Appendix F: Air Study

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AIR QUALITY STUDY

FOR THE PROPOSED

KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT

PUNA DISTRICT, HAWAII

Prepared for:

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1.0 SUMMARY

The Hawaii Department of Transportation is proposing highway improvements in the Puna District on the island of Hawaii. These improvements involve widening Keaau-Pahoa Road (State Route 130) between Keaau and Pahoa and improving several intersections in the Keeau-Pahoa corridor. The proposed improvements are needed to alleviate existing traffic congestion and to provide sufficient capacity to accommodate the projected increase in traffic volume at least through the year 2038.

This study examines the potential short- and long-term air quality impacts that could occur as a result of construction and use of the proposed highway facilities. Mitigative measures are suggested where possible and appropriate to lessen any impacts from the project.

Both federal and state standards have been established to maintain ambient air quality. At the present time, seven parameters are regulated including: particulate matter, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, carbon monoxide, ozone and lead. Hawaii air quality standards are comparable to the national standards except those for nitrogen dioxide and carbon monoxide which are more stringent than the national standards.

Regional and local climate together with the amount and type of human activity generally determine the air quality of a given location. The climate of the project area is very much affected by its near coastal situation and by nearby mountains. Winds are predominantly light and variable, although storms generate occasional strong winds from the south or southwest during winter. Temperatures in the project area are generally very consistent and moderate with average daily temperatures ranging from about 65°F to 85°F. The extreme minimum temperature recorded at nearby Hilo is 53°F, while the extreme maximum temperature is 94°F. Average annual rainfall in the area amounts to about 144 inches.

Except for periodic impacts from volcanic emissions (vog) and possibly occasional localized impacts from traffic congestion, the present air quality of the project area is believed to be relatively good. The limited air quality data that are available for the area from the Department of Health indicate that (despite the occasional vog) concentrations are well within state and national air quality standards.

If the proposed project is given the necessary approvals to proceed, it is inevitable that some short- and long-term impacts on air quality will unavoidably occur either directly or indirectly as a consequence of project construction and use. Short-term impacts from fugitive dust will likely occur during the project construction phase. To a lesser extent, exhaust emissions from stationary and mobile construction equipment and from the disruption of traffic may also affect air quality during the period of construction. State air pollution control regulations require that there be no visible fugitive dust emissions at the project boundary. Hence, an effective dust control plan should be implemented to ensure compliance with state regulations. Fugitive dust emissions can be controlled to a large extent by watering of active work areas, using wind screens, keeping adjacent paved roads clean, and by covering of open-bodied trucks. Other dust control measures could include limiting the area that can be disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Paving and landscaping of project areas early in the construction schedule will also reduce dust emissions. Excess exhaust emissions from traffic disruption can be mitigated by moving construction equipment and workers to and from the project site during off-peak traffic hours and by minimizing road closures during peak traffic periods.

To assess the potential long-term impact of emissions from vehicles operating on roadways within the project corridor, both mesoscale and microscale analyses were performed, and a qualitative assessment of mobile source air toxics was prepared. The mesoscale analysis was designed to provide estimates of air pollution emissions from traffic for the entire highway corridor, while the microscale analyses assessed ambient air quality impacts near selected intersections within the project study area. The mesoscale analyses considered an existing (2006) case and five alternatives for the design year (2038). The design year alternatives included a no-action scenario (Alternative 1) and four with-project alternatives (designated as Alternatives 2, 3, 4 and 5). The microscale analyses were performed for the existing case and for year 2038 Alternatives 1, 3, 4 and 5 only.

The mesoscale analysis indicated that in 2006 the totals of emissions from traffic using Keaau-Pahoa Road within the study area were 780 tons per year of carbon monoxide, 63 tons per year of volatile organic compounds and 93 tons per year of nitrogen oxides. Without the project in the year 2038, it was estimated that carbon monoxide emissions would increase by 17 percent while volatile organic compounds emissions would decrease by 19 percent and nitrogen oxides emissions would decrease by 61 percent. With Alternative 2 in the year 2038, emissions of carbon monoxide, nitrogen oxides and volatile organic compounds would remain essentially unchanged compared to the no-action alternative. With Alternatives 3, 4 or 5, carbon monoxide emissions would increase very slightly compared to the no-action alternative while nitrogen oxides emissions would remain unchanged and volatile organic compounds emissions would remain nearly unchanged or decrease slightly with Alternative 5. The mesoscale emission estimates pertain to traffic on Keaau-Pahoa Road only, and thus the mesoscale analysis may not measure the full positive impact of the project due to intersection improvement and reduced queuing of traffic on cross roads in the study area. Thus, it is probable that with project Alternatives 3, 4 or 5, based on a mesoscale viewpoint, there would either be little negative impact or a net positive impact.

The microscale analyses performed for this project involved the use of computerized emission and atmospheric dispersion models to estimate existing (2006) worst-case ambient concentrations of carbon monoxide during peak travel hours at eight intersections in the project study area. The highest worst-case carbon monoxide concentration for 2006 was predicted to occur at the intersection of Keaau-Pahoa Road and Shower Drive during the morning. The predicted concentration at this location reached 8.4 mg/m^3, which is about 21 percent of the national standard and about 84 percent of the more stringent state standard. In the year 2038 without the project, predicted worst-case concentrations generally decreased in the northern areas of the project corridor and mostly increased in the southern portion. The predicted highest concentration in the study area for this scenario was 5.9 mg/m^3 and occurred at the intersection of Keaau-Pahoa Road and Kaloli Drive during the morning. Concentrations remained within the state and national standards at all locations studied. Although it is expected that there would be significantly more traffic and congestion by the year 2038 without roadway improvements, much of the emissions should be offset by the retirement of older vehicles with less efficient emissions controls. In the year 2038 with project Alternatives 3, 4 or 5, worst-case concentrations were predicted to be lower (better) at almost all of the locations studied. All locations would remain in compliance with the state and national standards with any of the 2038 alternatives, but Alternative 5 would likely provide the best alternative in terms of the microscale impacts and maximum carbon monoxide concentrations. Most intersections with the project in the future were assumed to be signalized for this analysis. If a round about design is used instead, air quality impacts would likely be lower.

A qualitative assessment of the potential impacts from mobile source air toxics (MSATs) indicated that none of the four with-project alternatives would likely result in higher MSAT emissions. Further, it is probable that MSAT emissions will decrease in the future, with or without the project, due to fleet turnover and as new vehicle and fuel regulations are implemented.

Based on the results of the analyses of the potential long-term impacts of the project, it may be concluded that the proposed roadway improvements would likely have a net positive impact on the air quality of the area. None of the four with-project alternatives is significantly better or worse in this regard, but Alternative 5 would likely yield the best results insofar as air quality is concerned. Although options are available to mitigate long-term traffic-related air quality impacts, requiring these be implemented is probably unnecessary and unwarranted in this case.

2.0 INTRODUCTION AND PROJECT DESCRIPTION

The State of Hawaii Department of Transportation (HDOT) is proposing to improve the Keaau-Pahoa Road (State Route 130) in the Puna District on the island of Hawaii. The project includes approximately 9.5 miles of Keaau-Pahoa Road from the terminus of the existing four-lane Keaau Bypass to its intersection with

Pahoa-Kapoho Road (see Figure 1 for general project location). The proposed project would involve the widening of Keaau-Pahoa Road for all or part of the project’s length from the existing two-lane roadway to a four-lane or six-lane road (depending on the alternative selected) and the improvement and signalization of several intersections within the project corridor.

The proposed improvements are needed to alleviate existing traffic congestion and to provide sufficient capacity to accommodate the projected increase in future traffic volumes. The design year for the project has been designated as 2038.

The purpose of this study was to evaluate the potential air quality impacts of the proposed project and recommend mitigative measures, if possible and appropriate, to reduce or eliminate any project-related degradation of air quality in the area. Before examining the potential impacts of the project, a discussion of ambient air quality standards is presented and background information concerning the regional and local climatology and the present air quality of the project area is provided.

3.0 AMBIENT AIR QUALITY STANDARDS

Ambient concentrations of air pollution are regulated by both national and state ambient air quality standards (AAQS). National AAQS are specified in Section 40, Part 50 of the Code of Federal Regulations (CFR), while State of Hawaii AAQS are defined in Chapter 11-59 of the Hawaii Administrative Rules. Table 1 summarizes both the national and the state AAQS that are specified in the cited documents. As indicated in the table, national and state AAQS have been established for particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. The state has also set a standard for hydrogen sulfide. National AAQS are stated in terms of both primary and secondary standards for most of the regulated air pollutants. National primary standards are designed to protect the public health with an "adequate margin of safety". National secondary standards, on the other hand, define levels of air quality necessary to protect the public welfare from "any known or anticipated adverse effects of a pollutant". Secondary public welfare impacts may include such effects as decreased visibility, diminished comfort levels, or other potential injury to the natural or man-made environment, e.g., soiling of materials, damage to vegetation or other economic damage. In contrast to the national AAQS, Hawaii State AAQS are given in terms of a single standard that is designed "to protect public health and welfare and to prevent the significant deterioration of air quality".

Each of the regulated air pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration for prolonged periods of time. The AAQS specify a maximum allowable concentration for a given air pollutant for one or more averaging times to prevent harmful effects. Averaging times vary from one hour to one year depending on the pollutant and type of exposure necessary to cause adverse effects. In the case of the short-term (i.e., 1- to 24-hour) AAQS, both national and state standards allow a specified number of exceedances each year.

The Hawaii AAQS are in some cases considerably more stringent than the comparable national AAQS. In particular, the Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit.

The Hawaii AAQS for sulfur dioxide were relaxed in 1986 to make the state standards essentially the same as the national limits. In 1993, the state also revised its particulate standards to follow those set by the federal government. During 1997, the federal government again revised its standards for particulate, but the new standards were challenged in federal court. A Supreme Court ruling was issued during February 2001, and as a result, the new standards for particulate were finally implemented during 2005. To date, the Hawaii Department of Health has not updated the state particulate standards. In September 2001, the state vacated the state 1-hour standard for ozone and an 8-hour standard was adopted.

During the latter part of 2008, EPA revised the standard for lead making the standard more stringent. So far, the Hawaii Department of Health has not revised the corresponding state standard for lead. Most recently (January 2010), a national 1-hour standard for nitrogen dioxide was implemented.

4.0 REGIONAL AND LOCAL CLIMATOLOGY

Regional and local climatology significantly affect the air quality of a given location. Wind, temperature, atmospheric turbulence, mixing height and rainfall all influence air quality. Although the climate of Hawaii is relatively moderate throughout most of the state, significant differences in these parameters may occur from one location to another. Most differences in regional and local climates within the state are caused by the mountainous topography.

The entire state of Hawaii lies well within the belt of northeasterly trade winds generated by the semi-permanent Pacific high pressure cell to the north and east of the islands. Areas along the eastern coasts of the islands are particularly affected by the trade winds and are usually well-ventilated nearly year round. Although the project site is situated along the eastern coast of Hawaii Island, the high mountains of Mauna Loa and Mauna Kea significantly modify the trade wind influence. The nearest long-term wind data available for the project area are collected at the Hilo Airport located about 20 miles to the north. These data are probably at least semi-representative of the project corridor. Mean annual wind speed at the airport is about 8 mph, which is lower than many windward locations in the state, and wind directions are bimodal showing either a northeast or southwest preference [1]. Northeast trade winds typically occur during the daytime, while winds from the southwest typically occur during the nighttime due to cold air drainage from the mountains. Winds from the south or southwest also occur occasionally in association with winter storms.

Air pollution emissions from motor vehicles, the formation of photochemical smog and smoke plume rise all depend in part on air temperature. Colder temperatures tend to result in higher emissions of contaminants from automobiles but lower concentrations of photochemical smog and ground-level concentrations of air pollution from stack sources. In Hawaii, the annual and daily variation of temperature depends to a large degree on elevation above sea level, distance inland and exposure to the trade winds. Average temperatures at locations near sea level generally are warmer than those at higher elevations. Areas exposed to the trade winds tend to have the least temperature variation, while inland and leeward areas often have the most. At Hilo Airport, average annual daily minimum and maximum temperatures are 66°F and 82°F, respectively. The extreme minimum temperature on record is 53°F, and the extreme maximum is 94°F [2].

Small scale, random motions in the atmosphere (turbulence) cause air pollutants to be dispersed as a function of distance or time from the point of emission. Turbulence is caused by both mechanical and thermal forces in the atmosphere. It is often measured and described in terms of Pasquill-Gifford stability class. Stability class 1 is the most turbulent and class 6 the least. Thus, air pollution dissipates the best during stability class 1 conditions and the worst when stability class 6 prevails. In the Hilo area, stability classes 5 or 6 occasionally occur, developing during clear, calm nighttime or early morning hours when temperature inversions form due to radiational cooling or to drainage flow from the mountainous interior of the island. Stability classes 1 through 4 occur during the daytime, depending mainly on the amount of cloud cover and incoming solar radiation and the onset and extent of the sea breeze.

Mixing height is defined as the height above the surface through which relatively vigorous vertical mixing occurs. Low mixing heights can result in high ground-level air pollution concentrations because contaminants emitted from or near the surface can become trapped within the mixing layer. In Hawaii, minimum mixing heights tend to be high because of mechanical mixing caused by the trade winds and because of the temperature moderating effect of the surrounding ocean. Low mixing heights may sometimes occur, however, at inland locations and even at times along coastal areas early in the morning following a clear, cool, windless night. Coastal areas also may experience low mixing levels during sea breeze conditions when cooler ocean air rushes in over warmer land. Mixing heights in Hawaii typically are above 3000 feet (1000 meters).

Rainfall can have a beneficial affect on the air quality of an area in that it helps to suppress fugitive dust emissions, and it also may "washout" gaseous contaminants that are water soluble. Rainfall in Hawaii is highly variable depending on elevation and on location with respect to the trade wind. The project area has a wet climate. Normal annual rainfall for Hilo Airport is about 129 inches [2], while at nearby Pahoa, the normal annual rainfall is about 144 inches [3]. This is distributed fairly evenly throughout the year, although the summer months are slightly drier.

5.0 PRESENT AIR QUALITY

Present air quality in the project area is mostly affected by air pollutants from vehicular, industrial, natural and/or agricultural sources. Table 2 presents an air pollutant emission summary for the island of Hawaii for calendar year 1993. The emissions rates shown in the table pertain to manmade emissions only, i.e., emissions from natural sources are not included. As suggested in the table, much of the manmade particulate emissions on Hawaii originate from area sources, such as the mineral products industry and agriculture. Manmade sulfur oxides are emitted almost exclusively by point sources, such as power plants and other fuel-burning industries. Nitrogen oxides emissions emanate predominantly from area sources (mostly motor vehicle traffic), although industrial point sources contribute a significant share. The majority of carbon monoxide emissions occur from area sources (motor vehicle traffic), while hydrocarbons are emitted mainly from point sources.

It should be noted that Hawaii Island is unique from the other islands in the state in terms of the natural volcanic air pollution emissions that occur. Volcanic emissions periodically plague the project area. This is especially so since the latest eruption phase of the Kilauea Volcano began in 1983. Air pollution emissions from the Hawaiian volcanoes consist primarily of sulfur dioxide. After entering the atmosphere, these sulfur dioxide emissions are carried away by the wind and either washed out as acid rain or gradually transformed into particulate sulfates or acid aerosols. Emissions from Kilauea are vented to the atmosphere relatively close by (about 20 miles west of the project site), but the prevailing wind patterns carry the emissions away from the project area much of the time. On occasions when the winds are from the west or south, relatively high concentrations of sulfur dioxide may occur at the project site and volcanic haze (vog) can impact the area.

The nearest major industrial sources of air pollution in the project vicinity are Hawaii Electric Light Company power plants located in Keaau and Hilo. Air pollution emissions from these sources consist mostly of sulfur dioxide and oxides of nitrogen. Hydrogen sulfide emissions are also emitted from Puna Geothermal Venture's geothermal power plant located a few miles to the southeast of Pahoa.

Highway 130 (Keaau-Pahoa Road is the region's major arterial roadway. Emissions from motor vehicles using the roadway consist primarily of carbon monoxide, nitrogen oxides and volatile organic compounds. Daytime winds from the northeast will tend to carry emissions from motor vehicles traversing this roadway toward the southwest, while nighttime mountain drainage winds will carry emissions toward the northeast.

The State Department of Health operates a network of air quality monitoring stations at various locations around the state.

Unfortunately, very limited data are available for Hawaii Island. A monitoring station is located within Pahoa, but this station measures sulfur dioxide and hydrogen sulfide only. Table 3 summarizes the data from the Pahoa monitoring station for the four-year period from 2005 to 2008. Measurements of sulfur dioxide concentrations at Pahoa during the 2005-2008 monitoring period were consistently low in terms of the annual average concentrations which ranged from 3 to 5 $\mu g/m^3$ only. This represents about 6 percent of the state and national standard. The highest annual second-highest 3-hour and 24-hour concentrations (which are most relevant to the standards) for these four years were 159 and 55 $\mu g/m^3$, respectively; these are about 12 to 15 percent of the applicable standards. The higher short-term concentrations reflect periodic episodes of vog in the Pahoa area. While these concentrations are relatively high compared to most other locations in the state, no exceedances of the state/national 3-hour and 24-hour AAQS for sulfur dioxide were recorded.

The highest second-highest 1-hour concentration of hydrogen sulfide for this four-year period, 14 $\mu g/m^3$, is about 40 percent of the state standard. There were no violations of the state AAQS.

Particulate matter was monitored at Hilo, which is about 7 miles north of the project area, prior to 2005. The annual average particulate concentration in Hilo for 2000-2003 was 10 to 12 $\mu g/m^3$, which equates to about 25 percent of the state/national standard, and the second-highest 24-hour concentration of particulate matter for this period, 20 $\mu g/m^3$, is about 13 percent of the state/national standard. There were no violations of the state/national AAQS. Monitoring for particulate matter at the Hilo monitoring station was discontinued at the end of 2004.

At this time, there are no reported measurements of lead, ozone, nitrogen dioxide or carbon monoxide in the project vicinity. These are primarily motor vehicle related air pollutants. Lead, ozone and nitrogen dioxide typically are regional scale problems. Concentrations of lead and nitrogen dioxide generally have not been found to exceed AAQS elsewhere in the state. Ozone concentrations, on the other hand, have been found to exceed the state standard at times at Sand Island on Oahu. Carbon monoxide air pollution typically is a microscale problem caused by congested motor vehicular traffic. In traffic congested areas such as urban Honolulu, carbon monoxide concentrations have been found to occasionally exceed the more stringent state AAQS. Concentrations of carbon monoxide in the project area are estimated later in this study based on computer modeling of project-related motor vehicle emissions.

6.0 SHORT-TERM IMPACTS OF PROJECT

Short-term direct and indirect impacts on air quality could potentially occur during project construction. For a project of this nature, there are two potential types of air pollution emissions that could directly result in short-term air quality impacts during construction: (1) fugitive dust from vehicle movement and soil excavation; and (2) exhaust emissions from on-site construction equipment. Indirectly, there also could be short-term impacts from slow-moving construction equipment traveling to and from the project site and from the disruption of traffic due to road construction.

Fugitive dust emissions may arise from the grading and dirt-moving activities associated with land clearing and preparation work. The emission rate for fugitive dust emissions from construction activities is difficult to estimate accurately because of its elusive nature of emission and because the potential for its generation varies greatly depending upon the type of soil at the construction site, the amount and type of dirt-disturbing activity taking place, the moisture content of exposed soil in work areas, and the wind speed. The EPA [4] has provided a rough estimate for uncontrolled fugitive dust emissions from construction activity of 1.2 tons per acre per month under conditions of "medium" activity, moderate soil silt content (30%), and precipitation/evaporation (P/E) index of 50. Uncontrolled fugitive dust emissions in the project area would likely be somewhere near this level or possibly lower due to the wet climate. In any case, State of Hawaii Air Pollution Control Regulations [5] prohibit visible emissions of fugitive dust from construction activities at the project boundary, and thus an effective dust control plan for the project construction phase is essential.

Adequate fugitive dust control can usually be accomplished by the establishment of a frequent watering program to keep bare-dirt surfaces in construction areas from becoming significant sources of dust. In dust-prone or dust-sensitive areas, other control measures such as limiting the area that can be disturbed at any given time, applying chemical soil stabilizers, mulching and/or using wind screens may be necessary. Control regulations further stipulate that open-bodied trucks be covered at all times when in motion if they are transporting materials that could be blown away. Haul trucks tracking dirt onto paved streets from unpaved areas is oftentimes a significant source of dust in construction areas. Some means to alleviate this problem, such as road cleaning or tire washing, may be appropriate. Paving and/or establishment of landscaping as early in the construction schedule as possible can also lower the potential for fugitive dust emissions.

On-site mobile and stationary construction equipment also will emit air pollutants from engine exhausts. The largest of this equipment is usually diesel-powered. Nitrogen oxides emissions from diesel engines can be relatively high compared to gasoline-powered equipment, but the standard for nitrogen dioxide is set on an annual basis and is not likely to be violated by short-term construction equipment emissions. Carbon monoxide emissions from diesel engines, on the other hand, are low and should be relatively insignificant compared to vehicular emissions on nearby roadways.

Indirectly, slow-moving construction vehicles on roadways leading to and from the project area could obstruct the normal flow of traffic to such an extent that overall vehicular emissions are increased, but this impact can be mitigated by moving heavy construction equipment during periods of low traffic volume. Likewise, road closures during peak traffic periods should be avoided to the extent possible to minimize air pollution impacts from traffic disruption. Thus, with careful planning and attention to dust control, most potential short-term air quality impacts from project construction can be mitigated.

7.0 LONG-TERM IMPACTS OF PROJECT

After construction is completed, the proposed roadway improvements will result in modified traffic flow in the project area. To evaluate the potential long-term, ambient air quality impact of the proposed project, both mesoscale and microscale analyses were performed for each of six scenarios. The six scenarios studied included:

- 2006 with present conditions
- 2038 without the project (Alternative 1)
- 2038 with project Alternative 2
- 2038 with project Alternative 3
- 2038 with project Alternative 4
- 2038 with project Alternative 5.

The "no-build" alternative, Alternative 1, includes currently programmed actions only. Alternative 2 is a transportation systems management (TSM) alternative which would make lower-cost improvements along the project corridor, including signalizing intersections, access management and transit improvements. Alternative 3 would incorporate some or all of the TSM improvements plus widen Keaau-Pahoa Road to four lanes between Keaau Bypass and Ainaloa Boulevard and retain the two-lane cross section between Ainaloa Boulevard and Kapoho Road. Alternative 4 would incorporate some or all of the TSM improvements plus widen Keaau-Pahoa Road to four lanes between Keaau Bypass and Kapoho Road. Alternative 5 would also incorporate some or all of the TSM improvements plus widen Keaau-Pahoa Road to six lanes between Keaau Bypass and Paradise Drive, four lanes between Paradise Drive and Kahakai Boulevard, and retain the two-lane cross section between Kahakai Boulevard and Kapoho Road.

The project alternatives indicated above are described in more detail in the project traffic study [6]. The following subsections of this report discuss the air quality study methodologies and the results of these analyses.

7.1 Mesoscale Analysis

To evaluate the potential mesoscale impact of the proposed project, an analysis of daily and annual emissions from the roadway corridor in the project area was prepared. The mesoscale analysis was designed to quantify project-related emissions of carbon monoxide, nitrogen oxides and volatile organic compounds occurring within the study area for the existing case and for the future project alternatives.

The mesoscale emission estimates for each scenario were made by first dividing the roadway corridor up into segments and obtaining the estimated daily traffic volume and average travel speed for each segment from the project traffic analysis [6]. Vehicle-miles per day for each segment were then calculated. Emission estimates were then prepared for each scenario based on the estimated vehicle-miles of travel, average travel speeds, and U.S. EPA emission factors obtained using the computer model MOBILE6.2 [7]. MOBILE6.2 is the most recently released version of the EPA mobile emission model. Aside from vehicle speed, several other key inputs are required by the model. One of these is vehicle mix. Unless very detailed information is available, national average values are typically assumed, which is what was used for the present study. Based on national average vehicle mix figures, the present vehicle mix in the project area was estimated to be 40.9% light-duty gasoline-powered automobiles, 46.2% light-duty gasoline-powered trucks and vans, 3.6% heavy-duty gasoline-powered vehicles, 0.2% light-duty diesel-powered vehicles, 8.5% heavy-duty diesel-powered trucks and buses, and 0.6% motorcycles. For the future scenarios studied, the vehicle mix was estimated to change somewhat with fewer light-duty gasoline-powered automobiles and more light-duty gasoline-powered trucks and vans.

Another key input to MOBILE6.2 is ambient temperature. An average ambient temperature 77 degrees F was used for all of the mesoscale emission computations.

The resulting emission factors generated by MOBILE6.2 are given in terms of grams of volatile organic compounds (VOC), carbon monoxide (CO) and nitrogen oxides (NOx) emitted per vehicle mile. MOBILE6.2 emission factors are inversely proportional to vehicle speed below about 40 miles per hour; above about 40 miles per hour, the emission factors generally increase with speed. It should also be noted that at a given vehicle speed emission factors are generally lower for future years due to the effects of older, more-polluting vehicles being retired.

Tables 4 through 9 provide the details of the mesoscale analysis. A summary of the results is presented below:

Scenario	Emissions (tons/year)		
	CO	NOx	VOC
2006 Existing	780	93	63
2038 Alternative 1	914	36	51
2038 Alternative 2	909	36	54
2038 Alternative 3	945	37	56
2038 Alternative 4	955	37	55
2038 Alternative 5	930	36	50

In comparison to the island-wide emissions given in Table 2 for 1993 (the latest figures available), emissions in the year 2006 from traffic within the project area were relatively small but not insignificant. Carbon monoxide, nitrogen oxides and VOC emissions from traffic in the project area during 2006 likely account for a few percent of total island-wide emissions.

Without the project in the year 2038 (Alternative 1), carbon monoxide emissions within the project area were estimated to increase by about 17 percent compared to existing emissions. On the other hand, VOC emissions were estimated to decrease by about 19 percent, and nitrogen oxides emissions were estimated to decrease by about 61 percent.

There were no significant differences between the with-project alternatives. Alternative 2 would provide for slightly lower carbon monoxide emissions than the other with-project alternatives, while Alternative 5 would provide for slightly lower VOC emissions. None of the four with-project alternatives would result in substantial changes in the amounts emissions compared to the no-action alternative (Alternative 1).

It should be noted that the estimated emissions for the with-project alternatives may not fully reflect some of the potential benefits for the proposed roadway improvements in terms of the area-wide emissions from motor vehicle traffic. The emission estimates given above pertain only to traffic using Keaau-Pahoa Road. Several intersections along the roadway would be improved under the various with-project alternatives, and this could be expected to improve traffic flow on cross streets at these intersections, which would serve to reduce traffic queuing and reduce excess emissions from cross-street traffic idling and accelerating at the intersections.

7.2 Microscale Analyses

In most traffic-related air quality assessments, roadway intersections are one of the primary concerns because of traffic congestion and because of the increase in vehicular emissions associated with traffic queuing. To investigate potential air quality impacts near roadway intersections within the project area, microscale analyses were performed for selected locations using computerized emission and atmospheric dispersion models to estimate worst-case ambient carbon monoxide concentrations. Carbon monoxide was selected for the microscale analyses because it is both the most stable and the most abundant of the pollutants generated by motor vehicles. Furthermore, carbon monoxide air pollution is generally considered to be a microscale problem that can be addressed locally to some extent, whereas other air pollutants most often are regional issues that cannot be addressed by a single highway improvement.

The selected locations for microscale analyses included eight representative intersections along the project corridor. These included:

- Keaau-Pahoa Road at Opukahaia Road
- Keaau-Pahoa Road at Shower Drive
- Keaau-Pahoa Road at Kaloli Drive
- Keaau-Pahoa Road at Orchidland Drive
- Keaau-Pahoa Road at Paradise Drive
- Keaau-Pahoa Road at Ilima Street
- Keaau-Pahoa Road at Pahoa Village Junction (Old Pahoa Road)
- Keaau-Pahoa Road at Kahakai Boulevard.

These are all existing intersections and none are currently signalized. Based on the traffic analysis, these intersections are all expected to have longer traffic delay times. Thus, these locations are expected to be representative of areas within the project study area where air quality impacts may be greater. In the future with the project, intersections at Shower Drive, Kaloli Drive, Orchidland Drive, Paradise Drive, Pahoa Village Junction and Kahakai Boulevard were assumed to be signalized. Some of these intersections may instead operate as "round abouts", but for the purposes of this analysis, signalization likely provides a worst case.

The main objective of the microscale analyses was to estimate worst-case 1-hour average carbon monoxide concentrations for each of the scenarios studied. Five scenarios were studied for the microscale analyses. These included the existing (2006) case and four of the five defined alternatives for 2038. The four alternatives studied for 2038 included Alternative 1 (no action) and Alternatives 3, 4 and 5. Alternative 2, which includes TSM only, would not add any capacity to Keaau-Pahoa Road, and thus would not meet the purpose and need for the project. Therefore, this alternative was not considered a realistic long-term option, and it was not included in the microscale analyses.

To evaluate the significance of the estimated microscale concentrations, a comparison of the predicted values for each scenario can be made. A comparison of the estimated values to the national and state AAQS will provide another measure of significance.

Traffic estimates for the project indicate that traffic volumes generally are or will be higher during the afternoon peak hour than during the morning peak period. However, worst-case emission and meteorological dispersion conditions typically occur during the morning hours at most locations. Thus, both morning and afternoon peak-traffic hours were examined to ensure that worst-case concentrations were identified.

As for the mesoscale emission burden analysis, the EPA computer model MOBILE6.2 was used to calculate vehicular emissions for each year/scenario studied in the microscale analyses. Vehicle mix was assumed to be the same as that used for the mesoscale emission estimates.

Ambient temperatures of 59 and 68 degrees F were used for morning and afternoon peak-hour emission computations, respectively. These are conservative assumptions since morning/afternoon ambient temperatures will generally be warmer than this, and emission estimates given by MOBILE6.2 generally have an inverse relationship to the ambient temperature.

After computing vehicular carbon monoxide emissions through the use of MOBILE6.2, these data were then input to an atmospheric dispersion model. EPA air quality modeling guidelines [8] currently recommend that the computer model CAL3QHC [9] be used to assess carbon monoxide concentrations at roadway intersections. CAL3QHC was developed for the U.S. EPA to simulate vehicular movement, vehicle queuing and atmospheric dispersion of vehicular emissions near roadway intersections. It is designed to predict 1-hour average pollutant concentrations near roadway intersections based on input traffic and emission data, roadway/receptor geometry and meteorological conditions.

Although CAL3QHC is intended primarily for use in assessing atmospheric dispersion near signalized roadway intersections, it can also be used to evaluate unsignalized intersections. This is accomplished by manually estimating queue lengths and then applying the same techniques used by the model for signalized intersections. Currently, all of the study intersections are unsignalized.

Input peak-hour traffic data were obtained from the traffic study cited previously. This included vehicle approach volumes, saturation capacity estimates, intersection laneage and signal timings (where applicable). All emission factors that were input to CAL3QHC for free-flow traffic on roadways were obtained from MOBILE6.2 based on assumed free-flow vehicle speeds corresponding to the posted speed limits.

Model roadways were set up to reflect roadway geometry, physical dimensions and operating characteristics. Concentrations predicted by air quality models generally are not considered valid within the roadway-mixing zone. The roadway-mixing zone is usually taken to include 3 meters on either side of the traveled portion of the roadway and the turbulent area within 10 meters of a cross street. Model receptor sites were thus located at the edges of the mixing zones near all intersections that were studied for all scenarios. This implies that pedestrians currently walk along the edge of the existing highway in the shoulder area; in the future, pedestrian areas or improved shoulders will be used to accommodate pedestrians depending on the roadway width. All receptor heights were placed at 1.8 meters above ground to simulate levels within the normal human breathing zone.

Input meteorological conditions for this study were defined to provide "worst-case" results. One of the key meteorological inputs is the atmospheric stability category. For these analyses, atmospheric stability category 6 was assumed for morning scenarios and stability category 4 was assumed for afternoon cases. These are the most conservative stability categories that are generally used for estimating pollutant dispersion at suburban locations for these time periods. For all cases, a surface roughness length of 100 cm was assumed and a mixing height of 300 meters was used. Worst-case wind conditions were defined as a wind speed of 1 meter per second with a wind direction resulting in the highest predicted concentration. Concentration estimates were calculated at wind directions of every 5 degrees.

Existing background concentrations of carbon monoxide in the project vicinity are believed to be at relatively low levels. Hence, background contributions of carbon monoxide from sources or distant roadways not directly considered in the analysis were accounted for by adding a small background concentration of 0.5 ppm to all predicted concentrations for 2006. Although substantial development and increased traffic are expected to occur within the project area within the next several years, background carbon monoxide concentrations may not change significantly since individual emissions from motor vehicles are forecast to decrease with time. Hence, a background value of 0.5 ppm was assumed to persist for the 2038 scenarios that were studied.

Predicted Worst-Case 1-Hour Concentrations

Table 10 summarizes the final results of the microscale modeling study in the form of the estimated worst-case 1-hour morning and afternoon ambient carbon monoxide concentrations for 2006 and for each of the four 2038 alternatives. The locations of these estimated worst-case 1-hour concentrations all occurred at or very near the indicated intersections.

As indicated in the table, the highest estimated worst-case 1-hour concentration for the present (2006) scenario was 8.4 mg/m^3, and this occurred during the morning at the intersection of Keaau-Pahoa Road and Shower Drive. Worst-case values for other locations ranged from 2.4 to 7.2 mg/m^3. These concentrations are within both the national AAQS of 40 mg/m^3 and the state standard of 10 mg/m^3.

In the year 2038 without the proposed project (Alternative 1), the predicted highest worst-case 1-hour concentration occurred during the morning at the intersection of Keaau-Pahoa Road and Kaloli Drive with a value of 5.9 mg/m^3, which is about 30 percent lower compared to the existing case. Other concentrations for this scenario ranged between 2.4 and 5.4 mg/m^3. Without the project, carbon monoxide concentrations were predicted to decrease compared to the existing case at locations in the northern portion of the project corridor and increase at several locations in the southern portion of the corridor. Even with the increase in carbon monoxide concentrations in the southern portion of project corridor, worst-case values would likely remain within the state and federal standards at all locations.

In the year 2038 with any of the three proposed with-project alternatives that were studied (Alternatives 3, 4 and 5), the results would be substantially the same. Carbon monoxide concentrations were predicted to be lower than the without project scenario and lower than the existing scenario at most locations. In all three with-project scenarios, the highest worst-case concentration was predicted to occur during the morning at the intersection of Keaau-Pahoa Road and Kaloli Drive. A worst-case 1-hour concentration of 5.5 mg/m^3 was predicted to occur at this location and time for Alternatives 3 and 4, and a slightly lower concentration of 5.1 mg/m^3 was predicted to occur with Alternative 5. At all of the intersections that were studied, Alternative 5 concentrations were slightly lower than or equal to those for Alternatives 3 and 4. Worst-case 1-hour concentrations for all with-project alternatives at all locations studied continued to remain well within both the national and state standards.

Predicted Worst-Case 8-Hour Concentrations

Worst-case 8-hour carbon monoxide concentrations were estimated by multiplying the worst-case 1-hour values by a persistence factor of 0.5. This accounts for two factors: (1) traffic volumes averaged over eight hours are lower than peak 1-hour values, and (2) meteorological conditions are more variable (and hence more favorable for dispersion) over an 8-hour period than they are for a single hour. Based on monitoring data, 1-hour to 8-hour persistence factors for most locations generally vary from 0.4 to 0.8 with 0.6 being the most typical. One recent study based on modeling [10] concluded that 1-hour to 8-hour persistence factors could typically be expected to range from about 0.4 to 0.5. EPA guidelines [11] recommend using a value of 0.6 to 0.7 unless a locally derived persistence factor is available. Recent monitoring data for Honolulu reported by the Department of Health [12] suggest that this factor may range between about 0.35 and 0.55 depending on location and traffic variability. Considering the location of the project and the traffic pattern for the area, a 1-hour to 8-hour persistence factor of 0.5 will likely yield reasonable estimates of worst-case 8-hour concentrations. However, it should be noted that the 8-hour concentration estimates are generally less reliable than the 1-hour values due to the prediction methodology involved.

The resulting estimated worst-case 8-hour concentrations are indicated in Table 11. For the 2006 scenario, the estimated worst-case 8-hour carbon monoxide concentrations for the eight locations studied ranged from 2.0 mg/m^3 at the Keaau-Pahoa Road intersection with Paradise Drive to 4.2 mg/m^3 at the intersection of Keaau-Pahoa Road and Shower Drive. The estimated worst-case concentrations for the existing case were within both the national limit of 10 mg/m^3 and the state standard of 5 mg/m^3.

For the 2038 without project scenario (Alternative 1), worst-case concentrations decreased at four of the eight locations studied compared to the existing case. Concentrations increased slightly at three locations and remained unchanged at one location. Worst-case concentrations ranged from 2.2 mg/m^3 at the intersection of Keaau-Pahoa Road and Ilima Street to 3.0 mg/m^3 at the intersection of Keaau-Pahoa Road and Kaloli Drive. Even with the predicted increases at some locations, all predicted 8-hour concentrations for this scenario were within both the national and the state AAQS.

There was little difference predicted amongst the three with-project alternatives for 2038. All three alternatives provided a reduction in worst-case carbon monoxide concentrations at most locations studied compared to both the 2038 without-project case (Alternative 1) and the existing scenario. Alternative 5 would provide for the lowest (best) worst-case concentrations. Worst-case concentrations generally ranged between 1.5 and 2.8 mg/m^3 with the highest concentration occurring at the intersection of Keaau-Pahoa Road and Kaloli Drive. All predicted 8-hour concentrations for all three of the 2038 with-project alternatives were well within both the national and the state standards.

Conservativeness of Estimates

The results of this study reflect several assumptions that were made concerning both traffic movement and worst-case meteorological conditions. One such assumption concerning worst-case meteorological conditions is that a wind speed of 1 meter per second with a steady direction for 1 hour will occur. A steady wind of 1 meter per second blowing from a single direction for an hour is extremely unlikely and may occur only once a year or less. With wind speeds of 2 meters per second, for example, computed carbon monoxide concentrations would be only about half the values given above. The 8-hour estimates are also conservative in that it is unlikely that anyone would occupy the assumed receptor sites (within 3 m of the roadways) for a period of 8 hours.

7.3 Mobile Source Air Toxics Analysis

In addition to the criteria air pollutants for which there are National Ambient Air Quality Standards (NAAQS), EPA also regulates air toxics. Most air toxics originate from human-made sources, including on-road mobile sources, non-road mobile sources (e.g., airplanes), area sources (e.g., dry cleaners) and stationary sources (e.g., factories or refineries). Mobile Source Air Toxics (MSATs) are a subset of the 188 air toxics defined by the Clean Air Act. The MSATs are compounds emitted from highway vehicles and non-road equipment. Some toxic compounds are present in fuel and are emitted to the air when the fuel evaporates or passes through the engine unburned. Other toxics are emitted from the incomplete combustion of fuels or as secondary combustion products. Metal air toxics also result from engine wear or from impurities in oil or gasoline.

The EPA is the lead Federal Agency for administering the Clean Air Act and has certain responsibilities regarding the health effects of MSATs. The EPA issued a Final Rule on Controlling Emissions of Hazardous Air Pollutants from Mobile Sources on March 29, 2001. This rule was issued under the authority in Section 202 of the Clean Air Act. In its rule, EPA examined the impacts of existing and newly promulgated mobile source control programs, including its reformulated gasoline (RFG) program, its national low emission vehicle (NLEV) standards, its Tier 2 motor vehicle emissions standards and gasoline sulfur control requirements, and its proposed heavy duty engine and vehicle standards and on-highway diesel fuel sulfur control requirements. Between 2000 and 2020, Federal Highway Administration (FHWA) projects that even with a 64 percent increase in VMT, these programs will reduce on-highway emissions of benzene, formaldehyde, 1,3-butadiene, and acetaldehyde by 57 percent to 65 percent, and will reduce on-highway diesel PM emissions by 87 percent. As a result, EPA concluded that no further motor vehicle emissions standards or fuel standards were necessary to further control MSATs. The agency is preparing another rule under authority of the Clean Air Act (CAA) Section 202(l) that will address these issues and could make adjustments to the full 21 and the primary six MSATs.

7.3.1 Unavailable Information for Project Specific MSAT Impact Analysis

This document includes a basic analysis of the likely MSAT emission impacts of this project. However, available technical tools do not enable us to predict the project-specific health impacts of the emission changes associated with the project alternatives. Due to these limitations, the following discussion is included in accordance with Council on Environmental Quality (CEQ) regulations (40 CFR 1502.22(b)) regarding incomplete or unavailable information.

Information that is Unavailable or Incomplete. Evaluating the environmental and health impacts from MSATs on a proposed highway project would involve several key elements, including emissions modeling, dispersion modeling in order to estimate ambient concentrations resulting from the estimated emissions, exposure modeling in order to estimate human exposure to the estimated concentrations, and then final determination of health impacts based on the estimated exposure. Each of these steps as outlined below is encumbered by technical shortcomings or uncertain science that prevents a more complete determination of the MSAT health impacts of this project.

- **Emissions:** The EPA tools to estimate MSAT emissions from motor vehicles are not sensitive to key variables determining emissions of MSATs in the context of highway projects. While MOBILE 6.2 is used to predict emissions at a regional level, it has limited applicability at the project level. MOBILE 6.2 is a trip-based model, and emission factors are projected based on a typical trip of 7.5 miles and on average speeds for this typical trip. This means that MOBILE 6.2 does not have the ability to predict emission factors for a specific vehicle operating condition at a specific location at a specific time. Because of this limitation, MOBILE 6.2 can only approximate the operating speeds and levels of congestion likely to be present on the largest-scale projects, and cannot adequately capture emissions effects of smaller projects. For particulate matter, the model results are not sensitive to average trip speed, although the other MSAT emission rates do change with changes in trip speed. Also, the emissions rates used in MOBILE 6.2 for both particulate matter and MSATs are based on a limited number of tests of mostly older-technology vehicles. Lastly, in its discussions of particulate matter under the conformity rule, EPA has identified problems with MOBILE6.2 as an obstacle to quantitative analysis. These deficiencies compromise the capability of MOBILE 6.2 to estimate MSAT emissions. MOBILE6.2 is an adequate tool for projecting emissions trends, and performing relative analyses between alternatives for very large projects, but it is not sensitive enough to capture the effects of travel changes tied to smaller projects or to predict emissions near specific roadside locations.

- **Dispersion.** The tools to predict how MSATs disperse are also limited. The EPA's current regulatory models, CALINE3 and CAL3QHC, were developed and validated more than a decade ago for the purpose of predicting episodic concentrations of carbon monoxide to determine compliance with the national ambient air quality standards. The performance of dispersion models is more accurate for predicting maximum concentrations that can occur at some time at some location within a geographic area. This limitation makes it difficult to predict accurate exposure patterns at specific times at specific highway project locations across an urban area to assess potential health risk. The National Cooperative Highway Research Program (NCHRP) is conducting research on best practices in applying models and other technical methods in the analysis of MSATs. This work also will focus on identifying appropriate methods of documenting and communicating MSAT impacts in the National Environmental Policy Act (NEPA) process and to the general public. Along with these general limitations of dispersion models, FHWA is also faced with a lack of monitoring data in most areas for use in establishing project-specific MSAT background concentrations.

- **Exposure Levels and Health Effects.** Finally, even if emission levels and concentrations of MSATs could be accurately predicted, shortcomings in current techniques for exposure assessment and risk analysis preclude us from reaching meaningful conclusions about project-specific health impacts. Exposure assessments are difficult because it is difficult to accurately calculate annual concentrations of MSATs near roadways, and to determine the portion of a year that people are actually exposed to those concentrations at a specific location. These difficulties are magnified for 70-year cancer assessments, particularly because unsupportable assumptions would have to be made regarding changes in travel patterns and vehicle technology (which affects emissions rates) over a 70-year period. There are also considerable uncertainties associated with the existing estimates of toxicity of the various MSATs, because of factors such as low-dose extrapolation and translation of occupational exposure data to the general population. Because of these shortcomings, any calculated difference in health impacts between alternatives is likely to be much smaller than the uncertainties associated with calculating the impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against other project impacts that are better suited for quantitative analysis.

Summary of Existing Credible Scientific Evidence Relevant to Evaluating the Impacts of MSATs. Research into the health impacts of MSATs is ongoing. For different emission types, there are a variety of studies that show that some either are statistically associated with adverse health outcomes through epidemiological studies (frequently based on emissions levels found in occupational settings) or that animals demonstrate adverse health outcomes when exposed to large doses. Exposure to toxics has been a focus of a number of EPA efforts. Most notably, the agency conducted the National Air Toxics Assessment (NATA) in 1996 to evaluate modeled estimates of human exposure applicable to the county level. While not intended for use as a measure of or benchmark for local exposure, the modeled estimates in the NATA database best illustrate the levels of various toxics when aggregated to a national or State level.

The EPA is in the process of assessing the risks of various kinds of exposures to these pollutants. The EPA Integrated Risk Information System (IRIS) is a database of human health effects that may result from exposure to various substances found in the environment. The IRIS database is located at http://www.epa.gov/iris. The following toxicity information for the six prioritized MSATs was taken from the IRIS database *Weight of Evidence Characterization* summaries. This information is taken verbatim from EPA's IRIS database and represents the Agency's most current evaluations of the potential hazards and toxicology of these chemicals or mixtures.

- **Benzene** is characterized as a known human carcinogen.
- The potential carcinogenicity of **acrolein** cannot be determined because the existing data are inadequate for an assessment of human carcinogenic potential for either the oral or inhalation route of exposure.
- **Formaldehyde** is a probable human carcinogen, based on limited evidence in humans, and sufficient evidence in animals.

- **1,3-butadiene** is characterized as carcinogenic to humans by inhalation.
- **Acetaldehyde** is a probable human carcinogen based on increased incidence of nasal tumors in male and female rats and laryngeal tumors in male and female hamsters after inhalation exposure.
- **Diesel exhaust** (DE) is likely to be carcinogenic to humans by inhalation from environmental exposures. Diesel exhaust as reviewed in this document is the combination of diesel particulate matter and diesel exhaust organic gases.
- **Diesel exhaust** also represents chronic respiratory effects, possibly the primary noncancer hazard from MSATs. Prolonged exposures may impair pulmonary function and could produce symptoms, such as cough, phlegm, and chronic bronchitis. Exposure relationships have not been developed from these studies.

There have been other studies that address MSAT health impacts in proximity to roadways. The Health Effects Institute, a non-profit organization funded by EPA, FHWA, and industry, has undertaken a major series of studies to research near-roadway MSAT hot spots, the health implications of the entire mix of mobile source pollutants, and other topics. The final summary of the series is not expected for several years.

Some recent studies have reported that proximity to roadways is related to adverse health outcomes, particularly respiratory problems. Much of this research is not specific to MSATs, instead surveying the full spectrum of both criteria and other pollutants. The FHWA cannot evaluate the validity of these studies, but more importantly, they do not provide information that would be useful to alleviate the uncertainties listed above and enable one to perform a more comprehensive evaluation of the health impacts specific to this project.

Relevance of Unavailable or Incomplete Information to Evaluating Reasonably Foreseeable Significant Adverse Impacts on the Environment, and Evaluation of impacts based upon theoretical approaches or research methods generally accepted in the scientific community. Because of the uncertainties outlined above, a quantitative assessment of the effects of air toxic emissions impacts on human health cannot be made at the project level. While available tools do allow us to reasonably predict relative emissions changes between alternatives for larger projects, the amount of MSAT emissions from each of the project alternatives and MSAT concentrations or exposures created by each of the project alternatives cannot be predicted with enough accuracy to be useful in estimating health impacts. (As noted above, the current emissions model is not capable of serving as a meaningful emissions analysis tool for smaller projects.) Therefore, the relevance of the unavailable or incomplete information is that it is not possible to make a determination of whether any of the alternatives would have "significant adverse impacts on the human environment."

Within this document, a quantitative analysis of MSAT emissions relative to the various project alternatives cannot be provided, and it is acknowledged that the project alternatives may result in increased exposure to MSAT emissions in certain locations, although the concentrations and duration of exposures are uncertain, and because of this uncertainty, the health effects from these emissions cannot be estimated.

7.3.2 Qualitative Assessment of Project MSATs

As discussed above, technical shortcomings of emissions and dispersion models and uncertain science with respect to health effects prevent meaningful or reliable estimates of MSAT emissions and effects of this project. However, even though reliable methods do not exist to accurately estimate the health impacts of MSATs at the project level, it is possible to qualitatively assess the levels of future MSAT emissions under the project. Although a qualitative analysis cannot identify and measure health impacts from MSATs, it can give a basis for identifying and comparing the potential differences among MSAT emissions, if any, from the various alternatives. The qualitative assessment presented below is derived in part from U.S. Department of Transportation, Federal Highway Administration Memorandum from April Marchese to Division Administrators dated September 30, 2009.

For each project alternative, the amount of MSATs emitted would be proportional to the vehicle miles traveled, or VMT, assuming that other variables such as fleet mix are the same for each alternative. For this project, as indicated in Tables 4 through 9, the estimated daily VMT for each scenario were as follows:

Scenario	VMT/day
Existing	120,750
2038 No-Action Alternative	248,810
2038 Alternative 2	248,810
2038 Alternative 3	248,810
2038 Alternative 4	248,810
2038 Alternative 5	248,810

As indicated above, for this project, there are expected to be no differences in the estimated VMT for the year 2038 amongst the project alternatives. This is because the project roadway is the only available roadway for arterial traffic in the project area. Thus, on the basis of VMT, the proposed project is not expected to result in an increase in MSAT emissions.

The proposed project will include both roadway widening and the signalization of several intersections in the project area, which could affect average travel speeds. The relationship between travel speed and MSAT emission rates has not been well established. If it is assumed that the average travel speed is not a factor, then the expected fixed VMT for the various project alternatives means that MSATs emissions for any of the with-project alternatives would probably be unchanged compared to the No-Action Alternative.

Regardless of the alternative chosen, emissions will likely be lower than present levels in the design year as a result of EPA’s national control programs that are projected to reduce MSAT emissions by 57 to 87 percent from 2000 to 2020. Local conditions may differ from these national projections in terms of fleet mix and turnover, VMT growth rates, and local control measures. However, the magnitude of the EPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the study area are likely to be lower in the future in virtually all locations.

In sum, under the with-project alternatives in the design year, it is expected MSAT emissions in the immediate area of the project would remain unchanged relative to the No-Action

Alternative, due to the fact the project alternatives are not expected to cause an increase in the VMT. In comparing the project alternatives, MSAT levels could potentially be higher in some locations than others, but current tools and science are not adequate to quantify them. However, on a regional basis, EPA’s vehicle and fuel regulations, coupled with fleet turnover, will over time cause substantial reductions that, in almost all cases, will cause region-wide MSAT levels to be significantly lower than today.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Existing Conditions

Although relatively little ambient air quality data are available to characterize existing conditions, it is likely that state and federal ambient air quality standards are currently being met in the project area (despite chronic vog conditions), except perhaps for occasional exceedances of the stringent state carbon monoxide standards within small areas near high-volume traffic-congested locations.

Short-Term Impacts and Mitigation

The major potential short-term impact of the project on air quality will occur from the emission of fugitive dust during construction. Uncontrolled fugitive dust emissions from construction activities are estimated to amount to about 1.2 tons per acre per month, depending on rainfall and other factors. To control dust, active work areas and any temporary unpaved work roads should be watered at least twice daily on days without rainfall. Use of wind screens and/or limiting the area that is disturbed at any given time will also help to contain fugitive dust emissions.

Wind erosion of inactive areas of the project that have been disturbed could be controlled by mulching or chemical stabilization. Dirt-hauling trucks should be covered when traveling on roadways to prevent windage. A routine road cleaning and/or tire washing program will also help to reduce fugitive dust emissions that may occur as a result of trucks tracking dirt onto paved roadways in the project area. Establishment of landscaping early in the construction schedule will also help to control dust.

During construction phases, emissions from engine exhausts (primarily consisting of carbon monoxide and nitrogen oxides) will also occur both from on-site construction equipment and from the disruption of normal traffic flow. Increased vehicular emissions due to the disruption of traffic can be alleviated by minimizing road closures during peak traffic hours.

Long-Term Mesoscale Impacts

Without the project by the year 2038 (Alternative 1), mesoscale analysis indicates that emissions of carbon monoxide from motor vehicles operating on Keaau-Pahoa Road within the project study area would increase by about 17 percent compared to 2006 emissions while nitrogen oxides emissions would decrease by 61 percent and VOC emissions would decrease by 19 percent. With the proposed project, there is no significant difference amongst the four alternatives that were studied, but Alternative 2 would result in slightly lower carbon monoxide emissions and Alternative 5 would provide for the lowest VOC emissions. Emissions of nitrogen oxides would not be significantly affected by the project. Although the mesoscale analysis suggests that none of the four with-project alternatives would be significantly different from the no-project alternative, i.e., there would be no significant positive or negative project impact, the mesoscale analysis estimates emissions from traffic on Keaau-Pahoa Road only and does not account for emissions from cross-road traffic in the project area. Several intersections within the project corridor would be improved with the project, resulting in improved traffic flow, reduced cross-road traffic queuing, and reduced excess emissions near intersections. Thus, it is probable that the potential positive impact of the project in terms of the mesoscale emissions is underestimated.

Long-Term Microscale Impacts

Without the project, microscale analysis of selected intersections in the project area for the year 2038 indicate that worst-case concentrations of carbon monoxide can be expected to mostly decrease at locations in the northern portion of the project corridor compared to the existing case and generally increase at locations in the southern portion of the project corridor. All areas would remain within the state and federal standards in the year 2038 without the project. There are no significant differences amongst the three with-project alternatives that were studied (Alternatives 3, 4 and 5). All three of the with-project alternatives would provide for reduced carbon monoxide concentrations and improved air quality at most locations in the project area compared to Alternative 1 (no build). Alternative 5 would provide a slightly more positive impact than Alternatives 3 and 4. All three with-project alternatives would provide beneficial results, and compliance with ambient air quality standards for carbon monoxide should be achieved with any of the three. Use of roundabout intersections could serve to reduce impacts further.

Long-Term MSAT Impacts

The analysis of potential long-term impacts due to mobile source air toxics (MSATs) is primarily a qualitative assessment based on the estimated vehicle miles of travel for each alternative. This analysis did not reveal any significant differences amongst the alternatives studied. All four of the with-project alternatives were estimated to result in no change in MSAT emissions compared to the No-Action Alternative. Thus, no MSAT impacts from the project are anticipated.

Long-Term Mitigation

Options available to mitigate long-term, traffic-related air pollution are generally to further improve roadways, to reduce traffic and/or to reduce individual vehicular emissions. Aside from providing added roadway improvements, air pollution impacts from vehicular emissions could conceivably be additionally mitigated by reducing traffic volumes through the promotion of bus service and car pooling in the project area and/or by adjusting local school and business hours to begin and end during off-peak times. This mitigation measure is generally considered only partially successful. Reduction of emissions from individual vehicles would have to be achieved through the promulgation of local, state or federal air pollution control regulations. For example, Hawaii currently does not require annual inspections of motor vehicle air pollution control equipment. However, at the present time there is no indication that the state is contemplating adopting such rules.

From a mesoscale viewpoint, any of the four alternatives for the Keaau-Pahoa Road as proposed would, at worst, result in only small increases in air pollution emissions in the project area. When the improved traffic flow on intersecting roadways is considered, it is likely the project would have a net positive impact. Thus, it does not appear that mitigation for long-term impacts is warranted based on the mesoscale analysis of the project.

Mitigation measures to address microscale impacts are similar to those for mesoscale impacts. An additional mitigation measure for microscale impacts might be to provide added buffer zones between walkways and roadways, although technically, the public would have to somehow be excluded from the buffer zones. The predicted worst-case concentrations in this report are based on a separation distance of 3 m (10 ft) between walkways and roadways. Doubling this distance to about 6 m (20 ft) would reduce maximum concentrations by about 10 to 15 percent.

As indicated above, the analysis of microscale impacts indicated that any of the with-project alternatives would result in improved air quality compared to the without-project scenario, and worst-case concentrations of carbon monoxide with the project would be well within the state and national standards in the design year. Thus, mitigation of air quality impacts based on the microscale analysis does not appear to be warranted.

The analysis of MSAT impacts suggests that the project would not result in an increase in MSAT emissions with any of the four with-project alternatives. Thus, mitigation based on the MSAT impact analysis does not appear to be warranted.

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Figure 1 - Location Map

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Table 1

SUMMARY OF STATE OF HAWAII AND NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Units	Averaging Time	Maximum Allowable Concentration		
			National Primary	National Secondary	State of Hawaii
Particulate Matter (<10 microns)	μg/m³	Annual	-	-	50
		24 Hours	150[a]	150[a]	150[b]
Particulate Matter (<2.5 microns)	μg/m³	Annual	15[c]	15[c]	-
		24 Hours	35[d]	35[d]	-
Sulfur Dioxide	μg/m³	Annual	80	-	80
		24 Hours	365[b]	-	365[b]
		3 Hours	-	1300[b]	1300[b]
Nitrogen Dioxide	μg/m³	Annual	100	100	70
		1 Hour	189[d]	-	-
Carbon Monoxide	mg/m³	8 Hours	10[b]	-	5[b]
		1 Hour	40[b]	-	10[b]
Ozone	μg/m³	8 Hours	157[e]	157[e]	157[e]
		1 Hour	235[f]	235[f]	-
Lead	μg/m³	3 Months	0.15[g]	0.15[g]	-
		Quarter	1.5[h]	1.5[h]	1.5[h]
Hydrogen Sulfide	μg/m³	1 Hour	-	-	35[b]

[a] Not to be exceeded more than once per year on average over three years.

[b] Not to be exceeded more than once per year.

[c] Three-year average of the weighted annual arithmetic mean.

[d] 98th percentile value averaged over three years.

[e] Three-year average of fourth-highest daily 8-hour maximum.

[f] Standard is attained when the expected number of exceedances is less than or equal to 1.

[g] Rolling 3-month average.

[h] Quarterly average.

Table 2

AIR POLLUTION EMISSIONS INVENTORY FOR ISLAND OF HAWAII, 1993

Air Pollutant	Point Sources (tons/year)	Area Sources (tons/year)	Total (tons/year)
Particulate	30,311	9,157	39,468
Sulfur Oxides	9,345	nil	9,345
Nitrogen Oxides	4,054	8,858	12,912
Carbon Monoxide	3,357	23,934	27,291
Hydrocarbons	1,477	203	1,680

Source: Final Report, “Review, Revise and Update of the Hawaii Emissions Inventory Systems for the State of Hawaii”, prepared for Hawaii Department of Health by J.L. Shoemaker & Associates, Inc., 1996

Table 3

ANNUAL SUMMARIES OF AIR QUALITY MEASUREMENTS FOR MONITORING STATIONS NEAREST KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT

Parameter / Location	2005	2006	2007	2008
Sulfur Dioxide / Pahoa				
Period of Sampling (months)	12	12	12	12
3-Hour Averaging Period:				
No. of Samples	2266	2431	2406	2460
Highest Concentration (μg/m^3)	502	65	187	94
2nd Highest Concentration (μg/m^3)	128	56	159	31
No. of State AAQS Exceedances	0	0	0	0
24-Hour Averaging Period:				
No. of Samples	317	360	353	355
Highest Concentration (μg/m^3)	96	23	57	23
2nd Highest Concentration (μg/m^3)	30	18	55	10
No. of State AAQS Exceedances	0	0	0	0
Annual Average Concentration (μg/m^3)	3	5	5	5
Hydrogen Sulfide (H2S) / Pahoa				
Period of Sampling (months)	12	12	12	12
1-Hour Averaging Period:				
No. of Samples	8193	8286	8113	8308
Highest Concentration (μg/m^3)	44	21	7	17
2nd Highest Concentration (μg/m^3)	4	14	6	14
No. of State AAQS Exceedances	0	0	0	0
Annual Average Concentration (μg/m^3)	0	1	1	1

Source: State of Hawaii Department of Health, “Annual Summary, Hawaii Air Quality Data, 2005, 2006, 2007 and 2008”

Table 4

ESTIMATED MESOSCALE EMISSIONS FOR KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT - EXISTING CASE

Segment	Length (miles)	Average Daily Traffic Volume	Vehicle Miles Per Day	Average Travel Speed (mph)	Emission Factors (grams/veh-mile)			Emissions (lb/day)		
					CO	NOx	VOC	CO	NOx	VOC
1 - Opukahaia Road	0.4	21,300	8,520	56	16.9	2.06	1.23	317	39	23
2 - Transfer Station	0.8	20,400	16,320	40	14.7	1.72	1.36	528	62	49
3 - Shower Drive	0.6	22,100	13,260	52	16.3	1.93	1.25	476	56	37
4 - Pohaku Place	0.5	16,700	8,350	51	16.2	1.90	1.26	298	35	23
5 - Kaloli Drive	0.5	16,700	8,350	46	15.5	1.80	1.30	285	33	24
6 - Pohaku Circle South	0.2	16,700	3,340	51	16.2	1.90	1.26	119	14	9
7 - Orchidland Drive	0.6	13,800	8,280	54	16.6	1.99	1.24	303	36	23
8 - Paradise Drive	0.3	13,800	4,140	37	14.4	1.70	1.39	131	16	13
9 - Aulii Street	0.2	12,100	2,420	54	16.6	1.99	1.24	88	11	7
10 - Makuu Drive	0.6	12,100	7,260	50	16.0	1.88	1.27	256	30	20
11 - Ilima Street	0.2	12,100	2,420	33	14.1	1.69	1.45	75	9	8
12 - Ainaloa Drive	0.3	12,100	3,630	45	15.3	1.78	1.31	122	14	10
13 - Ka Ohuwalu Drive	1.0	11,700	11,700	53	16.4	1.96	1.25	423	51	32
14 - Kaluahine Street	1.0	11,700	11,700	56	16.9	2.06	1.23	436	53	32
15 - Pahoa Village Junction	1.0	6,000	6,000	54	16.6	1.99	1.24	219	26	16
16 - Kahakai Boulevard	0.4	4,200	1,680	32	14.1	1.69	1.46	52	6	5
17 - Nanawale Boulevard	0.3	4,000	1,200	48	15.8	1.84	1.29	42	5	3
18 - Unnamed Homestead Road	0.3	4,000	1,200	58	17.2	2.14	1.22	45	6	3
19 - Kapoho Road	0.3	6,600	1,980	32	14.1	1.69	1.46	61	7	6
Total	9.5		120,750		Totals (lb/day)			4276	509	343
					Totals (tons/year)			780	93	63

Table 5

ESTIMATED MESOSCALE EMISSIONS FOR KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT – 2038 ALTERNATIVE 1

Segment	Length (miles)	Average Daily Traffic Volume	Vehicle Miles Per Day	Average Travel Speed (mph)	Emission Factors (grams/veh-mile)			Emissions (lb/day)		
					CO	NOx	VOC	CO	NOx	VOC
1 – Opukahaia Road	0.4	50,600	20,240	50	8.37	0.320	0.407	373	14	18
2 – Transfer Station	0.8	50,400	40,320	39	7.57	0.303	0.439	672	27	39
3 – Shower Drive	0.6	49,800	29,880	46	8.07	0.313	0.417	531	21	27
4 – Pohaku Place	0.5	38,800	19,400	22	7.84	0.327	0.551	335	14	24
5 – Kaloli Drive	0.5	38,500	19,250	30	7.31	0.304	0.483	310	13	20
6 – Pohaku Circle South	0.2	33,000	6,600	43	7.86	0.308	0.426	114	4	6
7 – Orchidland Drive	0.6	32,700	19,620	39	7.57	0.303	0.439	327	13	19
8 – Paradise Drive	0.3	32,000	9,600	17	8.70	0.352	0.654	184	7	14
9 – Aulii Street	0.2	27,200	5,440	48	8.23	0.316	0.412	99	4	5
10 – Makuu Drive	0.6	27,200	16,320	44	7.93	0.309	0.423	285	11	15
11 – Ilima Street	0.2	23,700	4,740	30	7.31	0.304	0.483	76	3	5
12 – Ainaloa Drive	0.3	23,700	7,110	45	7.99	0.311	0.420	125	5	7
13 – Ka Ohuwalu Drive	1.0	23,300	23,300	46	8.07	0.313	0.417	414	16	21
14 – Kaluahine Street	1.0	23,600	23,600	54	8.68	0.329	0.399	451	17	21
15 – Pahoa Village Junction	1.0	23,600	23,600	51	8.45	0.322	0.405	439	17	21
16 – Kahakai Boulevard	0.4	16,000	6,400	26	7.50	0.314	0.511	106	4	7
17 – Nanawale Boulevard	0.3	10,800	3,240	46	8.07	0.313	0.417	58	2	3
18 – Unnamed Homestead Road	0.3	10,100	3,030	52	8.53	0.325	0.402	57	2	3
19 – Kapoho Road	0.3	10,400	3,120	30	7.31	0.304	0.483	50	2	3
Total	9.5		248,810		Totals (lb/day)			5006	196	278
					Totals (tons/year)			914	36	51

Table 6

ESTIMATED MESOSCALE EMISSIONS FOR KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT – 2038 ALTERNATIVE 2

Segment	Length (miles)	Average Daily Traffic Volume	Vehicle Miles Per Day	Average Travel Speed (mph)	Emission Factors (grams/veh-mile)			Emissions (lb/day)		
					CO	NOx	VOC	CO	NOx	VOC
1 – Opukahaia Road	0.4	50,600	20,240	51	8.45	0.322	0.405	377	14	18
2 – Transfer Station	0.8	50,400	40,320	30	7.31	0.304	0.483	649	27	43
3 – Shower Drive	0.6	49,800	29,880	50	8.37	0.320	0.407	551	21	27
4 – Pohaku Place	0.5	38,800	19,400	42	7.79	0.307	0.429	333	13	18
5 – Kaloli Drive	0.5	38,500	19,250	29	7.35	0.306	0.489	312	13	21
6 – Pohaku Circle South	0.2	33,000	6,600	31	7.31	0.303	0.476	106	4	7
7 – Orchidland Drive	0.6	32,700	19,620	39	7.57	0.303	0.439	327	13	19
8 – Paradise Drive	0.3	32,000	9,600	16	8.95	0.359	0.686	189	8	15
9 – Aulii Street	0.2	27,200	5,440	37	7.44	0.301	0.446	89	4	5
10 – Makuu Drive	0.6	27,200	16,320	33	7.30	0.301	0.464	262	11	17
11 – Ilima Street	0.2	23,700	4,740	20	8.08	0.336	0.577	84	4	6
12 – Ainaloa Drive	0.3	23,700	7,110	30	7.31	0.304	0.483	114	5	8
13 – Ka Ohuwalu Drive	1.0	23,300	23,300	39	7.57	0.303	0.439	389	16	23
14 – Kaluahine Street	1.0	23,600	23,600	53	8.61	0.327	0.400	448	17	21
15 – Pahoa Village Junction	1.0	23,600	23,600	45	7.99	0.311	0.420	415	16	22
16 – Kahakai Boulevard	0.4	16,000	6,400	8	12.4	0.452	1.137	175	6	16
17 – Nanawale Boulevard	0.3	10,800	3,240	28	7.40	0.309	0.496	53	2	4
18 – Unnamed Homestead Road	0.3	10,100	3,030	52	8.53	0.325	0.402	57	2	3
19 – Kapoho Road	0.3	10,400	3,120	32	7.30	0.302	0.470	50	2	3
Total	9.5		248,810		Totals (lb/day)			4980	198	296
					Totals (tons/year)			909	36	54

Table 7

ESTIMATED MESOSCALE EMISSIONS FOR KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT – 2038 ALTERNATIVE 3

Segment	Length (miles)	Average Daily Traffic Volume	Vehicle Miles Per Day	Average Travel Speed (mph)	Emission Factors (grams/veh-mile)			Emissions (lb/day)		
					CO	NOx	VOC	CO	NOx	VOC
1 – Opukahaia Road	0.4	50,600	20,240	57	8.94	0.337	0.394	399	15	18
2 – Transfer Station	0.8	50,400	40,320	15	9.24	0.367	0.722	821	33	64
3 – Shower Drive	0.6	49,800	29,880	49	8.30	0.318	0.409	546	21	27
4 – Pohaku Place	0.5	38,800	19,400	43	7.86	0.308	0.426	336	13	18
5 – Kaloli Drive	0.5	38,500	19,250	33	7.30	0.301	0.464	310	13	20
6 – Pohaku Circle South	0.2	33,000	6,600	39	7.57	0.303	0.439	110	4	6
7 – Orchidland Drive	0.6	32,700	19,620	52	8.53	0.325	0.402	369	14	17
8 – Paradise Drive	0.3	32,000	9,600	15	9.24	0.367	0.722	195	8	15
9 – Aulii Street	0.2	27,200	5,440	46	8.07	0.313	0.417	97	4	5
10 – Makuu Drive	0.6	27,200	16,320	41	7.71	0.305	0.432	277	11	16
11 – Ilima Street	0.2	23,700	4,740	22	7.84	0.327	0.551	82	3	6
12 – Ainaloa Drive	0.3	23,700	7,110	34	7.30	0.300	0.459	114	5	7
13 – Ka Ohuwalu Drive	1.0	23,300	23,300	40	7.63	0.304	0.436	392	16	22
14 – Kaluahine Street	1.0	23,600	23,600	53	8.61	0.327	0.400	448	17	21
15 – Pahoa Village Junction	1.0	23,600	23,600	31	7.31	0.303	0.476	380	16	25
16 – Kahakai Boulevard	0.4	16,000	6,400	12	10.2	0.398	0.836	144	6	12
17 – Nanawale Boulevard	0.3	10,800	3,240	38	7.51	0.302	0.442	54	2	3
18 – Unnamed Homestead Road	0.3	10,100	3,030	51	8.45	0.322	0.405	56	2	3
19 – Kapoho Road	0.3	10,400	3,120	32	7.30	0.302	0.470	50	2	3
Total	9.5		248,810		Totals (lb/day)			5180	205	308
					Totals (tons/year)			945	37	56

Table 8

ESTIMATED MESOSCALE EMISSIONS FOR KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT – 2038 ALTERNATIVE 4

Segment	Length (miles)	Average Daily Traffic Volume	Vehicle Miles Per Day	Average Travel Speed (mph)	Emission Factors (grams/veh-mile)			Emissions (lb/day)		
					CO	NOx	VOC	CO	NOx	VOC
1 – Opukahaia Road	0.4	50,600	20,240	57	8.94	0.337	0.394	399	15	18
2 – Transfer Station	0.8	50,400	40,320	16	8.95	0.359	0.686	795	32	61
3 – Shower Drive	0.6	49,800	29,880	50	8.37	0.320	0.407	551	21	27
4 – Pohaku Place	0.5	38,800	19,400	42	7.79	0.307	0.429	333	13	18
5 – Kaloli Drive	0.5	38,500	19,250	33	7.30	0.301	0.464	310	13	20
6 – Pohaku Circle South	0.2	33,000	6,600	39	7.57	0.303	0.439	110	4	6
7 – Orchidland Drive	0.6	32,700	19,620	51	8.45	0.322	0.405	365	14	18
8 – Paradise Drive	0.3	32,000	9,600	14	9.50	0.376	0.754	201	8	16
9 – Aulii Street	0.2	27,200	5,440	45	7.99	0.311	0.420	96	4	5
10 – Makuu Drive	0.6	27,200	16,320	40	7.63	0.304	0.436	274	11	16
11 – Ilima Street	0.2	23,700	4,740	23	7.74	0.323	0.540	81	3	6
12 – Ainaloa Drive	0.3	23,700	7,110	38	7.51	0.302	0.442	118	5	7
13 – Ka Ohuwalu Drive	1.0	23,300	23,300	46	8.07	0.313	0.417	414	16	21
14 – Kaluahine Street	1.0	23,600	23,600	56	8.85	0.334	0.395	460	17	21
15 – Pahoa Village Junction	1.0	23,600	23,600	51	8.45	0.322	0.405	439	17	21
16 – Kahakai Boulevard	0.4	16,000	6,400	16	8.95	0.359	0.686	126	5	10
17 – Nanawale Boulevard	0.3	10,800	3,240	40	7.63	0.304	0.436	54	2	3
18 – Unnamed Homestead Road	0.3	10,100	3,030	55	8.76	0.331	0.397	58	2	3
19 – Kapoho Road	0.3	10,400	3,120	32	7.30	0.302	0.470	50	2	3
Total	9.5		248,810		Totals (lb/day)			5234	204	300
					Totals (tons/year)			955	37	55

Table 9

ESTIMATED MESOSCALE EMISSIONS FOR KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT – 2038 ALTERNATIVE 5

Segment	Length (miles)	Average Daily Traffic Volume	Vehicle Miles Per Day	Average Travel Speed (mph)	Emission Factors (grams/veh-mile)			Emissions (lb/day)		
					CO	NOx	VOC	CO	NOx	VOC
1 – Opukahaia Road	0.4	50,600	20,240	59	9.12	0.343	0.392	407	15	17
2 – Transfer Station	0.8	50,400	40,320	42	7.79	0.307	0.429	692	27	38
3 – Shower Drive	0.6	49,800	29,880	53	8.61	0.327	0.400	567	22	26
4 – Pohaku Place	0.5	38,800	19,400	46	8.07	0.313	0.417	345	13	18
5 – Kaloli Drive	0.5	38,500	19,250	33	7.30	0.301	0.464	310	13	20
6 – Pohaku Circle South	0.2	33,000	6,600	41	7.71	0.305	0.432	112	4	6
7 – Orchidland Drive	0.6	32,700	19,620	52	8.53	0.325	0.402	369	14	17
8 – Paradise Drive	0.3	32,000	9,600	19	8.26	0.341	0.600	175	7	13
9 – Aulii Street	0.2	27,200	5,440	39	7.57	0.303	0.439	91	4	5
10 – Makuu Drive	0.6	27,200	16,320	40	7.63	0.304	0.436	274	11	16
11 – Ilima Street	0.2	23,700	4,740	24	7.64	0.320	0.529	80	3	6
12 – Ainaloa Drive	0.3	23,700	7,110	39	7.57	0.303	0.439	119	5	7
13 – Ka Ohuwalu Drive	1.0	23,300	23,300	45	7.99	0.311	0.420	410	16	22
14 – Kaluahine Street	1.0	23,600	23,600	56	8.85	0.334	0.395	460	17	21
15 – Pahoa Village Junction	1.0	23,600	23,600	37	7.44	0.301	0.446	387	16	23
16 – Kahakai Boulevard	0.4	16,000	6,400	13	9.80	0.386	0.792	138	5	11
17 – Nanawale Boulevard	0.3	10,800	3,240	37	7.44	0.301	0.446	53	2	3
18 – Unnamed Homestead Road	0.3	10,100	3,030	52	8.53	0.325	0.402	57	2	3
19 – Kapoho Road	0.3	10,400	3,120	32	7.30	0.302	0.470	50	2	3
Total	9.5		248,810		Totals (lb/day)			5096	198	275
					Totals (tons/year)			930	36	50

Table 10

ESTIMATED WORST-CASE 1-HOUR CARBON MONOXIDE CONCENTRATIONS NEAR INTERSECTIONS INCLUDED WITHIN KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT
(milligrams per cubic meter)

Roadway Intersection	Year/Scenario									
	2006 Present		2038 Alternative 1		2038 Alternative 3		2038 Alternative 4		2038 Alternative 5	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Keaau-Pahoa Road at at Opukahaia Road	7.2	3.8	4.8	3.2	4.8	3.1	4.8	3.1	4.5	3.0
Keaau-Pahoa Road at Shower Drive	8.4	3.7	5.4	3.2	5.1	3.1	5.1	3.1	4.5	3.0
Keaau-Pahoa Road at Kaloli Drive	6.3	3.7	5.9	3.1	5.5	2.4	5.5	2.4	5.1	2.8
Keaau-Pahoa Road at Orchidland Drive	5.0	3.2	5.0	2.6	5.2	2.8	5.2	2.8	4.6	2.8
Keaau-Pahoa Road at Paradise Drive	4.1	3.4	4.9	2.8	4.4	2.3	4.4	2.3	3.9	2.2
Keaau-Pahoa Road at Ilima Street	4.2	2.4	4.4	2.4	3.7	2.3	3.7	2.3	3.7	2.3
Keaau-Pahoa Road at Pahoa Village Junction	4.5	2.8	5.0	2.4	5.1	2.6	4.3	2.6	4.3	2.6
Keaau-Pahoa Road at Kahakai Boulevard	6.2	2.6	5.0	2.4	3.4	1.7	3.0	1.7	3.4	1.7

Hawaii State AAQS: 10 National AAQS: 40

Table 11

ESTIMATED WORST-CASE 8-HOUR CARBON MONOXIDE CONCENTRATIONS NEAR INTERSECTIONS INCLUDED WITHIN KEAAU-PAHOA ROAD IMPROVEMENTS PROJECT
(milligrams per cubic meter)

Roadway Intersection	Year/Scenario				
	2006 Present	2038 Alternative 1	2038 Alternative 3	2038 Alternative 4	2038 Alternative 5
Keaau-Pahoa Road at at Opukahaia Road	3.6	2.4	2.4	2.4	2.2
Keaau-Pahoa Road at Shower Drive	4.2	2.7	2.6	2.6	2.2
Keaau-Pahoa Road at Kaloli Drive	3.2	3.0	2.8	2.8	2.6
Keaau-Pahoa Road at Orchidland Drive	2.5	2.5	2.6	2.6	2.3
Keaau-Pahoa Road at Paradise Drive	2.0	2.4	2.2	2.2	2.0
Keaau-Pahoa Road at Ilima Street	2.1	2.2	1.8	1.8	1.8
Keaau-Pahoa Road at Pahoa Village Junction	2.2	2.5	2.6	2.2	2.2
Keaau-Pahoa Road at Kahakai Boulevard	3.1	2.5	1.7	1.5	1.7

Hawaii State AAQS: 5 National AAQS: 10

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