# Appendix 20D Photochemical Modeling Study to Support a Health Impact Analysis

# Appendix 20D Photochemical Modeling Study to Support a Health Impact Analysis

## 20D.1 Introduction

A quantitative assessment of health impacts due to increases in criteria pollutant emissions is performed pursuant to the California Environmental Quality Act (CEQA) per the December 2018 California Supreme Court "Friant Ranch" ruling due to the scale of the Project, and resulting exceedances of air district emissions thresholds. The health impact analysis (HIA) focuses on the worst-case year of construction activities associated with the Project. The Project consists of three alternatives (1, 2, and 3). The construction footprints are identical between Alternatives 1 and 3 and therefore the construction emissions are the same. The difference between Alternatives 1 and 3 pertain to differences in funding. Thus, the analysis looks only at Alternatives 1 and 2.

### 20D.1.1. Objective

This appendix includes methods and results for the photochemical grid modeling (PGM) HIA from worst-case emissions of construction activities associated with the Project for particulate matter (PM) with a diameter less than or equal to 2.5 micrometers ($PM_{2.5}$) and ozone precursors.

The analysis is conducted consistent with guidance from the Sacramento Metropolitan Air Quality Management District's (SMAQMD) *Guidance to Address the Friant Ranch Ruling for CEQA Projects in the Sac Metro Air District* (SMAQMD 2020) to support the Project's CEQA documentation.

### 20D.1.2. Project Sources Modeled

This HIA evaluates the impact of the Project-related emissions of carbon monoxide (CO), nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), PM with a diameter less than or equal to 10 micrometers ($PM_{10}$), $PM_{2.5}$, and reactive organic gases (ROG). Table 20D-1 below provides the Project components modeled and their associated alternative.

**Table 20D-1. Project Components Modeled**

| Project Component Details | Alternative (1 & 3, 2, All) | District |
|---|---|---|
| Dunnigan Pipeline and Batch Slurry Plant | All | YSAQMD |

| Project Component Details | Alternative (1 & 3, 2, All) | District |
|---|---|---|
| Funks Reservoir, Funks Pumping Generating Plant, Substation, Concrete Batch Plant, Batch Slurry Plant, and Funks/TRR Pipelines | All | CCAPCD |
| Terminal Regulating Reservoir (TRR) Pumping Generating Plant, Substation, TRR East/West, Topsoil Stockpiles, Batch Slurry and Soil Plants, and Funks/TRR Pipelines | All | CCAPCD |
| Western Area Power Administration (WAPA) Substations and Transmission Line | All | CCAPCD |
| Pacific Gas & Electric (PG&E) Substations and Transmission Line | All | CCAPCD |
| Red Bluff Pumping Plant | All | TCAPCD |
| Glenn-Colusa Irrigation District (GCID) Canal Improvements | All | GCAPCD |
| Golden Gate Dam, Topsoil Stockpile, Crushing and Processing, Blasting, and Batch Plant | All | CCAPCD |
| Saddle Dams (1-3, 5-6, 8A-B), Topsoil Stockpiles, Crushing and Processing, Blasting, Concrete Batch Plant | All | GCAPCD/CCAPCD |
| ERS-1 and ERS-2 Facilities | Alt 1 & 3 | GCAPCD/CCAPCD |
| Inlet/Outlet Tower and Transition Manifold, Blasting, and Concrete Batch Plant | All | CCAPCD |
| Sites Dam, Sites Diversion Tunnel, Topsoil Stockpile, Crushing and Processing, Blasting, Concrete Batch Plant, and Stone Corral Creek Recreation Area | All | CCAPCD |
| Sites Lodoga Road Bridge, Concrete Batch Plant | Alt 1 & 3 | CCAPCD |
| Sits Lodoga Road Realignment, Bridge, Detour (Rock Crushing and Processing) | Alt 2 | CCAPCD |
| Huffmaster Road Realignment (Earthwork, Rock Crushing and Processing) | All | CCAPCD |
| Construction Access, County, Ancillary, and Recreation Roads (Rock Crushing and Processing, Batch Hot Asphalt Mix Plant) | All | GCAPCD/CCAPCD |
| Early Site Access and Staging Development (Rock Crushing and Processing) | All | GCAPCD/CCAPCD |
| MI/O Facilities and Blasting | All | CCAPCD |

Notes: TCAPCD = Tehama County Air Pollution Control District; GCAPCD = Glenn County Air Pollution Control District; CCAPCD = Colusa County Air Pollution Control District; YSAQMD = Yolo Solano Air Quality Management District.

## 20D.2 Methodology

### 20D.2.1. Photochemical Grid Modeling

The United States Environmental Protection Agency (USEPA) Guideline on Air Quality Models (GAQM) (USEPA 2017) and the USEPA ozone and PM2.5 modeling guidance (USEPA 2018) recommend the use of a PGM to estimate $PM_{2.5}$ and ozone concentrations. Two PGMs are used extensively by USEPA, the Comprehensive Air Quality Model with Extensions (CAMx) and the Community Multiscale Air Quality (CMAQ) model. USEPA guidance does not recommend one PGM over the other; however, they prepared a memorandum (USEPA 2017a) that documents the suitability of both PGMs for modeling of $PM_{2.5}$ and ozone. CAMx (2021) was used for this analysis.

The latest publicly available PGM database for northern California was developed by the Bay Area Air Quality Management District (BAAQMD) for the year 2016. The BAAQMD PGM database uses a 4-km horizontal grid covering most of California (Figure 20D-1). The database contains initial conditions, boundary conditions, meteorological data, and 2016 emissions. Table 20D-2 presents the CAMx model configuration.

**Table 20D-2. CAMx model configuration**

| Science Options | CAMx | Comment |
|---|---|---|
| Model Code | CAMx V7.10 – Jan 2021 | |
| Horizontal Grid | 4-km – 185 columns x 185 rows | |
| Vertical Grid | 28 vertical layers up to ~ 19 km AGL | Collapsed from 50 WRF layers to 28 |
| Initial Conditions | Extracted from the MOZART global model outputs | BAAQMD provided CMAQ inputs. Converted using CMAQ2CAMX v2. 4-day spin-up period. |
| Boundary Conditions | Extracted from the MOZART global model outputs | BAAQMD provided CMAQ inputs. Converted using CMAQ2CAMX v2. |
| Photolysis Rates | Photolysis Rate Look-up table | Derived from satellite measurements |
| Aerosol-phase chemistry | ISORROPIA (inorganic aerosol)<br>SOAP v2.2 (organic aerosol) | |
| Gas Phase Chemistry | SARPRC07TC | Solved by the Euler Backward Iterative (EBI) solver |
| Meteorological Processor | WRFCAMX 5.1 | |
| Diffusion | Eddy diffusion algorithm | |
| Advection scheme | Piecewise Parabolic Method | |

PGM inputs provided by BAAQMD are for the CMAQ model. These inputs (meteorology, initial conditions, and boundary conditions) are converted for use in the CAMx model using processors developed by Ramboll. Emission inputs are discussed in Section 3.

CAMx is run three times. Once for the Baseline, which does not contain any Project emissions, and then once for each Alternative (Alternative 1 and 2). The Brute Force Method is used to determine the differences in concentrations between the Baseline and Alternatives by subtracting the Baseline concentrations from each Alternative's concentrations.

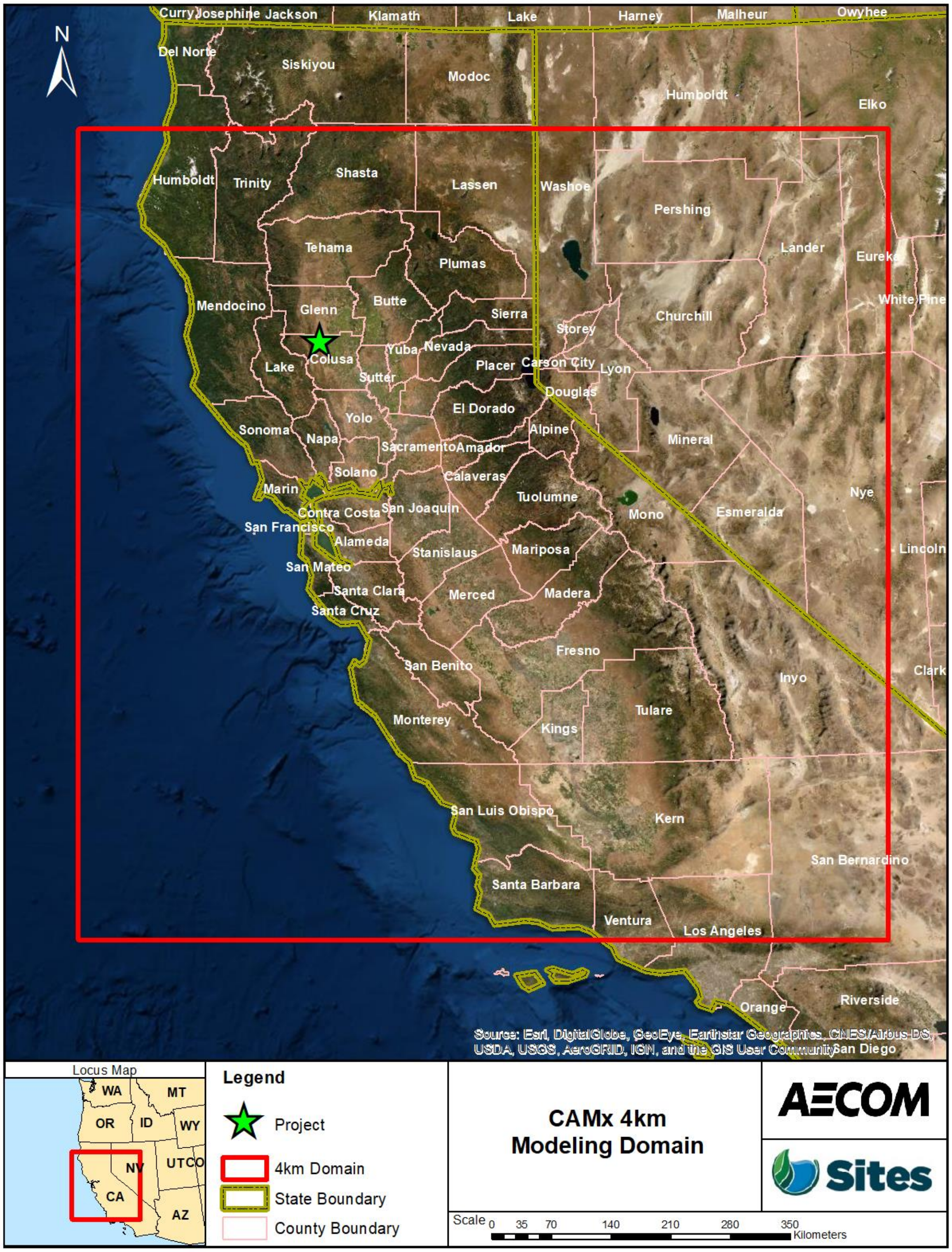


**Figure 20D-1. CAMx Modeling Domain**

### 20D.2.2. Health Effects Modeling

The potential health impacts of ozone and $PM_{2.5}$ concentrations due to the Project's emissions are estimated using the Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE) v1.5.8.5 (USEPA 2021). BenMAP-CE, originally developed by the USEPA, estimates human health and economic impacts resulting from changes in air quality. BenMAP-CE uses the following simplified formula to relate changes in air pollution to health endpoints, such as premature mortality, hospital admissions, and emergency room visits (AAI 2021).

Health Effect = Air Quality Change x Health Effect Estimate x Exposed Population x Background Health Inicidence

Where:

- Air Quality Change is the difference between the starting air pollution level (baseline) and the air pollution level after some change.
- Health Effect Estimate is an estimate of the percentage change in an adverse health impact due to a one unit change in air pollution. These are also referred to as concentration-response (C-R) functions and are obtained from epidemiological studies.
- Exposed Population is the number of people affected by the air quality change.
- Background Health Incidence is an estimate of the annual health incidence rate.

Each element of the above formula is discussed in the following sub-sections.

#### *20D.2.2.1. Air Quality Change*

The CAMx results summarized in Section 4 are used to estimate the health impacts (or Air Quality Change portion of the formula) of ozone and $PM_{2.5}$ due to the Project's emissions.

#### *20D.2.2.2. Health Effect Estimate*

BenMAP-CE contains a large number of health endpoints that can be included in an analysis. Health endpoints recommended in the Friant Ranch Guidance are used in this analysis. These recommended health endpoints are ones that are the focus of recent USEPA risk assessments. Health endpoints used in this analysis are shown in Table 20D-3 for ozone and Table 20D-4 for $PM_{2.5}$ below.

**Table 20D-3. Ozone Health Endpoints**

| Health Endpoint | Age Range | Daily Metric | Seasonal Metric | Annual Metric | C-R Function Selected |
|---|---|---|---|---|---|
| Hospital Admissions, All Respiratory | 65-99 | MDA8 | N/A | N/A | Katsouyanni et al., 2009 |
| Mortality, Non-Accidental | 0-99 | MDA8 | N/A | N/A | Smith et al., 2009 |

| Health Endpoint | Age Range | Daily Metric | Seasonal Metric | Annual Metric | C-R Function Selected |
|---|---|---|---|---|---|
| Emergency Room Visits, Asthma | 0-17 | MDA8 | N/A | N/A | Mar and Koenig, 2009 |
| Emergency Room Visits, Asthma | 18-99 | MDA8 | N/A | N/A | Mar and Koenig, 2009 |

**Table 20D-4. $PM_{2.5}$ Health Endpoints**

| Health Endpoint | Age Range | Daily Metric | Seasonal Metric | Annual Metric | C-R Function Selected |
|---|---|---|---|---|---|
| Emergency Room Visits, Asthma | 0-99 | 24-hr mean | N/A | N/A | Mar et al., 2010 |
| Mortality, All Cause | 30-99 | 24-hr mean | Quarterly mean | Mean | Krewski et al., 2009 |
| Hospital Admissions, Asthma | 0-64 | 24-hr mean | N/A | N/A | Sheppard, 2003 |
| Hospital Admissions, All Cardiovascular (excluding Myocardial Infarctions) | 65-99 | 24-hr mean | N/A | N/A | Bell, 2012 |
| Hospital Admissions, All Respiratory | 65-99 | 24-hr mean | N/A | N/A | Zanobetti et al., 2009 |
| Acute Myocardial Infarction, Nonfatal | 18-24 | 24-hr mean | N/A | N/A | Zanobetti et al., 2009 |
| Acute Myocardial Infarction, Nonfatal | 25-44 | 24-hr mean | N/A | N/A | Zanobetti et al., 2009 |
| Acute Myocardial Infarction, Nonfatal | 45-54 | 24-hr mean | N/A | N/A | Zanobetti et al., 2009 |

| Health Endpoint | Age Range | Daily Metric | Seasonal Metric | Annual Metric | C-R Function Selected |
|---|---|---|---|---|---|
| Acute Myocardial Infarction, Nonfatal | 55-64 | 24-hr mean | N/A | N/A | Zanobetti et al., 2009 |
| Acute Myocardial Infarction, Nonfatal | 65-99 | 24-hr mean | N/A | N/A | Zanobetti et al., 2009 |

#### *20D.2.2.3. Exposed Population*

Population data was obtained using PopGrid (USEPA 2021a). PopGrid allocates 2010 census data to each modeled 4x4 km grid cell. The population used for the estimated health impact and the background health incidence is 2029. This is the Project buildout year and is more conservative than using the population for 2026 which is the year modeled in CAMx. The 2029 population estimate does not take into account the fact that the residents of Sites, California will be relocated, thereby reducing the population in the Project area, leading to more conservative results.

#### *20D.2.2.4. Background Health Incidence Data*

The health impact analysis uses the health incidence data already contained in BenMAP. This includes the latest incidence dataset from 2014 for all morbidity endpoints. Mortality endpoints have incidence data in 5-year increments, so the dataset preceding the study year (2025) is used in this analysis. This is representative and conservative since air pollution and associated health impacts typically decline over time.

## 20D.3 Emission Estimates

### 20D.3.1. Non-project Emissions

The 2016 modeling database obtained from BAAQMD includes Sparse Matrix Operator Kernel Emissions Modeling System (SMOKE) output, CMAQ-ready emissions files for area, on-road mobile, off-road mobile, biogenic, and point source categories, covering the state of California.

The baseline year of the HIA is the future year that correlates to the maximum Project construction emissions, 2026. Therefore, the 2016 SMOKE output files are grown to this future year. To accomplish this, growth factors are calculated using data from the California Emissions Projection Analysis Model (CEPAM) (California Air Resources Board [CARB] 2021). CEPAM provides emissions for many years for all California counties. Emissions are obtained from CEPAM for the future year and the 2016 base year to calculate a growth factor for each pollutant by county and by source category. The source categories used are stationary (point), area, on-road mobile, and off-road mobile. Biogenic emissions remain constant, as the CEPAM data shows no change in the emissions.

The SMOKE 2016 output files are grown to the future year, 2026, for the non-Project emissions by applying the calculated growth factors for each source category, for each pollutant, and for each county.

### 20D.3.2. Project Emissions

Emissions of criteria pollutants and diesel particulate matter (DPM) would originate from off-road equipment exhaust, helicopter exhaust, employee and haul truck vehicle exhaust, and concrete and asphalt batch plants during construction of the Project. Fugitive dust emissions would occur from paved and unpaved road travel, earthmoving activities (i.e., grading, soil and rock loading/unloading), wind-blown dust from soil stockpiles, on-site crushing and processing of rock, and the use of explosives for blasting at the dam features. These emissions would be limited to the construction period and would cease when construction activities are completed.

The worst-case Project emissions are selected by determining the maximum emissions over the life of the project for each project emission category and feature. The year with the maximum project emissions is 2026. However, some features do not have emissions during the worst-case year. Therefore, the maximum emissions for each pollutant per emission category and construction feature over the construction period, years 2023 through 2029, are selected. This approach results in a conservative assessment of the worst-case construction emissions possible from the project.

Table 20D-5 summarizes the Project construction emissions in tons per year (tpy) for each alternative.

**Table 20D-5. Project Construction Emissions for each Alternative**

| Alternative | Project Emissions (tpy) | | | | | |
|---|---|---|---|---|---|---|
| | CO | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | ROG | $SO_2$ |
| Alternative 1 / 3 | 500.00 | 199.78 | 608.84 | 68.46 | 15.26 | 3.60 |
| Alternative 2 | 560.42 | 215.32 | 682.48 | 79.77 | 17.95 | 3.51 |

Project emissions are processed with SMOKE to create CAMx-ready emissions files using the following steps.

1. Project emissions are reformatted into a SMOKE input format. Each feature is assigned a unique Federal Information Processing System (FIPS) code and an appropriate Source Classification Code (SCC). Table 20D-6 shows the SCCs assigned to the Project sources.
2. Project emissions are spatially distributed to their corresponding grid cells. The grid cells containing Project emissions for each Alternative are shown in Figure 20D-2 below.
3. BAAQMD speciation profiles for the 2016 modeling platform are used to speciate the Project emissions into the Statewide Air Pollution Research Center chemical mechanism (SAPRC07) gas and aerosol species.

4. Project construction emissions are allocated temporally by day-of-week and hour-of-day profiles based on the construction schedule shown in Table 20D-7 below. All construction is assumed to occur Monday through Friday.

5. The SMOKE output, CMAQ-ready emissions files are converted to CAMx-ready files using the CMAQ2CAMX preprocessor.

**Table 20D-6. Project Emissions Source Classification Codes**

| Emissions Category | SCC | SCC Description |
|---|---|---|
| Off-Road Emissions | 2270002000 | Mobile Sources; Off-highway Vehicle Diesel; Construction and Mining Equipment; Total |
| Earthmoving Emissions | 2311000010 | Industrial Processes; Construction: SIC 15 - 17; All Processes; Land Clearing |
| Topsoil Emissions | 2311000100 | Industrial Processes; Construction: SIC 15 - 17; All Processes; Wind Erosion |
| Crushing/Processing Emissions | 2311000050 | Industrial Processes; Construction: SIC 15 - 17; All Processes; Cut and Fill Operations |
| Demolition and Blasting Emissions | 2311000020 | Industrial Processes; Construction: SIC 15 - 17; All Processes; Demolition |
| Helicopter Emissions | 2275000000 | Mobile Sources; Aircraft; All aircraft type and operations; Total |
| Concrete and Asphalt Emissions at Batch Plants | 30501101 | Industrial Processes; Mineral Products; Concrete Batching; General (non-fugitive) |
| Paving Emissions | 2270002021 | Mobile Sources; Off-highway Vehicle Diesel; Construction and Mining Equipment; Paving Equipment |
| On-site Truck Emissions | 2230007000 | Mobile Sources; Highway Vehicles - Diesel; All HDDV including Buses (use subdivisions -071 thru -075 if possible); Total: All Road Types |
| Worker Vehicle Emissions | 2201001000 | Mobile Sources; Highway Vehicles - Gasoline; Light Duty Gasoline Vehicles (LDGV); Total: All Road Types |
| Off-site Truck Emissions | 2230007000 | Mobile Sources; Highway Vehicles - Diesel; All HDDV including Buses (use subdivisions -071 thru -075 if possible); Total: All Road Types |

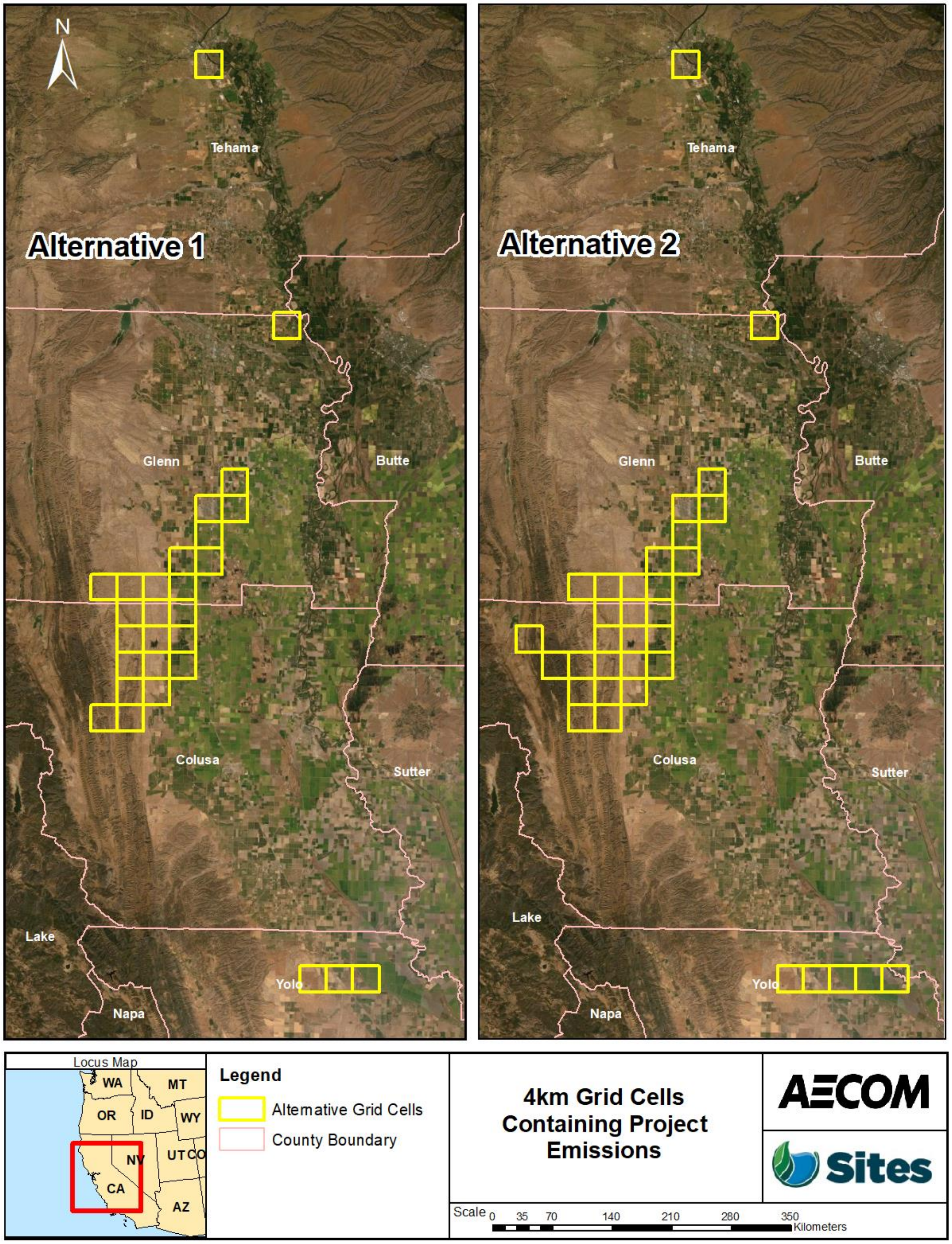


**Figure 20D-2. Project Grid Cells for Each Alternative**

**Table 20D-7. Daily Construction Schedule**

| Feature | Hours (On/Off-Road) |
|---|---|
| Batch Plants - I/O, Golden Gate, Sites, Diversions, Saddle Dams, ERS-1, ERS-2 | 7 AM – 7 PM |
| Batch Plants – Funks, Funks/TRR, Dunnigan, TRR | 7 AM – 7 PM |
| Sites Dam and Stone Corral Creek Recreation Area | 7 AM – 5 PM |
| Terminal Regulating Reservoir (TRR) Pumping Plant and TRR Pipelines | 8 AM – 4 PM |
| Glenn-Colusa Irrigation District (GCID) Main Canal | 8 AM – 4 PM |
| Funks Reservoir and Funks/TRR Pipelines | 8 AM – 4 PM |
| Dunnigan Pipeline | 8 AM – 4 PM |
| Golden Gate Dam | 7 AM – 5 PM |
| Peninsula Hills Recreation Area | 7 AM – 7 PM |
| Red Bluff Pumping Plant | 7 AM – 7 PM |
| Transmission Lines | 7 AM – 7 PM |
| Transition Manifold | 7 AM – 7 PM |

# 20D.4 Photochemical Modeling Analysis

This section presents the CAMx modeling results. Section 4.1 compares the impact of Project emissions on local and regional ozone concentrations to the Baseline concentrations. Section 4.2 compares the impact of Project emissions on local and regional concentrations of $PM_{2.5}$ to the Baseline concentrations.

## 20D.4.1. Ozone Concentration Analysis

The model results of hourly ozone concentrations are processed into metrics relevant to health effects. First, 8-hour average ozone concentrations are calculated. Then, the maximum daily average 8-hour (MDA8) ozone concentrations for each day are calculated.

The ozone modeling results are presented in tables below. Table 20D-8 compares the ozone concentration for the Baseline and Alternative 1 at the grid cell with the greatest change. The comparison between the Baseline and Alternative 2 is shown in Table 20D-9. The maximum MDA8 Project change for the Alternatives is 3.6 percent, for Alternative 2.

**Table 20D-8. Baseline and Alternative 1 Daily Maximum 8-Hour Average Ozone, At Grid Cell with the Greatest Change**

| Baseline Concentration (ppbv) | Alternative 1 Concentration (ppbv) | Maximum Change (ppbv) | Maximum Change (%) |
|---|---|---|---|
| 42.901 | 44.358 | 1.457 | 3.4 |

Note: Maximum change occurs approximately 14 km west-northwest of the Saddle Dam area of the Project in grid cell (52,140).

**Table 20D-9. Baseline and Alternative 2 Daily Maximum 8-Hour Average Ozone, At Grid Cell with the Greatest Change**

| Baseline Concentration (ppbv) | Alternative 2 Concentration (ppbv) | Maximum Change (ppbv) | Maximum Change (%) |
|---|---|---|---|
| 42.768 | 44.320 | 1.552 | 3.6 |

Note: Maximum change occurs approximately 14 km west of the Saddle Dam area of the Project in grid cell (52,139).

Figure 20D-3 shows the annual maximum modeled MDA8 ozone concentrations at each grid cell for the Baseline in the top panel. The bottom two panels show the maximum Project contribution for each Alternative.

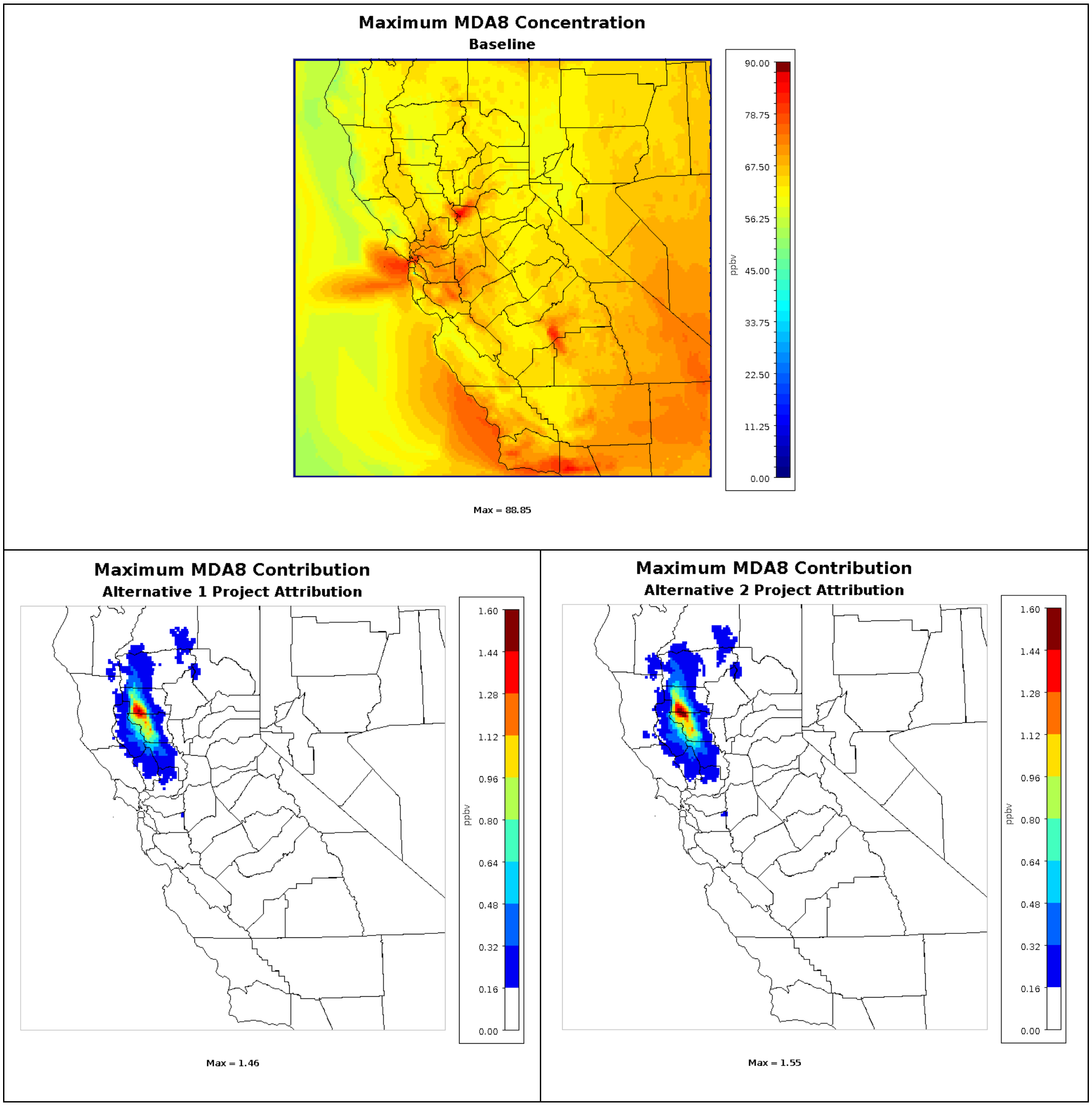


**Figure 20D-3. Maximum Baseline MDA8 Concentrations and Maximum Project Contributions for each Alternative**

#### *20D.4.1.1. Possible Impact on Exceedance Days*

Table 20D-10 shows the annual maximum MDA8 concentrations and number of exceedance days for the monitors located near the Project area for 2018 through 2020 (USEPA 2021b). Figure 20D-4 shows the location of these ozone monitors and the grid cells that show at least a 1 ppb ozone concentration increase due to the Project for Alternative 2. Since the 1 ppb ozone concentration increases due to the Project do not overlap any monitors, it is assumed that the Project emissions will have no effect on exceedance days.

**Table 20D-10. Annual Maximum MDA8 Concentrations and Number of Exceedance Days at Nearby Monitors**

| Monitor | County | Site ID | 2018 | | 2019 | | 2020 | |
|---|---|---|---|---|---|---|---|---|
| | | | Maximum Concentration (ppb) | Number of Exceedance Days | Maximum Concentration (ppb) | Number of Exceedance Days | Maximum Concentration (ppb) | Number of Exceedance Days |
| Colusa | Colusa | 06-011-1002 | 62 | 0 | 55 | 0 | 68 | 0 |
| Willows | Glenn | 06-021-0003 | 63 | 0 | 60 | 0 | 61 | 0 |
| Lakeport | Lake | 06-033-3002 | 63 | 0 | 54 | 0 | 63 | 0 |
| Red Bluff | Tehama | 06-103-0007 | 87 | 8 | 67 | 0 | 63 | 0 |
| Woodland | Yolo | 06-113-1003 | 84 | 2 | 67 | 0 | 75 | 2 |

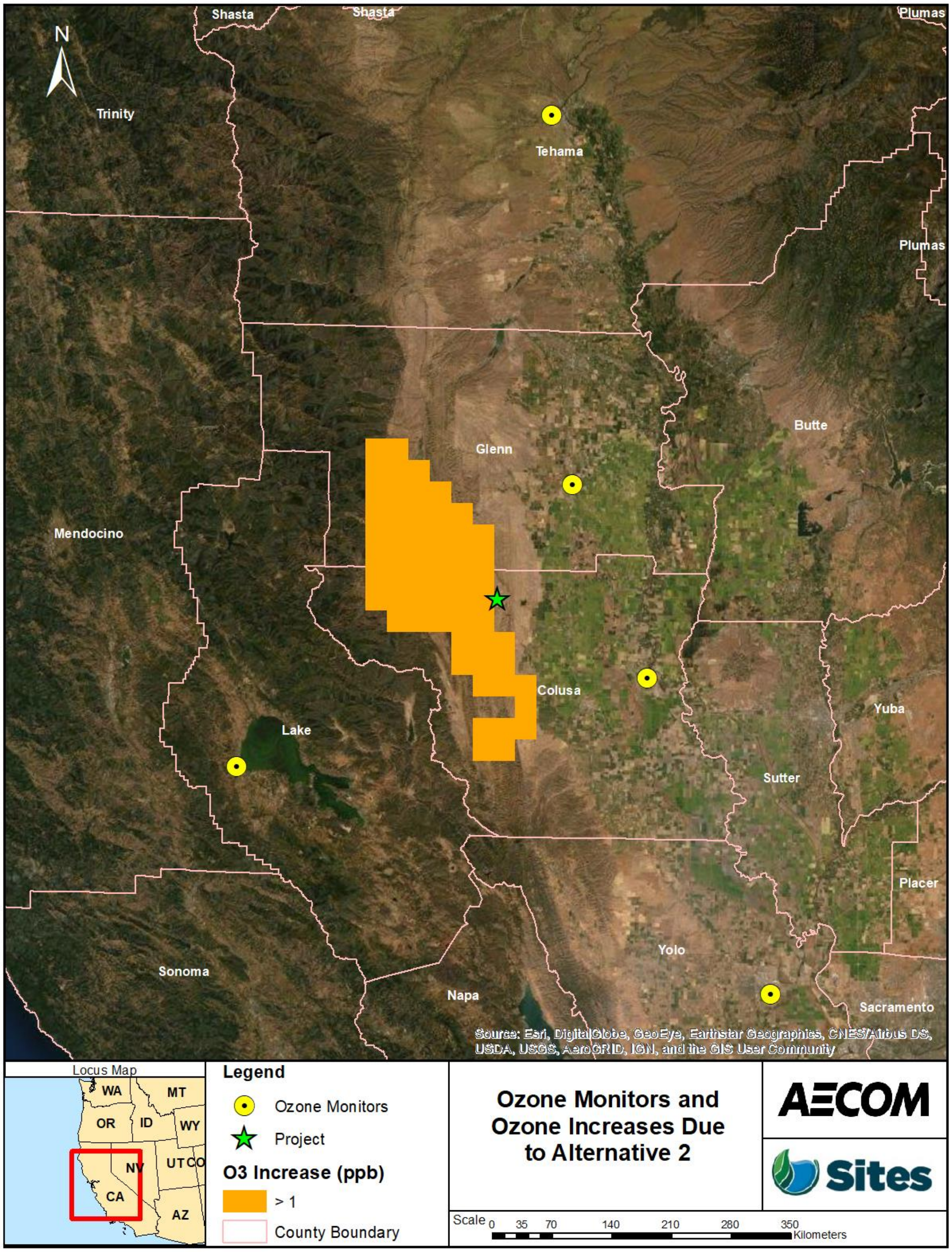


**Figure 20D-4. Ozone Monitors and Ozone Increases Due to Alternative 2**

## 20D.4.2. PM2.5 Concentration Analysis

The model results of hourly $PM_{2.5}$ concentrations are processed into metrics relevant to health effects. Annual average and daily average $PM_{2.5}$ concentrations are calculated.

The $PM_{2.5}$ modeling results are presented in the tables below. Table 20D-11 compares the $PM_{2.5}$ concentration for the Baseline and Alternative 1 at the grid cell with the greatest change. The comparison between the Baseline and Alternative 2 is shown in Table 20D-12. The maximum daily average $PM_{2.5}$ Project change for the Alternatives is 26.3 percent, for Alternative 1; while the maximum annual average $PM_{2.5}$ Project change is 5.4% for Alternative 2.

**Table 20D-11. Baseline and Alternative 1 Annual and Daily Average $PM_{2.5}$, At Grid Cell with the Greatest Change**

| Averaging Period | Baseline Concentration (μg/m$^3$) | Alternative 1 Concentration (μg/m$^3$) | Maximum Change (μg/m$^3$) | Maximum Change (%) |
|---|---|---|---|---|
| Daily Average | 8.789 | 11.102 | 2.313 | 26.3 |
| Annual Average | 13.383 | 13.829 | 0.446 | 3.3 |

Note: Maximum change occurs in the grid cell containing the new Sites Lodoga Road and the Golden Gate Dam in grid cell (56,137).

**Table 20D-12. Baseline and Alternative 2 Annual and Daily Average $PM_{2.5}$, At Grid Cell with the Greatest Change**

| Averaging Period | Baseline Concentration (μg/m$^3$) | Alternative 2 Concentration (μg/m$^3$) | Maximum Change (μg/m$^3$) | Maximum Change (%) |
|---|---|---|---|---|
| Daily Average | 16.506 | 19.712 | 3.206 | 19.4 |
| Annual Average | 14.118 | 14.881 | 0.763 | 5.4 |

Note: Maximum change occurs in the grid cell containing the Funks Reservoir in grid cell (57,137).

Figure 20D-5 shows the annual maximum modeled daily average $PM_{2.5}$ concentrations at each grid cell for the Baseline in the top panel. The bottom two panels show the maximum Project contribution for each Alternative.

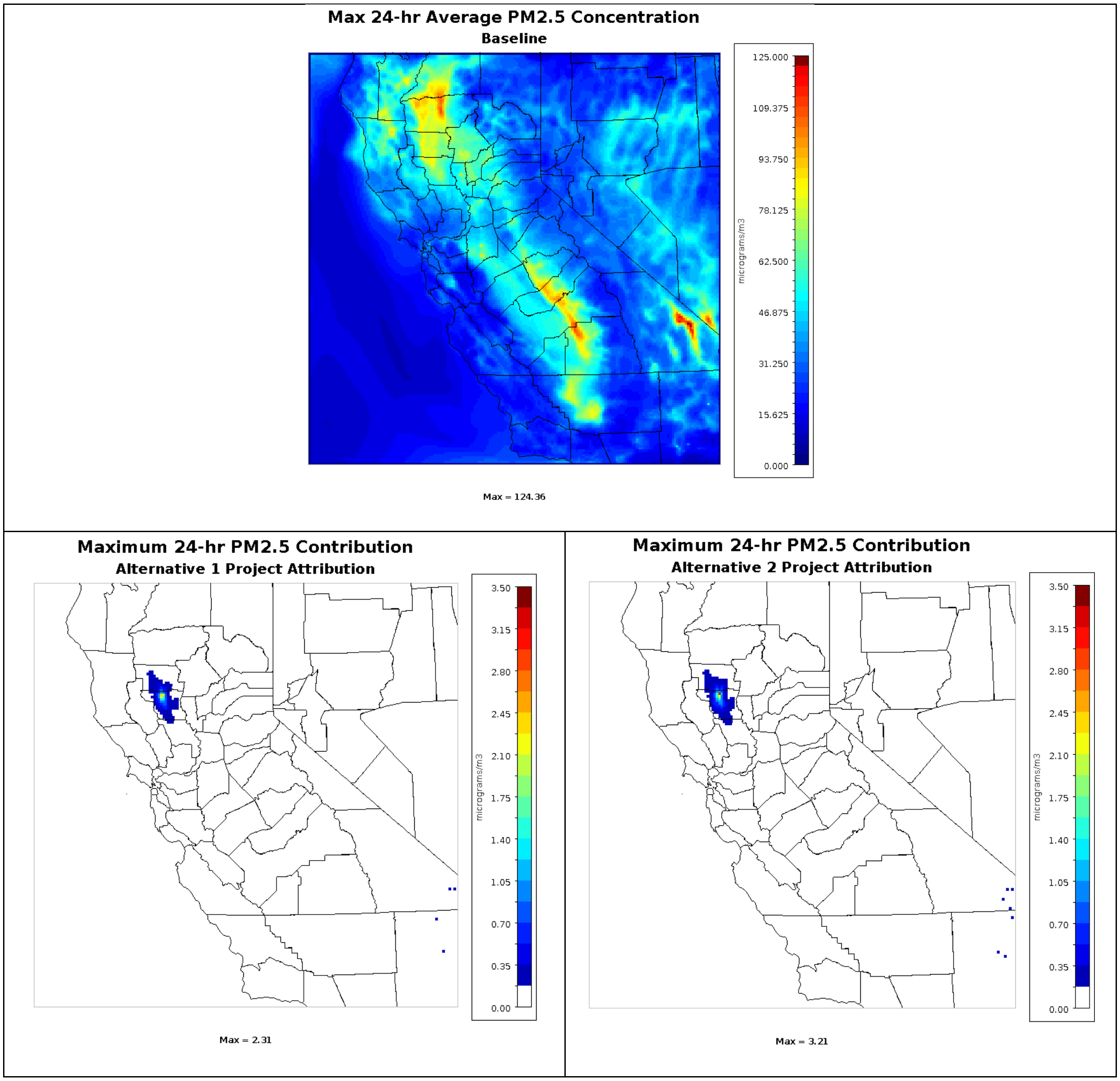


**Figure 20D-5. Maximum Daily Average Baseline $PM_{2.5}$ Concentrations and Maximum Project Contributions for each Alternative**

Figure 20D-6 shows the modeled annual average $PM_{2.5}$ concentrations at each grid cell for the Baseline in the top panel. The bottom two panels show the maximum Project contribution for each Alternative.

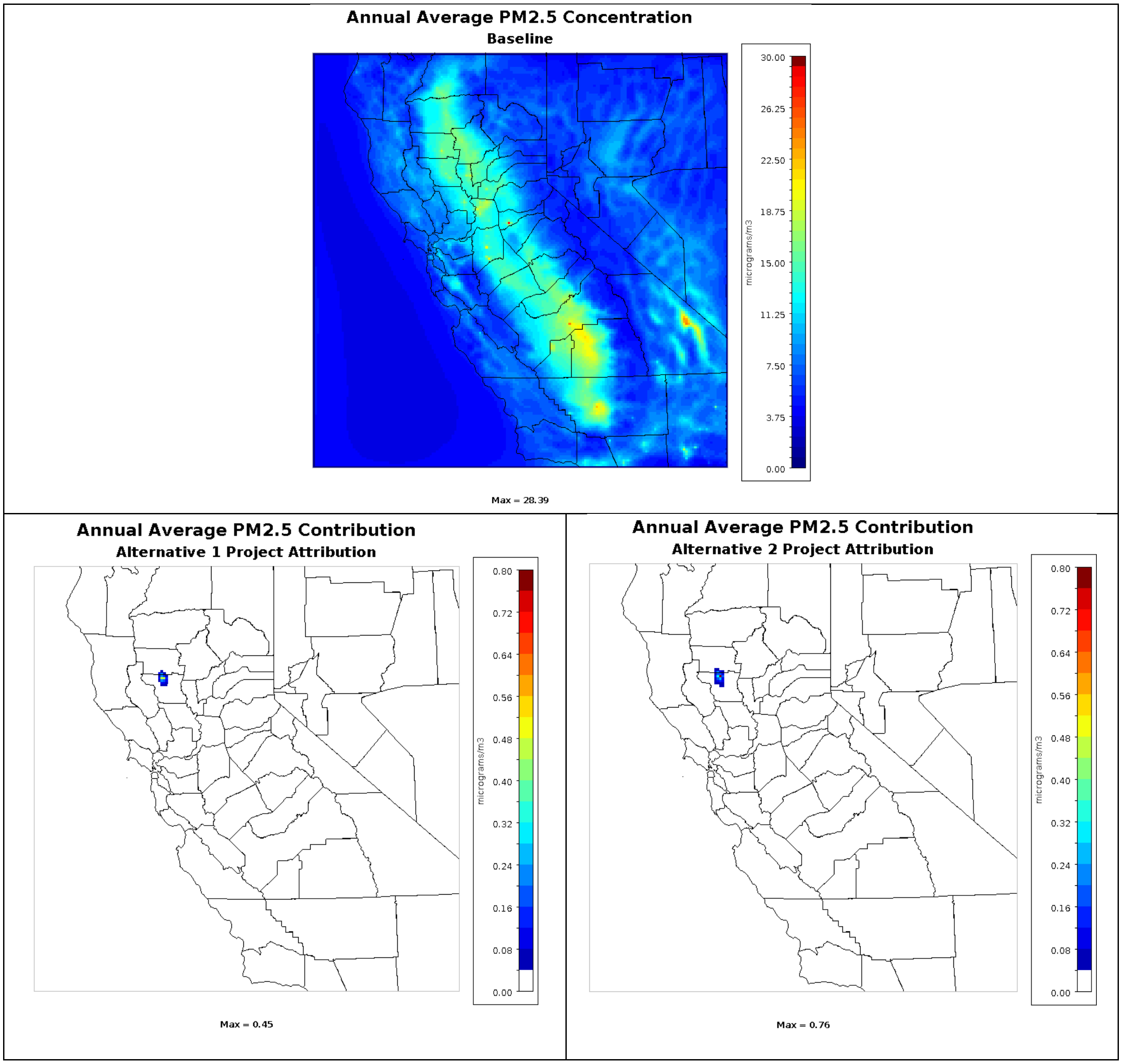


**Figure 20D-6. Annual Average Baseline $PM_{2.5}$ Concentrations and Maximum Project Contributions for each Alternative**

### *20D.4.2.1. Possible Impact on Exceedance Days*

Table 20D-13 shows the annual maximum daily average $PM_{2.5}$ concentrations and number of exceedance days for the monitors located near the Project area for 2018 through 2020; while Table 20D-14 shows the annual average concentrations for the same monitors and time periods (USEPA 2021b). Figure 20D-7 shows the location of these $PM_{2.5}$ monitors and the grid cells that show at least a 0.5 $\mu g/m^3$ daily average concentration increase due to the Project for Alternative 2. Figure 20D-8 shows the same monitors and the grid cells that show at least a 0.05 $\mu g/m^3$ annual average concentration increase due to the Project for Alternative 2. Since the concentration increases due to the Project do not overlap any monitors, it is assumed that the Project emissions will have no effect on exceedance days.

**Table 20D-13. Annual Maximum Daily Average $PM_{2.5}$ Concentrations and Number of Exceedance Days at Nearby Monitors**

| Monitor | County | Site ID | 2018 | | 2019 | | 2020 | |
|---|---|---|---|---|---|---|---|---|
| | | | Maximum Concentration (μg/m$^3$) | Number of Exceedance Days | Maximum Concentration (μg/m$^3$) | Number of Exceedance Days | Maximum Concentration (μg/m$^3$) | Number of Exceedance Days |
| Colusa | Colusa | 06-011-1002 | NA | NA | NA | NA | 97 | 4 |
| Cortina Indian Rancheria | Colusa | 06-011-0007 | 118 | 24 | 18 | 0 | 119 | 29 |
| Lakeport | Lake | 06-033-3002 | 158 | 3 | 8 | 0 | 112 | 4 |
| Red Bluff | Tehama | 06-103-0007 | 131 | 24 | 23 | 0 | 143 | 31 |
| Woodland | Yolo | 06-113-1003 | 165 | 2 | 28 | 0 | 134 | 4 |

**Table 20D-14. Annual Average $PM_{2.5}$ Concentrations**

| Monitor | County | Site ID | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|
| | | | Concentration (μg/m$^3$) | Concentration (μg/m$^3$) | Concentration (μg/m$^3$) |
| Colusa | Colusa | 06-011-1002 | NA | NA | 13.0 |
| Cortina Indian Rancheria | Colusa | 06-011-0007 | 10.5 | 6.0 | 26.3 |
| Lakeport | Lake | 06-033-3002 | 9.2 | 3.1 | 9.6 |
| Red Bluff | Tehama | 06-103-0007 | 10.6 | 5.4 | 13.3 |
| Woodland | Yolo | 06-113-1003 | 12.9 | 7.7 | 14.7 |

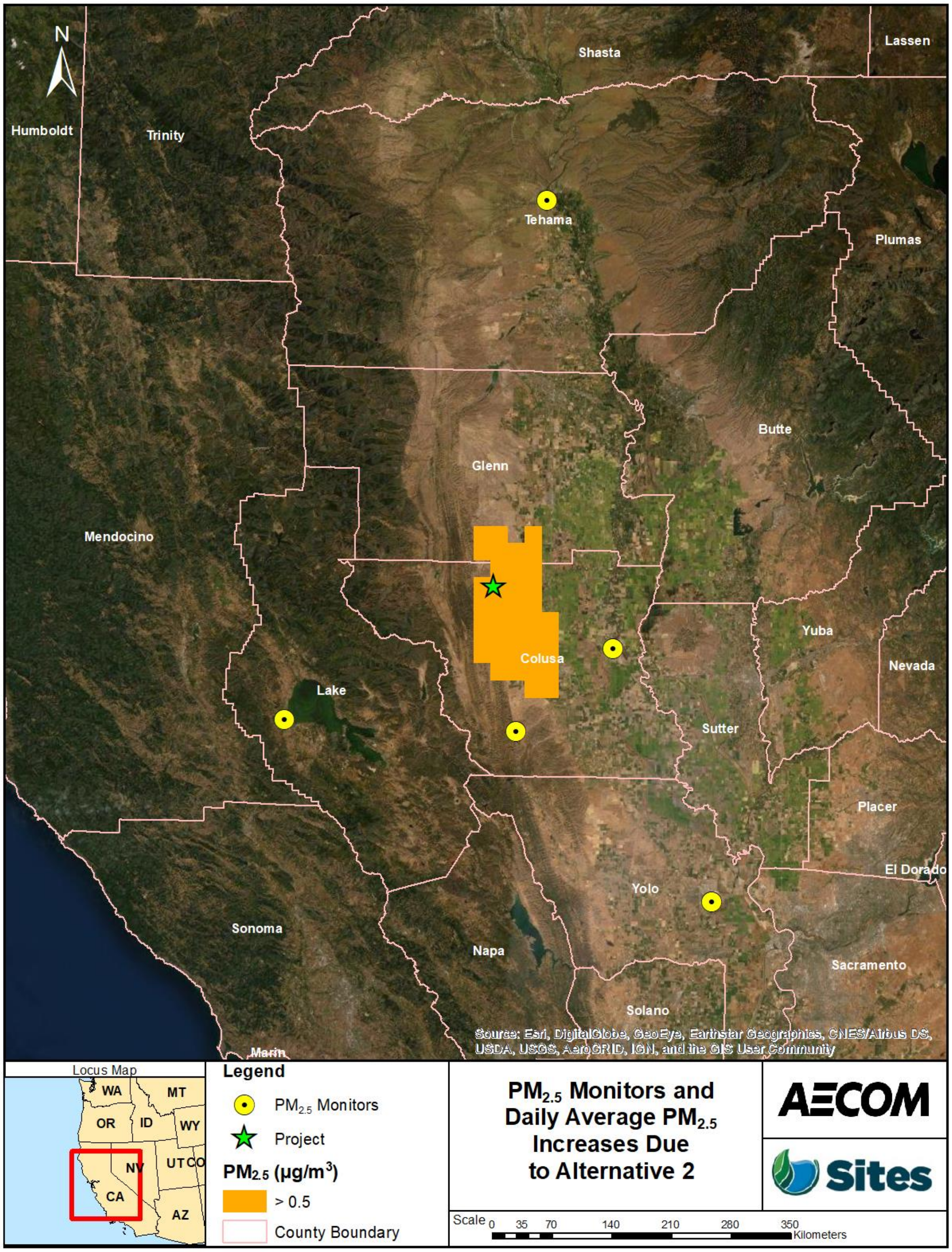


**Figure 20D-7. $PM_{2.5}$ Monitors and Daily Average $PM_{2.5}$ Increases Due to Alternative 2**

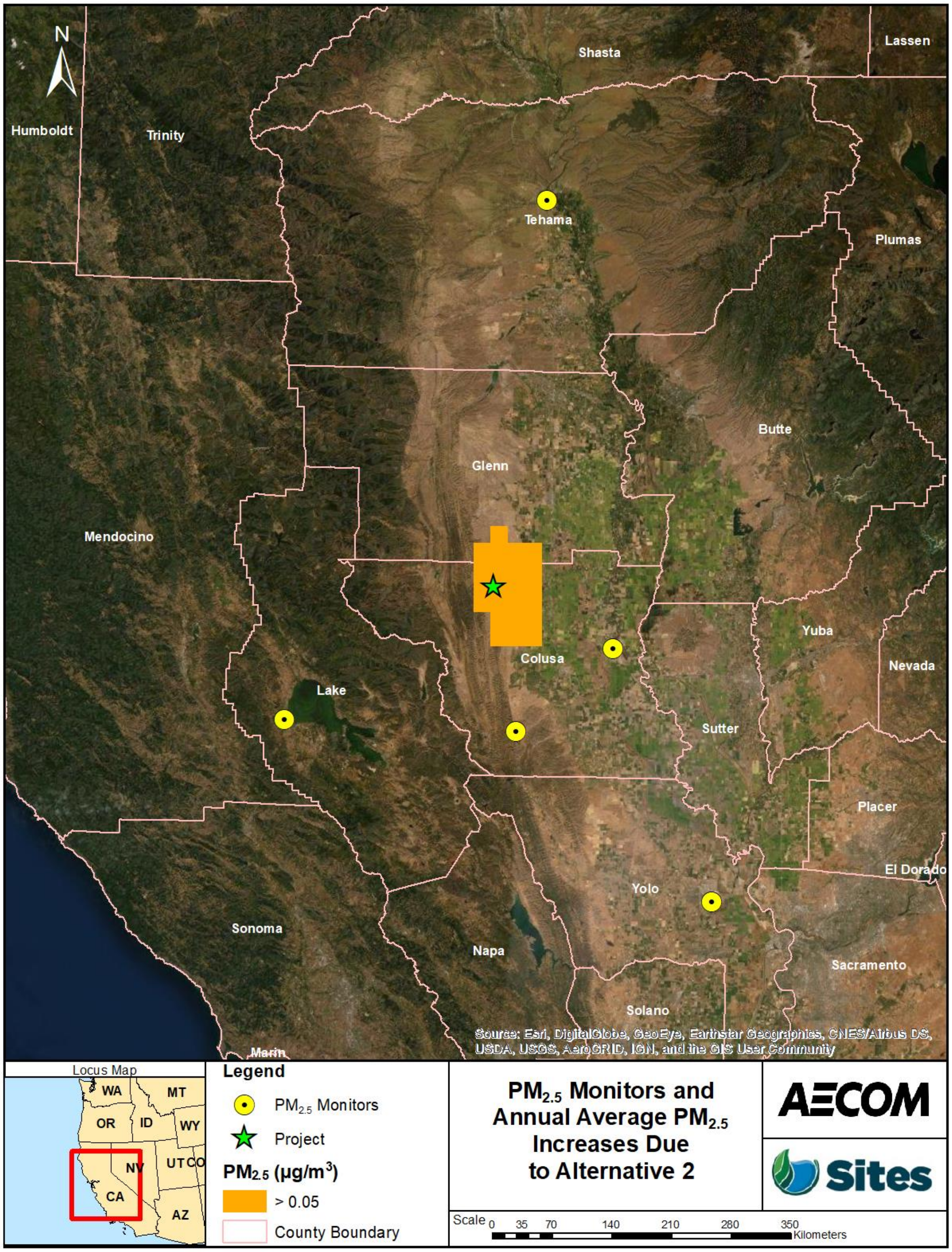


**Figure 20D-8. $PM_{2.5}$ Monitors and Annual Average $PM_{2.5}$ Increases Due to Alternative 2**

# 20D.5 Health Impact Analysis

The CAMx results summarized in Section 4 are used to estimate the health impacts of ozone and $PM_{2.5}$ due to the Project's emissions. The modeled concentrations of MDA8 for ozone and daily average $PM_{2.5}$ are input into BenMAP-CE. BenMAP-CE internally calculates the quarterly and annual averages that are required for certain health endpoints. The modeled concentrations are input for the Baseline and one Alternative for each BenMAP-CE run. BenMAP-CE then calculates the difference, or delta, as Baseline concentration minus the Alternative concentration.

## 20D.5.1. Ozone Health Impact

Increases in the health effect incidences and percent of the background health incidence for ozone due to the Project emissions, estimated by BenMAP-CE, are presented in the Tables 20D-15 and 20D-16 for each Alternative. These values show the total health impact across the entire CAMx domain and do not include any potential reductions in incremental incidence. The results show that the greatest incremental increase in incidence is for emergency room visits for asthma for ages 0 to 17, with an increase of 0.64 cases for Alternative 2. This equates to 0.004% of the background health incidence rate.

**Table 20D-15. Estimated Ozone Health Impacts for Alternative 1**

| Health Endpoints | | Aggregated Results | | |
|---|---|---|---|---|
| **Health Endpoint Group** | **Health Endpoint** | **Incremental Incidence (# per year)** | **Baseline Incidence (# per year)** | **Percent of Background Health Incidence (%)** |
| Emergency Room Visits – Respiratory | Asthma [0-17] | 0.61 | 15,763 | 0.004 |
| | Asthma [18-99] | 0.46 | 30,155 | 0.002 |
| Hospital Admissions | All Respiratory [65-99] | 0.06 | 46,466 | 0.0001 |
| Mortality | Non-Accidental [0-99] | 0.07 | 67,216 | 0.0001 |

**Table 20D-16. Estimated Ozone Health Impacts for Alternative 2**

| Health Endpoints | | Aggregated Results | | |
|---|---|---|---|---|
| **Health Endpoint Group** | **Health Endpoint** | **Incremental Incidence (# per year)** | **Baseline Incidence (# per year)** | **Percent of Background Health Incidence (%)** |
| Emergency Room Visits – Respiratory | Asthma [0-17] | 0.64 | 15,763 | 0.004 |
| | Asthma [18-99] | 0.48 | 30,155 | 0.002 |
| Hospital Admissions | All Respiratory [65-99] | 0.06 | 46,466 | 0.0001 |
| Mortality | Non-Accidental [0-99] | 0.07 | 67,216 | 0.0001 |

### 20D.5.2. $PM_{2.5}$ Health Impact

Increases in the health effect incidences and percent of the background health incidence for $PM_{2.5}$ due to the Project emissions, estimated by BenMAP-CE, are presented in the Tables 20D-17 and 20D-18 for each Alternative. These values show the total health impact across the entire CAMx domain and do not include any potential reductions in incremental incidence. The results show that the greatest incremental increase in incidence is for all causes of mortality for ages 30 to 99, with an increase of 0.23 cases for Alternative 2. This equates to 0.0001% of the background health incidence rate.

**Table 20D-17. Estimated PM2.5 Health Impacts for Alternative 1**

| Health Endpoints | | Aggregated Results | | |
|---|---|---|---|---|
| **Health Endpoint Group** | **Health Endpoint** | **Incremental Incidence (# per year)** | **Baseline Incidence (# per year)** | **Percent of Background Health Incidence (%)** |
| Acute Myocardial Infarction | AMI, Nonfatal [18-24] | 0.000007 | 26 | 0.00003 |
| | AMI, Nonfatal [25-44] | 0.0004 | 1,558 | 0.00003 |
| | AMI, Nonfatal [45-54] | 0.001 | 3,634 | 0.00003 |
| | AMI, Nonfatal [55-64] | 0.002 | 6,666 | 0.00003 |
| | AMI, Nonfatal [65-99] | 0.006 | 24,840 | 0.00002 |
| Emergency Room Visits | Asthma [0-99] | 0.07 | 109,543 | 0.00007 |
| Hospital Admissions | Asthma [0-64] | 0.005 | 12,827 | 0.00004 |
| | All Cardiovascular (less AMI) [65-99] | 0.01 | 129,875 | 0.00001 |
| | All Respiratory [65-99] | 0.03 | 110,850 | 0.00002 |
| Mortality | All Cause [30-99] | 0.11 | 166,766 | 0.00007 |

**Table 20D-18. Estimated PM2.5 Health Impacts for Alternative 2**

| Health Endpoints | | Aggregated Results | | |
|---|---|---|---|---|
| **Health Endpoint Group** | **Health Endpoint** | **Incremental Incidence (# per year)** | **Baseline Incidence (# per year)** | **Percent of Background Health Incidence (%)** |
| Acute Myocardial Infarction | AMI, Nonfatal [18-24] | 0.00002 | 26 | 0.00006 |
| | AMI, Nonfatal [25-44] | 0.0009 | 1,558 | 0.00006 |
| | AMI, Nonfatal [45-54] | 0.002 | 3,634 | 0.00006 |
| | AMI, Nonfatal [55-64] | 0.004 | 6,666 | 0.00005 |
| | AMI, Nonfatal [65-99] | 0.01 | 24,840 | 0.00005 |
| Emergency Room Visits | Asthma [0-99] | 0.16 | 109,543 | 0.0001 |

| Health Endpoints | | Aggregated Results | | |
|---|---|---|---|---|
| Health Endpoint Group | Health Endpoint | Incremental Incidence (# per year) | Baseline Incidence (# per year) | Percent of Background Health Incidence (%) |
| Hospital Admissions | Asthma [0-64] | 0.01 | 12,827 | 0.00008 |
| | All Cardiovascular (less AMI) [65-99] | 0.02 | 129,875 | 0.00002 |
| | All Respiratory [65-99] | 0.05 | 110,850 | 0.00005 |
| Mortality | All Cause [30-99] | 0.23 | 166,766 | 0.0001 |

### 20D.5.3. Qualitative Assessment of Operational Impacts

Upon completion of the Project, sources of emissions from day-to-day activities would involve public vehicles traveling to and from the reservoir along with on-water sources, such as water vessels. Both source types would be mobile in nature. The ozone precursor with the highest operational emissions is ROG with average daily emissions that could approach 270 lbs/day on average. For perspective, the average daily emission rate of ROG during the highest construction year is approximately 99 lbs/day in CCAPCD and GCAPCD areas combined. Another ozone precursor, NOx, is expected to have average daily emissions from operations approaching 98 lbs/day, while daily average construction emissions are approximately 1,200 lbs/day in the highest year. Given that ozone formation in the area is NOx-limited (USEPA 2008, Chapter 2) and thus ozone production is more responsive to changes in NOx emissions, impacts from operational activities are expected to be lower than those modeled during construction. $PM_{10}$ and thus $PM_{2.5}$ emissions is substantially less for operational activities in comparison to construction. The average $PM_{10}$ emission rate from the highest construction year is over 4,000 lbs/day whereas the average emission rate for operational activities is less than 300 lbs/day.

## 20D.6 Uncertainties

The following discussion summarizes the main uncertainties associated with the photochemical grid modeling and HIA. The methodology of this analysis ensures that the uncertainty is of a conservative nature.

### 20D.6.1. Emission Estimates

Uncertainties exist in estimating emissions from construction equipment. Since the maximum daily or maximum annual emissions at a given Project site are modeled concurrently with the maximum emissions for the other sites, emission estimates are likely conservative. Furthermore, the equipment estimated for use during construction is estimated to operate more hours than it will actually occur.

### 20D.6.2. CAMx Modeling

In addition to the uncertainty associated with emission estimates, uncertainty exists regarding the pollutant concentrations estimated by CAMx. CAMx, and other PGMs, attempt to estimate the complex and dynamic chemical and physical processes occurring in the atmosphere through mathematical representation. Through this attempt, uncertainty is introduced.

Uncertainty and error in CAMx are also introduced through model inputs (e.g., emissions, boundary conditions, meteorological predictions, chemistry, and model formulation). The limitations of the PGM provide a source of uncertainty in the estimation of exposure concentrations.

### 20D.6.3. Health Impact Analysis

The HIA inherits the uncertainties of its inputs, from the emissions estimations through the CAMx outputs. There are also uncertainties in the HIA itself. The BenMAP-CE model relies on epidemiological studies and health impact functions that develop statistical relationships between air pollution exposures and human health effects. These studies report correlations between health effects and exposure to $PM_{2.5}$ and ozone, not a direct link. There is also the assumption that the health effects seen at large concentration differences can be linearly scaled down to small concentration differences, even though there is a potential threshold below which health effects may not occur.

Uncertainty is also introduced in estimation of the 2029 population numbers. As mentioned previously, the 2029 population estimate does not take into account the fact that the residents of Sites, California will be relocated, thereby reducing the population in the Project area, leading to more conservative results.

## 20D.7 References Cited

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