2018 Pedro Bay Emissions Inventory Report: Criteria Air Pollutants and Greenhouse Gases

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Figure 1: Photo of Pedro Bay and Lake Iliamna, October 2018

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ACRONYMS AND TERMINOLOGY

ADEC	Alaska Department of Environmental Conservation, Division of Air Quality
ADFG	Alaska Department of Fish and Game
AE	Angry Eagle Lodge
ANCSA	Alaska Native Claims Settlement Act of 1971
ANILCA	Alaska National Interest Lands Conservation Act of 1980
AP-42	EPA's standardized list of Criteria Air Pollutant emission factors
ATV	All-Terrain Vehicle
BBNC	Bristol Bay Native Corporation
CAA	Clean Air Act of 1970
CAP	Criteria Air Pollutant
CARB	California Air Resources Board
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalents
CO	Carbon Monoxide
EC	Environmental Coordinator
EPA	Environmental Protection Agency (Federal)
EF	Emissions Factors
EP	Eagle's Peak Lodge
IGAP	Indian General Assistance Program, managed via the Bureau of Indian Affairs
GHG	Greenhouse Gases
HFC	Hydrofluorocarbons
HCs	Hydrocarbons
Lbs	Pounds
LTO	Landing Take-Off Cycle
MMBTU	One Million British Thermal Units (energy measurement)
MT	Metric Tons
NEI	National Emissions Inventory
N_2O	Nitrogen Dioxide
NOX	Nitrous Oxide
PAH	Polyaromatic Hydrocarbons
Pb	Lead
PDB	Pedro Bay
PBC	Pedro Bay Corporation (ANCSA Village Corporation)
PBVC	Pedro Bay Village Council
PFC	Perfluorocarbons
$PM_{2.5}$	Particulate Matter at 2.5 microns/nanometers
PM_{10}	Particulate Matter at 10 microns/nanometers
RH	Regional Haze/Regional Haze Rule, part of the 1990 Clean Air Act Amendment
SF_6	Sulfur Hexafluoride
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
SUV	Sport Utility Vehicle
SWAMC	Southwest Alaska Municipal Conference
VOC	Volatile Organic Compounds
WHO	World Health Organization

1. SUMMARY

This report provides a detailed description and results of an emissions inventory carried out by the Alaska Department of Environmental Conservation, Division of Air Quality (ADEC), at the request of, and in collaboration with, the Pedro Bay Village Council (PBVC). It summarizes the methodology, results, and implications of the inventory results. The inventory is divided into two categories of emissions: Greenhouse Gases (GHGs) and Criteria Air Pollutants (CAPs). Results are also divided into emissions source categories including Residential Homes, Tribal/Government Operations, and Commercial/Institutional sources. Those sources under the broad heading of "Commercial/Institutional" are private entities that provide goods and services to the village. In Pedro Bay, these operations are limited to three destination sport fishing lodges and transportation related commercial operations. This report ends with a discussion of possible future scenarios which could change the emissions footprint of the community in coming years.

2. INTRODUCTION

In 2018, PBVC committed in their Indian Environmental General Assistance Program (IGAP) Plan to develop a GHG and CAP inventory. The inventories would be used by the community to support decisions made by the tribal council, and collectively in community forums, in the development of a Climate Action Plan for Pedro Bay. PBVC contacted the Alaska Department of Environmental Conservation (ADEC), Division of Air Quality for assistance in the development of these inventories and the Climate Action Plan. ADEC has already assisted several other rural Alaskan communities in the development of emissions inventories. Among these was the community of Igiugig, a neighboring community along Lake Iliamna that shares many of the same infrastructure and supply challenges as Pedro Bay.

In addition to assisting PBVC in their IGAP commitments, ADEC would also use data collected for the inventory to supplement available data for its 2017 Triennial National Emissions Inventory (NEI). Part of the triennial inventory involves the collection of data from rural communities to compile and submit for analysis by the Environmental Protection Agency (EPA).

This report summarizes both the CAP and GHG inventories and outlines how ADEC and Pedro Bay Environmental Staff undertook data gathering, compilation, analysis, and emissions calculation tool use. The data presented in this report are estimated from survey results provided by Pedro Bay residents along with non-residential data collected during the spring and summer of 2018. ADEC conducted two follow-up trips to the area in the fall of 2018 and late spring of 2019, where additional data was collected. The inventories include residential, government and commercial operations based on fuel consumption, mileage rates and emissions source figures. The survey information resulted in an accurate portrait of yearly emissions from the community and surrounding area.

Emissions inventories such as this one provides useful information to state and local planning agencies. For local agencies, such as PBVC, these inventories can assist in long-term policy planning or more immediate community decision-making. For state agencies, these inventories assist in understanding rural Alaska communities more specialized needs, especially those off the state road system and which are dependent on air and marine cargo shipments.

In addition, information gathered for this survey will be used in in the Regional Haze State Implementation Plan (SIP) process for understanding small communities in rural Alaska. This survey will also be used to analyze other emissions inventories carried out in previous years and comprehend where gaps in reporting might have occurred. This will allow ADEC to conduct more representative inventories in future years.

3. PEDRO BAY COMMUNITY DESCRIPTION

Pedro Bay is located at the eastern end of Lake Iliamna, 30 miles southeast of the town of Iliamna and 180 miles southwest of Anchorage in the Lake and Peninsula Borough. Pedro Bay is accessible by air and water. There is a state-owned 3,000 foot long by 60 foot wide gravel airstrip.[1] Scheduled and charter air services are available from Iliamna, Port Alsworth, and Anchorage. Barge service is available from Naknek via the Kvichak River, and from Pile Bay via an unpaved portage road from Cook Inlet ten miles to the east.

The Pedro Bay Corporation (PBC) is the village corporation for Pedro Bay, Alaska, located on the eastern shores of Iliamna Lake, in the Bristol Bay region. PBC was formed in 1973 under the Alaska Native Claims Settlement Act (ANCSA) of 1971.[2] PBC is responsible for the oversight of 92,100 acres of surface land, allotted under ANCSA.[3] The PBC is a constituent member of the Bristol Bay Native Corporation, the regional corporation formed under ANCSA. According to the United States Census Bureau, Pedro Bay village has a total area of 19.0 square miles (49 km^2), of which, 17.3 square miles (45 km^2) of it is land and 1.6 square miles (4.1 km^2) of it (8.65%) is water.[4] PBVC serves as the elected representative body and local government for residents. It is also the largest employer in the area, with many full-time residents working for the PBVC year-round.

The population of Pedro Bay is approximately 42 year round residents.[5] In the summer, the population doubles as a result of seasonal residents returning to the area to participate in the subsistence economy.[6] There are also several seasonal employees of the three lodges which operate during the summer months (May-September). They are counted in the commercial/industrial emissions inventory for the lodge and are not counted as seasonal residents for the purposes of population estimation.

The Lake and Peninsula Borough Comprehensive Plan identifies critical village operations which include the following functions and community services:

- Electrical generation
- Waste management (incineration and landfill)
- Community center
- Tribal office
- Boat storage
- Small boat harbor and barge landing
- Post office

[1] For more technical information on the Pedro Bay Airport, see the following website: https://www.airnav.com/airport/4K0 (Accessed 5/14/2020).
[2] "Our Corporation," *Pedro Bay Corporation*, available at: https://www.pedrobaycorp.com/about-1 (Accessed 5/14/2020).
[3] "Our Land," *Pedro bay Corporation*, available at: https://www.pedrobaycorp.com/projects (Accessed 5/14/2020).
[4] "Pedro Bay, Alaska," *Wikipedia: The Free Encyclopedia*, available at: https://en.wikipedia.org/wiki/Pedro_Bay,_Alaska (Accessed 5/14/2020).
[5] Ibid.
[6] Information gathered from Pedro Bay Environmental Staff.

- Fire department and EMS
- School (closed in 2010)
- Electrical generation
- Landfill (class III unpermitted) and associated burn unit for waste incineration
- Water and sewer operations[7]

Other community operations include a bulk generator fuel facility with two 10,000 gallon diesel tanks. One tank runs a generator owned by the Village Council, and the other fuels an electrical generator (currently not operating) owned by the Lake and Peninsula Borough School District. The tank farm is a fueling station that contains three 12,000 gallon diesel tanks and one 8,000 gallon gasoline tank. In 2008 Pedro Bay added insulation to community buildings to reserve heating costs. The community has been in the planning process to construct a small hydroelectric power station that will replace the current diesel generator for power production during most of the year. The diesel electrical generators will be maintained for redundancy and low-water periods during winter when the river freezes and hydro power is not sufficient for community needs.

3.1. COMMUNITY ECONOMIC AND SUBSISTENCE ACTIVITIES

According to federal census records, Pedro Bay's population has fluctuated between 40 and 60 residents since 1950. Unlike other parts of Alaska along the state's coastline and in the interior, the region that Pedro Bay inhabits (Lake Iliamna Watershed) is comparatively stable in terms of its natural environment.[8] As the community is inland from Cook Inlet, it does not participate in the Cook Inlet fisheries beyond individual subsistence activities in the Williamsport area, at the end of the portage road from Pile Bay.[9]

The value of the salmon harvest in Bristol Bay, the Kvichak River, and Lake Iliamna is valued in the hundreds of millions of dollars ($281 million in 2018) and is a source of economic vitality for local communities.[10] The 2018 salmon catch was estimated by the Alaska Department of Fish and Game (ADFG) at 242% above the 20-year average. According to a National Ocean and

[7] For more information, see the Lake and Peninsula Borough Comprehensive Plan, available at: http://www.lakeandpen.com/departments/community_development_coordinator/information/comprehensive_plan (Accessed 5/14/2020).

[8] Unlike environmentally sensitive areas of the North Slope and northwest Alaska, Pedro Bay is not located in an area with large amounts of permafrost which are undergoing rapid thawing as the statewide environment warms. The area of the Lake and Peninsula Borough that Pedro Bay is located in is best described as a forested environment most similar to northern inland British Columbia. For long-term environmental planning purposes, besides the ongoing changes in forest ecology due to warming temperatures and the growth of yearly spruce bark beetle infestation rates, the regional environment is quite stable and will likely become more hospitable in the years to come. Local residents reported increasingly mild winters and longer stretches of favorable warm weather during the summer.

[9] Please note that the portage road between Pile Bay and Williamsport is only accessible following the spring thaw in May through late September when snowfall makes the pass inaccessible. Should they choose, locals can access Williamsport via the portage road when it is open and take advantage of the local subsistence resources located in the region.

[10] For economic figures on the value of the salmon run in Bristol Bay, see the Alaska Department of Fish and Game report entitled, "2018 Bristol Bay Salmon Season Summary." Available at: http://www.adfg.alaska.gov/static/applications/dcfnewsrelease/989536277.pdf (Accessed 4/9/2019).

Atmospheric Administration (NOAA) study on the neighboring community of Igiugig, the commercial value of their salmon landings reported in 2001 (152,055 lbs.) was worth $64,008.[11]

Most residents of Pedro Bay and the larger Lake Iliamna Watershed participate in subsistence activities and the larger statewide subsistence economy during summer months. This is thanks to the abundant fish runs, including salmon, during the summer. Many homes in Pedro Bay are only inhabited during the late spring through late summer months (May-September), reflecting the importance of subsistence activities during this period. For many seasonal households, these activities include catching and smoking salmon and other marine species, as well as trapping and hunting activities that can add to the relative value of yearly household subsistence catches on Lake Iliamna. Subsistence activities also includes gathering berries and plants for preservation and consumption.

[11] "Igiugig," *NOAA-TM-AFSC-259, Vol. 8: Community Profiles for North Pacific Fisheries – Alaska: Igiugig*, National Oceanic and Atmospheric Administration, p. 13. Available at: https://www.afsc.noaa.gov/REFM/Socioeconomics/Projects/communityprofiles/Igiugig_Profile_2000_2010.pdf (Accessed 4/9/2019).

4. EMISSIONS INVENTORY METHODOLOGY

This emissions inventory was carried out in three stages: Source identification and the associated development of residential and non-residential surveys; working with PBVC staff in collecting information needed in the surveys; and finally, calculating emissions from the information provided in the surveys. Source lists and survey forms are included in Appendix C and D of this report.

Emissions sources were identified by examining commercial, government, and residential activities. The source lists were developed by ADEC and reviewed by the Pedro Bay Environmental Coordinator. Once complete, information from the source lists was used to develop survey form fields for data collection. Each community is unique; this process reduces duplicity in information gathering and is essential for ensuring the surveys collect the information required for a representative and accurate inventory.

ADEC personnel calculated emissions for CAPs and GHGs using two different methods. For CAPs, ADEC personnel built a calculation spreadsheet from scratch using emissions factors from previous emissions inventories, as well as from current factors put out by the California Air Resources Board (CARB). The process of emissions factor selection is explained further in this report.

To calculate GHGs, ADEC personnel used the EPA Tribal GHG Toolkit which was developed for small rural and tribal communities to calculate their GHG emissions footprint. This is the first time that this toolkit has been field-tested in Alaska. In testing this tool, ADEC identified several shortcomings and modifications that need to be made in order for this to be useful ‘out of the box’ for Alaska communities. These shortcomings, along with a longer description of the toolkit, will be explained further in this report.

4.1. DATA COLLECITON

4.1.1. Residential

For the community’s residential sources, ADEC and the Pedro Bay Environmental Coordinator (EC) collected surveys from eleven year-round households and two seasonal households. The survey covered a host of residential activities that could generate emissions. These included home heating, handheld motorized tools, personal vehicles, aircraft, marine craft, and other personal use activities that could generate measurable emissions. Unlike previous emissions surveys ADEC included subsistence activities, (i.e. Smoking of fish and game, and cultural activities, Wood-fired steam-baths, campfires, etc.) which generate emissions. Previous emissions inventories did not include these activities. This limited the scope of emissions to household support emissions only. During the summer, rural residences engage in subsistence activities which increase household emissions through harvesting and food preparation. Several households utilize culturally-specific steam-baths year-round. The inclusion of these activities reflects the seasonal cycles in the community and the central role these economic activities play in community life and seasonal behaviors.

The motorized equipment covered in these surveys included leaf-blowers, weed/brush trimmers, and propane-fired household dryers. It also included personal aircraft operations, as well as personal watercraft (boats, jet skis, etc.) as measured in hours of operations and fuel consumed.

4.1.2. Typical Emissions Footprint: Residential Households

Most households had at least one All-Terrain Vehicles (ATVs) which served as their primary form of transportation. Many households have one larger vehicle, usually a light truck or Sport Utility Vehicle (SUV) which they use occasionally for activities such as hauling wood or equipment to and from homes. This contrasts with communities like Anchorage and Fairbanks where vehicles such as these are used primarily for single-family or personal transportation. In addition, most year-round homes had a snowmobile (snowmachine in Alaska parlance) for use during the winter months (late October/early November-March/April).

Every residence in the community except for two have some sort of marine vehicle that they use to access Lake Iliamna and the subsistence fishing grounds. This detail is important as these emissions can be categorized as both household emissions as well as subsistence/economic activity emissions during the spring and summer months. Reported hours of use vary; ranging from seven hours per household per year on the low end to 120 hours or more on the high end.

In addition to the above vehicles, there were also stationary home emissions that needed to be accurately counted. All residents of Pedro Bay, except for those who reside in the community library building apartments, use a woodstove to heat their homes. These woodstoves are all new (within the last fifteen years) and built to EPA efficiency standards for wood smoke emissions. The Pedro Bay Environmental Coordinator verified to ADEC staff that woodstoves were changed out over the past 15 years as part of a local voluntary woodstove change-out program. This occurred after a local resident purchased a new woodstove and was observed using less wood than the older stoves. In the years since, all homes (except one) have changed out their woodstoves in favor of EPA-certified catalytic woodstoves.

Many homes in the area have either a smokehouse (for curing and preparation of subsistence catches), or a sauna (for bathing/relaxation) which is used regularly. These smokehouses and saunas are wood-fired. Both smokehouses and saunas have been in use in the community for many years and are part of local indigenous cultural practices. A small number of homes have both a sauna and a smokehouse.

In addition to these, about a third of all residential households reported using an outdoor camp and cooking-fire during the spring and summer months. Half of all surveyed households reported the use of a chainsaw and over a third reported using a brush or weed trimmer. Lastly, a third of households operated a log splitter.

According to the Pedro Bay Environmental Coordinator, all homes in the community run a water pump and utilize well water for their household consumption. These are electric pumps which receive power from the community electrical grid. Households in the community use septic systems and haul their waste to the community landfill which has a capped sewage lagoon. In addition, many households practice some limited form of backyard refuse burning; either trash, yard debris, or brush burning during the months which permit these activities. Refuse burning was reported as burn barrel operation and residents provided an estimate of pounds burned per year.

4.1.3. Data Collection - Tribal/Government Operations

Pedro Bay has no large emissions source requiring a state air permit for operations. The village government operates a small fleet of vehicles for its operations. Among these are a handful of ATVs, light trucks, a van to provide service to and from the community airfield, heavy diesel trucks, back-hoes and other motorized equipment for the community landfill. This heavy equipment provided service for the small community gravel pit. But, in the years since the gravel pit has been closed this construction equipment has been repurposed to the landfill and other needed areas in town. There is a single chainsaw that village council reported using during the year, along with its fuel consumption during that time frame.

The government also operates a number of fixed site emissions sources. Among these are a trio of small diesel generators under 100 kilowatts, gasoline powered water and sewage pumps, diesel and waste oil space heaters, and large central building heating units for the library and other public buildings. The central heating unit is rarely used in the Village Council Building due to its use of waste heat from the community's electrical generating unit. The library central building heating unit is used extensively during the winter months. These are operated along with a central community diesel-fired power generator which runs year-round.

4.1.4. Data Collection Commercial Operations

4.1.4.1. *Sport Fishing Lodges*

In the vicinity of Pedro Bay are three destination fishing lodges which provide adventure tourism services. The Angry Eagle Lodge and Eagle's Peak Lodge are both located close to Pedro Bay and can be accessed by ATV, motorcycle, or on foot. The third lodge, Iliamna River Lodge, is located across Lake Iliamna but utilizes the community air strip and service airlines for guests arriving. Angry Eagle and Eagle's Peak both use a pair of DeHavilland Beaver aircraft with floats to access more distant fishing grounds in the region. Iliamna River Lodge also uses a DeHavilland Beaver on floats for fishing grounds access, as well as ferrying guests and employees between properties located in Iliamna and Pedro Bay.

All three destination fishing lodges have provided seasonal activity data for inclusion in this emissions inventory. Initial estimates were based on generic data collected in the residential section of the survey and scaled to represent employees and guests. During the last visit to the community in June 2019, ADEC personnel were able to meet with representatives from all three fishing lodges and collect representative use data. This data was input into CAP and GHG spreadsheets and emissions calculated.

Data for two of the three lodges, the Angry Eagle and Eagle's Peak Lodge, were included in the community's overall commercial/institutional emissions estimate. These lodges are both located within community limits and are easily accessible by local residents by light truck, ATV, or by foot. Data for the last lodge, Iliamna River Lodge, was not included in the community's emissions inventory as it is not located within community limits. It is instead included in lodge emissions figures as a separate category of emissions.

4.1.4.2. *Air Passenger and Cargo Operations*

For the community's air cargo and passenger service operators, ADEC personnel contacted airlines and inquired as to the number of take-offs and landings (LTOs) carried out in the area during the year. The local airline services are divided between passenger/light mail services and cargo delivery services. Responding airlines are as follows:

Passenger/Light Mail Service Providers:

- Iliamna Air Taxi
- Lake Clark Air
- Lake and Peninsula Airlines

Air Cargo Service Providers:

- Everts Air Cargo
- Desert Air Cargo

All three lodges reported using the above passenger service providers for bringing guests to and from the area. This combined with the return of part-time residents, results in an increase in air passenger services during the spring and summer months. Air cargo service providers did not report a seasonal uptick in their deliveries to Pedro Bay.

To calculate total emissions, ADEC personnel requested information on the aircraft utilized, number of landings and take-offs, as well as flight time from origin to Pedro Bay. Along with fuel consumption factors, this allowed for calculation of emissions generated during both the LTO Cycle for both categories of aircraft providing services to the community.

For further information regarding emissions calculations choices and data in the air cargo and passenger operations section is in Appendix A.

4.1.4.3. *Barge Operations*

Information on the community's barge service was collected by ADEC personnel who contacted the single barge service in operation, Iliamna Transportation. The barge service operator provided ADEC with estimates of trips per year. They also provided an estimate of overland travel between Williamsport on Cook Inlet, and Pile Bay on Lake Iliamna by their semi-truck. This semi-truck utilizes an unpaved portage road which is only accessible during the spring and summer months after thawing. All cargo transported by the service is hauled up the portage road by the service's semi-truck and loaded onto the barge in Pile Bay for transport to Pedro Bay and other parts of the Lake Iliamna region. Barge operations occur from May-September when the portage road is accessible.

4.2. INVENTORY COLLECTION SURVEYS

ADEC worked with the Pedro Bay Environmental Coordinator to identify emission sources that were community specific. Source lists were then used to generate survey questions which were used to gather government, commercial and residential information.

Source lists and surveys have been used in other community emission inventories run by ADEC in the past. But these surveys need to be fine-tuned to each community for accuracy. Surveys gather fuel combustion and waste management information. This is the base of all of the emissions data in this study for both CAP and GHG pollutants. For government operations, the community EC filled out the surveys for government operations which included waste management, electrical generation, infrastructure, and fuel storage and handling facilities.

4.2.1. Seasonal Differences and Generic Data Calculations

ADEC was able to differentiate several categories of emissions between summer and winter emissions based on the type of vehicle used (ATV vs. snowmachine) and with specific survey questions regarding summer and winter activities and use.

Annual data collected from the passenger and cargo air carriers were differentiated by dividing the figures in half. Community air service providers verified that their number of flights did not substantially increase during the summer months even with returning seasonal residents and lodge guests. Flights continue as scheduled during the fall and winter months, though flights may be delayed due to inclement weather either in Port Alsworth or in Pedro Bay when departing. For some equipment, such as aircraft, there is a seasonal variance in emissions calculations which is noticeable in emissions generated in summer versus winter. Other equipment has a single set of emissions factors which are valid throughout the year, regardless of season. This seasonal variance is specifically applied for CAP emissions. The GHG emissions calculations do not include any seasonal variance or differentiation.

Along with the above seasonal data variation, ADEC also needed to calculate generic data for seasonal households which did not submit activity surveys. This required an averaging of all year-round household activity data, including woodstoves, ATVs, and other activities. Once averaged data was calculated, emissions were divided in half to represent seasonal households inhabited during the summer months only for subsistence activities. All winter-specific data, such as snowmachine activity, was left out of the yearly average used for seasonal household emissions calculations.

5. INVENTORY CALCULATIONS AND ANALYSIS

Emission calculations for each pollutant require a combustion source, fuel type, an activity measurement, and an emission factor to calculate the pollution amount. The EPA defines an emissions factor as, "[…] a representative value that attempts to relate the quantity of a pollutants released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of the pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. Such factors facilitate estimation of emissions from various sources of air pollution."[12]

The general equation for emissions estimation is:

E = A x EF x (1-ER/100)

Where:

- E = emissions;
- A = activity rate;
- EF = emission factor, and
- ER =overall emission reduction efficiency, %

Below are CAP emissions factors for a mobile source (4-Stroke Motor ATV) and a non-mobile source (catalytic woodstoves). The below chart presents basic emissions factors for calculating emissions generation. To calculate, take the amount and multiply by each of the factors which produces an estimated emissions total which may need to have a second calculation run for conversion to pounds or tons (if necessary).

Emissions Unit	Amount	Conversion Assumption	HC	CO	NOX	PM10	PM2.5	SOX
ATV: 2-Stroke Engine	Miles	G/Mile	0.68	19.8	0.64	0.06	0.06	0
Woodstove	Cords	LB/Ton Wood	---	104.4	2	20	19.6	0.4

Woodstove CAP emissions are estimated from the number of cords burned by a household in a given year. The ATV calculations require a conversion of grams to pounds. This is done by taking the resulting estimates and dividing by 453.592, providing a final calculation of pounds per mile. For measurement purposes, CAP emissions are read as either pounds or standard tons. Any CAP

[12] "Basic Information of Air Emissions Factors and Quantification," *U.S. Environmental Protection Agency*, available at: https://www.epa.gov/air-emissions-factors-and-quantification/basic-information-air-emissions-factors-and-quantification (Accessed 4/29/2019).

calculations that produce measurements other than pounds or tons should be converted for public use or reference.

The EPA GHG Emissions Toolkit calculates emissions automatically, rather than the above example of CAP emissions which require manual calculation. In the GHG Toolkit, emissions are calculated in metric tons (MT), rather than kilograms or tons. For the purposes of calculating the total carbon footprint of the emissions, the GHG Toolkit uses a Carbon Dioxide equivalence, or CO_{2e}. For example, the Pedro Bay landfill produced one ton of methane (CH_4), which is expressed by the GHG Toolkit as 1 MT CO_{2e}. This translates to one additional ton of CO_2 emitted by the community during the year.

More generally, the GHG toolkit bases its calculations on a specific reading of fuel consumption and mileage/activity per year. For example, to calculate an ATV's yearly GHG emissions the ADEC personnel needed to have the mileage (~1600 miles-per-year), as well as the gallons of fuel consumed (120 gallons) to complete the emissions equation and produce a reading of GHGs emitted per year. This was difficult, as some households did not have both mileage and fuel consumption for their vehicles. Other equipment, such as log splitters or chainsaws, did not have a mileage factor at all.

The above made it necessary for ADEC personnel to conduct research to establish miles-per-gallon and fuel economy figures to generate either fuel consumption or mileage numbers which could be input into the GHG Toolkit. This process was time consuming and difficult, especially for older aircraft which have fallen out of use elsewhere outside of hobbyist circles. GHG emissions are much more rigid in their data collection demands than CAP emissions calculations. This resulted in some equipment, such as chainsaws and weed trimmers, being calculated as stationary sources rather than mobile sources for ease of calculation.

6. POLLUTANTS AND HEALTH IMPACTS

This study calculates two types of emissions: CAP, and GHG pollutants. These are differentiated because of the impact they have on human health and the environment.

CAPs have been identified by the EPA as having a negative impact on human health and welfare. Rxposure to these pollutants has been connected to respiratory, circulatory, and central nervous system damage. Each of the CAPs has its own health impact which will be briefly outlined in the following section.

GHGs, by comparison, have been tied to declining global environmental health and stability going back to the early twentieth century when the greenhouse effect was first described in scientific literature.

6.1. CRITERIA AIR POLLUTANTS (CAPs)

CAPs were identified by the EPA in the Clean Air Act (CAA) of 1970 for their impact on human health and wellbeing. Some pollutants (carbon monoxide) differ from their GHG variant (carbon dioxide) by a single molecule. Both CAPs and GHGs are created through the combustion process, or via natural causes. The following pollutants have been identified by the EPA under the umbrella of CAPs:

- Particulate Matter (PM) 2.5 and 10 Micrometers
- Carbon Monoxide (CO)
- Lead (Pb)
- Sulfur Dioxide (SO_2)
- Nitrogen Dioxide (NO_2)[13]

6.2. CAP HEALTH IMPACTS

All five of these pollutants are linked to various cardiovascular and circulatory side-effects which can range from mild to serious. A sixth pollutant, hydrocarbons (HCs), is not listed in the above list of CAPs, but will be discussed at the end of this section. A seventh pollutant, Ozone, is a listed CAP but was not calculated for this inventory as amounts of ozone pollution are extremely small from the community.

6.2.1. Particulate Matter

> Particulate matter is what the EPA calls a "[…] mixture of solid particles and liquid droplets found in the air. Some…such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope."[14]

[13] "Criteria Air Pollutants," *U.S. EPA*, available at: https://www.epa.gov/criteria-air-pollutants (Accessed 4/11/2019).
[14] "Particulate Matter (PM) Basics," Particulate Matter (PM) Pollution, *U.S. EPA*, available at: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM (Accessed 4/11/2019).

There is a difference between the two categories of PM. PM_{10} is a broad category of particles which are smaller than a single grain of sand and inhalable into the lungs. But these particles are too large to enter the human bloodstream. According to the EPA's website on particulate matter pollution, these particles can be caused by dust, pollen, mold, or other sources.[15] Some of these particles can penetrate deep into a person's lungs and carry additional pollutants with them that could possibly enter the bloodstream.[16] The second category of particulate matter, $PM_{2.5}$, poses a greater risk to human health and well-being. These are ultra-fine particles smaller than 2.5 micrometers which penetrate deep into the lungs and enter the bloodstream.

For communities in rural Alaska, exposure to both PM_{10} and $PM_{2.5}$ is a matter of daily life. For example, many communities have unpaved roads, which can be vectors for PM_{10} through road dust. Additionally, communities also utilize diesel engines for power production and transportation, which can produce $PM_{2.5}$ through the combustion process. For small communities such as Pedro Bay, policy objectives to reduce community exposure to these pollutants might be difficult given the reliance on diesel power generation, challenges in managing dust from unpaved roads, and complexities of addressing other sources of particulate matter such as wood heating. Mitigation strategies could include moving emissions-based sources of PM away from residential homes, and other initiatives could decrease public exposure to these pollutants and improve community health. These are a few examples of PM within the community.

6.2.2. Carbon Monoxide (CO)

CO is a colorless and odorless gas that can cause harm when inhaled in large amounts.[17] This gas is created by the combustion process and can be generated by vehicles, power plants, woodstoves, and campfires. Indoors, the State of Alaska mandates the use of carbon monoxide detectors in all dwellings to alert residents if their exposure to this gas reaches harmful levels.[18] In ambient air, there is no law requiring use of carbon monoxide detectors given that there is atmospheric mixing of the gas with oxygen. A short list of health effects of carbon monoxide poisoning is provided below:

- Headache
- Dizziness
- Vomiting
- Nausea
- Unconsciousness or death (if CO levels are high)[19]

[15] Ibid.
[16] Ibid.
[17] "Basic Information about Carbon Monoxide (CO) Outdoor Air Pollution," Carbon Monoxide (CO) Pollution in Outdoor Air, *U.S. EPA*, available at: https://www.epa.gov/co-pollution/basic-information-about-carbon-monoxide-co-outdoor-air-pollution#What%20is%20CO (Accessed 4//11/2019).
[18] "Carbon Monoxide Detectors are Required by State and Local Laws," *City and Borough of Juneau*, available at: http://www.juneau.org/cddftp/documents/CarbonMonoxide.pdf (Accessed 4/11/2019).
[19] "Carbon Monoxide Poisoning: National Environmental Public Health Tracking, *U.S. Centers for Disease Control and Prevention*, available at: https://ephtracking.cdc.gov/showCoRisk.action (Accessed 4/11/2019).

There are no detailed studies for the long-term consequences of low level CO exposure over extended periods of time. However, some studies have shown that exposure to moderate to high levels of CO over extended periods of time are linked with an increased risk of heart disease.[20] In addition, those who survive what the U.S. Centers for Disease Control and Prevention (CDC) terms as "severe CO poisoning" may suffer undetermined long-term health problems.[21]

6.2.3. Lead (Pb)

Lead is a pollutant with which many are familiar in an indoor setting. The United States and other countries have reduced environmental lead exposure in household settings over the past forty years through banning lead-based paints and removing lead water pipes in homes and businesses. The greatest source of lead in the ambient air was leaded gasoline, which was used prior to EPA's 1980 regulations.[22] According to the EPA, ambient atmospheric lead exposure decreased by 98 percent between 1980 and 2014.[23]

Unlike carbon monoxide or particulate matter, lead has been shown to have an impact on every organ and system in the human body. It has a significant impact on children's development and can cause significant issues in pregnant women and fetuses. For adults, there are other health effects, all of which are listed below:

Small Children

- Behavior and learning problems
- Lower IQ and Hyperactivity
- Slowed Growth
- Hearing Problems
- Anemia
- Seizures, coma, and death (in rare cases of lead ingestion)

Pregnant Women

- Cause premature birth or fetal size disfigurement
- Damages fetal brain, kidney, and nervous system
- Increases likelihood of learning or behavioral problems
- Increased risk of miscarriage

Adults

- Cardiovascular effects (increased blood pressure and incidences of hypertension)
- Decreased kidney function
- Reproductive problems[24]

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[20] Ibid.
[21] Ibid.
[22] "Basic Information about Lead Air Pollution," Lead Air Pollution, *U.S. EPA*, available at: https://www.epa.gov/lead-air-pollution/basic-information-about-lead-air-pollution#how (Accessed 4/11/2019).
[23] Ibid.
[24] "Learn About Lead," Lead, *U.S. EPA*, available at: https://www.epa.gov/lead/learn-about-lead#effects (Accessed 4/11/2019).

As this is a pollutant that can negatively impact all age groups and categories, it is strongly suggested that exposure to lead be mitigated or avoided entirely, if at all possible. But, with the removal of leaded gasoline starting almost four-decades ago, atmospheric exposure to lead has plummeted.

Within the state of Alaska there are still vectors for personal lead exposure, which include lead-based paint used for marine vessels, leaded aviation gasoline in small aircraft, and leaded ammunition among others. If residents are concerned about their levels of exposure, they can contact their community environmental health offices, ADEC, or the Alaska Native Tribal Health Consortium (ANTHC) to discuss lead exposure and ways to limit possible exposure.

6.2.4. Sulfur Dioxide (SO_2)

SO_2 is an atmospheric pollutant caused by the burning of fossil fuels at power plants and other industrial facilities. Other sources of sulfur dioxide include natural sources such as volcanoes, along with the burning of fuel in marine vessels, vehicles and heavy equipment. Ultra-low sulfur diesel is sold in Alaska and is used in diesel-fired equipment, which has significantly reduced the amount of sulfur emissions.[25]

Because many rural communities rely on shipping to import fuel, food, and supplies, this can increase local exposure to sulfur dioxide and other harmful pollutants from vessels.

Health effects associated with sulfur dioxide exposure include:

- Eye, skin, mucous membrane, and respiratory tract irritation
- Bronchospasm, pulmonary edema, pneumonitis, and acute airway obstruction can occur
- Aggravation of asthma or emphysema
- Bronchospasm among certain highly sensitive asthmatics[26]

SO_2 has been linked, along with nitrogen oxides (NOx), to the formation of acid rain once these pollutants interact with water and other chemicals.[27]

6.2.5. Nitrogen Dioxide (N_2O)

NO_2 is primarily emitted by the burning of fuel in cars, trucks, power plants, and other types of motorized equipment.[28] There are a number of negative health effects of nitrogen dioxide exposure. Among these are:

- Aggravated respiratory diseases, particularly asthma
- Coughing
- Wheezing

[25] Sulfur Dioxide Basics," Sulfur Dioxide (SO2) Pollution, *U.S. EPA*, available at: https://www.epa.gov/so2-pollution/sulfur-dioxide-basics#what%20is%20so2 (Accessed 4/11/2019)
[26] "Sulfur Dioxide Basics," *U.S. EPA*.
[27] "What is Acid Rain?" Acid Rain, *U.S. EPA*, available at: https://www.epa.gov/acidrain/what-acid-rain (Accessed 4/11/2019).
[28] "What is NO_2 and how does it get in the air?" Nitrogen Dioxide (NO_2) Pollution, *U.S. EPA*, available at: https://www.epa.gov/no2-pollution/basic-information-about-no2#What%20is%20NO2 (Accessed 4/11/2019)

- Difficulty breathing
- Development of asthma (with chronic/long-term exposure)
- Increased susceptibility to respiratory infections (with chronic exposure)

6.2.6. Hydrocarbons

HCs are not listed as a CAP but are included in this report. HCs are volatile organic chemicals (VOCs), which are widely used in a number of applications. The EPA defines VOCs as, "…any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate, which participates in atmospheric photochemical reactions…"[29] In addition to gasoline and diesel, HCs are found in engine lubricants (such as motor oil), lighter fluid, kerosene, paint solvents, dry cleaning solutions, rubber cement, and other chemicals.[30] HCs can be inhaled, digested, or through dermal exposure (touch).[31] The primary form of HCs that this study takes into consideration are unburned HCs from motor vehicles, personal watercraft, aircraft, power plants, or other fossil fuel-powered sources which are inhaled.

Symptoms of hydrocarbon poisoning are as follows:

- Coughing or choking after swallowing or inhalation
- Burning sensation in stomach and possible vomiting
- Severe coughing if respiratory system is badly irritated
- Cyanosis (low blood oxygen levels) if heavily exposed
- If ingested, hydrocarbon poisoning could cause drowsiness, poor coordination, stupor, seizures, or coma
- If persistent exposure continues, pneumonia and chemical pneumonitis could occur[32]
- Dermal exposure could cause dermatitis, chemical burns, and defatting injury[33]
- Oral exposure can cause local irritation, vomiting, diarrhea, and abdominal pain[34]

If exposure is chronic, due to the likely carcinogenic nature of HCs, the following diseases could result:

- Malignant and non-malignant respiratory disease
- Possible connections to cancers[35]

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[29] "Technical Overview of Volatile Organic Compounds," Indoor Air Quality, *U.S. EPA*, available at: https://www.epa.gov/indoor-air-quality-iaq/technical-overview-volatile-organic-compounds (Accessed 4/29/2019).
[30] "Hydrocarbon Toxicity," Michael D. Levine and Chip Gresham, *Medscape*, June 6, 2017, available at: https://emedicine.medscape.com/article/821143-overview (Accessed 4/12/2019)
[31] "Hydrocarbon Toxicity: A Review," L.M. Tormoehlen, KJ Tekulve, and KA Nanagas, *Clinical Toxicology*, Vol. 52, No. 5, June 2014, pp. 479-489, available at: https://www.ncbi.nlm.nih.gov/pubmed/24911841 (Accessed 4/12/2019)
[32] "Hydrocarbon Poisoning," Gerald F. O'Malley and Rika O'Malley, *Merck Manual Consumer Version*, available at: https://www.merckmanuals.com/home/injuries-and-poisoning/poisoning/hydrocarbon-poisoning (Accessed 4/12/2019)
[33] "Hydrocarbon Toxicity: A Review," LM Tormoehlen et. Al. *Clinical Toxicology*, available at: https://www.ncbi.nlm.nih.gov/pubmed/24911841 (Accessed 4/12/2019)
[34] Ibid.
[35] Ibid.

HCs are primarily found in fossil fuels which are the most commonly utilized energy source on the planet.

6.3. CRITERIA AIR POLLUTANT CALCULATIONS

Calculations for CAPs use emissions factors for specific individual fuel types and combustion sources.

Each of the CAP emissions factors has been established elsewhere, either by state air agencies or by the EPA in its standard AP-42 emissions factors. The AP-42 standards were released thirty years ago and are updated by the EPA on a semi-regular basis. Other state air agencies, including the California Air Resources Board (CARB), have established their own emissions factors to calculate emissions more efficiently than EPA's AP-42 standards based on emissions testing in laboratory settings.

ADEC used emission calculations from previous emission inventories conducted in the state (AP-42 based), except where newer information was available. The majority of the updated emissions factors used in this inventory were adopted from CARB. CARB produced new emissions factors for woodstoves, ATVs, and other motorized vehicles.

A new emission source added from previous inventories was emissions from transport to the community via cargo and passenger flights. In 2005, ADEC contracted out for an aviation inventory in the state of Alaska, which produced several sets of useful emissions factors which were adopted and used in this study[36].These emissions factors also included a seasonal differentiation in emissions, which is reflected in Section 9.

ADEC used a combination of emissions factors for woodstoves. This was due to the local woodstove changeover which has occurred in the last fifteen years. CARB woodstove emissions factors were applied to those homes which changed out their woodstoves and installed new, EPA-certified catalytic woodstoves. The newer models have lower $PM_{2.5}$ and PM_{10} emissions compared to older models. We retained the older calculations used in previous inventories to use with fireplaces and outdoor wood-burning sources (campfires/cooking fires, saunas, and smokehouses).

Emission factors for ATV and snowmobiles (snowmachines) were updated from previous inventories. The new standards reflect improvements in engine combustion efficiencies for these vehicles in recent years, allowing for ADEC personnel to use new CARB emissions factors. The older AP-42 calculations had no chronological differentiation in the emissions factors and produced uniformly heavy emissions. Because most households were able to identify what year their ATVs were built in, ADEC personnel could reference the CARB factors and change which factor to use based on the year and engine-size.

Unless the household indicated otherwise, all ATVs were calculated using a 2-stroke engine rather than a more efficient 4-stroke engine. CARB categorizes all emission factors used for these calculations as "zero hour" emissions, meaning those produced during start-up. This is a

[36] "Alaska Aviation Emission Inventory," *Sierra Research*, Prepared for the Western Regional Air Partnership, June 14, 2005, Report SR2005-06-02.

conservative way to calculate emissions, as ADEC did not have access to the driving patterns of community vehicles. As such, it was deemed as prudent to calculate all emissions at zero hour levels. For future emissions inventories, ADEC personnel and local EC's assisting should take note of driving times which would allow for more accurate calculation of total emissions.

All other emissions factors used in this report are those which have been used and vetted prior to this inventory by ADEC staff in previous emissions inventories.

6.4. GREENHOUSE GAS EMISSIONS

GHGs were designated by the Kyoto Protocols, and later Paris Agreement, as primary pollutants which contribute to ongoing Anthropogenic Climate Change; climate change fueled by human activities. These pollutants are as follows:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Hydroflourocarbons (HFCs)
- Perflourocarbons (PFCs);
- Sulfur Hexaflouride (SF_6)[37]

Three of the GHGs listed are not included in the GHG Toolkit and are produced in industrial processes which do not occur in Pedro Bay. HFCs and PFCs have been used in all refrigeration and air conditioning units produced since the Montreal Protocols were ratified in the United States in 1988. As the community has limited power production, it is likely that SF_6 is also present in low amounts. For GHG emission results, the most important gasses for analysis are CO_2, CH_4, and N_2O.

6.5. GREENHOUSE GAS (GHG) TOOLKIT CALCULATIONS

ADEC tested the EPA's GHG Tribal Community Toolkit (Toolkit) for the first time in Alaska. The tool is free to download from the EPA website and easily accessible to budget restricted communities. It automatically calculates the following GHG emissions based on mileage and fuel consumption activity factors entered into the different fields in the inventory form:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)

The emissions are categorized into the following sectors:

- Stationary
- Mobile
- Solid Waste
- Wastewater

[37] "Kyoto Protocol – Targets for the first commitment period," *United Nations Framework Convention on Climate Change*, United Nations, 2019. Available at: https://unfccc.int/process/the-kyoto-protocol (Accessed 4/11/2019).

- Electricity
- Water
- Agriculture & Land Management
- Urban Forestry
- Waste Production

In addition to these emissions categories, the Toolkit allows the user to categorize emissions as Residential, Commercial/Institutional, Industrial, and Energy Generation. These categories allow for more detailed analysis of specific emissions-generating activities by environmental planners and policy specialists.

The GHG Toolkit requires both fuel and activity information to calculate the emissions produced. While this is more accurate, as it encompasses both fuel and activity information be collected, it can be difficult for resource-limited communities. Many environmental officers in rural Alaska that might want to use this tool could be put off or intimidated by the larger upfront technical data investment required to make this tool function correctly. While the tool allows users to input data for large and small equipment, it does not include a detailed user's guide, or generic miles-per-gallon (MPG) or fuel economy figures which could be used in the absence of hard data.

The absence of generic figures for fuel economy/MPG meant that ADEC personnel had to collect these figures in order to make this tool function correctly. This was a time-consuming process which does not make this tool conducive to immediate use by untrained environmental officers with other competing responsibilities.

One of the benefits of the GHG Toolkit is the function that calculates the impact of "Land Use/Land Change" (LULC). This function considers the impact of greenspace around a community and how much of the GHG emissions are reabsorbed or offset by the designated greenspace area.

There are some limitations in the Toolkit that should be modified to make it more applicable to Alaska. For example, one of the questions asked for the number of urban trees that were planted in the community. This does not apply in rural Alaska. Also, this would not apply to communities that are located in ecological areas which are tundra or grassland dominant. Lastly, the Toolkit does not include input for vegetation types and accurate carbon storage potential for Alaska, such as tundra. Regardless of the limitations, the LULC calculation provides a rough estimate of the balance of GHGs and carbon sequestration.

7. EMISSION INVENTORY RESULTS

7.1. RESIDENTIAL HOMES

7.1.1. Residential - GHG

The greatest source of GHG emissions in the community of Pedro Bay are the residential homes. These emissions come from combustion sources in or near the homes, specifically woodstove heating and use of wood-fired saunas, smokehouses, and campfires. As calculated in the GHG Toolkit, the community's use of wood (calculated using a stand-in for wood combustion: propane) constituted approximately 4,625.86 MMBTUs (millions of British Thermal Units) of energy use. The next most prevalent fuel source used was gasoline at 1,710.33 MMBTUs, followed by diesel and Residual Fuel Oil No.5 (a stand-in for heating oil).

The community's woodstoves generate approximately 287 MT of GHG emissions. Of these, 284 MT are released as CO_2, one ton as CH_4, and two tons as N_2O. The next highest used fuel source, gasoline, released 128 tons of CO_2, and a smaller amount of CH_4 and N_2O was produced - approximately one ton of GHGs. Diesel and Residual Oil No.5 resulted in 26 and 22 tons, respectively. In total, the community's residential stationary emissions generated 465 MT of GHGs, of which 461 tons was CO_2, two tons were CH_4, and two tons were N_2O.

Gasoline emissions are generated primarily from water and sewage pumps run by the village council, and a small number of gas-fired generators operated by lodges and the PBVC. Gasoline is also used in the operation of chainsaws, weed trimmers and log splitters. Diesel and residual fuel No. 5 -is used by the PBVC and a single homeowner for building heating purposes.

For the purposes of emissions calculation, a number of generic households were used as representatives to calculate emissions in the GHG Toolkit. These households are stand-ins for the fifteen seasonal households which are owned by residents who make use of them during the subsistence season (May-September). ADEC assumed that all fifteen seasonal households used woodstoves, as well as that seasonal households had access to running water. This was based on information from the Pedro Bay Environmental Coordinator, who reported that all houses had access to well water rather than a centralized municipal water system.

Figures 2 and 3 provide an overview of residential GHG emissions.

Figure 2: CO_2 Household Emissions Total (In Metric Tons)

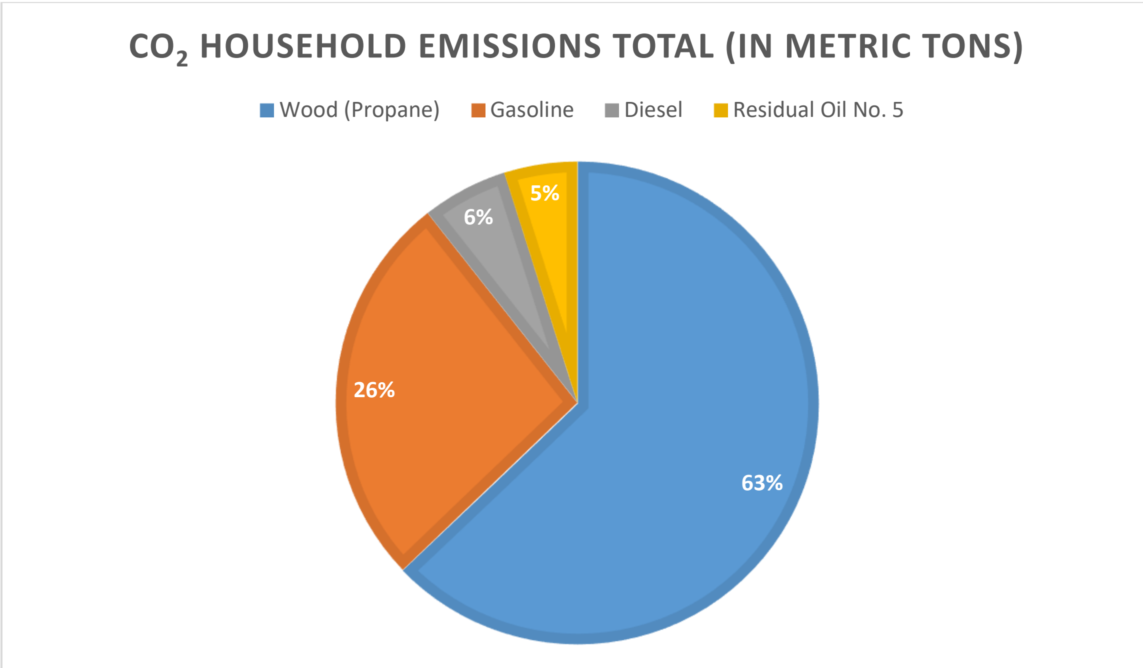
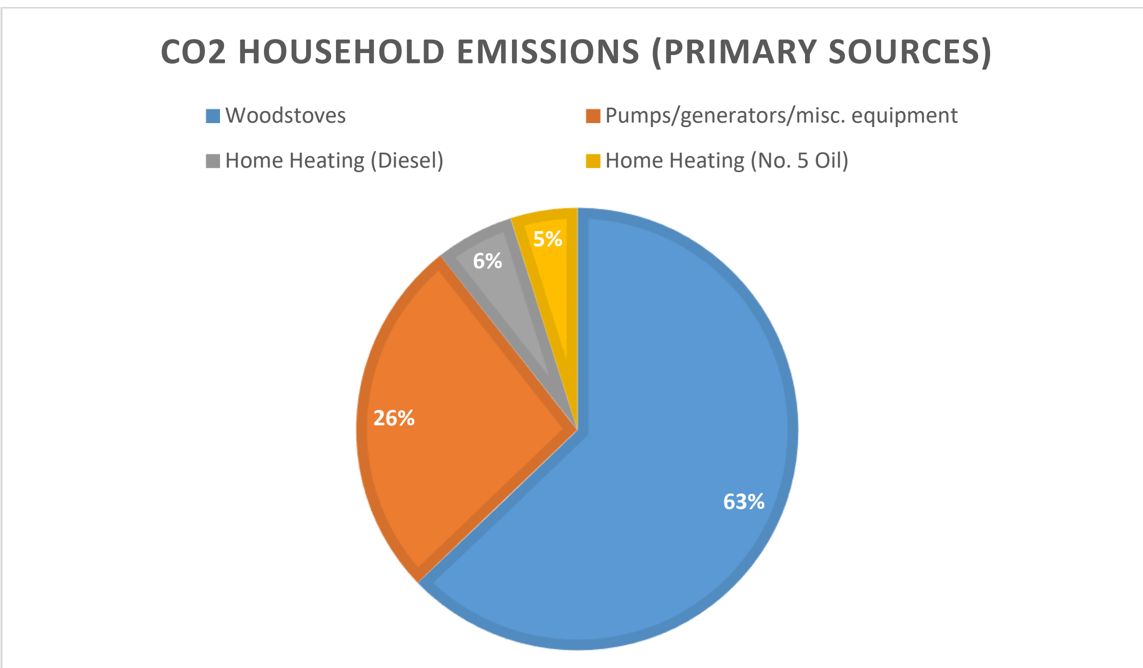


Figure 3: CO_2 Household Emissions (Primary Sources)



7.1.2. Residential Transportation – GHG

The community's mobile emissions sources constitute a smaller footprint than stationary emissions. Pedro Bay's residential transportation energy use was 681 MMBTUs, with an additional 57 MMBTUs created by the two personal aircraft declared on the survey forms.

Residential gasoline consumption for mobile emissions units was 5,449 gallons of gasoline in total, with 478 gallons of aviation gasoline consumed by the two personal aircraft. CO_2 emissions were calculated to be 55 MT representing all of the vehicles in the community declared on the survey forms plus generic vehicles.

Generic vehicle emissions, for those homes that did not participate in the study, were calculated seasonally. After reviewing the reported numbers of ATVs and other private vehicles, ADEC calculated vehicle use based on an average of one marine pleasure craft, one light truck, and two ATVs per generic household during summer months. ADEC also calculated generic households as having two ATVs with an averaged mileage per-vehicle at 1596 miles. In addition, each vehicle was given a fuel use of 30 gallons of gasoline per season. In the community, these vehicles are primarily used for personal transportation and subsistence use. As such, the mileage and fuel consumption were kept at the averaged figure.

For the residential generic light truck and personal marine pleasure craft, ADEC used an averaged mileage and fuel consumption amount to represent activity in these homes. Because these seasonal homes are likely engaged in subsistence activities, light trucks were assigned 309 miles of activity per season with 16 gallons of gasoline consumption. Personal watercraft generic mileage and fuel consumption were based on an average of 2,872.5 miles per season and 123.2 gallons of fuel consumed. As it was assumed that seasonal households would be utilizing Lake Iliamna for subsistence and recreational purposes, these fuel and activity figures seemed to be reasonable assumptions.

For further information regarding the specific vehicle categories, please see Appendix A for specific calculations and data. For a visual overview of these emissions, please see the below graph.

Figure 3: Residential Transportation Fuel Consumption

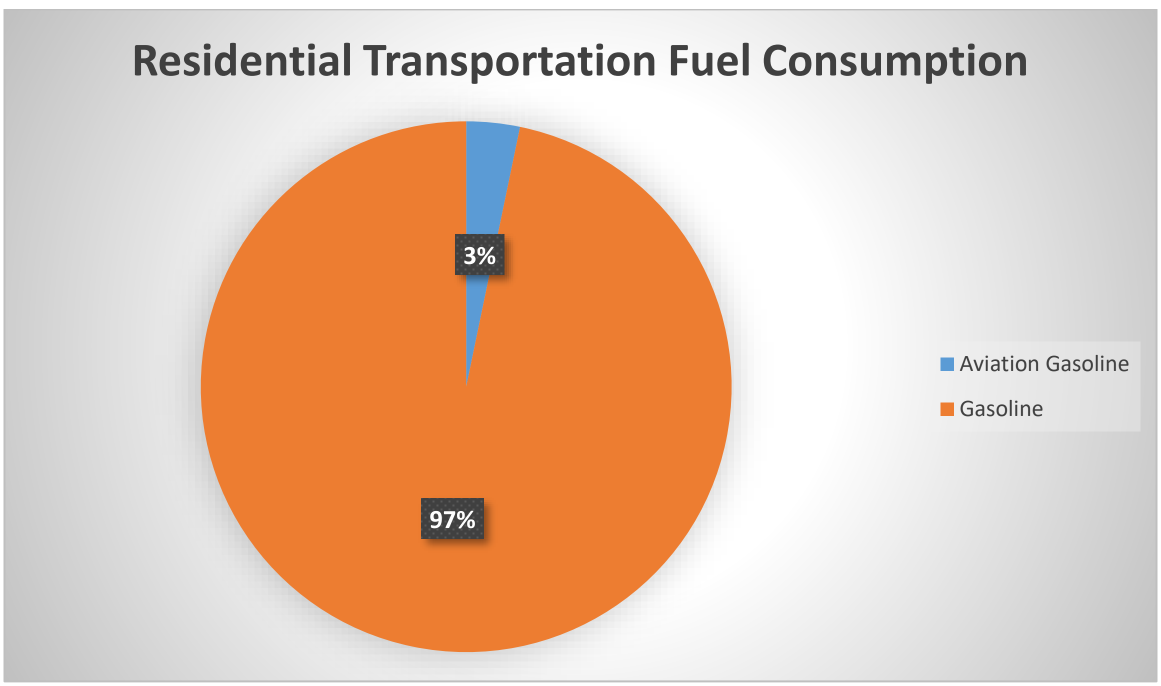
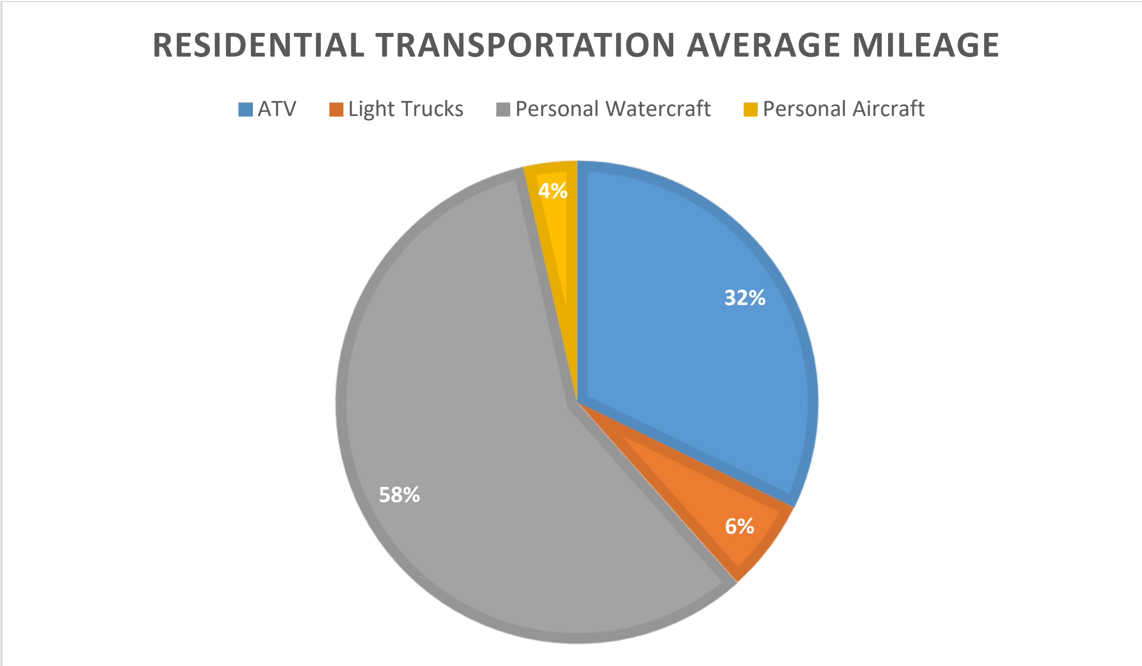


Figure 4: Residential Transportation Average Mileage



7.1.3. Residential Homes - CAPS

For the large residential emissions sources in the community, such as residential woodstoves or smokehouses, calculations have been established using emissions factors that represent changes in emissions control technology. Generic seasonal household CAP emissions are established by using the average emissions from documented household usage. In addition, unlike the GHG toolkit all CAP calculations are represented using the appropriate fuel source.

Please note that all emissions cited in the CAP section of this inventory use the same units of measurement as those in the GHG inventory.

7.1.3.1. *Carbon Monoxide*

Pedro Bay's residential emissions sources, combined, produced a total of 542,616.7 lb. (271.3 tons) of CO emissions per year. Emissions in this category include household heating, outdoor burning, and other stationary sources (Figure 6). CO emissions rates differ little between summer and winter, as community wood consumption shifts from subsistence-utilization in summer to home heating in winter.

7.1.3.2. *Particulate Matter*

Residential sources in Pedro Bay emitted 5,358.8 lbs. (2.6 tons) of PM_{10}, and 3,846.7 lbs. (1.9 tons) of $PM_{2.5}$ per year. The two largest sources of household PM emissions were community woodstoves, which released 3,077.1 (1.5 tons) of $PM_{2.5}$ and PM_{10}, and saunas/ smokehouses which released 3,181.7 lbs. (1.5 tons) of $PM_{2.5}$ and PM_{10}. For the purposes of analysis, saunas and smokehouses are grouped together as these are local cultural practices which many community-members utilize. Woodstoves are grouped together, and catalytic and non-catalytic woodstove figures are combined under a single category. Figure 6 provides a breakdown of residential PM sources.

Please note that road dust emissions were not included in these emissions estimates.

Figure 5: Residential CAP Emissions - Carbon Monoxide

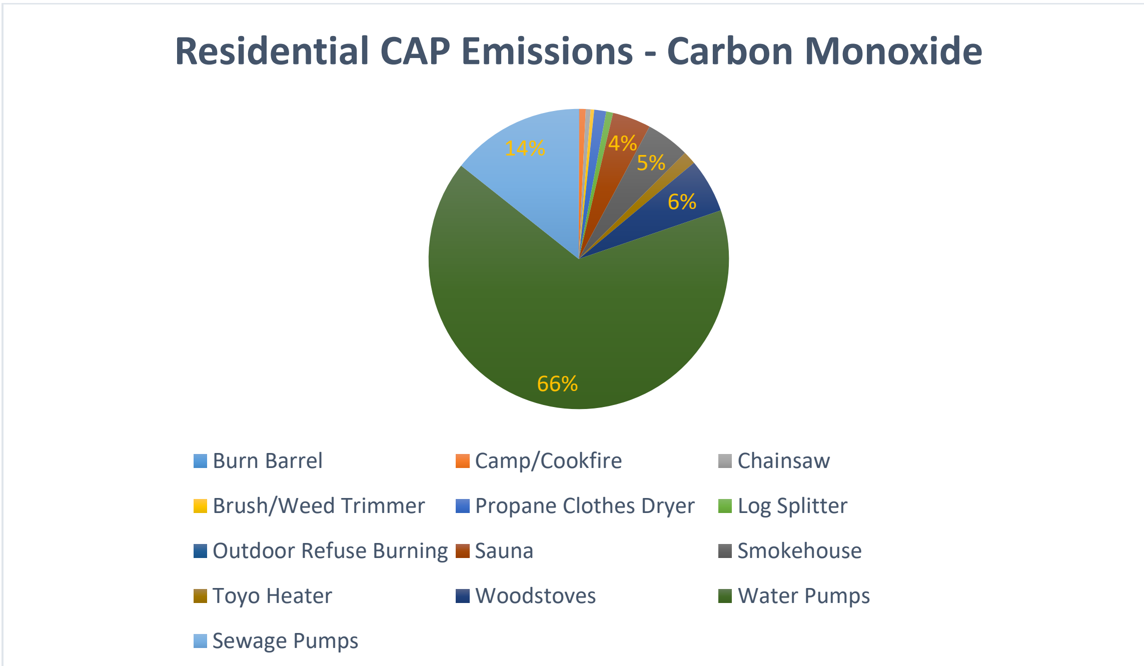
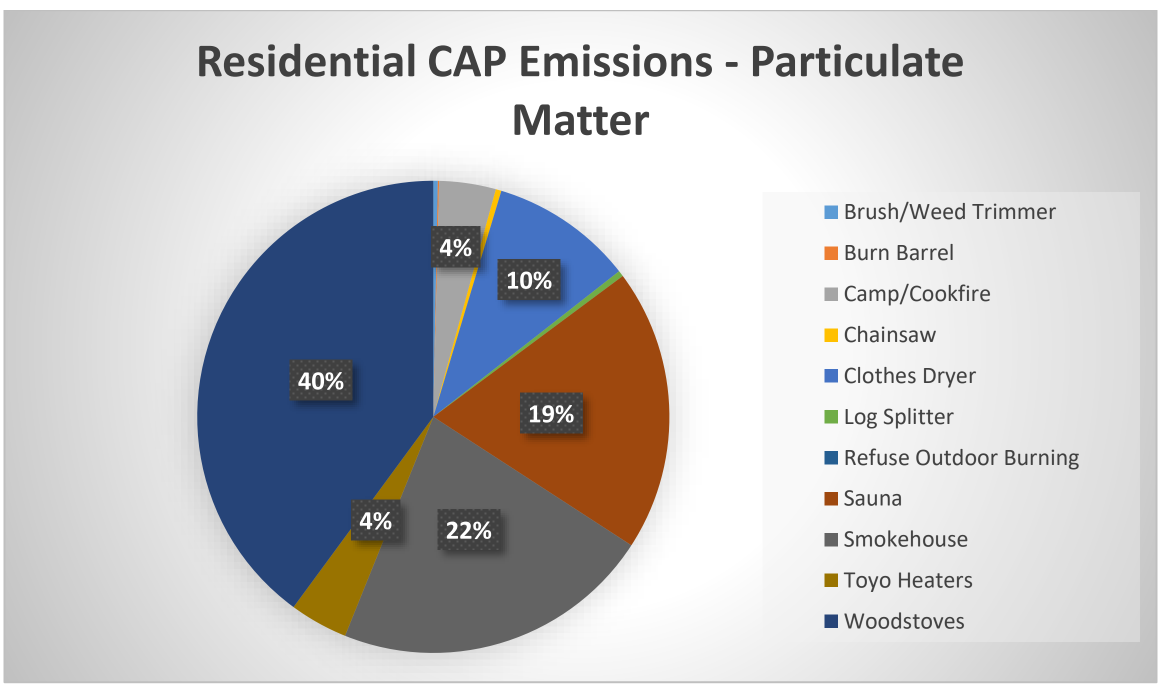


Figure 6: Residential CAP Emissions - Particulate Matter



7.1.4. Residential Transportation - CAPS

Residential transportation includes light gasoline-powered trucks, ATVs, snowmachines, marine pleasure craft, and personal motorcycles. The community's marine pleasure craft and snowmachine emissions are seasonally specific. During fall freeze up and spring thaw, it is unlikely that local residents would utilize a boat or snowmobile for transportation. Additionally, as the community's subsistence season is May through September it is unlikely that any marine vessel use would occur outside of these months.

The four pollutant categories that will be analyzed in this section are CO, PM_{10} and $PM_{2.5}$, and HCs. As these vehicles are largely gasoline powered and extensively used in the community, it is important to analyze the hydrocarbon emissions footprint of these emissions sources.

7.1.4.1. *Carbon Monoxide*

Residential vehicles released a total of 30,868.5 lbs. (15.4 tons) of CO during the year. The largest emissions source was marine pleasure craft, which released 23,493.45 lbs. (11.75 tons) and represent 76% of the total residential CO emissions. ATV use was the second largest category with a total of 3,687 lbs. (1.84 tons). The other emissions sources combined together emitted 3,688.04 lbs. (1.844 tons) one pound of CO greater than ATVs alone. See Figure 8.

7.1.4.2. *Particulate Matter*

PM_{10} emissions constituted 45 lbs. total, while $PM_{2.5}$ emissions were 40 lbs. The greatest source of emissions in the category of PM_{10} were the community's marine pleasure craft (15.2 lbs.) followed by light trucks (11.2 lbs.). $PM_{2.5}$ emissions included marine pleasure craft (14.4 lbs.) followed by snow machines (10.1 lbs.). See Figure 9.

7.1.4.3. *Hydrocarbons*

The community's total HC emissions are 3,119.5 lbs. (1.559 tons). The greatest source of HC emissions was from snow machines (1,443.2 lbs.) followed by marine pleasure craft (1,158 lbs.). The community's ATVs, while being more widely used during the year for non-subsistence or recreational use, produced 263.9 lbs.[38]

For further information about data results, or for differences in emissions factors that generated these calculations, please see Appendix A.

[38] Emissions Calculations: Please note that those results which came in below 0.5 tons (1000 lbs.) are only calculated in pounds and not tons. This is done to save space, as well as to present a more representative figure for emissions totals.

Figure 7: Residential Transportation CAP Emissions - Carbon Monoxide

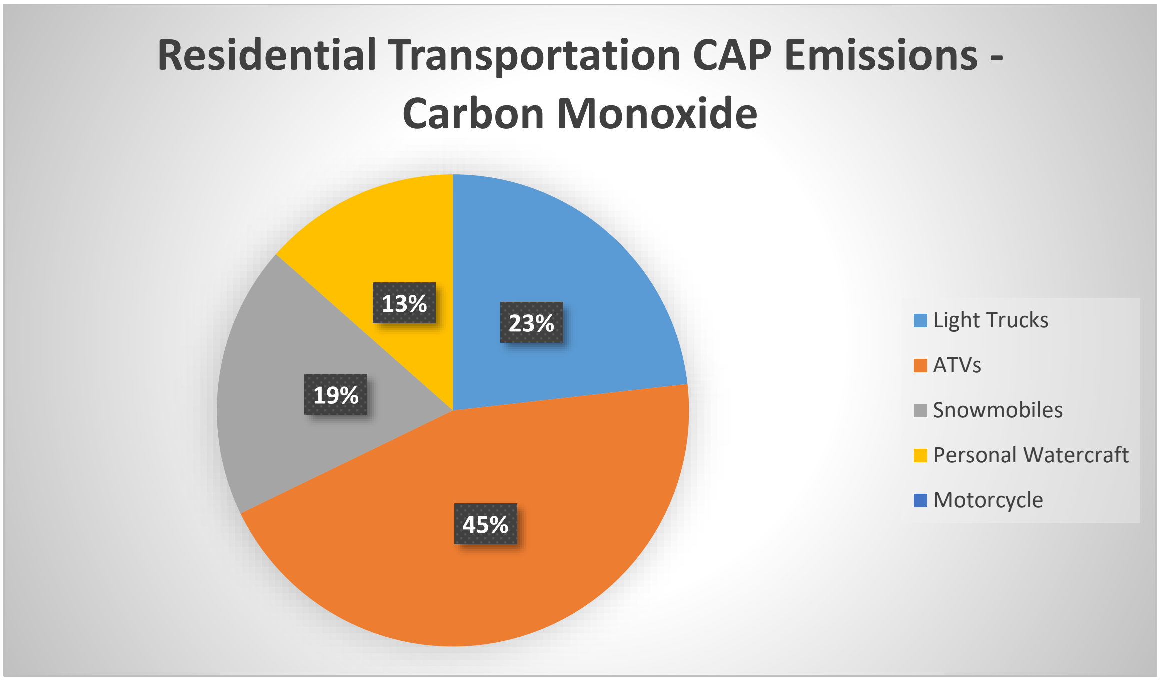
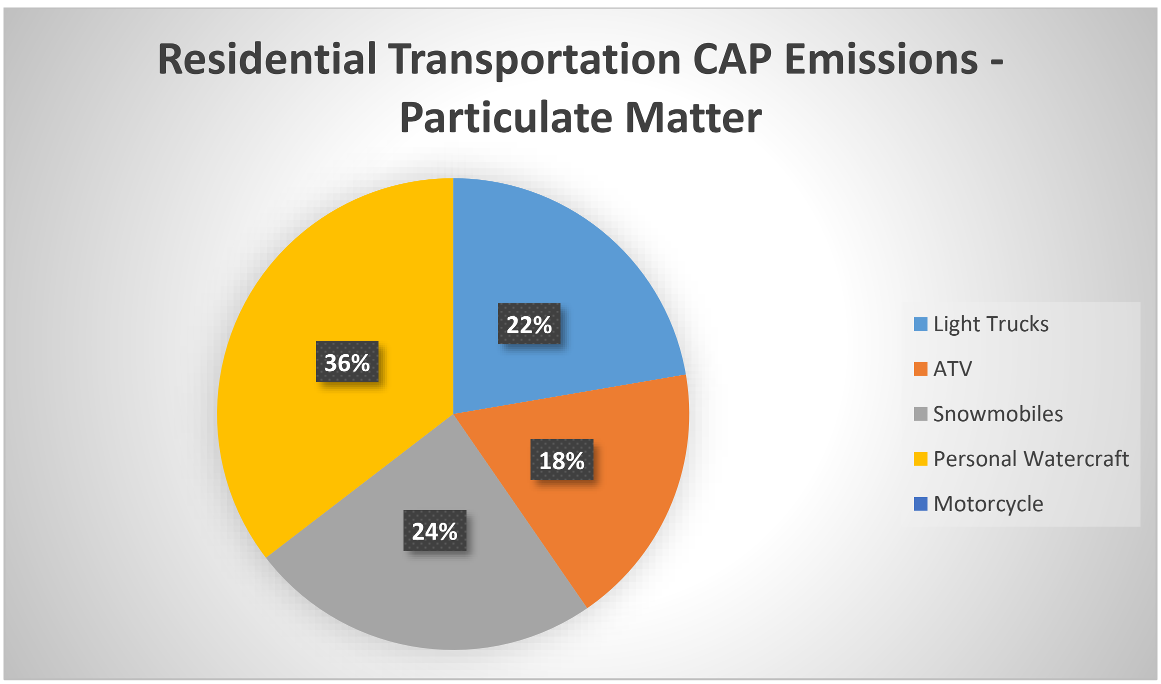


Figure 8: Residential Transportation CAP Emissions - Particulate Matter



7.2. COMMERCIAL EMISSIONS

7.2.1. Commercial/Institutional Stationary Sources - GHG

Commercial and Government GHG emissions are calculated together in the GHG Toolkit as Commercial/Institutional. This section addresses Commercial CAPS and other commercial operations. Government-generated CAPs are located in Section 7.3. The sources counted as commercial/institutional for the purposes of the GHG Toolkit calculations include PBVC operations, the community's lodges, air and barge transport.

The commercial/institutional sources produced 153 MT of CO_2 during the year and consumed 17,319 gallons of fuel to produce 2089 MMBTUs of energy. Compared to the number of households in the area, the village council and the lodges are only a handful of buildings. In addition, any emissions created by the community lodges are isolated to the summer months and are closed after September. Government operations, by comparison, are year-round.

Fuel consumption for commercial/institutional was 17,319 gallons of petroleum products. Gasoline consumption between the lodges and the government totaled 4,783 gallons in all, while propane consumption came in at 3,476 gallons. The stationary source calculations summary does not provide an analysis of how these gallons of gasoline are broken out into sector-specific gasoline consumption. The propane consumption is a replacement for wood combustion in the GHG Toolkit and is included as lodge recreational burning.

Commercial/institutional emissions totaled 153 MT of CO_2 from all sources, including lodges, government operations, barge operations and aviation. The commercial emissions include lodge operation emissions, which occur during the summer months (May-October), and airline emissions which occur year-round. The sources with the greatest amounts of fuel consumption and activity during the year were from commercial aviation operations, as well as those aircraft which serviced the two destination fishing lodges in the community. These sources consumed 9,795 gallons of aviation gasoline and flew a total of 51,951 miles during the calendar year, which averages out to 5.30 miles per gallon of fuel.

According to the lodge owners who ADEC spoke with during the June 2019 community site visit, both lodges utilize commercial aviation services to bring guests to and from the area. They utilize DeHavilland Beaver aircraft on floats to transport guests to and from fishing grounds located in more distant parts of the Lake Iliamna watershed during guest stays. However, these aircraft do not bring guests from Anchorage to the lodge. This makes it more difficult to separate lodge-generated emissions from general community-generated commercial aircraft emissions. As local residents would be flying to and from the area during subsistence months on the same flights as guests, separating emissions becomes more challenging, requiring additional inputs to allow for specified emissions assignment.

Of the 153 metric tons of CO_2 produced by the commercial/institutional sector as calculated by the GHG Toolkit, 89 tons were produced by aircraft burning aviation gasoline and 7 tons produced by gasoline. Those seven tons of CO_2 emissions produced by gasoline-fired emissions sources represent the two lodges' ATV trips by guests and staff and all vehicles operated by the PBVC during a calendar year. Fuel consumption for the ATVs was established at 105 gallons, with 405 gallons of gasoline attributed to the lodges' marine pleasure craft.

7.2.2. Commercial Stationary Sources - CAPS

The calculation of CAP emissions for Government operations is included in Section 7.3. CAP calculations for commercial stationary operations include seasonal lodge facility operations. There are no shopping centers, grocery stores, or other commercial operations in Pedro Bay.

As with the above residential emissions, all emissions in the CAP section are calculated using four key indicator pollutants: CO, PM_{10}, $PM_{2.5}$, and HCs. Measurable emissions of SO_2 and NO_2 were minimal.

7.2.3. Commercial Lodge Operations - CAPS

CAP emissions from lodge operations include facility water and sewage pumps, facility heating, grounds keeping equipment (chainsaw, brush trimmer, and lawnmower), and the propane dryer which is used to support lodge housekeeping as well as the use of the lodge's ATVs for personal trips to and from the community.

7.2.3.1. *Carbon Monoxide*

Commercial lodge operations produced 29,673.8 lbs. (14.8 tons) of CO. The largest source of CO came from various guest services, including recreational activities (campfires), and recreational transportation after arrival. These activities generated 15,057.3 lbs. (7.5 tons) of CO. The second largest category of emissions-generating activity came specifically from transportation-related emissions, these being guest transportation to and from the airport as well as in transporting guests directly to and from destination fishing locations in the region. These services produced 9,176.53 lbs. (4.588 tons) of CO. See Figure 10.

7.2.3.2. *Hydrocarbons*

Total HCs released from the commercial facilities are 1,933.5 lbs. Both facilities released 905.7 lbs. of HCs in total. Employee emissions were 121.9 lbs., which included the use of the propane dryers for personal use, as well as the use of lodge ATVs for trips to and from Pedro Bay. The largest source of hydrocarbon emissions were water pumps which produced 458.53 lbs., followed by sewage pumps with 250.11 lbs. Under employee emissions, the largest source of hydrocarbon emissions the propane dryer, which released 72 lbs. of HCs into the atmosphere. See Figure 11.

7.2.3.3. *Particulate Matter*

Combined, the lodges and employee operations released under 430 lbs. each of PM_{10} and $PM_{2.5}$. PM_{10} emissions from both lodges and employees are 429.3 lbs., with the largest emissions source being the propane dryer, which released 96 lbs. followed by the lodge fireplaces which released 80 lbs. See Figure 12.

For more information about the emissions factors used to generate data on the lodge propane dryer and the fireplace, please see Appendix A.

Figure 9: Commercial CAP Emissions - Carbon Monoxide

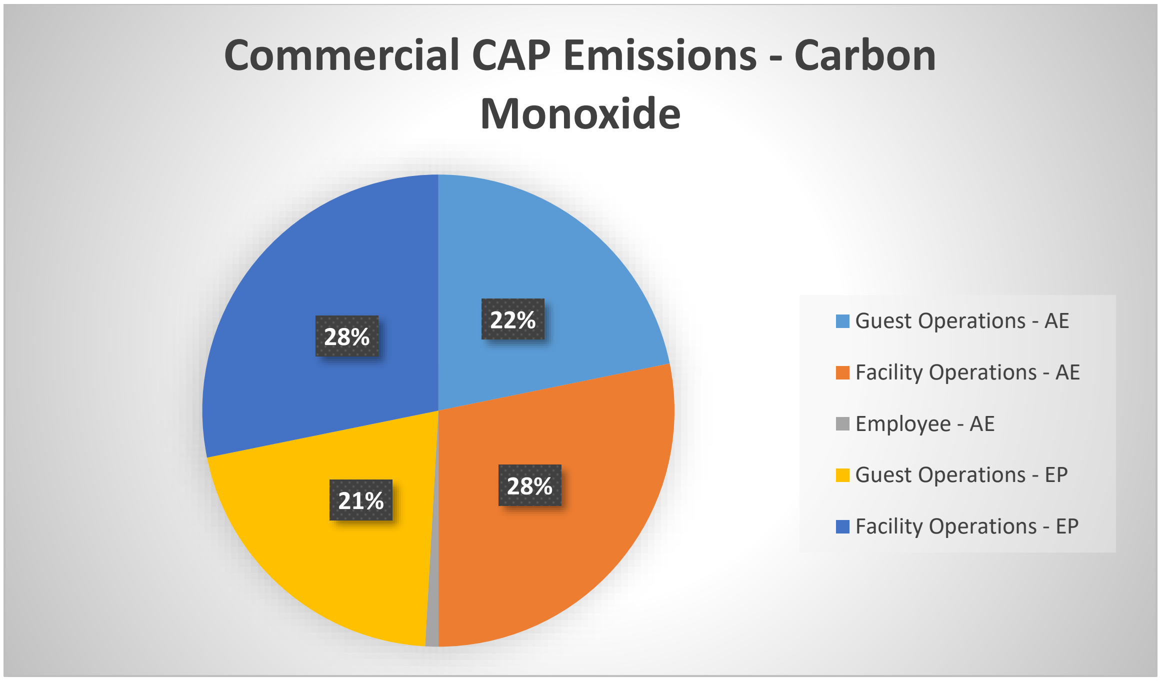


Figure 10: Commercial CAP Emissions - Hydrocarbons

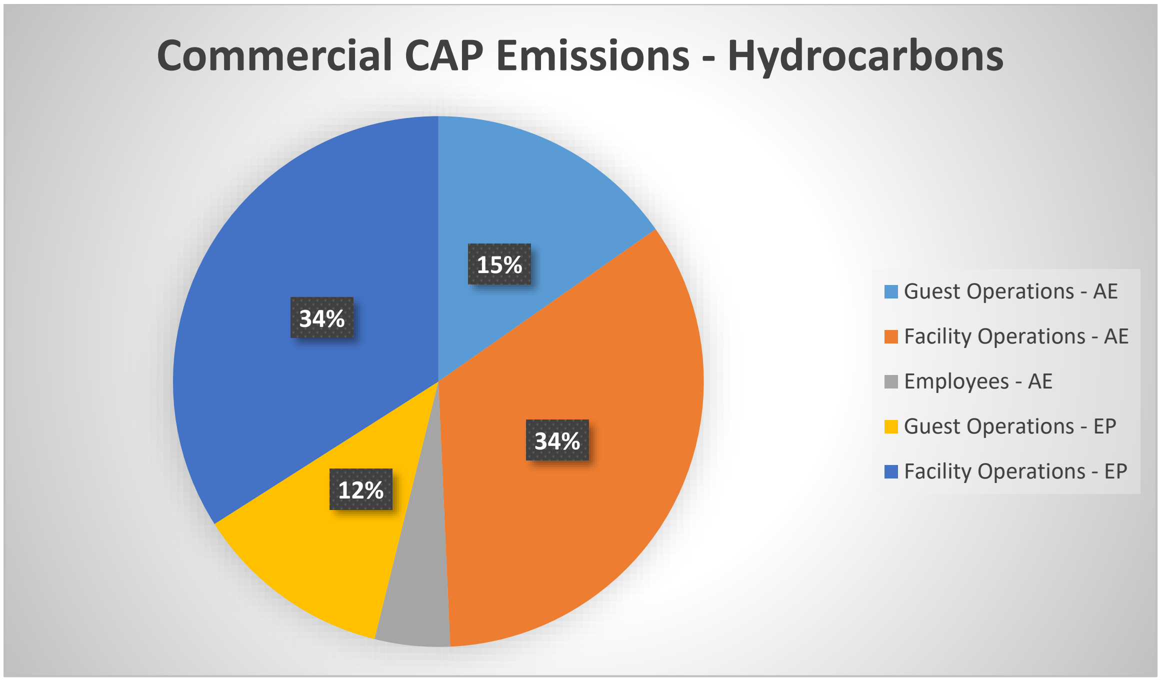
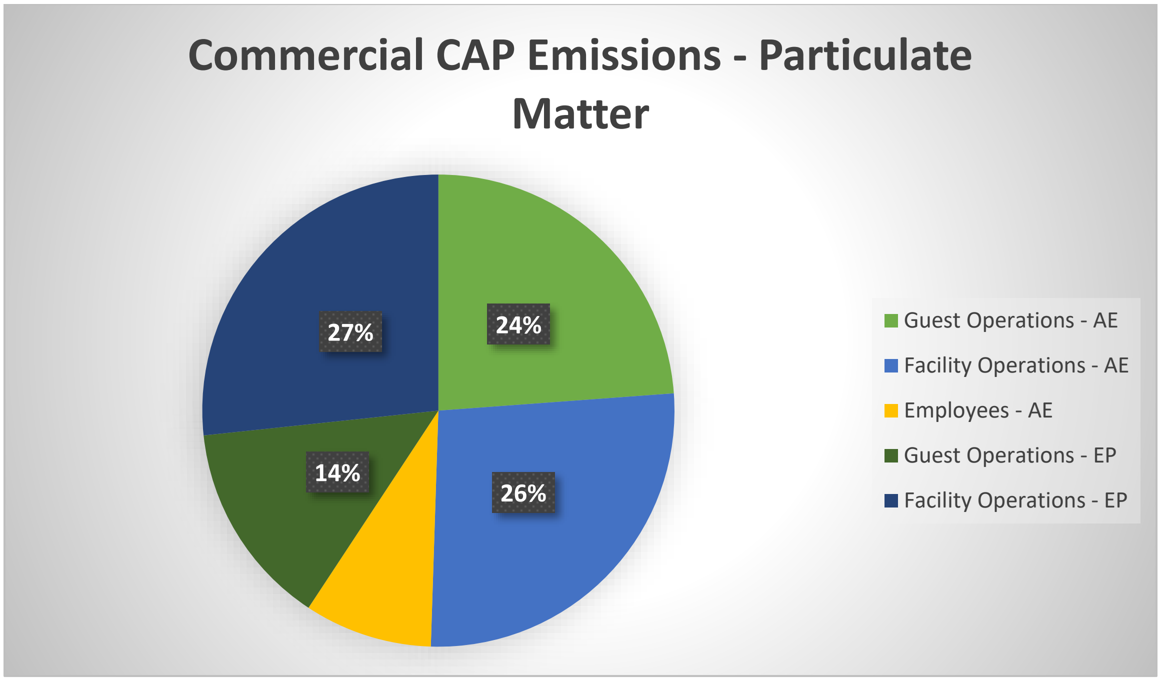


Figure 11: Commercial CAP Emissions - Particulate Matter



7.2.4. Commercial Lodges – Guest Transportation - CAPS

Lodge guest operations include guest use of the lodge's ATVs and marine pleasure craft. For aircraft flights operated by the lodge, these emissions cover both the landing and takeoff cycle from the lodges to destination fishing locations around Lake Iliamna.

7.2.4.1. *Carbon Monoxide*

Guest transportation operations at these lodges produce approximately 34,770.8 lbs. (17.3 tons) of CO emissions. The largest source of emissions are the lodge aircraft, which produce 19,369.7 lbs. (9.6 tons). Guest operations at both lodges produced 7,860 lbs. (3.9 tons) at Angry Eagle and 7540.97 (3.7 tons) at Eagle's Peak. It should be noted that emissions produced by the aircraft are limited only to the LTO Cycle for air flights bringing guests to and from the destination fishing spots around the lake. All of the lodges in the Lake Iliamna region bill themselves as adventure/sport fishing lodges and they primarily use float aircraft to bring their guests to and from guided fishing or hiking locations. During ADEC's site visit in June 2019, lodge owners verified the number of flights they conducted during the summer months, as well as the relative length of each flight.

7.2.4.2. *Hydrocarbons*

Lodge aircraft use is one of the largest sources of emissions with 705 lbs. of HCs produced. Although there was a great deal of utilization by guests of the ATVs and marine pleasure craft, the lodge aircraft are a considerable source of hydrocarbon emissions. In addition, given their relative age and utilization during the busy tourist season, the engines could produce more emissions than are estimated in this study based on available emissions factors.

7.2.4.3. *Particulate Emissions*

Lodge aircraft were the largest source of PM 2.5 and 10. In the category of PM_{10}, lodge aircraft produced 491 lbs., with aircraft from Angry Eagle producing 390 lbs. For $PM_{2.5}$, lodge aircraft overall produced 426 lbs. Angry Eagle Lodge aircraft produced 338 lbs. Iliamna River Lodge produced 88 lbs.

7.2.5. Commercial Air Cargo– Transportation Sources

Commercial passenger and cargo air service emissions generated by airlines and services flying into and out of Pedro Bay Airport are calculated for residential, government and commercial sectors. These calculations include summer and winter emissions generated by the two air cargo services that reported back to ADEC. In addition, the three passenger air services all provided their own estimates of the number of air flights into and out of the Pedro Bay Airport during a calendar year.

Aircraft emissions include the LTO Cycle, as well as those produced at cruise altitude to and from the airport. All cruise emissions are estimated using Anchorage Merrill Field as the initiating airport and Pedro Bay Airport as the landing strip. Commercial emissions include air flights which serve local residents as well as lodge guests. Calculations of the identified CAP pollutants include both LTO and cruise emissions.

7.2.5.1. *Carbon Monoxide*

Total aircraft CO emissions from all sources were 40,866.8 lbs. (20.4 tons). Cargo flights to and from Pedro Bay added up to 1,686.9 lbs. of CO (0.84 tons). See Figure 14. Passenger flights emitted 10543.9 lbs. (5.27 tons) of CO. See Figure 13. There are seasonal differences in engine performance (Appendix B) that generate different emissions factors reflected in the emissions totals generated for both the LTO Cycle as well as at cruise altitude. See Figure 13.

7.2.5.2. *Hydrocarbons*

Total aircraft emissions of HCs were 1,511.3 lbs. (0.75 tons), with 125 lbs. generated by cargo flights, and passenger service generating 1,293 lbs. While these emissions are under one ton for the calendar year, there are differences between summer and winter. Those emissions generated during summer months produce 0.15 lbs. per LTO more in summer than in winter. The emission volume is more variable in calculating cruise altitude emissions, as there are differences in how each aircraft generates emissions based on age, airframe, engine size and horsepower, and other factors.

7.2.5.3. *Particulate Matter*

Aircraft PM emissions are below 450 lbs. for both categories of pollutants. Total annual PM_{10} emissions are 413.4 lbs., with 392.2 lbs. of this pollutant coming from passenger air service and 21.2 from cargo flights. PM2.5 emissions are 340.4 lbs., primarily from passenger air service and 18.4 lbs. from cargo flights.

Although the cargo flights coming and going from the community use larger and older aircraft, the number of LTOs are comparatively few. Both air cargo services provided 20 flights in total during the calendar year to Pedro Bay. By comparison, all three air passenger services provided 370 total flights to and from the community during the calendar year.

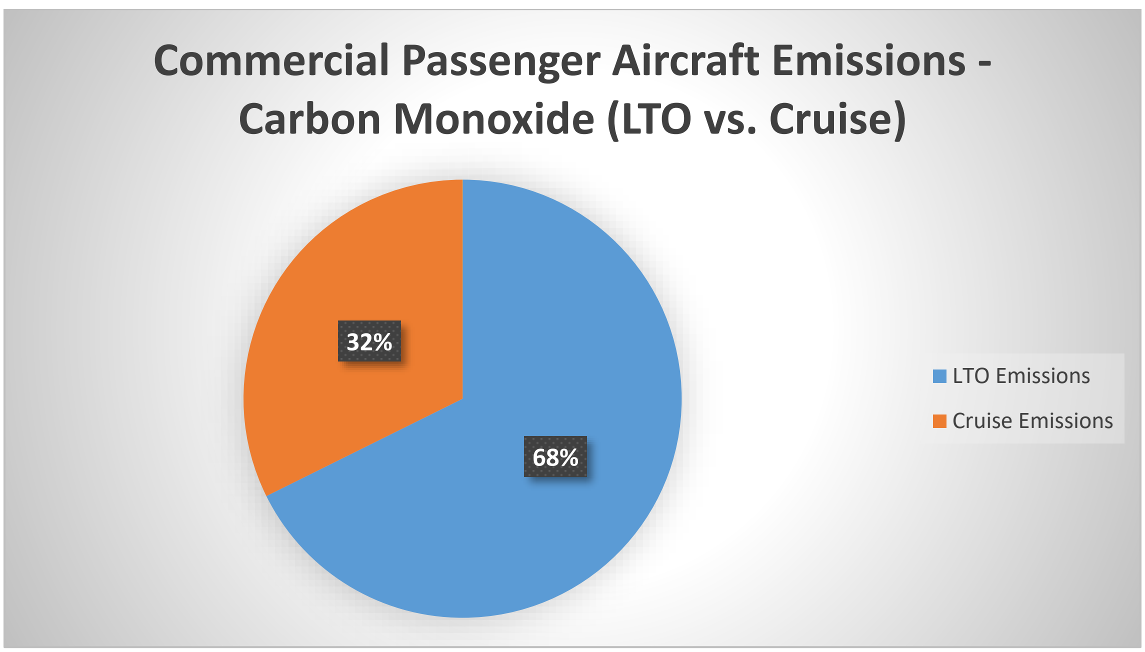
7.2.6. Commercial Barge Operations

Barge emissions are calculated as a whole, including semi-truck emissions generated by hauling cargo to the barge landing on southern Lake Iliamna and barge emissions to Pedro Bay.

Barge services on Lake Iliamna are limited to a single service company which operates a small tug-and-barge from the southern shores of the lake during the summer months. All cargo is initially barged across Cook Inlet from the port of Homer, where it is offloaded in Pile Bay and driven north on an unpaved portage road by a semi-truck which is only accessible during the summer. Once there, the small tug-and-barge load cargo from May through the end of September.[39] The barge makes approximately 10 trips per year from Pile Bay north to Pedro Bay. With the mileage added together for the semi-truck and the barge, emissions are as follows: CO at 59 lbs. HCs at 13 lbs. and PM_{10} and $PM_{2.5}$ at 7.2 and 7 lbs. respectively. These emissions calculations do not include transport of goods from Homer across Cook Inlet to Pedro Bay.

For any additional information or guidance on emissions factors substitution explanation or other guidance, please see Appendix A. For emissions factors, please see Appendix B.

Figure 12: Commercial Passenger Aircraft Emissions - Carbon Monoxide (LTO vs. Cruise)



[39] For more information about current operations of the Iliamna Barge, please see the following article: "Iliamna Lake levels barely high enough for Bristol Bay boat portage," Nick Ciolino, *KDLG*, June 8, 2017, available at: https://www.kdlg.org/post/iliamna-lake-levels-barely-high-enough-bristol-bay-boat-portage#stream/0 (Accessed 4/16/2019).

Figure 13: Commercial Cargo Aircraft Emissions - Carbon Monoxide (LTO vs. Cruise)

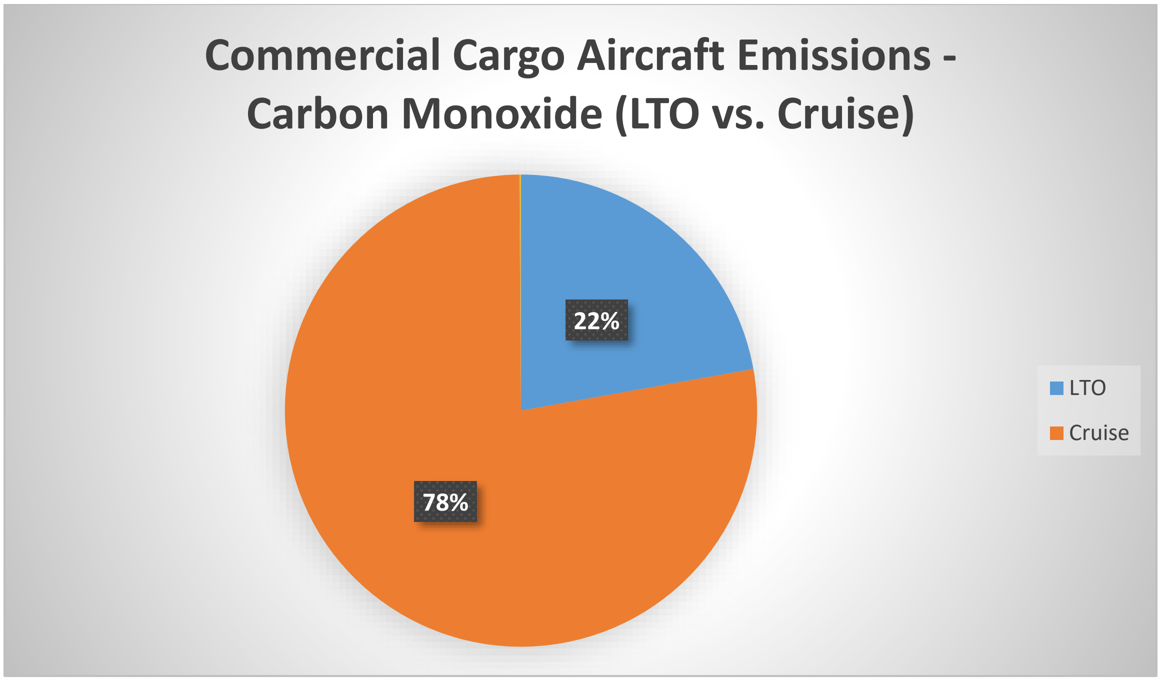


Figure 15: Commercial Aircraft Emissions: Cargo and Passenger Carbon Monoxide (LTO vs. Cruise)

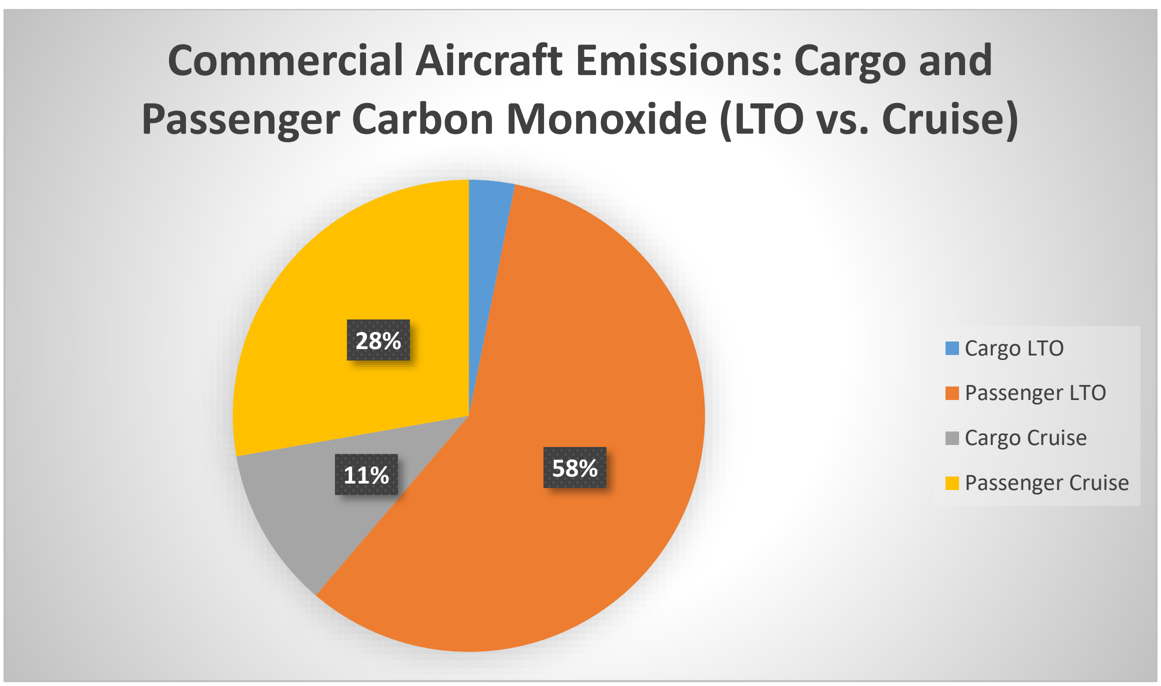
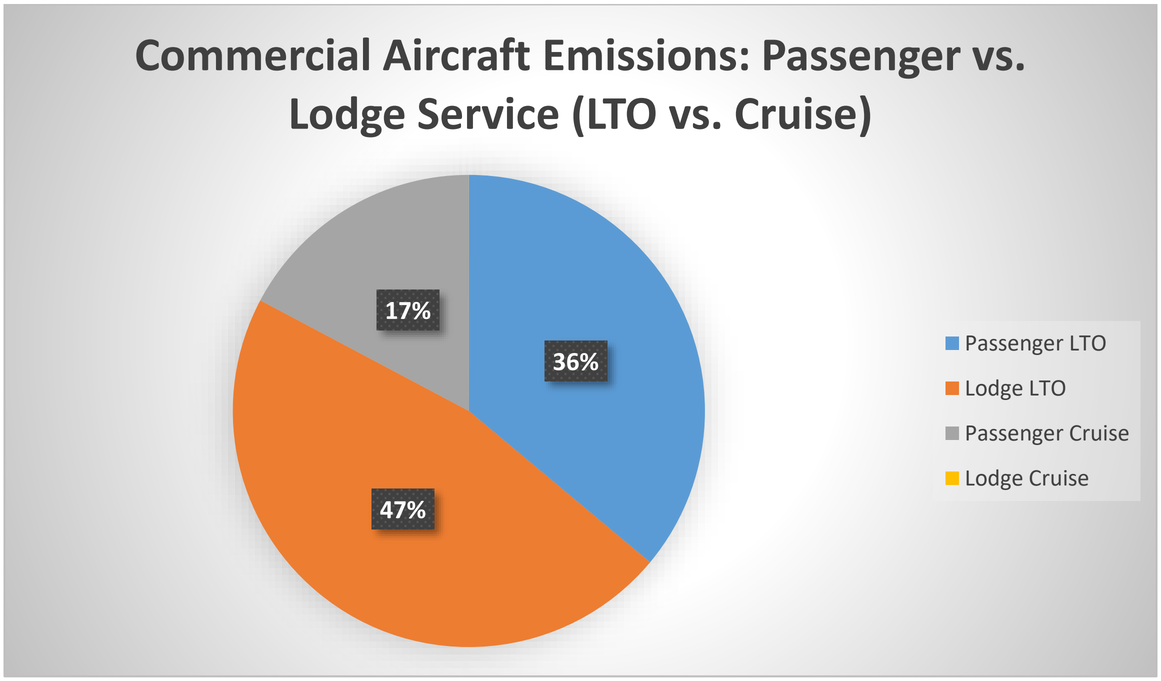


Figure 16: Commercial Aircraft Emissions: Passenger vs. Lodge Service (LTO vs. Cruise)



7.3. GOVERNMENT SOURCES - CAPs

Sources covered under the larger heading of "Government Sources" includes stationary and mobile sources. Stationary sources include water pumps, facility heating, and space heaters used in government buildings. Mobile sources include the ATVs, construction equipment, light trucks, and garbage haulers used by the PBVC to service the community's landfill. In addition, under landfill operations GHG emissions are included in CAP emissions. This is because the only CAP emissions that could be estimated were those generated by the landfill burn box, which is used once a week for two to four hours according to the Pedro Bay Environmental Coordinator.

7.3.1. Government Operations – Community Power Generator, Facility Heating, Water Pumps, and Backup Generators

GHG calculations for government operated facilities are included in Commercial/Industrial Section 7.2. Only CAPS are included in this section. The stationary government sources are the main community power generators, two generators that the PBVC uses for temporary operations, water pumps that service the main Pedro Bay Village Building, as well as the space heaters and facility heating for government operated buildings.

The electrical generator emissions are calculated separately from facility heating, pumps, and backup generators which allows for a more direct comparison between these fixed emissions sources. These fixed emissions sources operate year-round to provide electricity generation capacity to the community and associated emissions s are much higher than those smaller intermittently run fixed sources.

Pedro Bay also has three, 12,000 gallon diesel tanks and one 8000 gallon gasoline tank which supply fuel for the community. In addition, community power generators are fueled by two 10,000 gallon diesel tanks located next to the generator building. During the site visit in June 2019, the community environmental officer verified that community tanks are filled once per year. Fugitive emissions (emissions of VOC's and CAP's generated by fuel tank venting and vehicle refueling) were not calculated for these tanks.[40]

Please note that Figures 18 and 19 show government operations without the community power generators. Comm. The large power generator outweighs all other stationary emissions sources. As it produces power for all public buildings, private homes, and two of the three local destination lodges, its emissions footprint reflects this usage pattern.

7.3.1.1. *Carbon Monoxide*

The community's primary power generator produced 21,516 pounds (10.758 tons) of CO for the year. This breaks down to approximately 0.896 tons per month, or 413.76 pounds per week. It should be noted that the power generator supplies all necessary power to local residents, as well as all public buildings. By comparison, the space heaters and building heaters are only used in public spaces at times during winter months when necessary.

The three smaller fixed sources together (Facility Heating, Water Pumps, and Backup Generators) produced 16,412.16 lbs. (8.206 tons) of CO. The majority of CO emissions came from the large facility forced air heaters that are used in the Administrative House, the Big Hill House, and the Mid-Residential Unit in the community (10,644 lbs., or 5.32 tons). The other large source of emissions is from the space heaters in use in the community shops and buildings where space heaters are required to maintain a comfortable temperature. These emissions resulted in 4,121.90 lbs. (2.06 tons) of CO.

7.3.1.2. *Particulate Matter*

The community's large electrical generation unit produced approximately 2,370,628 lbs. (1,185 tons) of PM_{10} and 1,981,729 lbs. (990 tons of $PM_{2.5}$). Monthly emissions are calculated at 98 tons of PM_{10} and 82 tons of $PM_{2.5}$.

The largest $PM_{2.5}$ and PM_{10}, emissions from the smaller fixed sources were the facility heating system and space heaters. Facility heating released 851 lbs. of PM_{10} and 825 lbs. of $PM_{2.5}$, with space heaters producing 329 lbs. of PM_{10} and 319 lbs. of $PM_{2.5}$. These are large heaters which are used to maintain public buildings and workspaces at comfortable temperatures at all times of the year. Pumps and generators produced very little overall PM at either size. Backup Generators produced under one pound of both, while pumps produced 1.5 lbs. each for the entire year. See Figure 19.

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[40] Information on tank farm size and capacity found in following: "CIAP WEAR Trip Report: Pedro Bay (population 42) May 30, 2013," Alaska Department of Environmental Conservation- Solid Waste Program, Coastal Impact Assessment and Review, May 30, 2013.

Given the disparity in overall PM emissions between the electrical generating unit and the remaining stationary government sources, a graph was not created to illustrate this category of emissions.

7.3.1.3. *Hydrocarbon Emissions*

Facility and space heaters are the largest of the small source hydrocarbon emitters with 5,307.1 lbs. (2.65 tons) produced by facility heating, and 2,055.30 lbs. (1.02 tons) by space heaters. These heaters are in use for much of the year and are essential to maintain building function and public comfort during fall, winter, and early spring. The community power generators by comparison produced 3,723,499 lbs. (1861.7 tons) (of hydrocarbons per year, or 155 tons per month. Please note that the community power generator emissions represent continuous use throughout the year, while the space heaters are in use during the winter and spring months to raise ambient temperatures in work and public spaces to comfortable levels.

Figure 14: All Government Stationary Sources - Carbon Monoxide

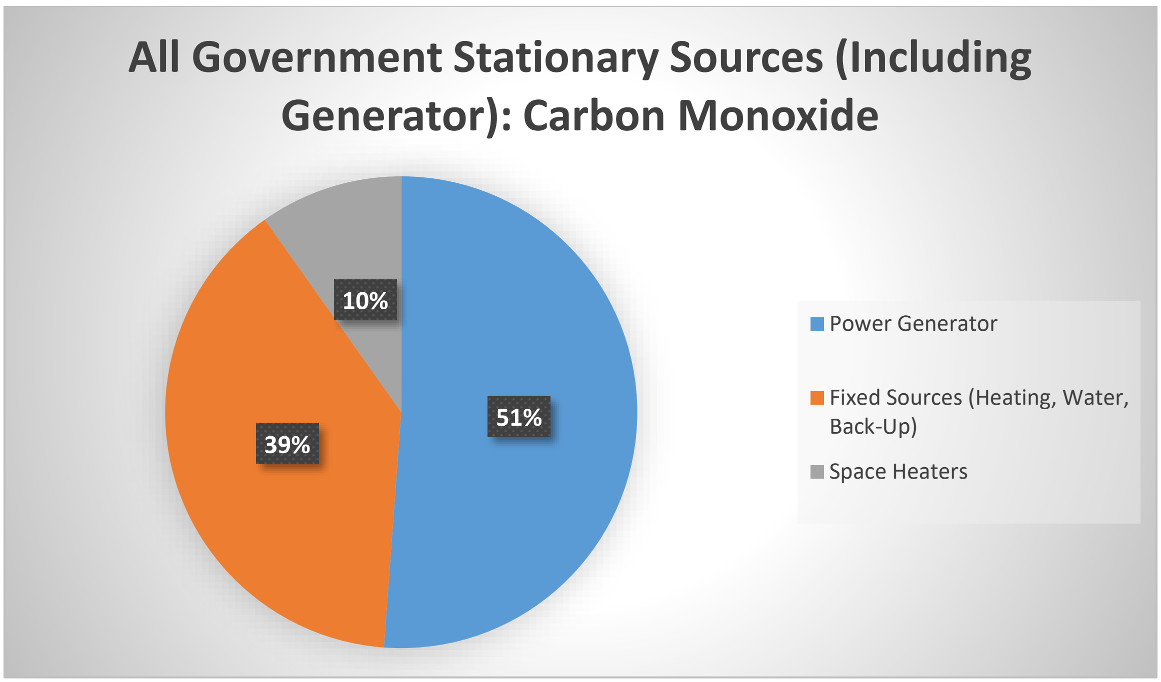


Figure 18: Small Government Stationary Sources - Carbon Monoxide

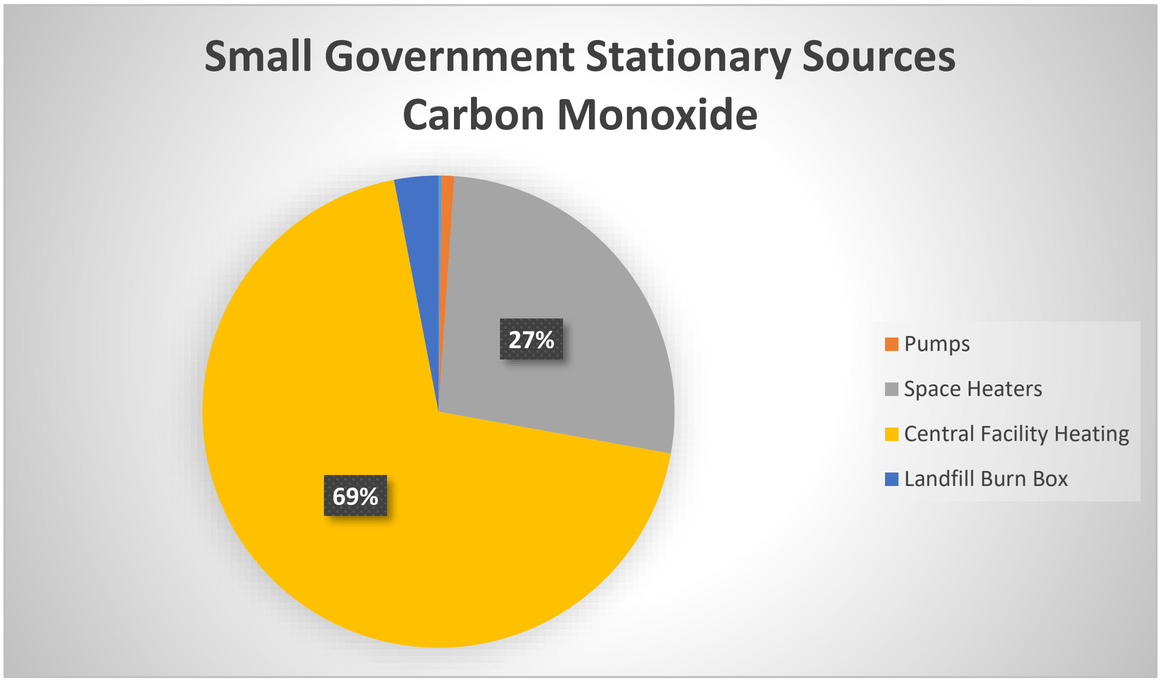
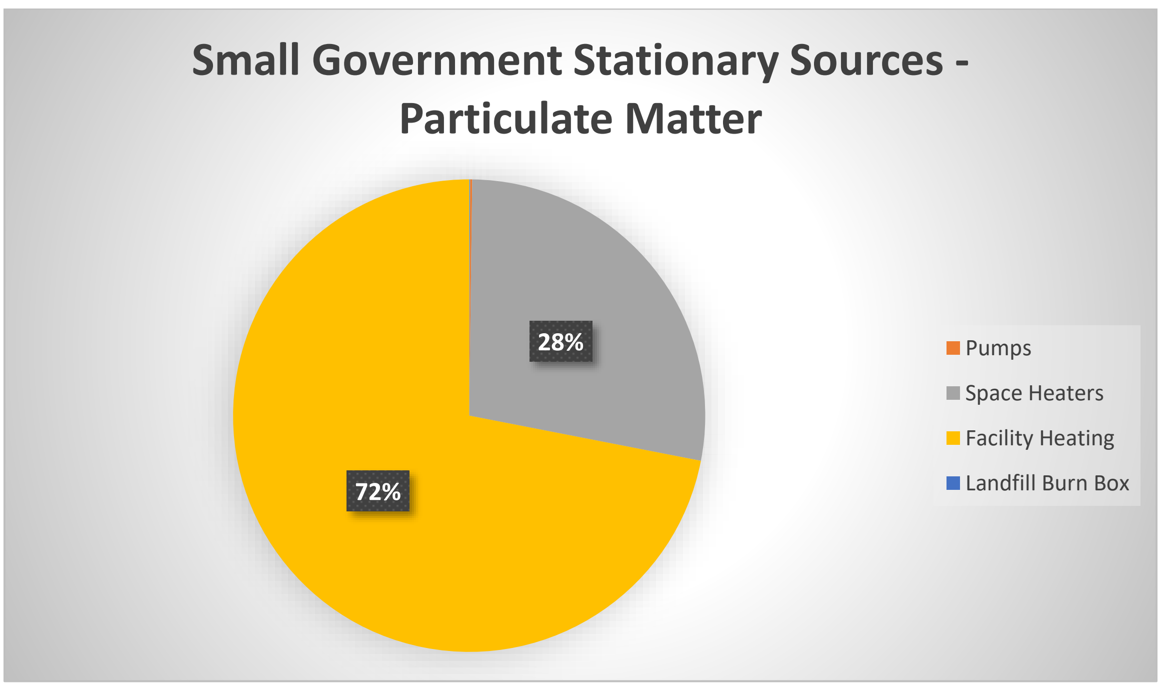


Figure 19: Small Government Stationary Sources - Particulate Matter



7.3.2. Government Transportation (trucks, service vehicles, construction equipment)

Government transportation includes all government owned vehicles used for transport and village operations. These include refuse haulers and construction equipment, along with the heavy diesel trucks and gasoline-fired light trucks used by the village council.

Under the category of government light-trucks and the community van, all vehicles produced 304 lbs. of HCs, 189 lbs. of NO_2, 4 lbs. of PM_{10}, 2.7 lbs. of $PM_{2.5}$, and 1,576.85 lbs. of CO. These vehicles are widely used throughout the year by the PBVC for all government activities. By comparison, the heavy diesel trucks used to service the landfill and other labor-intensive areas of the community produced much less. These vehicles produced 31 lbs. of HC, 66 lbs. of CO, 105 lbs. of NOx, 7 lbs. of PM_{10}, and 6 lbs. of $PM_{2.5}$. These emissions have a much smaller footprint because of the limited uses of these trucks, which is to haul trash and heavy equipment to and from the community landfill.

For the government owned light motorized and heavy motorized equipment (including road graders, tractors, etc.), emissions went up significantly compared to the smaller light trucks. Light motorized equipment produced 50 lbs. of HC, over one ton of CO, 151 lbs. of NO_2, 1 lb. of PM_{10}, and 0.78 lbs. of $PM_{2.5}$. This light motorized equipment had the same comparative mileage as the heavy diesel trucks used by the Pedro Ba Village Council. The difference is that these vehicles are using diesel and they have much less efficient engines.

The community's heavy diesel machinery, which includes the refuse haulers and other equipment, produced 46 lbs. of HC, 212 lbs. of CO, 557 lbs. of NOX, 34 lbs. of PM_{10}, and 60 lbs. of $PM_{2.5}$. This construction equipment's activities were all for the purposes of maintaining the community landfill, as well as to grading the local road surfaces.

Lastly, the PBVC's ATVs produced 5 lbs. of HC, 5 lbs. of CO, 0.01 lbs. of NO_2, 0.23 lbs. of PM_{10}, and 0.74 lbs. of $PM_{2.5}$. These vehicles, along with their smaller and more efficient engines, are not as widely used as the light trucks and vans by the village council. The ATVs can also be rented out to visitors to the community on an hourly or daily basis.

7.3.3. Waste Management (landfill, incineration, burn box)

This segment of emissions includes GHG emissions and CAPs. But, as it does not include CAP estimates for landfill emissions, it is not fully representative of community waste management emissions. Using the GHG Toolkit, the community's landfill was estimated to produce one MT of CH_4 per year. The only portion of these calculations which has CAPs are for the landfill burn barrel. According to estimations, the community incinerated 12,220 pounds of trash per year. These came out to 232.18 lbs. HC, 464.36 lbs. CO, 32.99 lbs. NOX, and 85.54 lbs. of PM_{10} and $PM_{2.5}$.

Figure 150: Government Transportation Sources - Carbon Monoxide

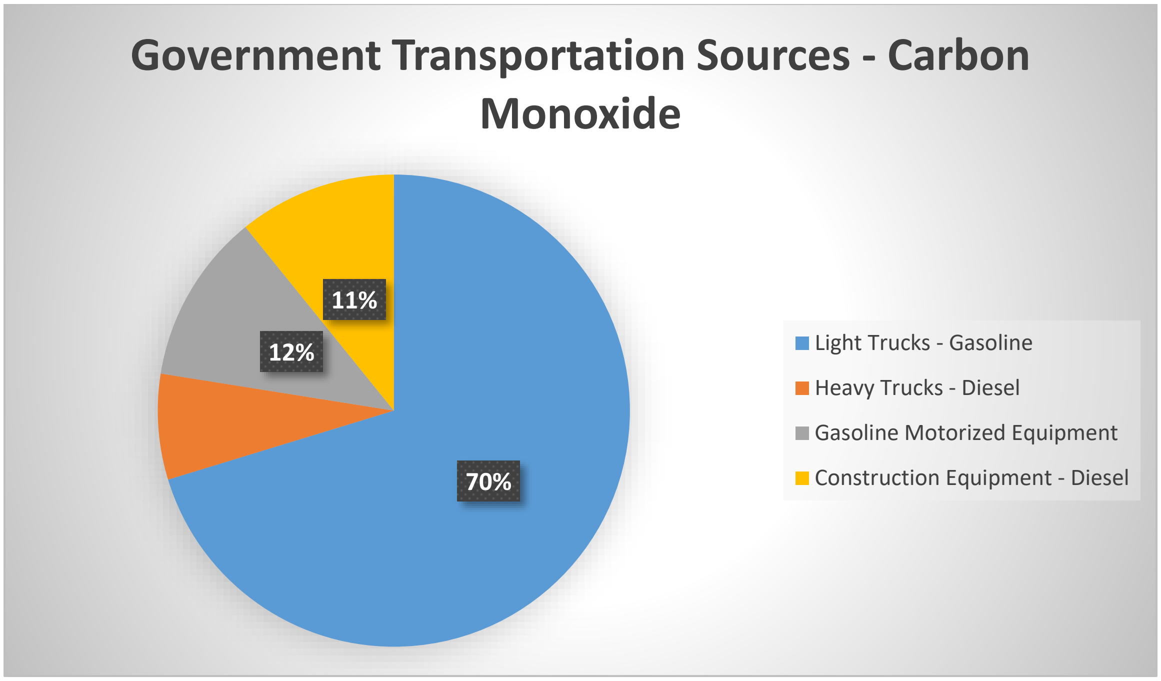
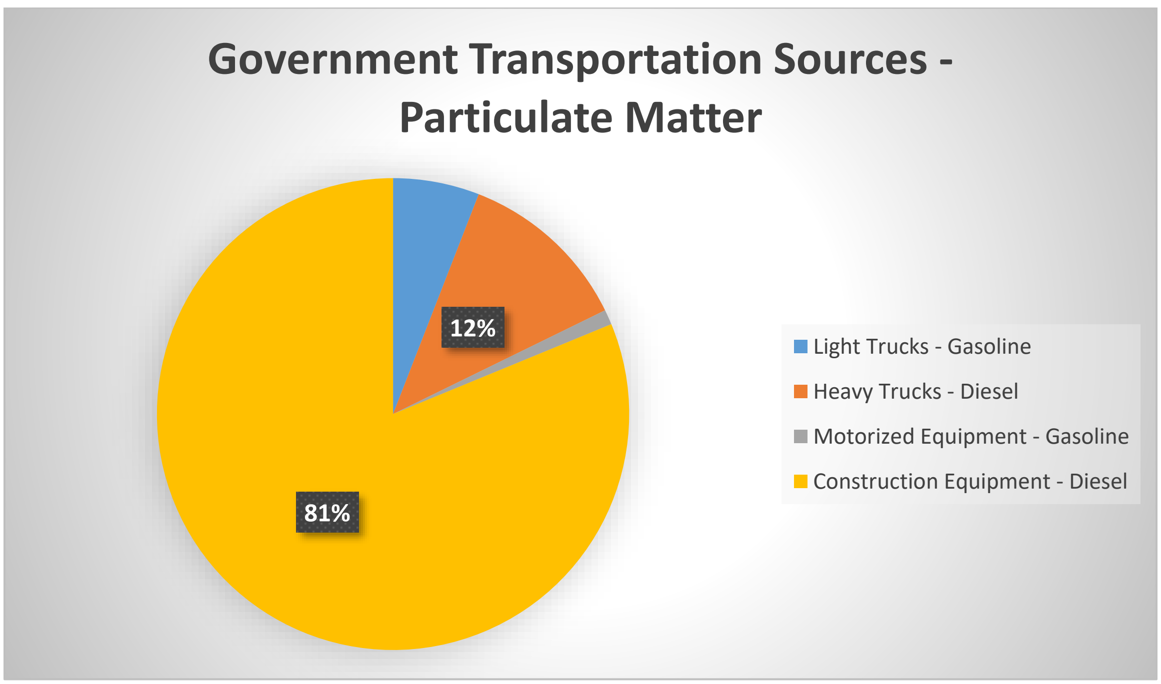


Figure 161: Government Transportation Sources - Particulate Matter



8. INVENTORY AND DATA ANALYSIS

8.1. OVERVIEW DISCUSSION

Emission inventories, while not exact, allow researchers and environmental officers to understand the emissions generating capacity of different sources. The results provide a rough measurement for governments, businesses and residents to visualize their overall emissions footprint.

This section compares sources with the aim to better understand typical emissions from a rural Alaskan community not on a road system and which brings in goods via air and water transport. This inventory is the most comprehensive rural inventory produced by the State and can be used for similar communities apportioned to population. The inventory focused on the emissions from the year 2017. Should the population change in a more dramatic fashion, additional lodges open in the area, or other changes occur, the community's emissions footprint would likely change.

8.2. TRIBAL GHG TOOLKIT RESULTS

8.2.1. Total GHG Emissions

The community of Pedro Bay produces approximately 604 metric tons (MT) of CO_2, 11 metric tons of CH_4 and one ton of NOx, with a total of 616 metric tons of CO_2e per year.

The community's per capita GHG footprint is smaller than that of the rest of the United States. As of 2014, according to the World Bank, the per capita carbon footprint of the United States was 16.5 MT CO_2 per person.[41] While the community is still dependent on air flights and barge traffic to bring goods and services to and from the remote location, Pedro Bay still has a comparatively small carbon footprint when placed alongside national emissions: 7.33MT CO_2e per capita. State per capita emissions are 48 MMT CO_2e, which includes the State's share of all industrial and commercial emissions.[42] If these state-level emissions are calculated without industrial emissions, per capita emissions are reduced to 25 MMT CO_2e.[43]

8.2.2. GHG Emissions by Emissions Sector

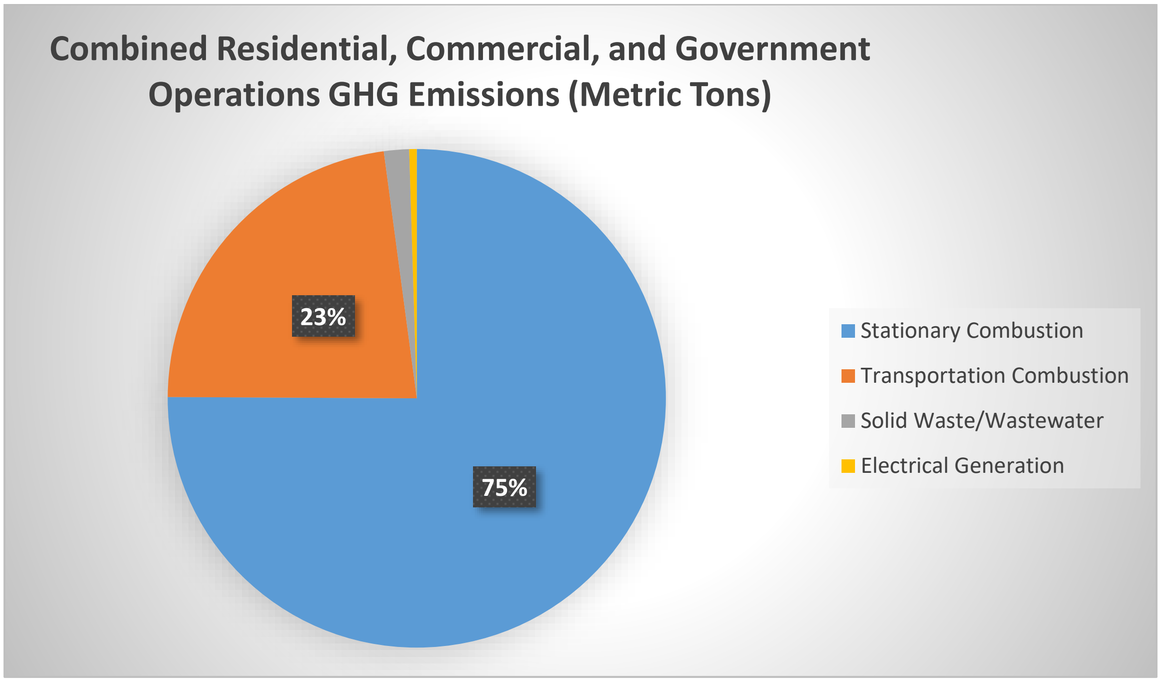
Combined residential, commercial and government operations by sector are:

- Stationary combustion = 461 MT CO_2
- Transportation related combustion = 140 MT CO_2
- Solid waste and wastewater treatment = 10 MT CH_4, 10MT CO_{2e}
- Electrical generation= 3 MT CO_2

[41] For more information, see World Bank CO2 Per Capita Emissions data, available at: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC (Accessed 5/14/2020).
[42] "Alaska Greenhouse Gas Emissions Inventory: 1990-2015," Alaska Department of Environmental Conservation, Division of Air Quality, January 30, 2018, available at: https://dec.alaska.gov/media/7623/ghg-inventory-report-overview-013018.pdf (Accessed 4/16/2019), p. 19.
[43] Ibid, p. 20.

The percentage of these emissions are depicted in Figure 22.

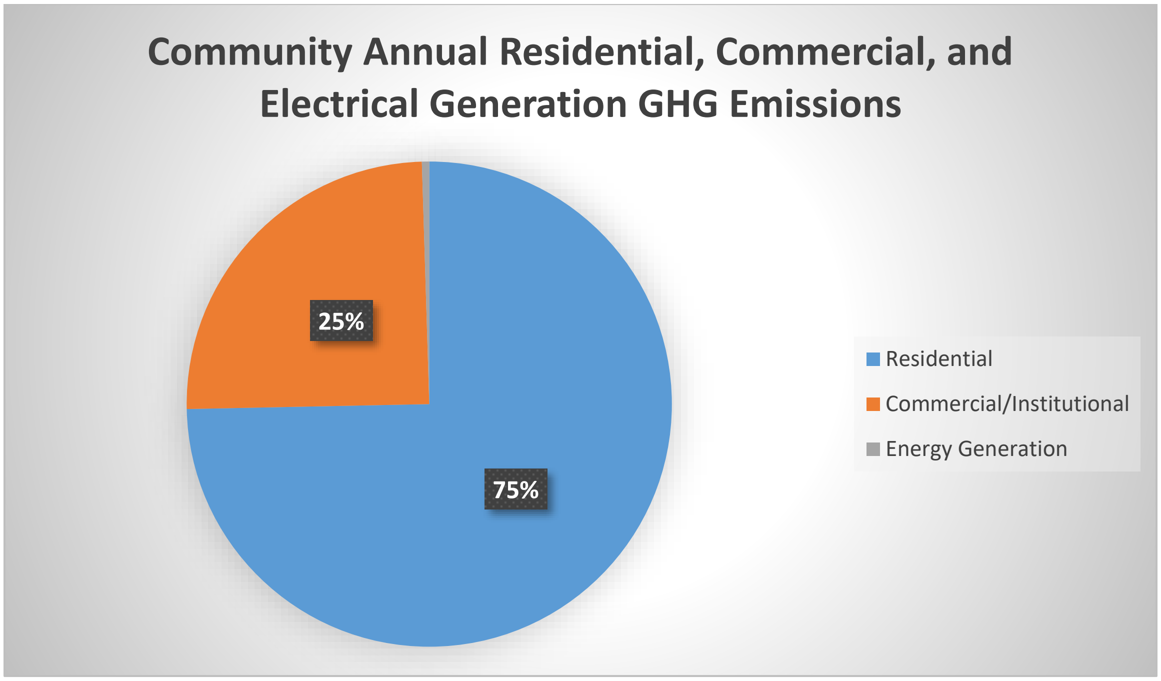
Figure 172: Combined Residential, Commercial, and Government Operations GHG Emissions



8.2.3. Residential and Commercial/Government GHG Emissions

The residential sector produced 74% (448 MT CO_2) of the community's annual emissions, the commercial/institutional category produced 25% (153 MT CO_2) and industrial and electrical generation was 1% (3 MT CO_2) of total emissions. One final sector of the emissions by source, agricultural and land management, had no emissions as there were no organized (or unorganized) agricultural activities that took place on Pedro Bay lands during the calendar year. See Figure 23.

Figure 183: Community Annual Residential, Commercial, and Electrical Generation Emissions



8.2.4. GHG Emissions by Fuel Type

Within the stationary emissions sources, the largest single source of emissions was recorded as wood. Since the GHG Toolkit does not include wood, propane was used as the data replacement. Using the wood-propane calculation described in Appendix A, the community's approximate emissions from propane burned during the year (50,883 gallons) was 284 MT CO_2. In addition, one ton of methane and two tons of nitrous oxide were released according to this stand-in for wood consumption. These emissions are an estimation, though are likely underestimated as propane is a much cleaner burning fuel source than wood. In addition, as it was not clear whether or not all homes burned dry, wet, or a mixture of dry and wet wood, the likelihood is that the emission estimate is likely larger.

8.2.5. Land Use/Land Change (LULC)

LULC measures the amount of CO_2 that can be absorbed by the surrounding forested areas around a community. Submerged lands and non-vegetated lands (15%) were subtracted from lands owned and managed by the PBVC resulting in an estimated vegetated land cover of 17.5 square kilometers. The GHG Toolkit calculated that the total amount of carbon sequestration available from the surrounding area was 12,162.79 MT CO_2. When the community's 616 MT CO_2 are subtracted from available carbon sequestration potential the net result is a credit of 11,547 MT of CO_2.

What this means for the community of Pedro Bay is that their overall carbon footprint is much smaller than the surrounding forested area is capable of sequestering in a given year.

8.3. CRITERIA AIR POLLUTANT CALCULATION RESULTS BY POLLUTANT – TOTAL COMMUNITY EMISSIONS

The overall CAP emissions of the community of Pedro Bay are small, given the size, location, and economic underdevelopment of the area compared to other parts of the state. Its geographical isolation and physical isolation, being only accessible via an unpaved portage road passable during summer months or by air, means that the community has been insulated from statewide economic growth over the past 40 years. There is no large-scale industry to speak of in the community which could produce large amounts of CAPs and generate the type of emissions which could negatively impact human health. The only large source of CAPs in the community are from its households, and more specifically from the burning of wood as the primary fuel source for heating and conducting subsistence activities like food preservation.

8.3.1. Carbon Monoxide

During 2017, the community of Pedro Bay released 666,076.1 pounds (333.04 tons) of CO from all emissions sources. Residential households contributed 85% of the total CO emissions (542,616.7 lbs.). The lodges were the second largest contributor of CO at 85,397.9 lbs. (42.6 tons). Government CO emissions were third highest at 21,516.1 lbs. (10.5 tons).

CO emissions generated by air passenger and cargo services were the fourth highest at 5,333.4 lbs. (7.6 tons). Community emissions from air passenger and cargo services were calculated from landing and take-off data only.

8.3.2. Hydrocarbons

The community released 26,693.4 lbs. (14.8 tons) of HCs in 2017. Of these, residential households released 89% of these emissions at 16,594.65 lbs. (8.29 tons). Government sources were responsible for 27% of these emissions at 8,116.61 lbs. (4.05 tons). Commercial sources released approximately 3% and came out to the following totals:

- Lodges released 3,457.502 lbs. (1.72 tons)
- Air services released 1,511.34 lbs. (< one ton)
- Barge services released 13.38 lbs.

8.3.3. Particulate Matter

The community released a total of 14,852.69 lbs. (7.42 tons) of PM_{10}, and 13,280.23 lbs. (6.64 tons) of $PM_{2.5}$ from all emissions sources.

In both categories of emissions, the community's households released the largest amounts of pollutants at 12,516 and 11,019 lbs. Because the majority of PM_{10} and $PM_{2.5}$ emissions are from the community's woodstoves, saunas, smokehouses, and campfires, these figures can be seen as a reflection of the local culture's reliance on wood as a source of energy, heating, and subsistence practices support.

The total reported wood consumption in Pedro Bay during the calendar year, including the generic figures used as a stand-in for seasonal households, were a total of 109.22 cords of wood. Based on an average of all of the categories, most households burned 2 cords of wood during the year. It is unknown whether all households are using dry or wet wood in their woodstoves, saunas, or smokehouses. However, one of the local residents informed ADEC personnel during the kick-off meeting in October 2018 that they primarily used spruce bark beetle-kill trees which are dry wood. The use of primarily dry wood results in a lower PM count in both PM_{10} and $PM_{2.5}$ emissions.

These emissions also represent the community's adoption of catalytic, low PM release woodstoves. The Pedro Bay environmental officer verified that all homes, except one, were using these new EPA-certified woodstoves.

8.3.4. Sulfur Dioxide

Community emissions of SO_2 totaled 1,206.3 lbs. (0.603 tons). The majority of emissions came from the residential sector, which produced 932.1 lbs. The second source of SO_2 emissions in the community were its woodstoves (30.9 lbs.), smokehouses (11.2 lbs.), and saunas (9.92 lbs.).

SO_2 is a pollutant which ADEC monitors for regional haze purposes. Because the total amount of SO_2 in the community is low, this provides ADEC with a good baseline from which other communities can be measured.

8.4. SUMMARY OF LARGEST EMISSION SOURCES

8.4.1. Wood Combustion

In examining the data provided by both the GHG Toolkit and the CAP emissions calculations, the largest source of emissions in Pedro Bay are from its residential sector.

In particular, the community's use of wood as a primary source of energy for heating, recreation, and subsistence activities demonstrates how, despite the development of more efficient fuels, in many rural areas of Alaska wood is still the fuel of first choice. The availability and ease of collection make it the most important energy source in Pedro Bay besides gasoline and diesel for vehicles and power production. The community's consumption of wood for the year was 109.22 cords, an average of ~2 cords per household. The local voluntary woodstove change-out program likely reduced the community's emissions by a significant amount compared to what it might have been before. This type of program's voluntary nature was largely based on the efficiency of these stoves.

8.4.2. Aviation – Transportation and Cargo Services

Another important factor in the community's emissions footprint is the reliance on air flights. Pedro Bay's geographical and physical isolation off the road and rail-grid means that all goods and services must be either flown or barged into the area. While this generates a large amount of emissions, the end result is not as large as was initially thought. Cargo and passenger air emissions combined emitted only 6.5 tons of CO. Gross CO_2 emissions are difficult to calculate, as the commercial/institutional calculation includes government, air services, and lodges combined.

The most important factor in this is the use of smaller aircraft by the local passenger air services, as well as the limited number of cargo flights into the airfield. Local air cargo providers reported a total of 20 flights per year to Pedro Bay. Compare these figures to the 370 flights by small passenger aircraft. These smaller aircraft, primarily one and twin-engine Cessna's, only carry up to a half-dozen passengers in addition to their baggage. These flights can also serve double-duty as air mail flights, bringing letters and smaller packages into the community from Anchorage and elsewhere.

Even though these aircraft provide daily service to and from Pedro Bay, their overall emissions impact is small. That footprint provides access to goods and services from the rest of the world, without which Pedro Bay would likely be unable to function in the way that it currently does. The CAP footprint of the cargo flights is also small with 1.08 tons of CO and less than one ton of combined emissions from the remaining sources (HCs, NO_2, and SO_2). These flights provide heavy lift capabilities to bring in building materials and other large and bulky materials that cannot be delivered via the smaller passenger aircraft.

One of the cargo carriers also transports bulk fuel to the community, keeping the power grid operational and allowing the government to heat the PBVC Building from waste-heat, rather than operating another large central heating unit. These fuel flights also bring in gasoline to power the community's vehicles. The community's mobility depends on these flights continuing to bring in the fuel necessary to power their ATVs, trucks, and snowmobiles.

8.4.3. Commercial Lodge Emission Impact

The commercial lodges operate five months out of the year (May-September) and produce 42.6 tons of CO, 10.8 tons of N_2O, one ton of HCs, and less than one ton each of other pollutants including PM. These emissions include all air travel and other activities which draw a limited but growing number of destination fishing tours from around the world. That tourist draw generates a negligible amount of pollutants compared to household activities or subsistence.

The emissions-generating activities carried out by the lodge owners and guests have similar levels of variance as households. Guests have the opportunity to use the lodge's watercraft to go fishing on Lake Iliamna, utilize ATVs to travel to the community or use the hunting trails throughout the region to go sightseeing, or use the lodge's aircraft to access more distant rivers and trails. With that variety of activities, the comparative footprint of these activities is small.

8.5. POTENTIAL AND FUTURE EMISSION SCENARIOS

For communities such as Pedro Bay, with a relatively small emissions footprint and a population of under 100 including seasonal residents, the growth or reduction of any single sector of the economy could bring significant changes to their overall yearly emissions footprint. Electrical generation power shifting, growth of their local tourism industry, and other scenarios could change how Pedro Bay's emissions footprint looks in the decades to come. Population growth or contraction would have a greater impact still on the community's emissions, as the residential sector is the single largest sector of the community's pollution footprint.

The following scenarios can change the amount of air emissions.

8.5.1. Knutson Creek Hydropower Station

According to the Alaska Energy Data Inventory, in 2010 the State of Alaska funded the Pedro Bay Village Corporation to carry out a feasibility study for a new hydropower station, which would be a run-of-the-river station.[44] This station, according to the AEDI, would provide 95.6% of the community's power needs 2/3 of the community's building heating needs and lower electricity costs by 92%.[45]

The production of 95% of the community's electric needs means that if that last 5% of energy needs could be filled with non-petroleum based power generation capacity, the community would be almost energy independent. That independence would mean they could shut down their diesel generators entirely and stop importing diesel fuel for anything other than their construction equipment. The generators would need to be maintained for redundancy, or for periods when water levels in Knutson Creek would be too low to effectively generate electricity.

8.5.2. Population Change: Increase/Decrease

Another major impact on community emissions could be an increase in the number of residents who make Pedro Bay their year-round place of residence. Currently, 42 people claim Pedro Bay as their year-round residence. There are very few children who live in the community, and the school has been closed for several years. If the population were to grow, emissions would likely increase.

Population decline, even relative decline, is something that should also be considered. Pedro Bay's year-round population is 42, and doubles during the summer months. If a few more homes were converted from year-round residences to seasonal homes there would be an impact on the community's emissions footprint as woodstove usage decreases during winter months.

8.5.3. Government Building Upgrades

The most immediate change in current emissions would likely come from the renovation and re-opening of the teacher apartments as residences for locals and additional building energy efficiency upgrades. Currently, there are several apartments located in the library building which are inhabited. However, the building heating comes from central facility heating, which is the largest source of government-produced emissions in the community other than the diesel power generators. This heating unit consumed 1,576 gallons of diesel fuel, according to the emissions survey which translated to several tons of CO, NO_X, and other pollutants.

Presently, the teacher residence and Pedro Bay School, called the Dena'ina School, are owned by the Lake and Peninsula Borough School District. The school has been closed for several years and has been boarded up by the school district. If the school and teacher residence were to be transferred to the Village Council or the Pedro Bay Corporation, it is likely that the

[44] "Knutson Creek Hydroelectric Feasibility Study," Alaska Energy Data Inventory, available at: http://akenergyinventory.org/catalog/entries/8332-knutson-creek-hydroelectric-feasibility-study (Accessed 4/17/2019).
[45] Ibid.

buildings would need some sort of renovation work to reconnect the power, turn the water pumps back on, reconnect to the PBVC Building sewage system, and prepare the buildings for human habitation.

For the PBVC, the immediate impact of these renovations would be to cut the amount of fuel used to fire the library building central heating unit as residents would move to a more energy efficient teacher building. That would give PBVC the opportunity to survey the library structure and begin budgeting for upgraded weatherization to make the building more energy efficient.

8.5.4. Pebble Mine Opening

The Pebble Mine has been at the center of regional economic discussions for decades. First proposed by Cominco Limited in the latter part of the 1980's, the proposed mine will be one of the largest producers of copper, gold, and molybdenum in the United States.[46]

Pedro Bay is located midway between the proposed mine and a support dock located near Pile Bay on Cook Inlet. This dock will provide a shipping terminal through which minerals will be placed on barges and taken to Anchorage for transfer to large cargo carriers for export to the continental U.S., Asia, and Europe. In order to access this dock, the mine owners propose to construct a two-way unpaved road from the mine to the dock which will pass on the backside of the community. This proposal would result in an increase in local motor vehicle activity compared to current levels. At a minimum, PM would likely increase from traffic on the gravel road.

8.6. CONCLUSION

Pedro Bay's emissions, when compared to other communities in the state, are quite small. Its GHG emissions footprint is entirely offset by the surrounding forests and green-space. The community's willingness to engage in self-directed adaptations and emissions reduction strategies, such as the voluntary woodstove change-out program and building insulation upgrades, has resulted in a community which has a smaller footprint than many similar communities in Alaska. When the Knutsen Creek Hydropower Station comes online in years to come, the community's footprint will be further cut as diesel fuel shipments are reduced and the diesel generator operating hours will be reduced.

This sort of self-directed improvement will increase the likelihood that further adaptations and changes will occur in coming years.

[46] "The future of Alaska's Pebble Mine – and its salmon," Paul Greenberg, *High Country News*, June 28, 2018, Analysis Section, available at: https://www.hcn.org/articles/climate-desk-the-future-of-alaska-pebble-mine-and-its-wild-sockeye-salmon (Accessed 4/9/2019).

APPENDIX A: DATA ASSUMPTIONS, CLARIFICATIONS, CALCULATIONS, AND MODIFICATIONS TO EMISSIONS CALCULATIONS

Author's Note:

The information described below is a description of the Alaska Department of Environmental Conservation (ADEC) calculations process and a 'how-to guide' for community environmental officers, or village councils wanting to conduct an emissions inventory. Undertaking a detailed inventory can be a long and tedious process, involving hours of research to dig up a small piece of data to assist in calculating fuel economy, cruise speed, or burn rate. It is our hope that this document will provide a demonstration of how ADEC approached calculating emissions for Pedro Bay and assist your community in building its own emissions inventory

This appendix demonstrates that an inventory process is a large task, even for a small community and involves countless small decisions and assumptions. The most important piece of advice that can be given to a community considering taking an emission inventory is that it is a manageable task even for a small environmental staff. ADEC personnel had to make informed guesses and logical assumptions without residing in the community. While some guesses turned out to be wrong after speaking with local staff, others turned out to be close enough that changing them was unnecessary.

If you live and work in the community and are trying to establish emissions for households, a good yardstick to measure by is your own behaviors. If you burn a cord of wood per winter and use 15 gallons of gasoline in your snow machine, then odds are that your neighbor with a similar lifestyle likely does as well. This does not apply for every category but having local knowledge and understanding can get you a long way towards an inventory construction.

This appendix is divided into two categories; a walkthrough for the Greenhouse Gas Toolkit, and one for our Criteria Air Pollutant (CAP) calculations process. The detailed emissions factors and generic household data is included in Appendix B for those who want to use ADEC work as a basis for their own inventories.

If there are any questions regarding either Appendix A or B, readers are invited to reach out to ADEC-Air Quality, Non-Point and Mobile Sources.

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1. INTRODUCTION

ADEC personnel had to make many assumptions, informed logical guesses, and seasonally adjust emission estimations to calculate the community's yearly emissions footprint. These assumptions include a set of averaged emissions for generic households (including activity data). These were made as most of the community's seasonal households, except two, did not participate in the local emissions surveys during the survey period. Without this information, ADEC personnel used averages and assumptions based on surveyed households for seasonal resident behaviors. These may or may not reflect actual behaviors, but the assumptions were based on the idea that seasonal residents engaged in activities similar to the year-round residents and that their homes energy needs were similar to their neighbors.

That being said, this data is as close to accurate as we can make it under the circumstances using appropriate input from community leadership. Thanks to assistance from community environmental coordinator, Ben Foss, ADEC personnel were able to identify more accurate CAP emissions calculations for community woodstoves. After speaking with the environmental coordinator, ADEC personnel verified that community residents had undertaken a woodstove change-out program that replaced all but one woodstove in the community. Older, less efficient woodstoves were changed-out in favor of EPA-certified catalytic woodstoves, which use a catalyst similar to those in automobiles to ignite unburnt carbon particles.

This information allowed ADEC personnel to use resources published by the California Air Resources Board (CARB) to compare to previously used CAP calculations. The change in emissions calculations allowed us to reflect the reduction in carbon monoxide and other pollutants from this community initiative. While the CAP calculations that we used allowed us to accurately reflect these changes, the EPA's Tribal Greenhouse Gas (GHG) Toolkit did not include this level of specialization. It is, instead, a one-size-fits-all calculator with fixed/pre-established GHG emissions calculations. Although it is user friendly with some training, there are improvements to be made for better accuracy for use with Alaska rural communities. Specific limitations are identified in this report.

2. EPA GREENHOUSE GAS TOOLKIT: SUMMARY OF LIMITATIONS AND MODIFICATIONS FOR USE WITH RURAL COMMUNITIES IN ALASKA

2.1. INTRODUCTION AND GENERAL OVERVIEW

The EPA released its Greenhouse Gas Toolkit for Tribal Communities with the intention of providing resources to assist communities in measuring and quantifying emissions. For tribal communities located in the Continental United States, these emissions could include any number of industrial or infrastructure sources that would outweigh local community emissions and negatively impact air quality. For instance, if a large coal-fired power plant which provided power production for a metropolitan area were located on tribal lands, the EPA's GHG Toolkit is set up so that it can take these emissions into consideration along with emissions from vehicles, the tribal community or reservation's landfill, and other emissions sources located in the area.

For Alaska communities, these considerations are less pressing. Many of the 231 recognized tribal communities in the state of Alaska are located off the Rail/Road-Belt (the geographical area between Homer on the Kenai Peninsula north to Fairbanks, and southeast to Delta, Tok, and the Canadian Border connected via the Alaska Highway System). Within the Alaska context, a community's location on or off the road-belt can make a large difference in how it receives fuel, food, and mail. For remote communities, like Pedro Bay, these are barged or flown in rather than driven in by semi-truck or on freight trains as in most of the continental United States. This difference in physical infrastructure arrangement can change how these tools are used and applied in Alaska.

While these smaller, rural Alaska communities are in many regards easier to plan around (given their smaller footprint and lack of comparable economic development), using the GHG Tool requires an amount of regionalization to reflect Alaska's unique conditions and infrastructure realities. These include increased use of wood or biomass for home heating, reliance on air and marine shipping for community supplies and fuel, and few, if any, large emissions sources besides local electrical generating units (EGUs). Except for a few communities, electrical generation relies on diesel. Many communities depend on All-Terrain Vehicles (ATVs) for personal transportation inside and outside of the village and often these far outnumber cars and trucks. Snowmachine usage is also heavy for many communities off the road network, as are small outboard motorboats during subsistence fishing season.

For any communities in Alaska which would like to use the GHG Toolkit, the following changes and limitations should be kept in mind when using this tool.

2.2. FUEL AND ACTIVITY CALCULATIONS LIMITATIONS

2.2.1. Fuel Use Calculation Restrictions

The GHG Toolkit's largest weakness is its lack of a fuel source used in most rural Alaska communities: Wood. Although the GHG calculator did have every other fuel source that is used in rural Alaska, the absence of firewood is an important *current* restriction. Because of this, ADEC personnel had to identify a replacement fuel that could stand in for wood to complete the emissions calculations. Although it does not accurately reflect particulate or smoke emissions, a calculation from the University of Missouri was identified which provides an equivalency from wood to propane, which the EPA Toolkit did include. This allows users to calculate an equivalency for wood to propane (165 gallons of propane to 1 cord of wood, based on stored energy equivalency) which could then be used in the GHG toolkit to provide a partial picture of total emissions.

2.2.2. Heating Oil Use Restrictions

In addition to wood, the GHG Toolkit calculator was also missing heating oil in the fuel source selection. Heating oil is a petroleum product refined from crude oil and is closely related to diesel fuel. Heating oil is a distillate fuel sold mainly for use in boilers, furnaces, and water heaters. As a replacement from the available selections, Residual Fuel Oil No. 5 was used although it is less clean burning than heating oil. This was chosen as the best fuel option for heating oil because of the absence of other fuel options available. It is important to note that there are a variety of other fuels used in rural Alaska for home heating, including Diesel 1 or 2 and downgraded Jet-A. If these are used in your community, it could prove useful to identify an additional fuel stand-in which could better reflect your community's fuel usage and emissions portfolio. Although only one home in the Pedro Bay study used heating oil for home heating, it is an oversight that should be changed in the next release of the GHG Toolkit.

2.2.3. General Calculations Restrictions

Unlike the CAP emissions calculations which require mileage estimates to produce the emissions, the GHG calculator required both a mileage and a fuel consumption estimate to complete its emissions equation. This is a shortcoming of the GHG calculator, which resulted in a lot of staff time calculating fuel efficiency to provide the requisite data. Without this additional information, the GHG toolkit would not provide the necessary emissions estimates to complete the study. The following sections provide greater detail to these modifications and changes required to make this tool work for a remote community off the road belt.

2.2.4. Aircraft Restrictions

GHG Toolkit calculations for aircraft emissions in Pedro were challenging due to several limitations. Primarily, it does not include the EPA's National Emissions Inventory (NEI) approach to estimating landing-take-off (LTO) cycle emissions, as well as the minutes spent at cruise altitude. This is done as an aircraft produces the majority of its emissions during its landing and take-off cycle, when the aircraft needs to speed up quickly to gain lift, slow down, and come to a stop when it reaches its destination. Once an aircraft reaches its cruising altitude, it can reduce the amount of fuel consumed as it needs to maintain its current speed for lift, not gain aerodynamic lift.

In addition to the lack of LTO cycle emissions, the GHG Toolkit calculator lacks any data to assist in estimating aircraft usage or fuel consumption. This makes the process of completing the emissions inventory that much more difficult as many small and rural Alaska airlines use older aircraft which have been phased out of common use in the rest of the United States. For common cargo aircraft in Alaska, such as the DC-3 and DC-6, this meant conducting extensive research using reported fuel consumption and speeds among hobbyists who still operate these aircraft. Because no major flag carrier has operated a DC-6 in many decades, the data that used to calculate emissions could be inaccurate or based on faulty readings of fuel mileage. ADEC relied on the fact that airplane hobbyists would accurately report to one another their fuel consumption.

There are also a number of smaller vintage light aircraft, including Piper Cubs and older Cessna models, which are regularly flown by individuals and local air taxi services. Their fuel economy can vary greatly based on the age of the engine and usage patterns. ADEC personnel were forced to rely on emissions calculations from hobbyists that might not reflect an aircraft's actual fuel economy. This especially applies to older piston-engine aircraft which are in common use in Alaska throughout more rural parts of the state. This is a unique quality within Alaska's air market and one which is not mirrored in the Continental United States.

2.2.5. Small Motorized Equipment Restrictions

For small handheld motorized gardening or outdoor equipment (such as two-stroke chainsaws and brush/weed trimmers), ADEC calculated emissions from fuel consumption only and entered this equipment into the stationary emissions category, rather than mobile emissions. This was decided because of the requirement to provide both fuel and mileage figures for mobile emissions. Mileage figures do not apply to small motorized equipment. Stationary calculations only required fuel consumption. Once solution would be to add the capability to the GHG Toolkit to include sources and emission factors for more accurate accounting.

2.2.6. Solid Waste Emissions Limitations

In addition to the fuel consumption calculations, the GHG Toolkit included a section for solid waste emissions. Part of the calculator was a Landfill Emissions Tool developed by the CARB. While this calculator is useful for communities located in the Continental United States and Canada, applicability to Alaska is difficult to use due to calculations for anaerobic decomposition (k values). While the tool provides a selection of geographic regions, Alaska is not included. The tool used a one-size-fits-all calculation for k values for a location, which is not reflective of the variety of geographic and climatic regions contained within the state.

Geographically speaking, the state of Alaska contains unique regional environments: temperate rainforests in Southeastern Alaska; Arctic tundra on the North Slope; and boreal forests in central and Southwestern Alaska. Rather than a single k value, the rates of anaerobic decomposition vary between geographical areas. It is important for any communities in the state of Alaska using this landfill emissions tool to identify the closest province in Canada to its environment.

For Pedro Bay, we identified the community as having an environment that would likely parallel that of British Columbia, with local snow and rainfall and a relatively mild winter. Other communities in the state would want to go through a similar review process before entering their data into the landfill emissions tool. Were EPA to approach ADEC for assistance in designing a new tool or modifying the current tool for use in Alaska, one suggestion would be to design an Alaska-specific k-value calculator based on geography and local ecosystems.

2.3. OTHER CONSIDERATIONS: CALCULATION SPECIALIZATION AND GENERIC DATA REQUIRMENTS

Models that emphasize larger communities, or communities with more established industries that have a large emissions footprint are hard to apply in rural Alaska. Communities like Pedro Bay, and other rural towns and villages throughout the state have few, if any, industries like those seen in the Continental United States. There are very few concrete mixers, or large power plants that would produce tens of thousands of tons of CO_2 or methane, nor are there industries which would provide tens of thousands of gallons of wastewater that would need to be accounted for in calculations such as these (with the exception of fish processing in the Aleutians, Alaska Peninsula, and Southeast communities). Also, with the very small footprint of farming in the Alaska, any concerns in regard to industrial nitrogen load or other farm run-offs are few (Excepting communities in the Delta area, Matanuska-Susitna Borough or the small farming communities in Southeast Fairbanks Census Area).

2.3.1. Generic Emissions/Mileage/Fuel Consumption Database

To improve end user satisfaction and increase the likelihood that the toolkit will produce viable and useful emissions data, this toolkit needs an accompanying database with generic activity, mileage, and fuel consumption for stationary and mobile categories. This would allow for calculations to be put together without requiring large amounts of outside research to compile estimated community emissions data. There were many times ADEC staff were using the GHG Toolkit when it would have saved time and effort had there been this type of accompanying file. Without it, ADEC personnel had to spend a great deal of time researching fuel efficiency and other factors to fill the gaps.

2.3.2. Light Truck Fuel Consumption

When ADEC personnel were building the datasets for use in the GHG Toolkit, it was necessary to establish a baseline miles-per-gallon figure for use with the seasonal households. As these were to be stand-ins for actual data to allow for calculation of general community emissions, it was necessary to use averaged mileage. In addition to the averaged mileage used for calculation purposes ADEC used a figure of 18.5 miles-per-gallon to calculate fuel consumption. This was developed from 309.2 miles reported from residents except those persons using their vehicles for village corporation business.

The vehicle used to establish this figure was a resident's 1997 Suzuki Sidekick. It was the only vehicle listed which had both a year, make, and model that could be identified on the national fuel economy website. Although this is an older vehicle, after comparing with other miles per gallon (MPG) figures for vehicles produced in the time frame commonly found in Pedro Bay (1980-2003), the number is an appropriate stand-in for the average age and mileage.

2.3.3. Water, Wastewater, Agriculture, & Land Management

Water services, agriculture and land management make up the last emissions categories in the GHG Toolkit and are the most difficult to quantify. For a category like water usage, it is extremely difficult for communities like Pedro Bay to quantify energy or electricity use as it relates to water use because all of the houses in the community use well water and pumps and a septic system. For the agricultural and land management calculator, unless the community has any form of large-scale agriculture, this part of the toolkit is unnecessary for rural Alaska and can be ignored.

2.3.4. Urban Forestry

For the purposes of calculating emissions, urban forestry is an offset for community emissions when measuring total carbon footprint. For almost all communities in Alaska, most (if not all) of their emissions will be cancelled out by the surrounding forests. The GHG Toolkit calculator calculates these offsets based the size of the total 'reservation' area, and an estimation of the percentage of the area with tree cover. For any Alaska tribe, reservation area should be replaced with the area of land controlled by the community or village council under ANCSA, or which fall under their community boundaries. This may change if the community is unincorporated or lacks recognition as a Class I, II, or III community under Alaska statutes.

The percentage of area with tree cover might be more difficult for communities to estimate. For the purposes of this survey, a generic figure of 85% to account for developed areas was calculated and the figure was confirmed by the community environmental officer. Another shortfall is the value of vegetated landscapes. A spruce forest had different CO_2 absorption rates than a deciduous mixed leaf forest. For those communities located in primarily tundra or grass ecosystems, this calculation will be more difficult to estimate as there is no option in the calculator for these vegetation ecosystems.

Along with that general figure, the forestry data is divided into the following categories: Residential, Commercial/Institutional, Industrial, and Energy Generation. Given that there are few, if any, large industrial operations in rural and interior communities, most to all of that land will be categorized as either residential or commercial/institutional. As the village corporation controls the majority of the land, these figures were assigned to the commercial/institutional category. Any land with tree cover in the residential category was left out for this community partially for ease of data entry and partially due to the difficulties of trying to estimate square kilometers and tree cover percentage for the very small residential footprint in the community.

For those tribal environmental officers attempting to use this tool, unless these figures will be used to pursue a larger tribal or regional policy (such as carbon credit sales), a general figure should suffice for the purposes of emissions calculations and discussions with village/tribal council. If these figures are going to be used to discuss or propose any sort of carbon credit sales, or to discuss more substantive policy issues, it is recommended to identify land cover vegetation species for more accurate calculations.

2.4. FINAL ANALYSIS

In summary, while the EPA's Tribal Greenhouse Gas Toolkit is a useful addition to the resources available to tribal environmental officers in the state of Alaska, as well as to the state and federal agencies who work with tribal communities, it is important to understand these limitations. Regardless, this is a genuinely useful tool that should be more widely adopted and used. While greenhouse gases are only part of the larger emissions picture, they are an important factor in understanding the environmental impact that villages and tribes have on our planet's ecosystem. Using the calculations revisions that ADEC used for this project, the EPA's GHG Toolkit should produce realistic and useful data for Alaska tribes.

If tribal environmental officers or their staff wish to discuss this tool further, please contact the ADEC, Division of Air Quality for more information.

3. CRITERIA AREA POLLUTANTS (CAPs): SUMMARY OF LIMITATIONS AND MODIFICATIONS FOR USE WITH RURAL COMMUNITIES IN ALASKA

3.1. INTRODUCTION

All calculations for CAPs were specific to each source. There currently is not an equivalent toolkit for CAP inventories to the EPA's GHG Toolkit. Similar to past rural community emission inventory surveys, the ADEC calculated CAP emissions by using fuel and activity data collected via survey forms and entered them into a calculations spreadsheet, running the calculations manually as needed.

These emissions inventories used emission factors that had been established using the EPA's AP-42 system of pollution calculation. EPA updates their emission factors to reflect emissions generated by engines or emissions sources with more modern control technologies. Several emissions calculations used in the Pedro Bay study were generated by the California Air Resources Board (CARB), and reflect detailed emissions studies done in recent years to measure the emissions potential of new engines and emissions-generating machinery and appliances. Other calculations have been carried forward from previous ADEC emissions inventories, as their results were similar to the current standards.

As the EPA accepts CARB emissions standards, the substitution of old AP-42 emissions calculations for these new emissions factors should not be an issue. Indeed, the use of up-to-date emissions factors increases the applicability of this study to rural communities in the state of Alaska. In addition to updating calculations for use in this inventory, these updated calculations should also assist ADEC in future rural inventories. ADEC has managed a number of rural emissions inventories since 2005, all of which used a set of standardized emissions factors based on AP-42. Now that new emissions factors have been field tested and shown to be more accurate than those previously in use, future ADEC personnel can rely on a mix of previous and new emissions factors to structure inventory calculations.

3.1.1. Aircraft Emissions Calculations

The CAP calculations process for aircraft emissions differs from the GHG emissions calculations process in that both the LTO (Landing-Take-Off) Cycle and Cruise Altitude emissions are taken into consideration and calculated as separate emissions activities. This is a critical difference between the two sets of calculations, and one that makes CAP emissions calculations more reflective of real world conditions.

In order to accurately estimate emissions generated by aircraft, ADEC used calculations generated by the 2005 Alaska Aviation Emission Inventory, prepared by Sierra Research. This was a field study which surveyed airlines serving minor rural airfields in more distant parts of the state. While these airfields were more remote, the dataset was influenced by the use of turbojet aircraft and larger turboprop aircraft such as the civilian C-130 turboprop transport version. However, as none of the previous emission inventories fully calculated commercial air emissions, there was little previous data to rely on for inventory design.

The three passenger air carriers providing service to the Pedro Bay area utilize smaller light aircraft, including Cessna 208's. This was an area of the inventory where ADEC staff could perform calculations without any major modifications or guess work.

The cargo carriers in the community, however, are not using aircraft equivalent to those used in the 2005 aviation inventory. The two cargo companies offering service to Pedro Bay operate very old aircraft not flown outside of hobbyist circles in the continental United States. One of the companies, which offers dry goods shipment to Pedro Bay and the Lake Iliamna communities, is currently operating a Douglas DC-3 twin-engine piston aircraft which was built from the mid 1930's through the mid-1940s. The other company, which supplies the community with fuel and cargo shipments, is currently flying a DC-6 piston-powered aircraft with a similar vintage as the DC-3.

For both LTO and Cruise Altitude emissions calculations, substitute aircraft had to be selected which could function as stand-ins for these aging aircraft. For the DC-6, the closest substitute with a similar wing length, weight, and cargo carrying capacity was the C-130 military transport which serves in both commercial and military contexts in the state. Although the C-130 runs on turboprops while the DC-6 uses piston engines, the height, weight, and cargo capacity are within comparable limits.

Unfortunately, the DC-3 was not comparable to any currently operated aircraft with respect to cargo carrying capacity, wing length, or air frame profile. As such, ADEC used the closest approximation of these emissions; a Piper Navajo, a twin-engine piston aircraft. The emissions were doubled to approximate size and cargo carrying capacity. While this is not a perfect replacement, it was good enough for us to generate calculations that can stand in for what is actually being produced. It is suggested that any communities with similar vintage aircraft providing cargo delivery services reach out to these companies and inquire if they could offer more suitable stand-ins for calculation purposes.

For the aircraft utilized by the lodges, this was also a situation where no clear replacement was available. The lodges are all currently utilizing DeHavilland Beaver aircraft, produced in the late 1940s through the mid-1950s and using a piston engine. The closest aircraft that could be used as a calculations stand-in was a Cessna 180 Skywagon. This aircraft was selected after comparing relative range, wingspan, and top speeds. The Cessna 180 has a longer range and is slightly faster, but was close enough to be a functional stand-in for the older DeHavilland Beaver.

After selection of the aircraft, the only additional computational requirement was to divide up the number of LTO cycles and minutes at cruise altitude into summer and winter categories, as directed in the 2005 Alaska Aviation Emission Inventory. Cargo flights occur primarily during fair weather periods in spring, summer, and early fall so summer LTO and cruise altitude calculations were used. Passenger flights occur on a regular schedule and were evenly divided between winter and summer emissions. Summer emissions, in both cruise altitude and LTO Cycles, are higher than those during the winter and calculation output reflect this higher emissions variance.

3.1.2. All-Terrain Vehicle (ATV) Emissions Calculations

CARB published a recent study on ATV, motorcycle, snowmobile and golf cart emissions in 2013, entitled "Emissions Inventory for Recreational Vehicles."[1] This study took into consideration a number of emission factors that could be applied to the vehicles operating in Pedro Bay. As every household in Pedro Bay had at least one, if not two ATVs that they used for daily activities, it was important to identify more accurate emissions factors that could be used to calculate their air emissions.

The new emissions factors released by CARB are more accurate than those used in previous studies by ADEC and are broken down by model year category for accuracy in model engine updates. As the primary mode of transportation, ATVs emissions benefit from updated emission factors. The emissions factors used in the Pedro Bay study were identified in the CARB study as, "Exhaust EF (zero hour)," defined as emissions generated upon starting up the vehicle and running it without warming the engine up. These emissions factor updates also took into consideration overall mileage and date of manufacture.

The categorization of ATVs by manufacturing date provides a stronger measurement of vehicle emissions than previous AP-42 factors. Vehicles are less fuel efficient as they get older and as

[1] See the following CARB Presentation dated March 2013: "Emissions Inventory for Recreational Vehicles," California Air Resources Board, March 6, 2013, available at: https://ww3.arb.ca.gov/msei/recreational-vehicle-inventory-presentation-030613.pdf (Accessed May 12, 2020).

wear and tear increases. Having emissions factors that reflect age and usage provides more accurate emissions results than static models alone. This new set of CARB emissions factors are broken down by date of manufacture, going back to the early 1990's. The emission inventory for ATVs in the Pedro Bay study were based only on grams per mile (g/mile) calculations in the "Exhaust EF (zero hour)" calculations.

ADEC calculated ATV emissions based on the assumption that all ATVs are using a 2-stroke motor. A single household reported the use of a 4-stroke ATV on its inventory form, and its calculations were run with the 4-stroke calculation. One other household did not report a model or date of manufacture. This household's mileage was calculated using emission factors for older 2-stroke ATVs built before the mid-1990s. The use of the 2-stroke calculation was an inherently conservative choice. These are dirtier and less efficient engines, even if manufactured within the last fifteen years.

The CARB emissions factors generate numbers broken down in grams per mile (g/mile) additional edits are made to generate final emissions figures in more applicable pounds per mile (lbs/mile) and tons overall. Although this does extend the amount of calculations that must be run, it is a two-step computation from grams to pounds, and pounds to tons, if needed.

3.1.3. ATV Generic Households Calculations

The village Environmental Coordinator estimated that there are15 households inhabited during the subsistence months (May-September). An average mileage was determined for the community's households which excluded those households that provide services to the village council. The average ATV mileage was estimated to be 1596.25 miles per household per year and was applied to both the seasonal and the households that did not respond to this survey. After looking at the number of households that reported two ATVs, along with at least one light truck, each generic household was assigned two ATVs. One was assigned as a newer vehicle from 2006, and the other was assigned as an older vehicle from 1994. This was done in order to reflect likely variation in vehicle age, weathering, and household preferences.

3.1.4. Light Trucks/SUVs

Unlike the ATV calculations, ADEC did not need to identify any new or additional emissions factors to generate the calculations for light trucks or SUVs in the community. Instead, previously established AP-42 based emissions factors for light trucks and SUVs were used. For the fifteen seasonal households in the community (labeled "seasonal household" or "generic household" an average annual mileage was established using the reported mileage from all community vehicles, excluding private vehicles used by village council employees for the purposes of community business. This average mileage was then cut in half to reflect seasonal usage rather than year-round usage. The mileage calculated was 309.2 miles for all fifteen of the seasonal household light trucks/SUVs.

For rural communities that wish to run this type of emissions inventory, the emissions factors will be provided in Appendix B. As with the ATV emissions factors, Emission factor units produced are in grams per mile (g/mile). These figures must be re-calculated into pounds mile (lb. /mile) and re-calculated again into tons overall. These are relatively easy calculations to make once the first set of figures is generated.

3.1.5. Snowmachine Emissions

CARB's emissions factors for snowmachines were broken down into manufacturing date categories, allowing for more accurate emissions calculations. Unlike ATVs or light trucks, there was no attempt by ADEC to establish average mileage for snowmobiles to apply to the fifteen generic or seasonal households. These households are not occupied during the fall, winter, or early spring months when snowmobiles would be utilized. This meant that the number of snowmobiles registered in the emissions inventory was relatively few, with five households registering six snowmobiles overall. Because the community members identified the year and make of the snowmachines, ADEC personnel were able to categorize by manufacture date to for emissions generation.

3.1.6. Residential Pleasure Craft: Boat

Most households reported hours of use for pleasure craft during the summer and provided the length of their personal boats. One household estimated for the miles driven during the summer months. ADEC used emissions factors for boats from previous emissions inventories, and applied them to those households that gave hours of total use. Calculations included time spent traveling at 20 miles-per-hour (established as cruising speed for boats on the lake) and 10 miles-per-hour (established as maneuvering and docking speed on the lake). Results were then applied to the pre-existing emissions factors to generate annual emissions.

These emissions were applied to all seasonal households since it was presumed that most of these households would likely be occupied for the purposes of subsistence activities, and the major subsistence activity in the area is fishing. It was determined that all seasonal households would likely have at least one small pleasure boat to utilize the resources available to them on Lake Iliamna. An average was established from the available hours of use reported to us by full-time households.

3.1.7. Residential Clothes Dryer

It was assumed that seasonal households used propane clothes dryers as was reported by the surveyed full time resident households. As older electrical dryers use quite a bit of electricity, it would make sense for seasonal households to instead use propane dryers for a few hours a week and ship propane tanks out via barge or light aircraft. Sixty hours represent the total seasonal use of a dryer for five months (May-September) at three hours a week, twelve hours per month.

3.1.8. Residential Brush Trimmer

It was determined that all residents, including seasonal residents would use brush trimmers for seasonal cleanup and so the calculations applied to all residents. It was assumed that each household would be likely to do at least one to two days' yard clean up in the spring and in the fall.

3.1.9. Residential Burn Barrel

Residential trash burning was reported on the survey forms and an average volume and percentage of the residents that burned trash was determined which was applied to the seasonal homes. Four seasonal households were assigned burn barrels for use during their subsistence season in the summer months.

3.1.10. Residential Camp/Cook Fires

Residential camp/cookfire emissions were based on hours of use reported in the surveys circulated throughout the community. The first household reported “five hours” of use. The hours of use were then converted to cords of wood based on an estimate of how long it would take for a bundle of wood to burn (using an estimation of a bundle of wood being some 0.9 cubic feet). Estimations for a bundle was used as this was an easier calculation to establish than guessing at cubic feet of wood used per-campfire-session. After determining the burn rate of 0.9 cubic feet per-hour the camp/cookfire emissions s were relatively simple to complete. The household was estimated to use 0.84 cords of wood in their camp/cookfire during the spring and summer months, which converted to 107.52 cubic feet. Although it may not be an entirely accurate measurement in respect to variations of wood consumption rates, fire intensity and other factors, it was a logical assumption to apply to other residences.

ADEC calculated the average cord consumption to apply to the community including the fifteen seasonal homes. The final calculation was 0.34 cords of wood or 43.52 cubic feet per household. It was assumed that seasonal residents would use camp/cookfires similarly to permanent residents. As campfires and cookouts are parts of outdoor recreation, it is easy to show this amount of wood consumed, especially if seasonal household residents are in the area for most (if not all) of the summer months.

3.1.11. Residential Chain Saw

The emission factors used for chainsaws were those cited in previous ADEC residential emission inventories and based on EPA’s AP-42 standards. The hours of use that are referenced in the Pedro Bay study are based on reported hours in the emissions survey. Seasonal households were included in these calculations as a result of reviewing the surveys received. All survey respondents referenced some use of a chainsaw during the summer months.

A total of 48 hours of chainsaw use was reported from the two households reporting the most hours of use and a household estimate was calculated with those households reporting the least amount of use of less than one hour. This came out to a final estimate at 14 hours of chainsaw use per household. Wood consumption volumes were taken into consideration in the process of estimation.

3.1.12. Residential Log Splitter

Log splitter use was estimated by averaging the three households that reported log splitter use under 200 hours per year. The household which reported 240 hours was eliminated from the average as it was an outlier among year-round households. For those communities that would use these calculations as a starting point, it would be useful to calculate the average and reduces the range to 10-20 hours, as log splitters are less common. This generic figure is not applied to every household in the community, only to those generic households which have log splitter activity assigned to them.

3.1.13. Residential Sauna

The wood consumption rates for the seasonal households was determined by averaging the reported resident households' wood usage for saunas No households identified actual amount of wood burned in the sauna. Therefore, considering all the household wood combustion sources, 1.4 cords was estimated as an average use. Usage was applied to year-round and seasonal residents, as it was assumed that seasonal households would take advantage of the ability to use a wood-fired sauna.

3.1.14. Residential Smokehouse

Unlike residential saunas, which represent a regional cultural practice, ADEC personnel believed that residential smokehouses would be universally used among the seasonal households in Pedro Bay. As all of the seasonal households would be inhabited for the purposes of subsistence activities that are carried out during the spring and summer months, it was assumed that all of the households would be utilizing some form of smokehouse for subsistence catches. With this in mind, an average of all of the reported yearly smokehouse wood consumption (1.407 cords) was applied to the full time residents and seasonal households.

3.1.15. Residential Wood Stoves

Almost all of Pedro Bay residents use woodstoves to heat their homes and with the available information on wood stove type, more accurate and efficient wood stove emissions factors were used. During the ADEC fact finding trip to Pedro Bay in October 2018, the community environmental coordinator verified that local residents had undertaken a voluntary woodstove change-out program in the previous decade. All older, less efficient, and non-EPA certified woodstoves were replaced with more efficient EPA-certified catalytic woodstoves with the exception of one household.

ADEC identified a set of replacement emissions factors for catalytic wood stoves from CARB that would be more representative of community practices. These reduced overall carbon monoxide and particulate matter emissions compared to AP-42 calculations. The emission calculations required a volume of fuel burned.

Five households were used to establish generic wood stove combustion. This resulted in 2.4 cords of wood burned per year for household heating purposes. Seasonal resident wood consumption was calculated by eliminating the higher reported outliers, resulting in an average of 1.75 cords of wood, or 224 cubic feet.

Using the previously established burn rate of 0.9 cubic feet of wood (or one bundle) per hour at a conservative burn rate; the total hours of wood stove use was approximately 248.8 hours. Catalytic woodstove emissions factors were applied to all of the seasonal households after conferring with the community environmental officer who verified seasonal household participation in the woodstove change out.

3.1.16. Pedro Bay Lodges

All lodge emissions included in this report represent verified emissions numbers provided by lodge owners and facility managers. During the ADECs site visit in June 2019 lodge owners and facility managers met with staff to complete the emissions survey. All three lodges provided ADEC with accurate information on lodge operations that produce emissions.

APPENDIX B: CRITERIA AIR POLLUTANT EMISSIONS FACTORS AND GENERIC HOUSEHOLD FIGURES, AND GREENHOUSE GAS CALCULATOR DATA ASSUMPTIONS

User's Note:

Appendix B provides the emissions factors, generic household estimates, and other data assumptions that ADEC used to develop the CAP and GHG emission inventories. These calculations are provided with the report to be used as a guide for communities wanting to develop a community emissions inventory. All aircraft are calculated for aviation gasoline (Avgas), while ground and marine equipment fuel types will be noted in the following tables. *Do not run an emissions calculation without first verifying the fuel type used by the vehicle*. If the vehicle has been modified to operate using a different fuel type, this will change the calculation and emission factors will need to be updated.

Please note that factors are divided between household, government, and aircraft emissions. CAP emission factors are listed in the following tables with any accompanying calculations required to complete emissions establishment. Generic household data includes fuel use and mileage figures. Assumptions for the Greenhouse Gas Toolkit are briefly explained along with the accompanying data.

In some cases, there are conversion calculations to transfer to different emission units which result in an additional step n (such as grams-pounds/pounds-tons). These conversions are noted, and the steps required are provided below the emissions factor.

If readers have any questions regarding the below, please contact the Alaska Department of Environmental Conservation, Air Quality Division, Air Non-Point Mobile Sources Section to request clarification or pose questions.

<u>Units of Measure Used in this Document</u>

Grams (g)
Mile (m)
Pound (lb)
Mile (m)
Hour (h)
Gallon (gal)
Hour (hr)
Minute (min)

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CRITERIA AIR POLLUTANT EMISSION FACTORS

1 RESIDENTIAL EMISSION CALCUATIONS

1.1 RESIDENTIAL VEHICLES AND MOTORIZED EQUIPMENT

1.1.1 Gasoline Trucks

Age/Model	Activity	Emission Factor (g/m))						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
1980 SUV	Mileage	3.870	24.989	1.195	0.026	0.012	0.053	0.099
1992 Truck	Mileage	4.911	20.362	4.178	0.090	0.065	0.097	0.045

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in grams per mile. In order to calculate into pounds, divide the results by 453.592. This will produce a figure in pounds. To calculate into tons (if necessary), divide pounds by 2000.

1.1.2 ATV/4-Wheeler

Age/Model	Activity	Emission Factor (g/m)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
2004 2-Stroke ATV	Mileage	0.68	19.8	0.64	0.06	0.06	0	0
1994 2-Stroke ATV	Mileage	3.59	39.1	0.49	0.06	0.06	0	0
1985 2-Stroke ATV	Mileage	34.2	54.1	0.01	0.42	0.42	0	0

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in grams per mile. In order to calculate into pounds, divide the results by 453.592. To calculate into tons (if necessary), divide pounds by 2000. For additional Emissions Factors, see CARB ATV/4-Wheeler emissions factors and report included with this emissions inventory.

1.1.3 Snowmachines

Age/Model	Activity	Emission Factor (g/m)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
1996 Snowmachine	Mileage	140.7	385.1	0.54	2.3	2.3	0	0
2008 Snowmachine	Mileage	74.5	19.8	0.64	0.06	0.06	0	0
2014 Snowmachine	Mileage	55.9	205	0.54	1.57	1.57	0	0

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in grams per mile. In order to calculate into pounds, divide the results by 453.592. To calculate into tons (if necessary), divide pounds by 2000. For additional Emissions Factors, see CARB Snowmachine emissions factors and report included with this emissions inventory.

1.1.4 Motorcycles

Age/Model	Activity	Emission Factor (g/m)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Mileage	0.68	19.8	0.64	0.06	0.06	0	0

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in grams per mile. In order to calculate into pounds, divide the results by 453.592. To calculate into tons (if necessary), divide pounds by 2000. For additional

Emissions Factors, see CARB emissions factors and report included with this emissions inventory.

1.1.5 Marine Pleasure Craft

Age/Model	Activity	Emission Factors (pound/hour (lb/hr)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Pre-1990 Outboard	Hours	3.59	39.1	0.49	0.06	0.06	0	0
Post-1990 Outboard	Hours	0.745	17.301	0.960	0.008	0.007	0	0

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

1.1.6 Chainsaw

Age/Model	Activity	Emission Factors (lb/hr)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hours	0.5345	1.3519	0.0026	0.0282	0.0259	0.0003	0.0001

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

1.1.7 Log Splitter

Age/Model	Activity	Emission Factor (lb/hr)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hours	0.272917	1.429307	0.00839	0.01111	0.010223	0.0000303	0.000000653

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

1.1.8 Gasoline Brush/Weed Trimmer

Age/Model	Activity	Emission Factor (lb/hr)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hours	0.5345	1.3519	0.0026	0.0282	0.0259	0.0003	0.0001

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

1.1.9 Propane/Gas Clothes Dryer

Age/Model	Activity	Emission Factor (lb/hr)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hours	0.5	1.9	14	0.4	0.4	0	0

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

1.1.10 Gasoline Water Pumps

Age/Model	Activity	Emission Factor (lb/hr)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hours	4.764	0.372	0.036	0.001	0.002	0.002	0.00

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

1.1.11 Gasoline Sewage Pumps

Age/Model	Activity	Emission (lb/hr)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hours	4.764	0.372	0.036	0.001	0.002	0.002	0.00

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

1.2 HOUSEHOLD HEATING AND OUTDOOR BURNING

1.2.1 Household Woodstove

Age/Model	Fuel	Emission Factor (Lb /ton)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Catalytic Woodstove	Wood	0	104	2	20	19.6	0.4	0.9
Non-Catalytic	Wood	0	230.8	2.8	30.6	29.5	0.4	0.9

To calculate emissions: Calculate square feet of wood burned using the following calculation: 0.9 cubic feet=1 bundle, 128 cubic feet of wood=1 cord. Divide estimated cubic feet of wood burned by 128 to produce a figure in cords of wood. Multiply estimated cords of wood (0.5, 1.2 cords, etc.) by the above emissions factor for each pollutant. One cord weighs 2 tons. On average. If cords burned are an odd number, such as 0.3 cords or 1.25, judgement is up to the person running the calculations.

1.2.2 Household Diesel/Fuel Oil Toyo Heater

Age/Model	Fuel	Emission Factor (lb / 1000 gallons)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Diesel/Fuel Oil	2.493	5	18	0.4	0.388	0.001656	0.00

To calculate emissions: Estimate amount of diesel or fuel oil burned during the calendar year. Measurement is in pounds of pollutants per 1000 gallons. To calculate into tons (if necessary), divide pounds by 2000.

1.2.3 Household Wood-Burning Sauna

Age/Model	Fuel	Emission Factor (lb/ ton wood)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Non-Catalytic	Wood	0	230.8	2.8	30.6	29.5	0.4	0.9

To calculate emissions: Calculate square feet of wood burned using the following calculation: 0.9 cubic feet=1 bundle, 128 cubic feet of wood=1 cord. Divide estimated cubic feet of wood burned by 128 to produce a figure in cords of wood. Multiply estimated cords of wood (0.5, 1.2 cords, etc.) by the pollutant emission emissions factors. One cord weighs 2 tons on average. If cords burned are an odd number, such as 0.3 cords or 1.25, judgement is up to the person running the calculations.

1.2.4 Household Wood-Burning Smokehouse

Age/Model	Fuel	Emission Factor (lb/ton)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Non-Catalytic	Wood	0	230.8	2.8	30.6	29.5	0.4	0.9

To calculate emissions: Calculate square feet of wood burned using the following calculation: 0.9 cubic feet=1 bundle, 128 cubic feet of wood=1 cord. Divide estimated cubic feet of wood burned by 128 to produce a figure in cords of wood. Multiply estimated cords of wood (0.5, 1.2 cords, etc.) by the pollutant emission factors. One cord weighs 2 tons on average. If cords burned are an odd number, such as 0.3 cords or 1.25, judgement is up to the person running the calculations.

1.2.5 Household Outdoor Refuse Burning

Age/Model	Fuel	Emission Factor (g/lb)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Wood/Refuse	0.019	0.038	0.0027	0.007	0.007	0.0004	0

To calculate emissions: Estimate amount of refuse burned in pounds per year. Multiply by the pollutant emission factors listed above. To calculate into pounds, divide the results by 453.592.

1.2.6 Household Outdoor Campfire or Cooking Fire

Age/Model	Fuel	Emission Factor (g/lb)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Campfire/Cook Fire	Wood	0	149	2.6	23.6	2.7	0.4	1.8

To calculate emissions: Calculate square feet of wood burned using the following calculation: 0.9 cubic feet=1 bundle, 128 cubic feet of wood=1 cord. Divide estimated cubic feet of wood burned by 128 to produce a figure in cords of wood. Multiply estimated cords of wood (0.5, 1.2 cords, etc.) by the pollutant emission emissions factors. One cord weighs 2 tons on average. If cords burned are an odd number, such as 0.3 cords or 1.25, judgement is up to the person running the calculations.

1.2.7 Burn Barrel

Age/Model	Fuel	Emission Factor (g/lb)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Wood/Refuse	0.019	0.038	0.0027	0.007	0.007	0.0004	0

To calculate emissions: Estimate amount of refuse burned in pounds per year. Multiply by the pollutant emission factors listed above. To calculate into pounds, divide the results by 453.592.

1.3 RESIDENTIAL GENERIC EMISSIONS EXAMPLES

1.3.1 Generic Stationary Emissions

Source	Volume	Emission Results						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Heating- Wood (lb/ton)								
Woodstove	1.75 cords	0	104.4	2	20	19.6	0.4	0.9
Outdoor Burning – Wood (lb/ton)								
Sauna	1.04 cords	0	230.8	2.6	30.6	29.5	0.4	1.7
Smokehouse	1.407 cords	0	230.8	2.6	30.6	29.5	0.4	1.7
Campfire/Cook fire	0.34 cord	0	149	2.6	23.6	22.7	0.4	1.80
Outdoor Burning - Refuse (g/Lb)								
Refuse Burning	219.39 lbs	0.019	0.038	0.0027	0.007	0.007	0.0004	0
Burn Barrel	60.6 lbs	0.019	0.038	0.0027	0.007	0.007	0.0004	0

Source	Volume	Emission Results						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Motorized Equipment - (lb/hour)								
Brush/Weed Trimmer	19 gal	0.5345	1.3519	0.0026	0.0282	0.0259	0.0003	0.0001
Chainsaw	14 gal	0.5345	1.3519	0.0026	0.0282	0.0259	0.0003	0.0001
Log Splitter	54.75 gal	0.2729	1.429	0.00083	0.0111	0.01022	0.0003	0.0000005
Motorized Equipment - (lb/hour)								
Water pump	1310.4	4.764	0.372	0.0027	0.007	0.007	0.0004	0
Sewage pump	819	4.764	0.372	0.036	0.001	0.002	0.002	0.00
Home Appliances – Propane (lb/hour								
Clothes Dryer	60 Gal.	0.5	1.9	14	0.4	0.4	0	0

Note: All of the generic residential emissions were calculated to represent the seasonal emissions generated by a household occupied during the summer months (May-September) and engaged in subsistence activities. The brush/weed trimmer and chainsaw are categorized as stationary emission sources in order to be included in the GHG Toolkit, which is reliant on mileage to calculate mobile emissions sources. To maintain uniformity across both the CAP and GHG calculations, this motorized equipment was calculated as a stationary emissions source rather than a mobile emissions source.

If a community located in a non-forested area lacking large amounts of wood for personal heating or energy wants to utilize the above generic emissions, they can remove the top four emissions categories which use wood as a fuel source. If these generic household figures are to be used to represent year-round household emissions, the results can be doubled to provide a rough estimate of twelve full months of household use. However, these figures are modeled using a small community in a temperate ecological and environmental area. These will likely not be representative of local wood use patterns in less temperate areas.

If a community has a small fishing or destination hiking lodge, these emissions can be used to model individual guest behavior. Previous versions of this emission inventory used the generic data to calculate for guest emissions, using a seasonal resident's behavior as a model and adding on additional instances of campfire and woodstove use. The only calculations left out of guest behavior modeling were those needed for household chores, such as a brush trimmer and chainsaw, or refuse disposal, such as burn barrels or open air refuse burning. Clothes dryer use was kept in and modeled per person on a weekly basis. Reference Appendix "A", as well as the Pedro Bay inventory for clarification on gallons consumed-weekly utilization of propane dryer.

1.4 RESIDENTIAL MOBILE (VEHICLE) GENERIC EMISSIONS

1.4.1 Residential Mobile Emissions Calculations and Generic Quantity

Vehicle	Fuel Type	Quantity	EF Units	Emission Calculations						
				HC	CO	NOX	PM10	PM2.5	SOX	NH3
2006 ATV	Gasoline	1596.25 Miles	g/mile	0.69	19.8	0.64	0.06	0.06	0	0
1994 ATV	Gasoline	1596.25 Miles	g/mile	3.59	39.1	0.49	0.06	0.06	0	0

Vehicle	Fuel Type	Quantity	EF Units	Emission Calculations						
				HC	CO	NOX	PM10	PM2.5	SOX	NH3
Generic SUV/Pickup	Gasoline	309.2 Miles	g/mile	3.870	24.989	1.195	0.026	0.012	0.053	0.099
20-foot Boat	Gasoline	52.877 hours	lb/hr	0.745	17.301	0.960	0.008	0.007	0.010	0.002
1985 ATV	Gasoline	1596.25 Miles	g/mile	34.2	54.1	0.01	0.51	0.51	0	0

1.4.2 Residential Mobile Emissions Generic Emissions Totals

Vehicle	CAP Emissions (lbs)						
	HC	CO	NOX	PM10	PM2.5	SOX	NH3
2006 ATV	1085.45	31605.75	1021.6	95.775	95.775	0	0
1994 ATV	5730.53	62413.375	782.16	95.775	95.775	0	0
Generic SUV/Pickup	1196.658	7726.747	369.593	7.948	3.696	16.380	30.541
20-ft Boat	39.419	914.834	50.772	0.404	0.371	0.517	0.091
1985 ATV	54591.75	86357.125	15.9625	670.425	670.425	0	0

Note: Table A of the above are emissions calculations, as well as emissions quantities, used to calculate emissions totals based on locally collected data. For those community environmental planners using the above calculations, if quantities differ they can be replaced with more representative figures. Table B of the above are generic emissions results that can be used to stand-in for community vehicle emissions absent available data.

All of the generic household emissions were calculated to represent the seasonal emissions generated by a household occupied during the summer months (May-September) and engaged in subsistence activities. There are three options for calculating ATV emissions: A newer 2-stroke engine from the mid-2000s, an older 2-stroke engine from the mid-1990s, or a 30-year old ATV using a 2-stroke engine. The 1985 ATV was included to ensure that communities wanting to utilize these figures would have an option for older vehicles remaining in their communities. All three are modeled with 1,596.25 miles per summer as their default. Depending on the road system, other communities may have less miles in average. All vehicle emissions are calculated in grams, rather than pounds. To convert emissions from grams to pounds divide the results by 453.592.

The boat in this section is a larger 20-foot outboard motorboat. If communities use smaller outboard skiffs, please reference the CARB emissions inventory to see if there are additional factors and calculations that can be used.

Calculations for the SUV/pickup truck represent the vehicle’s use for primarily subsistence-supporting activities, such as hauling wood or large animals back from hunting trips. An average mileage is community specific and should be modified if a community has a larger network of roads or is located on the central Alaska road-belt/Dalton Highway.

2 GOVERNMENT EMISSION CALCUATIONS

2.1 GOVERNMENT MOBILE EMISSIONS (TRANSPORTATION)

2.1.1 Gasoline Trucks

Age/Model	Activity	Emission Factor (g/mile)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
1980 SUV	Mileage	3.870	24.989	1.195	0.026	0.012	0.053	0.099
1992 Truck	Mileage	4.911	20.362	4.178	0.090	0.065	0.097	0.045

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in grams per mile. In order to calculate into pounds, divide the results by 453.592. This will produce a figure in pounds. To calculate into tons (if necessary), divide pounds by 2000.

2.1.2 Diesel Heavy Trucks

Age/Model	Activity	EF units	Emission Factor						
			HC	CO	NOX	PM10	PM2.5	SOX	NH3
Freightliner Semi	Fuel Consumed	lb/mile	0.318	1.43	5.447	0.155	0.1283	2.0022	0.027
Heavy Duty Truck	Miles	g/mile	0.930	1.696	1.521	0.191	0.164	1.135	0.007

To calculate emissions: Multiply activity by the pollutant emission factors listed above. For freightliner semi-trucks, results will be produced in pounds per mile. For heavy duty trucks (meaning larger diesel trucks classed below semi-trucks), results will be calculated in grams. To calculate into pounds, divide the results by 453.592.

2.1.3 ATV/4-Wheelers

Age/Model	Activity	EF units	Emission Factor (g/mi)						
			HC	CO	NOX	PM10	PM2.5	SOX	NH3
2004 2-Stroke ATV	Mileage	g/mile	0.68	19.8	0.64	0.06	0.06	0	0
1994 2-Stroke ATV	Mileage	g/mile	3.59	39.1	0.49	0.06	0.06	0	0
1985 2-Stroke ATV	Mileage	g/mile	34.2	54.1	0.01	0.42	0.42	0	0
Large Honda Rancher-Style[1]	Mileage	lb/gal	0.1276	0.1280	0.0003	0.0050	0.0046	0	0

[1] *The Large Honda Rancher emission Factor units are pounds/gallon*

To calculate emissions: Multiply activity by the pollutant emission factors. Results will be produced in grams per mile (g/mile). In order to calculate into pounds, divide the results by 453.592. To calculate into tons (if necessary), divide pounds by 2000. For additional Emissions Factors, see CARB ATV/4-Wheeler emissions factors and report included with this emissions inventory. For Honda Rancher-style larger ATVs, emissions are measured in pounds per gallon of fuel burned.

2.1.4 Motorized Equipment (Backhoes, Tractors, Etc.)

Age/Model	Activity	EF units	Emission Factor (g/mi)						
			HC	CO	NOX	PM10	PM2.5	SOX	NH3
Bucket Loader (Case XT621)	Fuel Consumed	lb/gal	0.072	0.316	0.340	0.053	0.052	0.040	0.0
Tractor (John Deere 570)	Fuel Consumed	lb/gal	0.101	0.480	1.451	0.103	0.100	0.200	0.002

Age/Model	Activity	EF units	Emission Factor (g/mi)						
			HC	CO	NOX	PM10	PM2.5	SOX	NH3
Bulldozer (Case 1150E)	Fuel Consumed	lb/gal	0.0852	0.4418	1.2026	0.0909	0.0881	0.1683	0.0020
Refuse Hauler	Fuel Consumed	g/m	0.318	1.43	5.447	0.155	0.1283	2.0022	0.027
Road Scraper/Grader	Time Operated	lb/hr	0.190	1.373	3.149	0.216	0.209	0.40	0.005
Front-End Loaders	Fuel Consumed	lb/gal	0.072	0.316	0.340	0.053	0.052	0.040	0.00
Case Front End Loader	Fuel Consumed	lb/gal	0.213	13.788	0.098	0.003	0.002	0.002	0.00

To calculate emissions: Please note three separate measurements used in this equipment category. Pounds per gallon (lb/gal), pounds per hour (lb/hr), and grams per mile (g/mile). For the refuse hauler, emissions are calculated in grams per mile. To calculate pounds, divide the results by 453.592. For equipment which is estimated in pounds per hour, it is necessary to estimate the number of hours per year the equipment has been operated, as opposed to how much fuel has been consumed by the equipment. Except the category of equipment which requires a second set of calculations to generate pounds, all other emissions factors produce pounds.

2.1.5 Chainsaw

Age/Model	Activity		Emission Factor (lb/mile)						
		EF units	HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hours	lb/hr	0.5345	1.3519	0.0026	0.0282	0.0259	0.0003	0.0001

To calculate emissions: Multiply activity by the pollutant emission factors listed above. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

2.1.6 Small Generators (Under 100 Kilowatts)

Age/Model	Activity	Emission Factor lb/mile)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hrs. Operation	0.223	8.332	0.110	0.007	0.007	0.006	0.00

To calculate emissions: Multiply activity by the pollutant emission factors listed. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

2.1.7 Space Heaters (Diesel/Waste Oil)

Age/Model	Activity	Emission Factor (lb/1000 gallons)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Hrs. Operation	2.493	5	18	0.4	0.388	0.001656	0.00

To calculate emissions: Estimate amount of diesel or fuel oil burned during the calendar year. Multiply activity by the pollutant emission factors listed. Measurement is in pounds of pollutants per 1000 gallons. To calculate into tons (if necessary), divide pounds by 2000.

2.1.8 Central Facility Forced Air Heating (Diesel)

Age/Model	Activity	Emission Factor (Lb/1000 gallons)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	Gal. Burned	2.493	5	18	0.4	0.388	0.001656	0.00

To calculate emissions: Estimate amount of diesel or fuel oil burned during the calendar year. Multiply activity by the pollutant emission factors listed. Measurement is in pounds of pollutants per 1000 gallons. To calculate into tons (if necessary), divide pounds by 2000.

2.1.9 Large Facility Water Pumps

Age/Model	Activity	Emission Factor (Lb/hr)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Water Pump (Generic)	Hrs. Use	0.325	1.119	0.003	0.026	0.024	0.00	0.00
Small/Medium Water Pump	Hrs Use	0.372	4.764	0.036	0.002	0.002	0.001	0.00

To calculate emissions: Multiply activity by the pollutant emission factors listed. Results will be produced in pounds. To calculate into tons (if necessary), divide pounds by 2000.

2.1.10 Government Landfill Burn Box

Age/Model	Activity	Emission Factor (g/lb)						
		HC	CO	NOX	PM10	PM2.5	SOX	NH3
Any	lbs. Burned	0.019	0.038	0.0027	0.007	0.007	0.0004	0.00

To calculate emissions: Estimate pounds of refuse burned per use of community landfill burn box. Multiply by the pollutant emission factors listed for each pollutant emissions. Results will be in grams. Divide the results by 453.592 to calculate results in pounds. To calculate tons (if necessary), divide pounds by 2000.

3 COMMERCIAL AND PRIVATE AIRCRAFT

3.1 DEFINITIONS

All aircraft in the following tables fall under the broad categories of "Commercial" and "Private" aircraft. This is done to categorize all operational aircraft coming in and out of Pedro Bay as civilian and not government or military aircraft. They are also split into both "Light Aircraft" as well as "Cargo Aircraft." All privately and commercially operated aircraft are either one- or two-engine piston powered aircraft. All cargo aircraft are either two- or four-engine piston powered aircraft. These details are included to denote operational airframes in this region as specifically light civilian piston aircraft and not turboprop or turbofan powered jet aircraft. If the aircraft flown in your community utilize turboprops or turbofans, please reference the 2005 Alaska Aviation Inventory included in the larger package of documents included alongside this Appendix. Identify the most appropriate surrogate aircraft to stand-in if your local airframes are not included in the 2005 inventory.

3.1.1 Light Aircraft - Single Engine Aircraft (Piston) Landing/Take-Off Calculations

Model- Original	Model Replacement	Emission Factor (lb/LTO)							
		CO	HC	NOX	SOX	SO4	PM10	PM2.5	NH3
Personal Use									
Cessna 185[1]	Cessna 206	16.01	0.86	0.44	0.1	0.02	0.53	0.46	0.004
1947 Piper Cub[1]	Cessna 180	16.01	0.86	0.44	0.1	0.02	0.53	0.46	0.004
1963 Cessna[1]	Cessna 206	16.01	0.86	0.44	0.1	0.02	0.53	0.46	0.004
Commercial Passenger									
Cessna 207[1]	Cessna 207	16.01	0.86	0.44	0.1	0.02	0.53	0.46	0.004

Commercial Passenger									
Cessna 207[2]	Cessna 207	8.07	0.71	0.23	0.06	0.01	0.53	0.46	0.004
Cessna 208[1]	Cessna 208	16.01	0.86	0.44	0.1	0.02	0.53	0.46	0.004
Cessna 208[2]	Cessna 208	8.07	0.71	0.23	0.06	0.01	0.53	0.46	0.004
Lodge (Personal/Commercial)									
DeHavilland Beaver[1]	Cessna 180	16.01	0.86	0.44	0.1	0.02	0.53	0.46	0.004

[1]-Summer operation

[2]-Winter operation

To calculate emissions: Estimate number of landings and take-offs (LTOs) conducted by each aircraft in a single year. Each flight is counted as two (one take-off and one landing). Multiply each LTO by the above pollutant emission factor. Divide the LTOs between summer and winter operations, with summer emissions applying between April and September, winter from October through March. For private aircraft, each of the owners should maintain a log book detailing flights that can be used to present an exact number. For commercial aircraft, local air taxis should be able to provide details on yearly/monthly flights into and out of an airstrip.

3.1.2 Commercial Cargo Multi-Engine Aircraft (Piston) Landing/Take-Off Calculations

Model-Original	Model-Replacement	Emission Factor (lb/LTO)							
		CO	HC	NOX	SOX	SO4	PM 10	PM 2.5	NH3
Douglas DC-3[1]	Piper Navajo (X2)	4.166694	0.044312	0.004596	0.00036376	0	0	0	0
Douglas DC-3[2]	Piper Navajo (X2)	4.166694	0.044312	0.004596	0.00036376	0	0	0	0
Douglas DC-6[1]	C-130 Military Transport	1.16531	0.23968	0.35394	0.022314432	0	0	0	0
Douglas DC-6[2]	C-130 Military Transport	1.1653	0.023968	0.0343394	0.022314432	0	0	0	0

[1]-Summer operation

[2]-Winter operation

To calculate emissions: Estimate number of landings and take-offs (LTOs) conducted by each aircraft in a single year. Each flight is counted as two (one take-off and one landing). Multiply each LTO by the e pollutant emissions factors. Divide the LTOs between summer and winter operations, with summer emissions applying between April and September, winter from October through March. Both of the aircraft listed are commonly flown in rural Alaska for cargo transport from hub communities to small, remote communities. If aircraft flown into your airport are not represented in the rural air survey, identify a working replacement based on engine HP, wing length, and cargo capacity. Also note whether aircraft are piston-fired or turboprop. If piston-fired, turboprop replacement will need to be identified using above substitution process.

3.1.3 Commercial Light Aircraft (Single Engine) Cruise Calculations

Model-Original	Model-Replacement	Emission Factor (lb/minu)							
		CO	HC	NOX	SOX	SO4	PM 10	PM 2.5	NH3
Commercial Passenger									
Cessna 207[1]	Cessna 207	0.115006	0.016246	0.025312	0.005503	0	0	0	0
Cessna 207[2]	Cessna 207	0.115006	0.016246	0.025312	0.005503	0	0	0	0
Cessna 208[1]	Cessna 208	0.115006	0.016246	0.025312	0.005503	0	0	0	0
Cessna 208[2]	Cessna 208	0.115006	0.016246	0.025312	0.005503	0	0	0	0

Commercial Passenger									
DeHavilland Beaver	Cessna 180	0.115006	0.016246	0.025312	0.005503	0	0	0	0

[1] summer operations

[2] winter operations

To calculate emissions: Estimate minutes spent at cruising altitude per flight, leaving out estimated time needed for the LTO cycle. ADEC used a fixed location for the beginning and endpoint for each flight (Anchorage Merrill Field to Pedro Bay Airstrip). Although the majority of passenger flights have a short layover in Port Alsworth, it was difficult to model this as the air carriers did not provide exact flight information. ADEC calculated estimated total flight time between the two airports and assigned 10 minutes on both sides to take-off and climbing to altitude, and descent/final landing with the remainder of the time being spent at cruise altitude.

3.1.4 Commercial Cargo Aircraft Multi-Engine Aircraft (Piston) Cruise Calculations

Original Aircraft	Replacement Aircraft	Emission Factors (lb/minute)							
		CO	HC	NOX	SOX	SO4	PM10	PM2.5	NH3
Douglas DC-3[1]	Piper Navajo (X2)	4.166694	0.04596	0.004596	0.000364	0	0	0	0
Douglas DC-3[2]	Piper Navajo (X2)	4.166694	0.044312	0.004596	0.00036376	0	0	0	0
Douglas DC-6[1]	C-130 Military Transport	1.16531	0.23968	0.35394	0.22314	0	0	0	0
Douglas DC-6[2]	C-130 Military Transport	1.1653	0.023968	0.0343394	0.022314	0	0	0	0

[1]summer operations

[2]winter operations

To calculate emissions: Estimate minutes spent at cruising altitude per flight, leaving out estimated time needed for the LTO cycle. ADEC calculated using a location starting and ending point for each flight (Anchorage Merrill Field to Pedro Bay Airstrip). Although the majority of passenger flights have a short layover in Port Alsworth, it was difficult to model this as the air carriers did not provide exact flight information. ADEC calculated estimated total flight time between the two airports and assigned 10 minutes on both sides to take-off and climbing to altitude, and descent/final landing with the remainder of the time being spent at cruise altitude. If aircraft flown into your airport are not represented in the rural air survey, identify a working replacement based on engine HP, wing length, and cargo capacity. Also note whether aircraft are piston-fired or turboprop. If piston-fired, turboprop replacement will need to be identified using the substitution process.

4 GREENHOUSE GAS DATA ASSUMPTIONS

4.1 INTRODUCTION

This section provides brief explanation of how assumptions were made to enter data into the EPA Greenhouse Gas (GHG) Toolkit. The toolkit calculates GHG emissions from information entered into established query forms.

These assumptions can be used to calculate the necessary fuel and mileage data required to fill in all required information in the Greenhouse Gas Toolkit. Please note that not all categories are included in the below assumptions.

4.2 COMMERCIAL AIRCRAFT

All assumptions for commercial aircraft are made with Anchorage's Merrill Field as the initiating point of flights, with Pedro Bay as the termination point. This is a distance of 175 Miles. There is one exception noted for DC-6.

4.2.1 *Douglas DC-3*

Assumptions

- Estimated average fuel consumption: 90-100 gallons Aviation Gasoline/Hour
- Estimated cruising speed: 200MPH
- Flight Time: approximately 55 minutes
- Fuel Consumption Used: 100 gal/hr
- Flight Time Used: 60 minutes

Data Sources: The Douglas DC-3 is no longer a standard aircraft operated in the United States, and its use is primarily relegated to less developed parts of Latin America and the Arctic due to the simplicity of its equipment. All of the information in this section was obtained from internet research using primarily airplane hobbyist websites used by pilots, hobbyists who own and operate these aircraft, and history enthusiasts interested in current and historical use with the military under the airframe designation C-47. If an air carrier can provide more accurate data, substitute the above for the direct use data from air carriers.

4.2.2 *Douglas DC-6*

Assumptions

- Estimated average fuel consumption: 380 gallons Aviation Gasoline/Hour
- Estimated cruising speed: 311MPH un-laden. 290-300MPH with full load of fuel and cargo
- Originating Point: Kenai Municipal Airport
- Flight Distance: 112 Miles
- Flight Time: 25 minutes
- Fuel Consumption: 90 Gallons

Data Sources: The DC-6 is no longer a standard aircraft operated in the United States. See. DC-3 for explanation.

4.2.3 *Cessna 207*

Assumptions

- Estimated average fuel consumption: 16-17 gallons Aviation Gasoline/Hour
- Estimated Cruise Speed: 164MPH
- Flight Time: 60-80 Minutes

Data Sources: Data collected from hobbyist and enthusiast websites primarily. Verification of fuel consumption by private owners in Pedro Bay who reported similar fuel use figures between Anchorage and Pedro Bay. Verification of flight time from private owners in Pedro Bay who reported flight times to ADEC personnel.

4.2.4 *Cessna 208*

Assumptions

- Estimated Average Fuel Consumption: 17 Gallons
- Estimated Cruise Speed: 164MPH
- Flight Time: 60-80 Minutes

Data Sources: See above Cessna 207.

4.3 HOUSEHOLD EMISSIONS

Wood Emissions: The EPA GHG Toolkit lacks wood as a primary fuel source choice for emissions estimation. All wood emissions for this inventory were calculated using a conversion factor of 165 gallons of propane to every 1 cord of wood. This conversion is an approximate value established by the University of Missouri.

Chainsaw Fuel Consumption: All chainsaw fuel consumption is based on an estimation given by a Pedro Bay resident on their household summary of wood consumption. Estimation is 1.2 gallons of fuel per day based on heavy use. This constitutes an extremely conservative reading of chainsaw fuel consumption. If your community has better/more accurate fuel consumption figures, replace the above estimate with those available from local residents.

Brush/Weed Trimmer: There is not enough information for fuel use. A conservative approach would be similar to the chainsaw. 1.2 gallons a day could be reduced to ½ gallon per hour based location and vegetation.

Log Splitter: As with the brush trimmers and chainsaws, there is no single standard fuel consumption. The most conservative estimate found was one quart of gasoline per hour of reported use for a small household log splitter or 1 gallon per 4 hours of use. As no better estimation could be found, this was applied to all log splitters.

Boat Average Fuel and MPH: ADEC averaged the quantity of the reporting households. Seasonal boat use was established to me 2,872.5 miles. The average fuel use during subsistence season was estimated to be 123.28 gallon with an average of 23.30 miles per gallon. Vessel cruise speed was calculated at 20miles per hour, docking/maneuvering at 10mph. For all marine traffic, an estimated 5-10 minutes was included for undocking and maneuvering during trip to and from fishing and hunting trips.

Refuse/Burn Barrel: Emissions were calculated using the wood emissions propane consumption calculations. Figure used was 1.2 gallons of fuel per hour.

Water/Sewage Pumps: It was estimated that a fuel pump used 1.2 gallons/hour which could be considered a conservative estimate. Reporting households provided insufficient information for an accurate estimations of fuel use.

4.4 HOUSEHOLD/COMMUNITY ENERGY CONSUMPTION

Energy consumption was estimated to be 10,399 kilowatts of electricity which was multiplied by 12 year-round households with 42 permanent residents. For seasonal households, emissions were divided in half to ensure accurate representation of emissions-generating activity.

4.5 END NOTE

If there are any questions that cannot be answered by referencing Appendix "A" or the Pedro Bay Emissions Inventory, please contact the Alaska Department of Environmental Conservation, Air Quality Division, Air Non-Point and Mobile Sources Section.

APPENDIX C: SOURCE LISTS

These source lists were developed to establish the survey form content and to better understand tribal government operations.

COMMERCIAL: Commercial operations include barge delivery services, commercial air, stores, lodges etc. that the government does not manage.

	#	Source Type	Name of Facility
Commercial Operations		Waste Incineration*	
		Barge Services (commercial operations)	
		Commercial Buildings (e.g. laundromat)	
		Air Taxi Services	
		Retail Stores (grocery or other)	
		Lodges- seasonal recreation	
		Fuel Delivery Suppliers	
Energy		Generators – electrical	
		Fuel Oil Combustion -Building Heat sources	
		Building heating sources – wood	
Transportation		Airplane Use -commercial	
		Airplane Use - recreational	
		Vehicles on-road	
		Boat Use	
		Construction Equipment	
Other			

*Waste incineration was determined to be a government operation.

RESIDENTIAL: The residential source list was used to identify the types of emission sources in the community. The tribal government representative was asked to identify emission sources and community activities that result in emissions.

	#	Source Type	Data collection
Energy		Generators	Type, fuel use, operation hours
		Home heating	Number of people in home, size of home, heating type and fuel type and volume
		Electrical use	Types of appliances, fuel type, hours of operation

	#	Source Type	Data collection
Transportation		Residential vehicles off-road e.g. ATVs, snow machine	Type of engine, fuel use (gallons)average per month, operation hours per month
		Residential vehicles on-road	Type, hours of use, fuel type and use
		Boat Use – recreation, subsistence activities, travel	Type, hours of use, fuel type and use
		Airplane Use – recreation, subsistence activities, travel	Type, hours of use, fuel type and use
Other		Motorized equipment use (chainsaws, snow blower, water pump, log splitter)	Type, hours of use, fuel type and use
		Outdoor burning (trash, camp/cook fires, smoke house, steam bath, etc.)	Hours of use, type of fuel
		Camp use - heating	Heat source and fuel use

PEDRO BAY VILLAGE COUNCIL OPERATIONS: This survey form was used to identify activities that the PBVC is responsible for. It includes those residences that are owned and managed by the PBVC and in which heating and electricity is provided.

1. Transportation (aircraft, marine, vehicles)
   - Aircraft transportation
   - PBVC marine transportation
   - PBVC transportation and service vehicles

2. Construction Equipment

3. Motorized Equipment (generators, pumps)

4. Facility Heating and Fuel Use
   - Facility Heater Information
   - Other PBVC Operations

5. Waste
   - PBVC Transfer Site (Landfill) – Solid waste processing
   - Wastewater

6. Bulk Fuel Facility

APPENDIX D: SURVEY FORMS

Government Operations Survey questions and forms

1. TRANSPORTATION

This section includes transportation of PBVC on work related business. Employee commutes to work are included in the residential survey. If a resident commutes to work in a PBVC provided vehicle and in which the PBVC provides fuel, then the vehicle and fuel use is included in this survey and is considered a government operation.

AIRCRAFT TRANSPORTATION

How many flights have PBVC staff been passengers for business purposes? ___________________

Total average number trips during 2017. _______________________

The fuel use and trips will also be recorded in the airline commercial survey.

PBVC MARINE TRANSPORTATION

Please indicate the number of boat trips that PBVC staff have taken for work related purposes (2017):

Boat	# Vessels summer	# Vessels Winter	# activity of boat or # of trips per day, week, month	Engine running hours *Summer* (day or week)	Engine running hours *Winter* (day or week)
Boat 1					
Boat 2					
Boat 3					
Boat 4					

Please provide vessel characteristics of PBVC owned vessels:

Vessel type	Fuel type (gasoline or diesel)	Vessel age	Average horsepower

PBVC TRANSPORTATION AND SERVICE VEHICLES

Please identify the types and number of vehicles that are owned and utilized by PBVC employees.

Vehicle Type	Vehicle Specific	Fuel Type		Engine Type (hp) or other measurement	*# Summer* miles driven	*# Winter* miles driven
		gas	diesel			
Cars						
Pickup trucks/SUVs						
Vehicle Type	Vehicle Specific	Fuel Type		Engine Type (hp) or other measurement	*# Summer* miles driven	*# Winter* miles driven
		gas	diesel			
Pickup trucks/SUVs						
4-wheelers/ ATV						
Motorcycles						
Sewage truck						
Fuel truck						

2. CONSTRUCTION EQUIPMENT

Equipment Type	Model	Fuel type	Engine Size	Summer operation hours	Winter operations hours
Loader					
Dozer					
Excavator					
Bobcat					
Screener					
Welder					
Chainsaw					
Compactor engine					
Concrete mixer					
Roller					

3. MOTORIZED EQUIPMENT (GENERATORS, PUMPS, HEATERS)

Equipment	Model	Fuel	Hp / BTU Rating	KW Capacity	Summer Hours per day/week/month	Winter Hours per day/week/month
Generator						
Generator						
Generator						
Gas pump						
Gas pump						
Sewage Pump						
Water Pump - fire						
Heater						
Space Heater						
Space Heater						
Waste oil heater						

Are generators equipped with emission controls? (circle one) Yes / No / Don't Know

If yes, please specify ____

4. FACILITY HEATING AND FUEL USE

FACILITY HEATER INFORMATION:

Directions: What heaters do you use for heat? Please mark an **X** next to each type that you use & mark the age and condition of each heating device. Estimate the percentage of time the heating unit is used in the summer (includes spring: April through includes August) or winter (includes fall: September through March).

Facility	Heater Type	Age and/or Condition Heater	Fuel Type	*Summer* [1] # Gal Fuel Used	*Winter* [2] # Gal Fuel Used	*Summer* % Used	*Winter* % Used
Public Health Office Bldg – Includes Clinic							
Shop / Butler Building	Black gold waste oil heater [4]						

Library – Sam Foss [3]	Diesel boiler						
EMS - Fire							
Admin House							
Bib Hill House							
Facility	Heater Type	Age and/or Condition Heater	Fuel Type	*Summer* [1] # Gal Fuel Used	*Winter* [2] # Gal Fuel Used	*Summer* % Used	*Winter* % Used
PB Electric Generator Building							
School - Denaina							
Mid Res Unit							
Lower Res Unit							

Heater types: wood stoves, outdoor wood boilers, pellet stoves, central oil furnace, heating with water (indoor hydronic), and portable fuel oil or kerosene device.

Fuel types: wood, diesel, gas, propane, wood pellets.

*1 cord = 4 ft x 4ft x 8ft stack

1. Summer months include March through August
2. Winter months include September through February
3. This list includes residences that PBVC pays for heating and fuel expenses. Other residences (25) are included in the residential survey
4. See Section 3: Motorized Equipment (heaters, generators, pumps)

OTHER PB OPERATIONS

Facility	Heater Type	Age and/or Condition Heater	Fuel Type	*Summer* Fuel Use (gal)	*Winter* Fuel Used (gal)	*Summer* % Used	*Winter* % Used
Boat Storage/harbor at Smoke House Bay							
Transfer Facility							

5. Waste

This section seeks to identify the CAP and GHG emissions from waste processing which includes incineration, other burning, Landfill gas is primarily composed of methane and, to a lesser but significant amount, volatile organic compounds (VOC). These gases are released from the landfill as fugitive emissions.

PBVC TRANSFER SITE (LANDFILL) – SOLID WASTE PROCESSESING

Please fill in the total amount of refuse processed at the landfill

Size of landfill ________ in acres

Total Waste Processed ________ in tons per (circle one) day / month / year

Total waste Landfilled ________ in tons per (circle one) day / month / year

Please indicate the processing method used in the facility (circle method).

- Incinerator
- Open Burning
- Burning Cage
- Enclosed Burn Box

Does your landfill have a landfill gas collection system? ___________________________________

Do you cover your landfill? If so, with what? ____

What year did your landfill begin operations _______________

Is refuse processed year-round or seasonally (e.g. more in the summer, winter, summer only, etc.)? Please explain.

____

____

Does your community have a compost operation? ____

Does your community recycle? ____

For a list of LANDFILL motorized equipment, see Section 2: Construction Equipment.

WASTEWATER TREATMENT

PBVC uses septic hauling, wells, and septic system for each home.

Equipment:

- Sewage pump – See Section 3: Motorized Equipment
- Sewage truck – See Section 1: Transportation, PBVC transportation and Service Vehicles

6. Bulk Fuel Facility

FUEL SOLD

Please indicate the amount of each fuel sold for each season.

SUMMER (April-September)

Diesel/Heating Oil _______ gallons per (circle one) day / week / month

Gasoline _______ gallons per (circle one) day / week / month

AvGas _______ gallons per (circle one) day / week / month

Propane _______ gallons per (circle one) day / week / month

WINTER (October-March)

Diesel/Heating Oil _______ gallons per (circle one) day / week / month

Gasoline _______ gallons per (circle one) day / week / month

AvGas _______ gallons per (circle one) day / week / month

Propane _______ gallons per (circle one) day / week / month

FUEL USE

If known, please estimate the percentage of each fuel sold for the following purposes for each season (total 100% per fuel).

Fuel Use	*Summer* % diesel	*Summer* % gasoline	*Summer* % propane	*Winter* % diesel	*Winter* % gasoline	*Winter* % propane
Residential						
Off-Road Equipment						
On-Road Vehicles						
Marine Industry						
Other:						

FUEL STORAGE TANKS

The Lake and Peninsula Borough (LPB) community plan identifies that the Village Council has 64,000 gal fuel storage and the LPB school district has 28,200 gal (total capacity of 92,200 gallons)

Please indicate the fuel tank sizes located in the premises, if any, and their refill frequencies for each season.

Tank Name and Location	Tank Size	Fuel Stored (av gas, gas or diesel)	Refill frequencies *Summer*		Refill frequencies *Winter*	
			# gallons	# times per week or month	# gallons	# times per week or month
Fuel tank farm 1	12,000	diesel				
Fuel tank farm 2	12,000	diesel				
Fuel tank farm 3	12,000	diesel				
Fuel tank farm 4	8,000	gasoline				
Generator Bldg	**10,000**	diesel				
Generator Bldg	**10,000**	diesel				

7. Land Management – Changes in Carbon Stock

Pedro Bay census area is 92,100 square miles (49 km2), of which, 17.3 square miles (45 km2) of it is land and 1.6 square miles (4.1 km2) of it (8.65%) is water. PBC is the steward, owner and manager of over 92,000 acres of surface lands between the proposed Pebble Mine Deposit and deep water port.

For changes in carbon stock, please identify projects and acreage in which land use has changed.

Trees managed by PBVC

Changes in carbon stocks in trees are calculated by estimating the total managed area, the percent of that area with tree cover, and applying a carbon storage factor to estimate carbon sequestration from trees.

What trees comprise the forest stock?

____

Development projects that require vegetation removal

____

Acreage burned for land management

____

Land Use Permits issued resulting in vegetation loss

____

Agriculture fertilizer use

____

Vegetation restoration

____

Other considerations:

____

____

____

____

____

Residence Name:

1. FUEL USED FOR HEATING PURPOSES AT HOME

What heaters do you use for heat? (please mark an **X** next to each type that you use & mark the age of each device)

Heater Type	Heater Used	Age of Heater	Condition of Heater	Percentage Used/Summer	Percentage Used/Winter
Wood Stove					
Outdoor wood boiler (hydronic)					
Pellet stove					
Central oil furnace					
Heating with water (indoor hydronic)					
Portable fuel oil or kerosene device					
Other:					
Other:					

What types of fuel do you use for heat in the **summer/winter** at home? (please mark an X for each type of fuel and season)

Fuel Type	**Summer** (including spring)	**Winter** (including fall)
Wood		
Fuel Oil		
Propane		
Other:		
Other:		

How much fuel do you use during a week or month in the **summer/winter** at home? (Please mark the time period that is easiest to remember). If you don't know, enter "DN."

Fuel Use	**Summer** (include spring)		**Winter** (include fall)	
	Week	**Month**	**Week**	**Month**
Wood (cords)*				
Fuel Oil (gallons)				
Propane (gallons)				
Other:				
Other:				

*1 cord = 4 ft x 4ft x 8ft stack

For **summer/winter** heating with wood, where do you get wood? (please mark how many cords of wood you cut or gather)

Gather or cut your own____________ Purchased_____________

Number of Cords of wood _________

How long does your wood dry or "season" before it is burned? (please mark the number of months)

Number of Months _____________

How big is your house? (please mark the area of your house in number of square feet)

Square feet _______________ OR Length and width of house in feet L: ________ W: _______

Additional Information:

2. FUEL USED FOR MOTORIZED EQUIPMENT

Fuel Use at Home

Do you operate any motorized equipment at home? (If yes, please mark the number of hours that you operate each type during the **summer/winter**). If you don't know, enter "DN."

Motorized Equipment	**Summer** (including spring)		**Winter** (including fall)	
	Week	**Month**	**Week**	**Month**
Chain saw				
Brush/weed trimmer				
Generator				
Log splitter				
Clothes Dryer (propane)				
Other:				
Other:				

How much fuel do you use in all of your motorized equipment during a week/month in the **summer/winter** at home? (Please mark the time period that is easiest to remember). If you don't know, enter "DN."

Fuel Type	**Summer** (including spring)		**Winter** (including fall)	
	Week	Month	Week	Month
Gasoline (gallons)				
Diesel (gallons)				
Propane (gallons)				
Other:				

3. Residential Outdoor Burning

Do you burn anything outdoors? (please specify with an **X** next to each type)

Outdoor burn (trash burn) ____
Burn barrel ____
Camp/cook fires ____
Barbecue (propane) ____
Barbecue (charcoal) ____
Smokehouse ____
Sauna ____

Others? ______________________________

If you burn trash outdoors, do you separate plastic from your burn materials? ____________

How many hours do you burn outdoors during a week/month in the **summer/winter** at home? (Please mark the time period that is easiest to remember). If you don't know, enter "DN."

Burn Type	**Summer** (include spring)		**Winter** (include fall)	
	Week	**Month**	**Week**	**Month**
Outdoor burn				
Burn barrel				
Camp/cook fires				
Barbecue (propane)				
Barbecue (charcoal)				
Smokehouse				
Sauna				
Other:				
Other:				

4. FUEL USED FOR TRANSPORTATION

Vehicle Type: Do you own any vehicles? (If yes, please mark the number of vehicles and their model years.)

Vehicle Type	Number	Model year(s)
Car		
Pickup Truck		
SUV		
Motorcycle/Dirt bike		
All-terrain vehicle (ATV)		
Snow machine		
Personal airplane		
Other:		

Fuel Use: How much fuel do you use in your vehicles (gallons)? (Please mark the number of gallons that you typically use during a week or month in the **summer/winter**). If you don't know, enter "DN."

Vehicle Type	Gasoline	Diesel	Other fuel	Summer (including spring)		Winter (including fall)	
Car							
Pickup Truck							
SUV							
Motorcycle/Dirt bike							
All-terrain vehicle (ATV) 2-stroke							
ATV 4-stroke							
Snow machine							
Personal airplane							
Boat							
Other:							

Hours of Operation: How many hours do you operate your recreational vehicles during a week/month in the **summer/winter**? (please mark the time period that is easiest to remember)

Vehicle Type	Vehicle Size	Hours of Operation Summer (including spring)	Hours of Operation Winter (including fall)
Personal airplane			
Boat			
Other:			