- End red sticker certification of new OHRV with no emissions controls beginning in model year 2022
- Lift the seasonal riding restrictions on existing red sticker vehicles starting on January 1, 2025
- Harmonize with USEPA evaporative standards for off-highway motorcycles of model years 2020 through 2026
- Harmonize with USEPA exhaust standards for off-highway motorcycles from 2022 through 2027
- Adopt more stringent California-specific emissions standards for new OHRV starting with the 2027 model year

In developing the exhaust and evaporative emission inventory for OHMCs and ATVs, the RV2018 model also reflects the phase-in schedule for the proposed standards reflecting the calendar year 2025 sunset date for eliminating seasonal riding restrictions for existing red sticker vehicles, as shown in Tables 13 to 16.

Table 13: Proposed Exhaust Tiers

Type	2022-2024	2025-2027	2028+
OHMC	2.0 g/km HC+NOx	2.0 g/km HC+NOx	1.2 g/km HC
ATV/UTV	1.1 g/km HC	1.0 g/km HC	0.9 g/km HC

Table 14: Proposed Evaporative Standards for OHMCs

Tier	Fuel Tank Permeation Grams/m2/day	Fuel Hose Permeation Grams/m2/day	Fuel Injection or Automatic Fuel Shutoff(3)	Carbon Canister Working Capacity Grams/Liter of Nominal Fuel Tank Volume
I	Certified per Cal. Code Regs., tit.13, § 2418(a) or 1976(b)(2)			
II	1.5 @ 28°C (82°F)(1)	15.0 @ 23°C (74°F)(1)	Required	1.0(1)(2)
III	1.5 @ 28°C (82°F)(1)	15.0 @ 23°C (74°F)(1)	None	None

(1) Certification and test procedures specified in Cal. Code Regs., tit.13, § 2418(c)(2) and (3)
(2) For motorcycles with engines greater than 110 cc displacement, the carbon canister must be actively purged during engine operation. Motorcycles with engines less than or equal to 110 cc displacement may use either actively purged or passively purged canisters. Active purge refers to ambient air being drawn through a carbon canister by a vacuum created by the intake system. Passive purge refers to ambient air being drawn through a carbon canister by the vacuum created by normal diurnal variations of the fuel tank temperature.
(3) Automatic fuel shutoff is a valve or similar mechanism that completely stops the flow of fuel to the carburetor automatically whenever the vehicle is turned off.

Table 15: Proposed Evaporative Standards for ATVs

Tier	Fuel Tank Permeation Grams/m2/day	Fuel Hose Permeation Grams/m2/day	Fuel Injection or Automatic Fuel Shutoff(3)	Carbon Canister Working Capacity Grams/Liter of Nominal Fuel Tank Volume
I	Certified per Cal. Code Regs., tit.13, § 2418(a)			
II	1.5 @ 28°C (82°F)(1)	15.0 @ 23°C (74°F)(1)	Required	1.0(1)(2)
III	1.5 @ 28°C (82°F)(1)	15.0 @ 23°C (74°F)(1)	None	None

(1) Certification and test procedures specified in Cal. Code Regs., tit.13, § 2418(c)(2) and (3).
(2) For ATVs with engines greater than 110 cc displacement, the carbon canister must be actively purged during engine operation. ATVs with engines less than or equal to 110 cc displacement may use either actively purged or passively purged canisters. Active purge refers to ambient air being drawn through a carbon canister by a vacuum created by the intake system. Passive purge refers to ambient air being drawn through a carbon canister by the vacuum created by normal diurnal variations of the fuel tank temperature.
(3) Automatic fuel shutoff is a valve or similar mechanism that completely stops the flow of fuel to the carburetor automatically whenever the vehicle is turned off.

Table 16: Proposed Evaporative Standards Phase-In Schedule

Type	Tier	2020-2021	2022-2026	2027+
Off-Road Motorcycles w/ Engines > 110 cc	I	0%	0%	> 50%
	II	0%	0%	50%
	III	100%	100%	0%
Off-Road Motorcycles w/ Engines ≤ 110 cc	II	0%	0%	100%
	III	100%	100%	0%
ATV w/ Engines >110 cc	I	0%	> 80%	> 80%
	II	0%	≤ 20%	≤ 20%
	III	100%	0%	0%
ATV w/ Engines ≤ 110 cc	II	0%	0%	100%
	III	100%	100%	0%

Snowmobiles, golf carts, and specialty vehicles are excluded from this proposed regulation. Snowmobiles are currently only subject to federal regulation and gasoline-fueled golf carts are regulated under CARB's existing small off-road engine (SORE) regulation.

4.2. Emissions Benefit

The emissions benefit (in the units of tons per day) for OHRV from the proposed rule is illustrated in Figure 10 below. Tables 17 and 18 provides the statewide ROG and NOx emission reductions beginning in the year 2022. The statewide ROG+NOx benefit increases to 1.86 tpd by 2028. The benefit further increases to 5.98 tpd ROG+NOx in 2040.

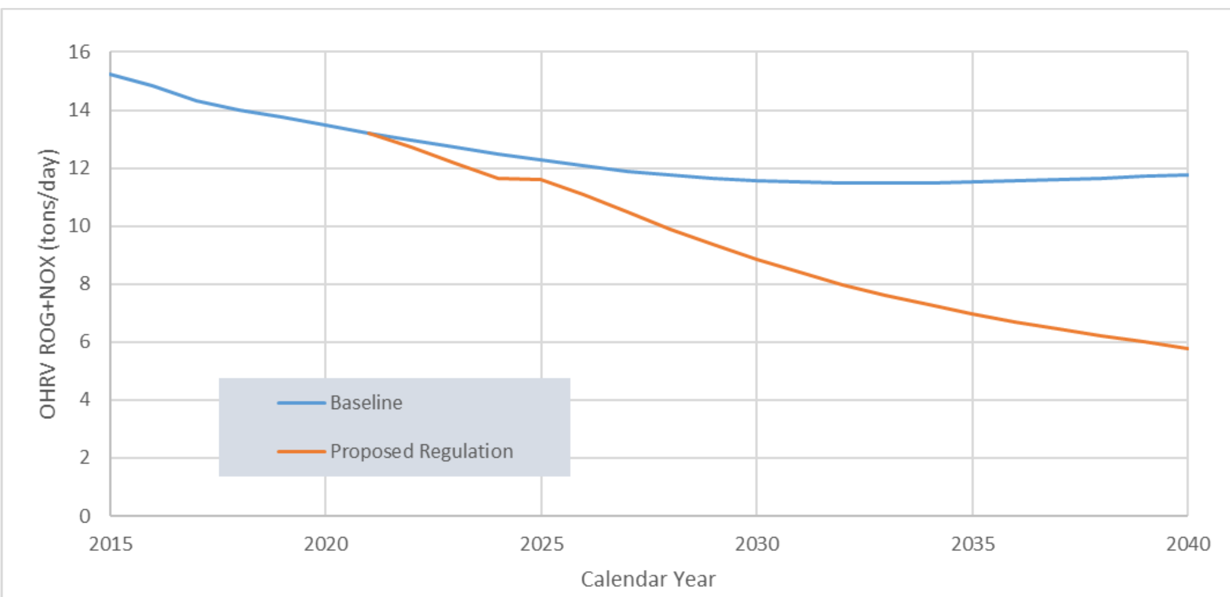

Figure 10: ROG+NOx Emissions under Baseline and Proposed Regulation Scenarios for OHRVs

Table 17: Statewide Summer OHRV ROG+NOx Benefit (tpd) under Baseline and Proposed Regulation Scenarios

CY	ROG+NOX Emissions (tpd)		
	Baseline	Proposed Rule	Benefit
2022	12.96	12.72	0.24
2023	12.72	12.16	0.56
2024	12.49	11.63	0.86
2025	12.27	11.60	0.67
2026	12.07	11.07	1.00
2027	11.88	10.47	1.41
2028	11.75	9.89	1.86
2029	11.65	9.36	2.29
2030	11.57	8.86	2.71
2031	11.51	8.40	3.11
2032	11.48	7.99	3.49
2033	11.47	7.62	3.85
2034	11.49	7.28	4.21
2035	11.52	6.98	4.54
2036	11.56	6.71	4.85
2037	11.61	6.46	5.15
2038	11.65	6.21	5.44
2039	11.71	5.99	5.72
2040	11.77	5.79	5.98

Table 18: Breakdown of Statewide OHRV Summer ROG Benefit (tpd) by Exhaust/Evaporative

CY	Baseline		Proposed Rule		Emissions Benefit	
	Exhaust	Evaporative	Exhaust	Evaporative	Exhaust	Evaporative
2022	6.89	5.59	6.64	5.59	0.25	0.00
2023	6.81	5.42	6.27	5.40	0.54	0.02
2024	6.76	5.24	5.91	5.21	0.85	0.03
2025	6.71	5.07	6.01	5.07	0.70	0.00
2026	6.67	4.90	5.65	4.89	1.02	0.01
2027	6.64	4.74	5.31	4.62	1.33	0.12
2028	6.63	4.60	4.99	4.36	1.64	0.24
2029	6.64	4.49	4.69	4.11	1.95	0.38
2030	6.65	4.39	4.42	3.88	2.23	0.51
2031	6.67	4.30	4.17	3.67	2.50	0.63
2032	6.71	4.23	3.95	3.48	2.76	0.75
2033	6.76	4.17	3.75	3.30	3.01	0.87
2034	6.81	4.12	3.57	3.14	3.24	0.98
2035	6.87	4.08	3.41	2.99	3.46	1.09
2036	6.94	4.05	3.27	2.86	3.67	1.19
2037	7.01	4.02	3.14	2.73	3.87	1.29
2038	7.07	3.99	3.01	2.61	4.06	1.38
2039	7.15	3.96	2.91	2.49	4.24	1.47
2040	7.23	3.93	2.81	2.37	4.42	1.56

5. RV2018 Updates (Other OHRVs)

Section 3 detailed the updated inventory inputs for OHMCs. Similarly, this section contains the updated inputs for the other Off-Highway Recreational Vehicles (ATVs, snowmobiles, golf carts & specialty vehicles) that are included in the RV2018 model, but not impacted by this regulation.

5.1. Population

DMV registration data, for calendar years 2000-2017, was utilized to update the ATVs, snowmobiles, golf carts & specialty vehicles population. Figures 11 to 13 show the updated population for these OHRVs as utilized in RV2018.

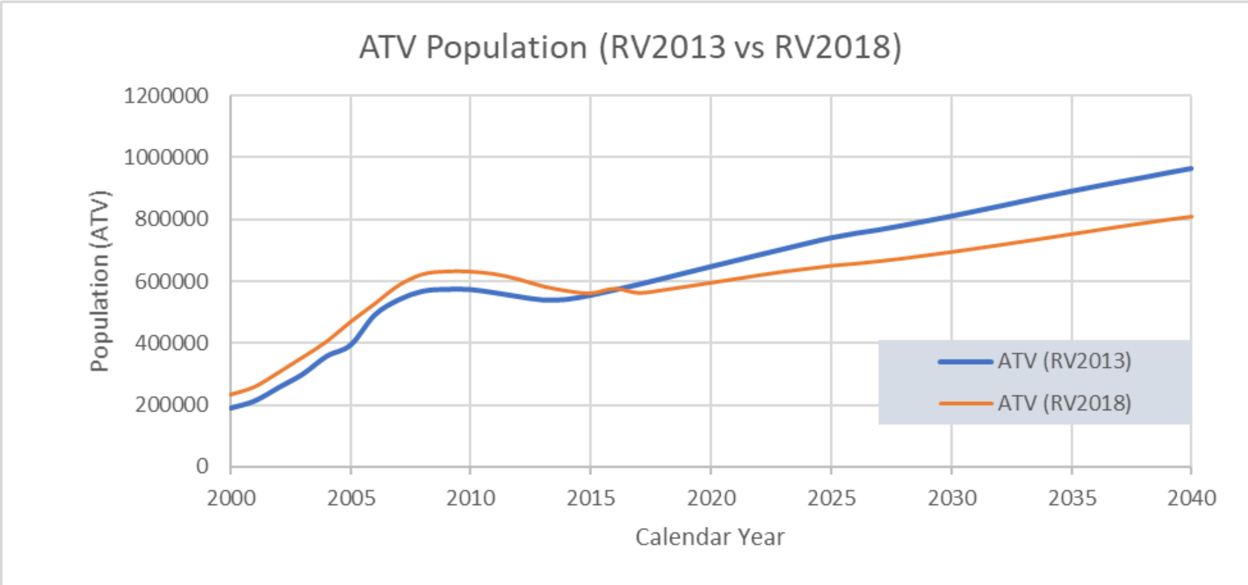

Figure 11: ATV Population (RV2013 vs RV2018)

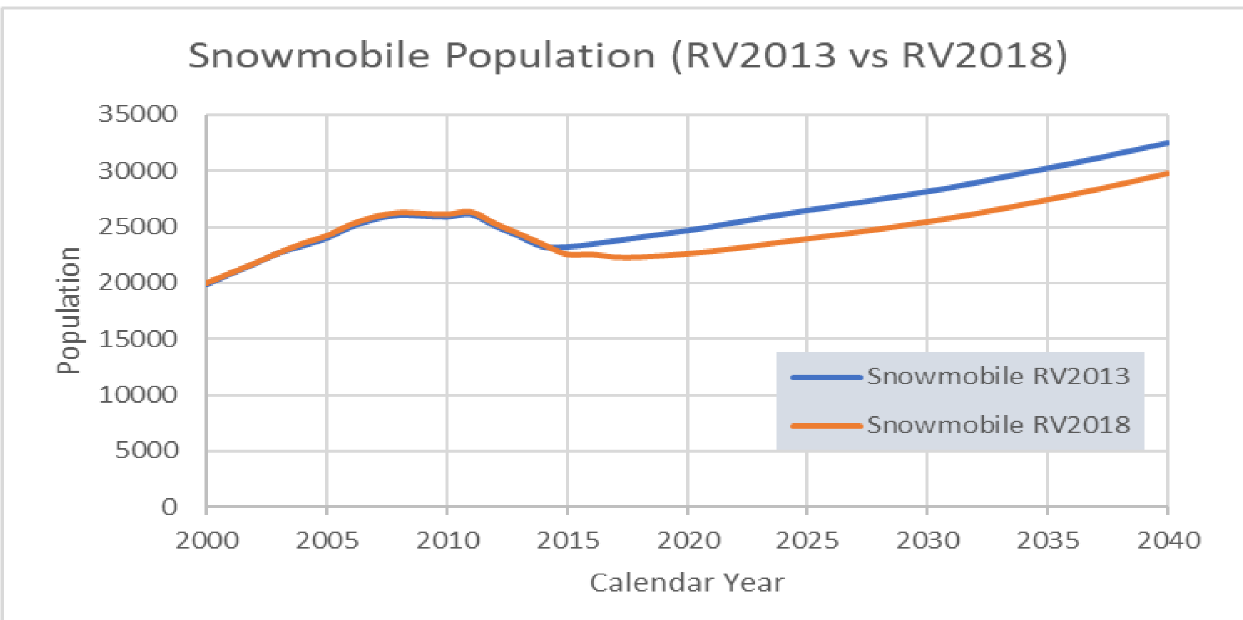

Figure 12: Snowmobile Population (RV2013 vs RV2018)

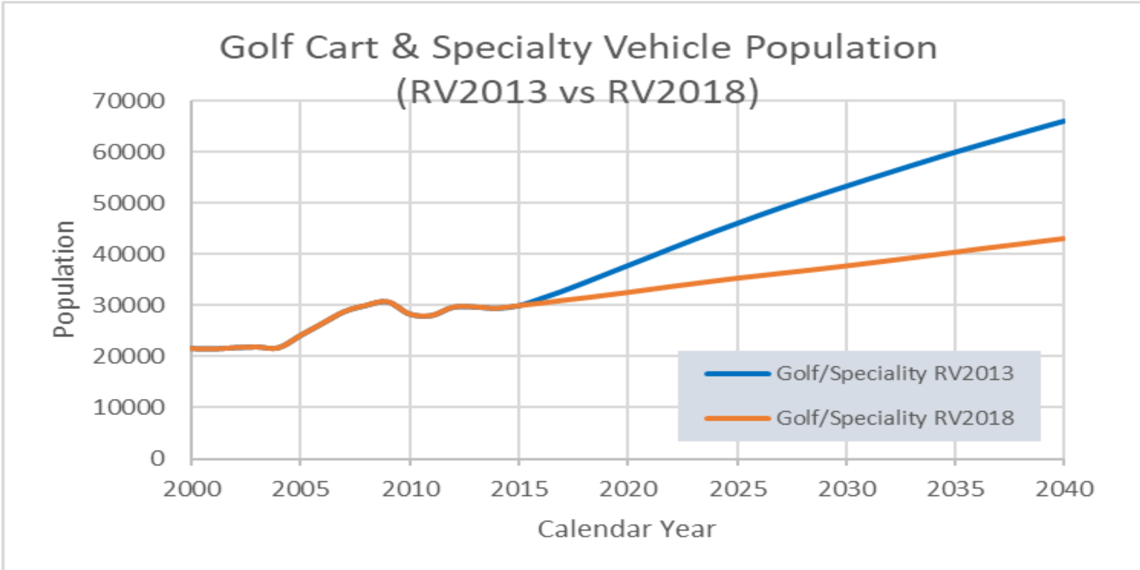

Figure 13: Golf Cart & Specialty Vehicles Population (RV2013 vs RV2018)

5.2. Spatial Allocation

Allocating emissions spatially is an essential part of an emissions inventory as represented in the operation and storage maps in Figures 14 to 16. Table 19 summarizes the surrogates used in the RV2018 model for allocating evaporative emissions associated with the other OHRVs operation and storage related emissions. The 2017 DMV registration data was used to update the allocation factor for storage allocation for golf carts and specialty vehicles. The area of operation was assumed to be in close proximity to where vehicles were registered. The areas, with elevation above 5000 feet, were designated as a surrogate for the operation allocation factor for snowmobiles during the winter.

Table 19: Spatial Allocation Sources for Other OHRVs

Vehicle Type	Operation	Storage
ATVs	UCD Survey (2016)	DMV Registration
Snowmobiles	Areas above 5000 ft (winter)	DMV Registration
Golf Carts & Specialty Vehicles	DMV Registration	DMV Registration

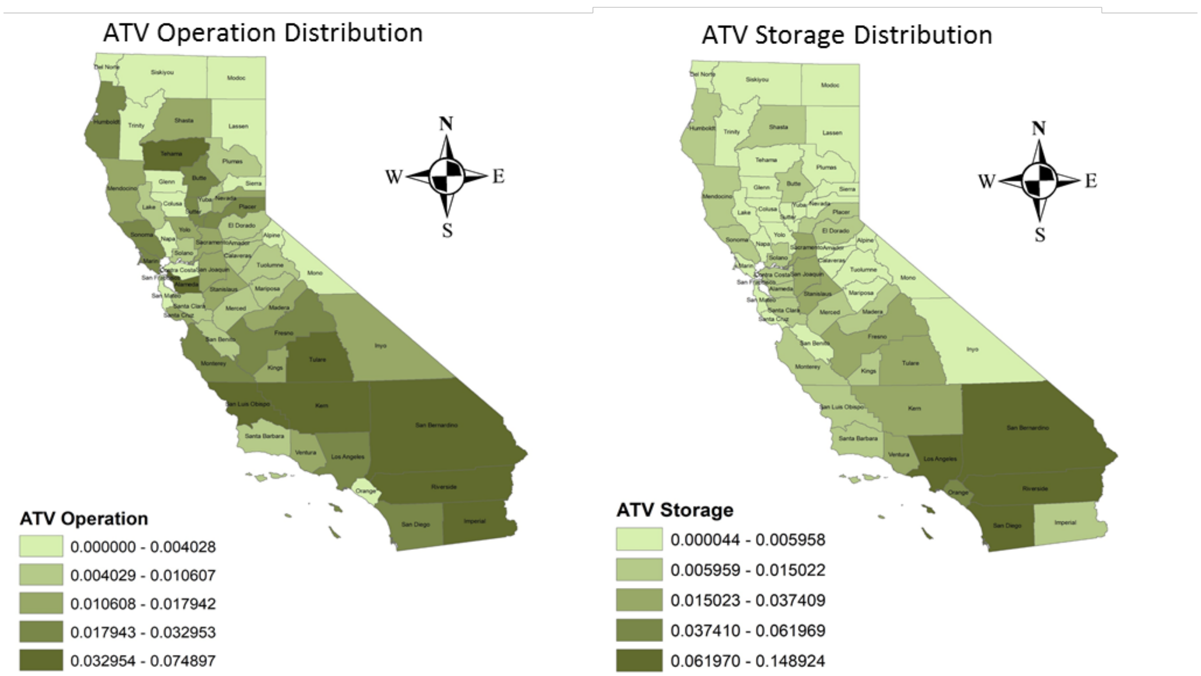

Figure 14: Updated Spatial Allocation for ATVs

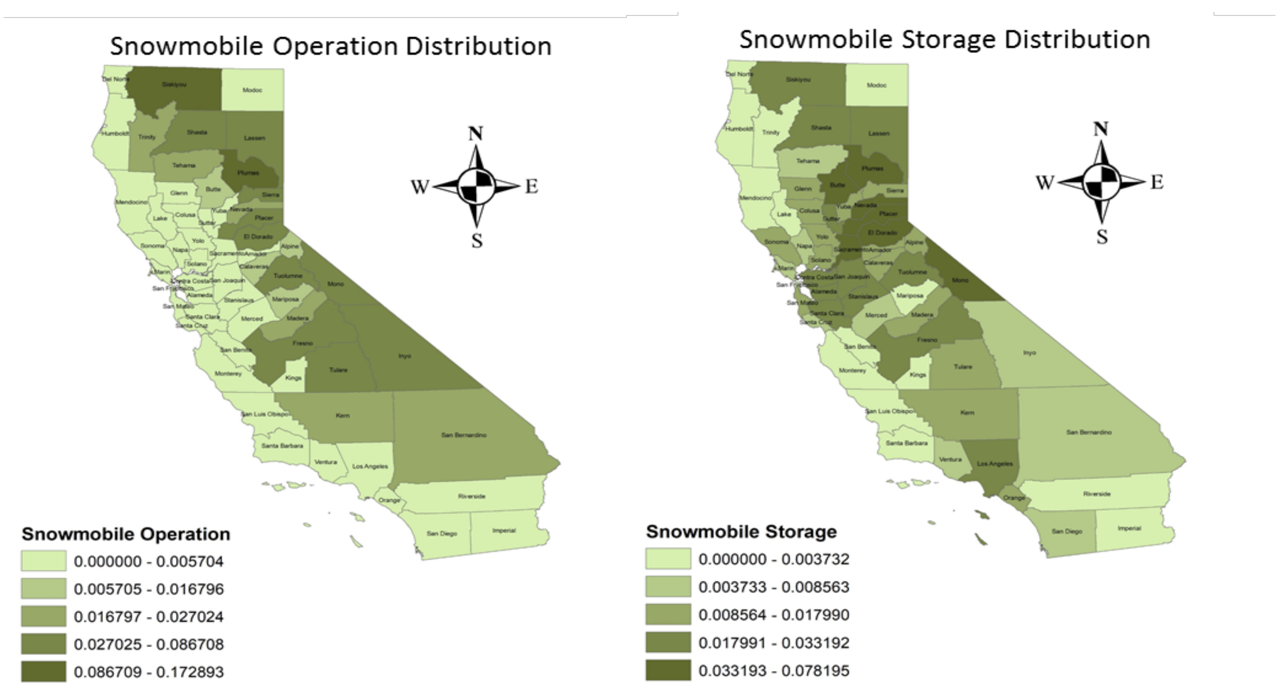

Figure 15: Updated Spatial Allocation for Snowmobiles

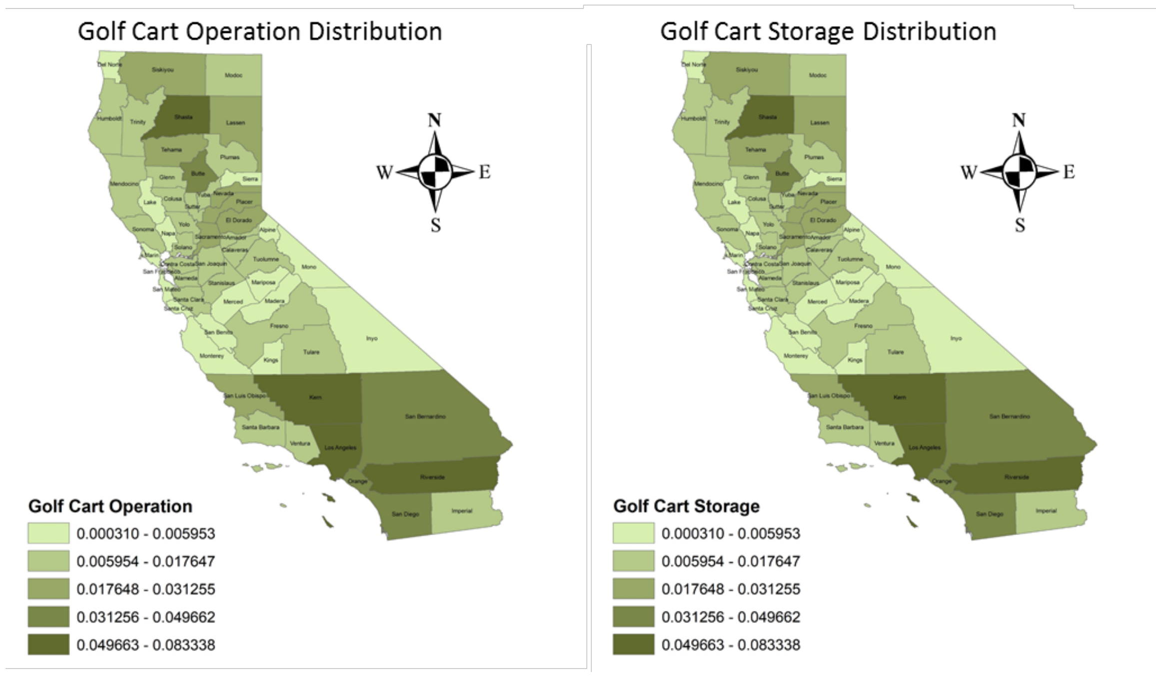

Figure 16: Updated Spatial Allocation for Golf Carts & Specialty Vehicles

6. RV2018 Emissions Model

The RV2018 emissions inventory model uses a Visual C++ platform to perform all calculations. Population, activity, emission factors, correction factors, and spatial allocation are some of the various inputs utilized by the model estimate tons per day emissions from OHRVs.

6.1. Modeling Process for RV2018

The RV2013 model initially contained five vehicle categories; however, RV2018 only includes four vehicle categories because mini-bikes were incorporated within the OHMC category. The current population input table includes four categories: OHMC, ATV, snowmobile and golf cart and specialty vehicle. Each category includes active or inactive status, calendar year, model year, horsepower group, and technology type. The technology type is subcategorized into 2-stroke-gasoline-carbureted (G2-CARBU), 2- stroke-gasoline-fuel injected (G2-FI), 4-stroke-gasoline-carbureted (G4-CARBU) and 4- stroke-gasoline-fuel injected (G4-FI). The activity input table provides the annual activity with respect to age, while the emission factor input tables include exhaust and evaporative emission factors grouped by calendar year group or technology type.

The top-down calculation process starts with multiplying the population input tables with activity table and emission factor tables, resulting in the statewide uncorrected emissions. The statewide uncorrected emissions are then allocated to the local GAI and adjusted with different correction factors to reflect the local conditions (e.g., Temperature/RVP, garage temperature effect, ambient temperature and humidity correction, etc.).

The model output provides emissions in tons per day, at the statewide, air district, and air basin levels, as well as by season and calendar year. End users may also specify the vehicle type, vehicle status (active or inactive), technology type, and horsepower prior to obtaining the emissions summary. In addition, the RV2018 model is capable of providing outputs by model year for a given calendar year.

6.2. Model Installation and User's Guide

The RV2018 model is available for download from the ARB website as follows: https://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles

The source code for RV2018 is available for download at: https://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles_RV2018_sourcecode.htm. Details on the model installation and user guide are included in Appendix C.

7. Appendix A: OHMC Activity Update Analysis

The activity for OHMCs was updated in the RV2018 model using data obtained from the 2016 online survey conducted by the University of California, Davis[1] and incorporated responses from both Round 1 (R1) and a supplemental survey (R2). Of the original 2300 R1 respondents, 310 answered the R2 supplemental survey. The methodology to estimate the updated activity for OHMCs included the following assessments:

- Quality Control – To determine if the responses received were reasonable
- Statistical Analyses – To develop the criteria to determine how or if the R1 survey should be adjusted
- Scaling Factor – To develop a scaling factor, applied to R1 results to more accurately represent real-world OHMC annual activity, based on supplemental R2 survey responses from the same respondent
- Zero Activity Users – To include a percentage of the population of OHMCs with zero annual activity

7.1. Quality Control & Statistical Analyses

The data from R1 and R2 was evaluated for quality control purposes and outliers or questionable responses were flagged for exclusion. Figure 17 below shows the days/year responses from the supplemental survey (R2).

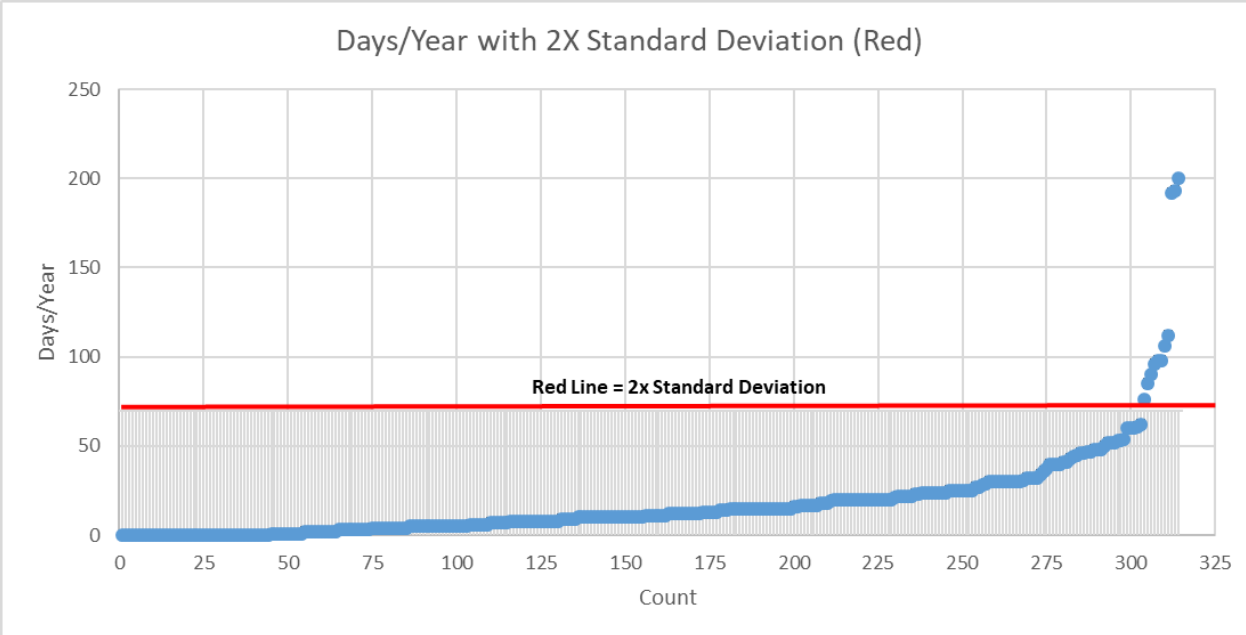

Figure 17: Standard Deviation of R2 Responses in Days/Year

The 2x standard deviation shows that R2 data above 70 days/year (6 days/month) were outliers. Staff believes that 6 days/month for R2 was a reasonable estimate for the maximum days/month usage because that equates to roughly 3 weekends of use per month. The corresponding R1 data was similarly assessed and the data points above 170 days/year (14 days/month) were identified as outliers. After the removal of the outliers for R1 and R2, the corresponding dataset consisted of 297 data points. An additional assessment compared the responses from the same person for R1 and R2 and concluded that approximately 90% of the supplemental survey (R2) responses were lower than the initial R1 response. Of the 10% that responded with R2 higher than R1, the 2x standard deviation was applied and 4 data points which were 150% or greater than the initial R1 responses were identified as outliers and removed. Therefore, the final corresponding R2/R1 data set included 293 data points.

7.2. Scaling Factor

A scaling factor was developed using the corresponding R2/R1 data set as detailed above and applied to the R1 responses. The R2 data, in days per year, was plotted versus age to establish the trend line. A similar technique was applied to R1 data to identify the trend line. The scaling factor was developed by dividing R2 trend line by R1 trend line. The scatter plots and trend lines are shown below in Figure 18 and 19. The scaling factors, varying by age, are shown in Table 20.

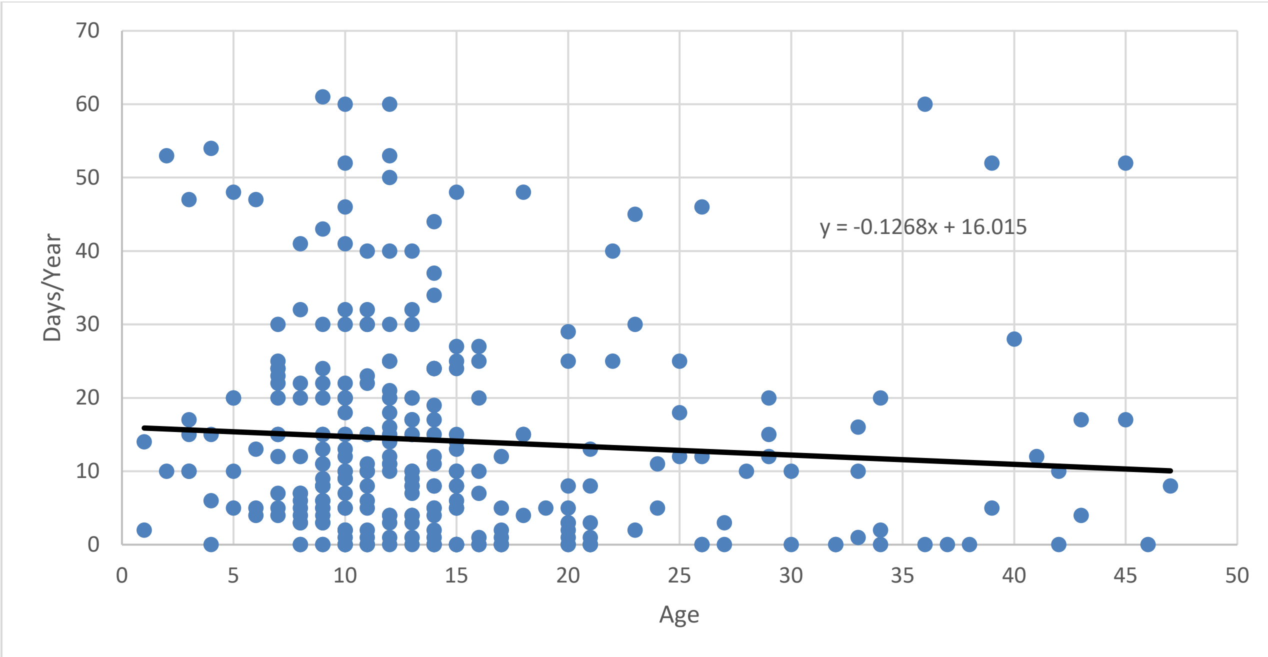

Figure 18: Trend Line for R2 Responses (Days/Yr)

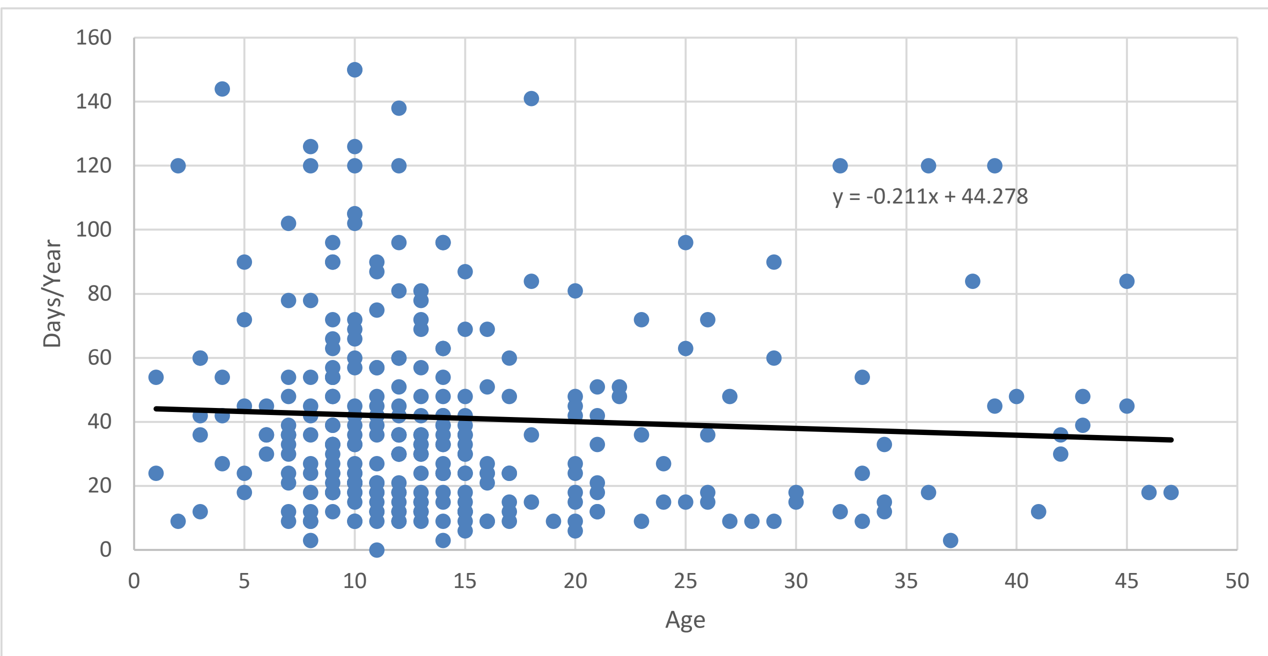

Figure 19: Trend Line for R1 Responses (Days/Yr)

Table 20: Scaling Factor by Age

Age	Scaling Factor
0	0.36
5	0.36
10	0.35
15	0.34
20	0.34
25	0.33
30	0.32
35	0.31
40	0.31

7.3. Zero Activity Users

Based on the 2009 Cal State Sacramento (CSUS) survey, 10% of the actively registered users did not use the equipment during the year even though the equipment was registered. Since the 2016 UCD survey resulted in only 2% with zero activity, this particular population may have been under-represented due to the nature and structure of the survey. The 2009 CSUS survey was conducted via telephone calls to registered OHRV owners, while the 2016 UCD survey was an online survey with postcard invitations mailed to registered OHMC owners. Riders with zero activity are unlikely to participate in an online survey about OHMC riding, so staff concluded that the 2% zero activity rate in the UCD survey is likely too low. For a more accurate representation, the 10% zero activity was applied to the R1 responses weighted by age, thus aligning with the trend that older equipment is used less and have a higher rate of zero activity. The trend line of zero activity users from the 2009 CSUS survey is shown below in Figure 20.

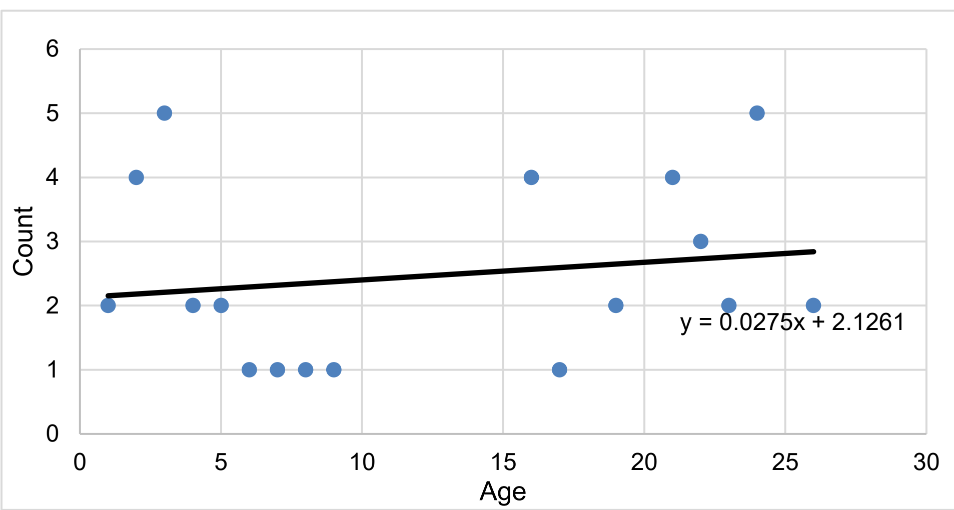

Figure 20: Trend Line of Zero Activity Users (2009 CSUS Survey)

7.4. Updated OHMC Activity

Table 21 below shows the updated activity based on the adjusted R1 data, including removal of outliers, application of the scaling factor and addition of zero activity users, as included in the RV2018 model.

Table 21: OHMC Activity by Age (mi/yr)

Age	Annual Activity (mi/yr)
0	774
1	761
2	748
3	735
4	722
5	709
6	696
7	683
8	670
9	657
10	644
11	631
12	618
13	605
14	592
15	580
16	567
17	554
18	541
19	528
20	515
21	502
22	489
23	476
24	463
25	450
26	437
27	424
28	411
29	398
30	385
31	372
32	359
33	346
34	333
35	321
36	308
37	295
38	282
39	269
40	256

7.5. OHMC Activity Validations

As compared to the activity in the 2009 CSUS survey, the updated activity in RV2018 is slighter higher, as shown below in Table 22 and Figure 21. This increase is accounted for by the larger sample size and the different survey structure, which included a high percentage of active users. The 2016 online survey had a targeted number of population of green/red stickers and historic vehicles, whereas the 2009 phone survey was completed once a certain total sample size was reached.

Table 22: OHMC Activity from 2009 & 2016 Surveys

Activity	2016 Survey	2009 Survey
Days/Year Age 0	18	21
Days/Year Age 10	16	15
Days/Year Age 20	13	9
Days/Year Age 40	9	1
Miles/Year Age 0	773	717
Miles/Year Age 10	645	528
Miles/Year Age 20	517	339
Miles/Year Age 40	261	25

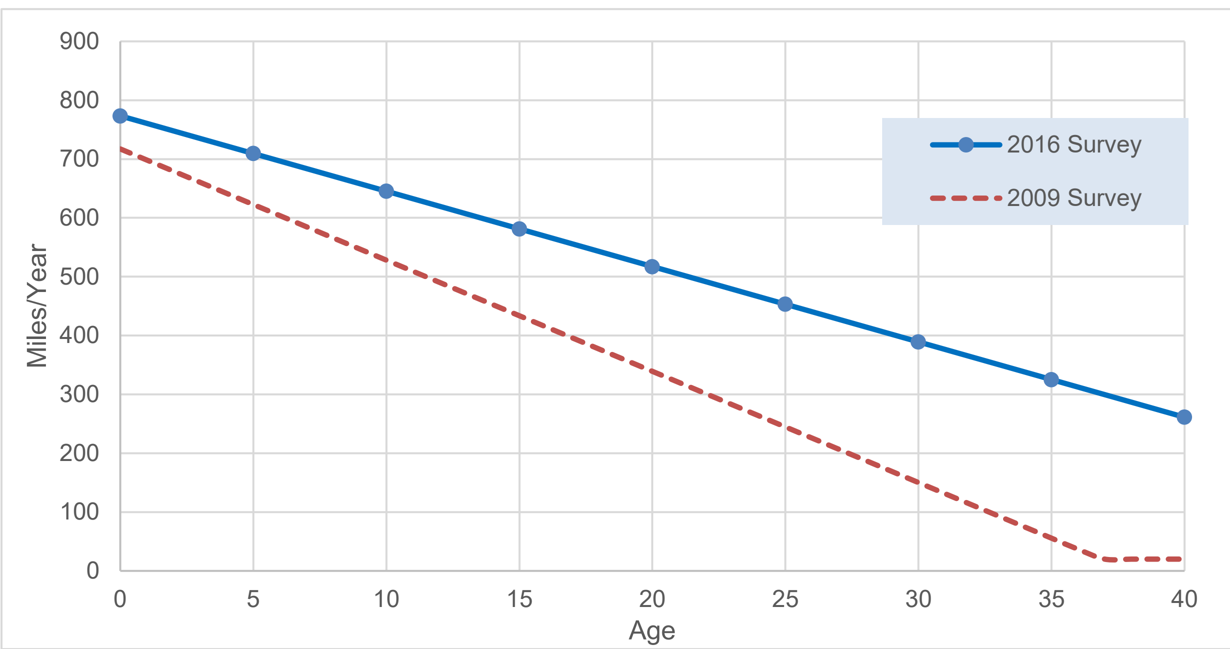

Figure 21: OHMC Activity Comparison (2009 vs 2016)

8. Appendix B: Carbureted Weathering and Fuel Line Correction Factor (Active)

The weathering correction factor for active carburetor vehicles were derived using test data from (5) test sample. Multiple-day diurnal day testing was done in a SHED at CARB. Table 23 lists the emission results from the multiple-diurnal day testing, in which the trend line was utilized to project to 26 days. The significance of 26 days is that it is equal to the average duration between uses for OHMC vehicle. The weathering correction factor is derived by dividing the average of the 26 day diurnal value by the first day diurnal.

Table 23: Multiple-Day Diurnal Testing Results

Test Sample	Test	Shutoff Valve	Evaporative Emission Controls	Day	Diurnal (g/day)	Day	Trendline Approximation Diurnal (g/day)	Average (26 days)	Correction Factor
1	**2007 Honda CFR450X7**	Fuel Line is Closed	No	1	10.6	1	10.66	4.83	0.45
				5	6.2	2	8.33		
				7	5.2	3	7.21		
						4	6.51		
						5	6.20		
						6	5.63		
						7	5.20		
						8	5.08		
						9	4.87		
						10	4.69		
						11	4.54		
						12	4.40		
						13	4.28		
						14	4.16		
						15	4.06		
						16	3.97		
						17	3.89		
						18	3.81		
						19	3.74		
						20	3.67		
						21	3.61		
						22	3.55		
						23	3.49		
						24	3.44		
						25	3.39		
						26	3.34		

Test Sample	Test	Shutoff Valve	Evaporative Emission Controls	Day	Diurnal (g/day)	Day	Trendline Approximation Diurnal (g/day)	Average (26 days)	Correction Factor
2	**2007 Honda CFR450X7**	Fuel Line is Closed	No	1	10.32	1	10.32	5.43	0.53
				2	8.71	2	8.71		
				3	7.99	3	7.99		
				4	7.44	4	7.44		
				5	6.22	5	6.22		
				6	6.43	6	6.43		
				7	6.07	7	6.07		
				8	5.63	8	5.63		
				9	5.44	9	5.44		
				10	5.14	10	5.14		
				11	4.98	11	4.98		
				12	5.17	12	5.17		
				13	4.79	13	4.79		
				14	4.92	14	4.92		
				15	4.67	15	4.67		
				16	4.68	16	4.68		
				17	4.65	17	4.65		
				18	4.41	18	4.41		
				19	4.46	19	4.46		
				20	4.25	20	4.25		
						21	4.26		
						22	4.20		
						23	4.15		
						24	4.10		
						25	4.05		
						26	4.00		
3	**2007 Honda CFR450X7**	Fuel Line is Open	No		15.73	1	14.09	7.81	0.55
					12.03	2	11.77		
					10.61	3	10.28		
						4	9.20		
						5	8.65		
						6	8.16		
						7	7.91		
						8	7.71		
						9	7.47		

Test Sample	Test	Shutoff Valve	Evaporative Emission Controls	Day	Diurnal (g/day)	Day	Trendline Approximation Diurnal (g/day)	Average (26 days)	Correction Factor
						10	7.35		
						11	7.25		
						12	7.17		
						13	7.10		
						14	7.04		
						15	6.99		
						16	6.95		
						17	6.91		
						18	6.87		
						19	6.84		
						20	6.82		
						21	6.79		
						22	6.77		
						23	6.75		
						24	6.73		
						25	6.72		
						26	6.70		
4	**2007 Honda CFR450X7**	Fuel Line is Closed	No		10.81	1	11.26	5.60	0.50
					11.53	2	8.58		
					8.85	3	7.39		
						4	6.87		
						5	6.58		
						6	6.30		
						7	6.14		
						8	5.83		
						9	5.65		
						10	5.49		
						11	5.36		
						12	5.24		
						13	5.13		
						14	5.03		
						15	4.94		
						16	4.85		
						17	4.78		
						18	4.71		
						19	4.64		

Test Sample	Test	Shutoff Valve	Evaporative Emission Controls	Day	Diurnal (g/day)	Day	Trendline Approximation Diurnal (g/day)	Average (26 days)	Correction Factor
						20	4.58		
						21	4.52		
						22	4.46		
						23	4.41		
						24	4.36		
						25	4.32		
						26	4.27		
5	**2014 Suzuki DRZ400S**	Fuel Line is Open	Yes	1	0.93	1	0.93	0.70	0.75
				2	0.95	2	0.95		
				3	0.94	3	0.94		
				14	0.62	4	0.81		
						5	0.78		
						6	0.75		
						7	0.74		
						8	0.72		
						9	0.71		
						10	0.69		
						11	0.68		
						12	0.67		
						13	0.66		
						14	0.66		
						15	0.65		
						16	0.64		
						17	0.63		
						18	0.63		
						19	0.62		
						20	0.62		
						21	0.61		
						22	0.61		
						23	0.60		
						24	0.60		
						25	0.59		
						26	0.59		

Carbureted OHMCs include a fuel shutoff valve, which can be either turned on or off, to restrict the flow of fuel to the carburetor. As shown in Table 24, the weathering correction factor with the valve on is 0.55 and the factor is 0.49 for the valve off for uncontrolled vehicle. The reason there is smaller diurnal emission, when the valve is closed, is because it is assumed that no fuel is refilled in the carburetor.

Table 24: Active Storage Correction Factor

Condition	Active Storage Correction Factor	
	Uncontrolled (Vehicle with no carbon canister)	Controlled (with carbon canister)
Fuel line is closed	0.49	0.67
Fuel line is open	0.55	0.75

Figure 22 shows the magnitude difference in uncontrolled carbureted OHMC with either the fuel valve is open or closed.

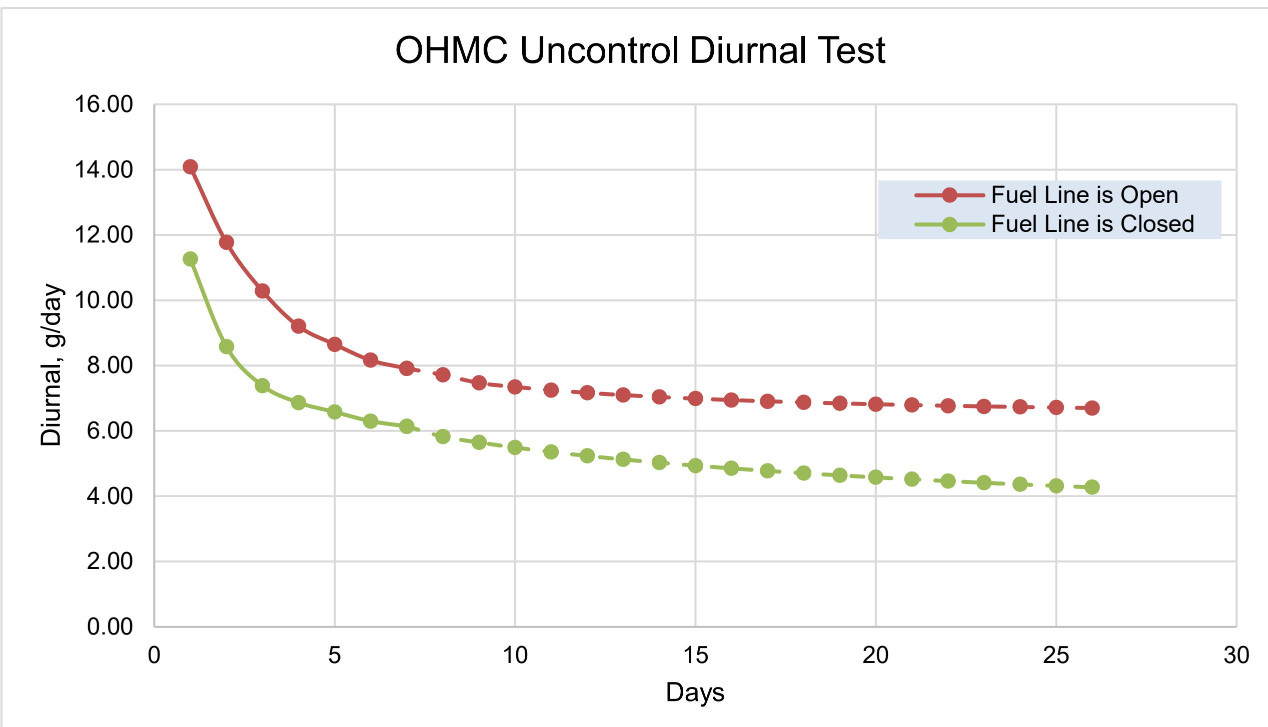

Figure 22: OHMC Uncontrolled Diurnal Test (Valve Open vs Closed)

The carbureted vehicle fuel line correction factor is the composite of when fuel line is open and when it is closed. The baseline evaporative emission factors are based on testing done with fuel line is closed. Therefore, the fuel line correction for the base case of fuel line closed is 1.0. Table 25 shows the composite fuel line correction factor.

Table 25: Fuel Line Correction Factor

Condition	Fuel Line Correction Factor	Composite Fuel Line Correction Factor
Fuel line is closed	1	1.15
Fuel line is open	1.3	

9. Appendix C: Installation and User's Guide

9.1. Installation Instructions and Computer Specifications

- Zip - Use any zipping utility to unzip the file. Most operating systems like Windows come with a utility like 'WinZip'. Others can be downloaded off the internet along with their user guides.

- Computer Requirements: Your computer needs to have sufficient memory to store and run the model (these requirements are fairly small). Unzipped the file will be about 1.2GB. When running the model it can grow up to 2.0GB. Model runtimes can vary depending on the processing power of the computer, estimates are provided in the user interface.

- Microsoft Access: The Recreation Vehicle Emissions Inventory model runs as an Access database file. The model was developed in Microsoft Access 2010 previous versions of Access may not support all the model functionality.

- Download Warnings: When the database is first loaded onto the computer, Access will warn the user of possible unsafe code in the program. It is important to allow the program to open without any restrictions. This means selecting options when Access opens that ENABLE the program content (if prompted with a warning such as 'Do you want to allow Access to open with these unsafe expressions' CLICK YES, OPEN, or ENABLE).

- Microsoft Access allows a user to define security restrictions that will apply to every file on a user's computer. If security restrictions have been set too restrictively, Access will not allow the Emissions Inventory model to open or run properly. The user might need to change the settings in the 'trust center', information about having the proper settings for Microsoft Access are available on Microsoft's website (one common setting is having the macro setting that does not inform the user when content has been blocked, in this case the question above will not come up).

*Note: Allow a few minutes for the model to compact itself when closing MS Access. If the model becomes unstable or errors/warnings occur, first close the form, then close MS Access and reopen it. If the problem still persists, the model may be corrupted and a new version should be downloaded from the ARB website.

9.2. Model Functionality

9.2.1. User Interface

When the RV2018 model is first open, the user interface appears as shown below in Figure 23. The user can choose between 'Baseline Runs' or 'Scenario Runs'. In addition, there is a 'Run Instructions' button that contains useful information if needed.

Figure 23: RV2018 User Interface

9.2.2. Selecting Model Parameters

Shown below, in Figure 24, is the screen that appears that allows the user to select the various parameters for the model run. This results in the estimation of Recreational Vehicle emissions for any combination of equipment type, fuel type, status, horsepower, model year, calendar year, season, and/or region for baseline or rule emissions.

*Note: By choosing to 'output by model year', the runtime will dramatically increase and only one region may be selected at a time. Specific equipment types and fuel types must be selected with the by model year output request.

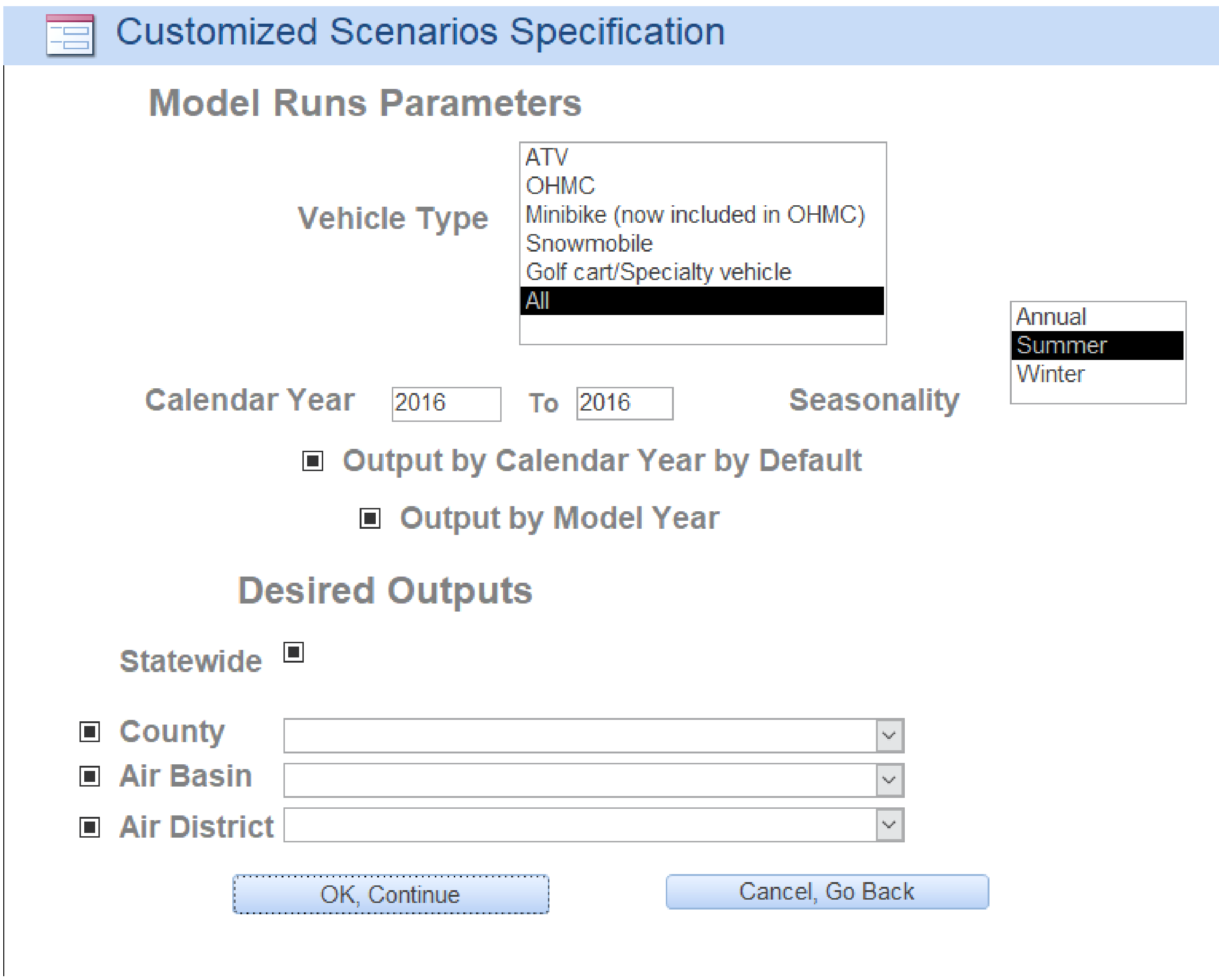

Figure 24: Selecting Model Parameters in RV2018