STATE OF NEW MEXICO
BEFORE THE SECRETARY OF THE ENVIRONMENT

IN THE MATTER OF THE APPLICATION
OF ROPER CONSTRUCTION, INC. FOR AN AIR QUALITY PERMIT NO. 9295,
ALTO CONCRETE BATCH PLANT

AQB 21-57(P)

THE PROPERTY OWNERS OF SONTERRA'S NOTICE OF INTENT TO PRESENT TECHNICAL EVIDENCE PURSUANT TO 20.1.4.7 NMAC

Pursuant to 20.1.4.7 NMAC and the Scheduling Order entered on December 2, 2021, the Property Owners of Sonterra ("Sonterra") submits the following technical evidence. This statement is filed by counsel for Sonterra, as identified below. Sonterra opposes the application for an air quality construction permit, and submits the following as technical evidence:

I. Carlos Ituarte-Villarreal, Ph.D.

Dr. Ituarte-Villarreal is an environmental specialist with significant experience in areas of atmospheric dispersion modeling, fate and transport, emissions inventory, air quality permitting, and environmental compliance in engineering. Dr. Ituarte-Villarreal is currently employed by SWCA Environmental Consultants ("SWCA"). Dr. Ituarte-Villarreal's SWCA address is 20 E. Thomas Road, Suite 1700, Phoenix, Arizona 85012. He received a Bachelor of Science in Industrial Engineering from the Instituto Tecnologico de Parral in Mexico in 2008, a Master of Science in Industrial Engineering from the University of Texas at El Paso in 2010, and his Ph.D. in Environmental Science and Engineering from the University of El Paso in 2015. Prior to his employment at SWCA in August 2013, Dr. Ituarte-Villarreal worked as an air quality engineer at El Paso Electric Company (January 2012 through August 2013). Dr. Ituarte-Villarreal has been a teaching assistant at the University of Texas at El Paso from May 2011 through August 2013 and a research associate and assistant at the University of Texas at El Paso from June 2009 through May 2011. Dr. Ituarte-Villarreal's direct testimony is anticipated to be two hours.

The following exhibits are submitted in connection with Dr. Ituarte-Villarreal's testimony:

1. Curriculum vitae of Dr. Ituarte-Villarreal, attached.

2. Summary of revisions to AERMOD air dispersion model and AERMET from the U.S. EPA dated May 11, 2021, attached.

3. EPA's requirement that the meteorological data input to AERMOD be "adequately representative." 40 C.F.R. 51, Appendix W, 8.4.1.b, attached.

4. EPA's guidance on the selection of meteorological data, including Appendix W, § 8.1.b(2)(i), attached.

5. Meteorological data collected for the modeling study for the Alto concrete batch plant, part of Record Proper and, in addition, applicant modeling data available on request.

6. Map depicting topographical conditions at Holloman Air Force Base, part of Record Proper.

7. Map depicting topographical conditions at the proposed Alto concrete batch plant, attached.

8. Map and wind rose depicting wind conditions at Holloman Air Force Base, including data used to generate wind rose, part of Record Proper.

9. WindMap and wind rose depicting wind conditions at the Alto concrete batch plant location, including data used to generate wind rose, attached.

10. NSR Minor Source Permit Application for Roper Construction, Inc. Alto CBP, including all revisions and modifications made by the applicant, part of Record Proper.

Summary of Opinions

A. The Modeling is Unreliable and Cannot Support the Requested Permit Because the Applicant Used the Incorrect Meteorological Data for the Modeling.

The selection of the appropriate meteorological data demonstration is a critical factor in the representation of the project. The U.S. EPA requires that the meteorological data input to AERMET be "adequately representative." 40 C.F.R. 51, Appendix W, 8.4.1.b states:

> The meteorological data used as input into a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and disposal conditions in the area of concern.

Applicant failed to follow the U.S. EPA's guidance in the selection of meteorological data sets for air quality monitoring. As indicated in the U.S. EPA's guidance, the representativeness of the measured data is dependent on a variety of factors, including the proximity of the meteorological monitoring site to the area under consideration, the complexity of the terrain, the exposure of the meteorological monitoring site, the period of time during which data are collected.

Appendix W, Section A.1(B)(2)(i) of 40 C.F.R. 51 succinctly summarizes this requirement to use representative data:

> Data used as input to AERMET should possess an adequate degree of representativeness to ensure that the wind temperature and turbulence profiles derived by AERMOD are both laterally and vertically representative of the source impact area.

The modeling study for the Alto concrete batch plant does not meet this standard. The modeling used meteorological data collected at the Holloman Air Force Base meteorological tower, located 45 miles south-southwest from the proposed Alto concrete batch plant.

Based on the review of existing topographical and wind conditions at Holloman Air Force Base and the Alto concrete batch location, it is my opinion that the modeling studies for the proposed concrete batch plant are invalid. The meteorological data and topographical conditions are not adequately representative of the dispersion conditions at the location of the proposed site. In this regard, please see the comparison of the wind rose for each location and the topographical conditions. The Ruidoso Regional Airport, located only approximately 8.5 miles from the proposed Alto concrete batch plant, does not match or even come close to depicting the wind directions recorded at the Holloman Air Force Base. As a result, the modeling conclusions are not a reflection of the dispersion conditions at the proposed concrete batch plant site.

Additionally, the surface characteristics at the Holloman Air Force Base are markedly different from the characteristics at the proposed location. In order to conduct reliable modeling, Appendix W, Section 8.1(b)(2)(i) of the CFR also states:

> The values for surface roughness, Bowen ratio, and Albedo should reflect the surface characteristics in the vicinity of the meteorological tower or representative grid cell when using prognostic data, and should be adequately representative of the modeling domain.

The Holloman Air Force Base meteorological station is located at an elevation of 1,248 meters above mean sea level, approximately 958 meters lower than the specified proposed concrete batch plant site elevation of 2,206 meters. As is evident from the comparison of the land use and land cover maps, the surface characteristics are markedly different. As noted in Section 16 of the application, a surface characteristics analysis was conducted for the location of Holloman Air Force Base meteorological station, but no such analysis was performed for the location of the proposed concrete batch plant. Consequently, no comparison was done of the surface characteristics of the two sites to determine if one could be representative of the other.

Given that the land use conditions at both locations are markedly different, the surface characterizations of both locations are also significantly different. As a result, use of the Holloman Air Force Base meteorological data is not adequately representative to obtain a reliable modeling for the proposed project's conditions. Accordingly, the modeling is unreliable because it is not representative of the dispersion conditions at the proposed Alto concrete batch plant site and does not capture the dispersion and transport conditions expected to occur in the Alto, New Mexico area.

B. The Applicant Used Incorrect Version of AERMET and AERMOD to Conduct Modeling.

The applicant processed the meteorological data by using AERMET (Version 19191) and conducted air dispersion modeling by using Version 19191of AERMOD. On May 11, 2021, the U.S. EPA announced revisions to the AERMOD air dispersion model and AERMET, its meteorological data pre-processor. These revisions included an update of AERMET and AERMOD from Version 19191 to Version 21112. The modeling results are unreliable because the applicant failed to use the most recent version of AERMET in the preparation of the meteorological data set and the most recent version AERMOD while conducting air dispersion modeling.

C. The Applicant Failed to Include Multiple Emission Sources in the Modeling.

The application modeling considered haul road emissions by including only trips from haul trucks used to deliver cement, fly ash, aggregate material, sand material and transport concrete product. Although the applicant stated that truck traffic areas and haul roads going in and out of the plant site will be paved to minimize and control particular emissions, it is unclear how the unpaved roads on the site will be maintained to reduce particulate emissions from truck traffic. Additionally, the A.11(2)(b) monitoring requirements state:

> The permittee shall monitor their frequency, quantity and locations of the water application under "controlled measures," such as sweeping.

The modeling is incomplete and unreliable because the applicant failed to quantify and model estimate emissions from vehicle miles traveled from water trucks or sweepers, or from the operations of control measures and other vehicle traffic on the proposed site.

D. The PM_{10} and $PM_{2.5}$ Models Were Not Updated to Account for Revisions to Haul Road Emissions Listed in Table 2-E.

A comparison of the universal air quality permit application ("UA"), Section 16 (Version 8/10/21) (posted 11/18/21) in Section 16 of the UA dated June 14, 2021, did not reveal any differences in the presented modeling results and source characterization parameters. Additionally, the maximum concentrations found by the modeling are unreliable because the elevations are often listed in meters instead of feet and are incorrect. For instance, a number of pollutant-averaging period results presented maximum concentrations at elevations significantly below ground level.

E. The NMED Has Never Approved Use of "Non-Default" Modeling Options in AERMET.

The applicant submitted a modeling protocol to NMED on April 18, 2021, but no approval was received as required in Section 1 of subsection 16-B of the revised application UA4. Consequently, the use of "non-default" modeling options in AERMET, particle densities and/or the use of meteorological data, was ever approved by the reviewing agency.

F. The Applicant Has Not Justified the Selection and Use of Particle Density Parameters.

In Section 16-M (page 7 of 17), the applicant failed to provide a justification for the selection of particle density parameters used in the modeling.

II. Breanna Bernal

Breanna Bernal is an air quality specialist with significant experience in conducting air quality permitting, compliance, and reporting required by state, federal and local air quality rules and regulations. Ms. Bernal is currently employed by SWCA Environmental Consultants as an air quality specialist and provides permitting and compliance services to electric generation, industrial and oil and gas sectors. Ms. Bernal's SWCA office is located at 2201 Brookhollow Plaza Drive, Suite 400, Arlington, Texas 76006. Ms. Bernal received a Bachelor of Science in Environmental Geoscience from Texas A&M University in 2017. She has been involved in numerous PSD/NSR permitting activities and Title V permitting. Significantly, Ms. Bernal served as one of the primary air quality consultants for multiple concrete batch plant projects across Texas for a three-year period, on behalf of Potter Redi-Mix, LLC. In this capacity, she prepared documentation and calculations for standard permits, alterations, and relocations for the concrete batch plants. Ms. Bernal's direct testimony is anticipated to be one and one-half hours.

The following exhibits are submitted in connection with Ms. Bernal's testimony:

1. Curriculum vitae of Ms. Bernal, attached.

2. Selected parts of the Roper air quality permit application, including Section 1-E, Table 1 in Section 16-K, and Section 1-E, part of Record Proper.

3. Version 19191 of AERMOD.

4. Version 21112 of AERMOD.

5. NMED Plume Depletion Parameters, attached.

6. Current Tier One BACT Requirements, attached.

7. Sections of EPA AP-42, attached.

Summary of Opinions

A. The Applicant Did Not Accurately Represent the Modeling Options They Used.

The applicant should have checked "No" in Section 16-F of the application because the latest version of AERMOD (21112) was not used. Instead, AERMOD 19191 was used, with flat terrain options for modeling, which is not the regulatory default option for terrain. Accordingly, the modeling using the flat terrain options in an old version of AERMOD is not reliable.

B. The Applicant Used the Incorrect Version of AERMOD.

Version 19191 of AERMOD was used to complete the modeling iterations. A new version of AERMOD (Version 21112, April 22, 2021) is currently available. The applicant failed to use the most recent version of AERMOD in the November 2021 submission and the modeling is therefore unreliable.

C. The Applicant Did Not Represent the Operating Schedule Consistently Throughout the Application.

The maximum operating hours per year in Section 1-E (4,509 hours total) does not match Table 1 in Section 16-K (5,422 hours total if operated 7 days a week, 52 weeks a year). Additionally, the facility's maximum daily operating schedule in Section 1-E represents a start time of 3:00 a.m. – 9:00 p.m., which does not represent any of the schedules in Table C of Section 16-K.

D. The Application is Incomplete Because the Applicant Did Not Check the Box Indicating Emissions Due to Routine Predictable Start-Up, Shut-Down or Scheduled Maintenance Are No Higher Than Those Listed on Table 2-E.

A malfunction emission limit is not permitted or prepared for submission. The Table was also left blank and does not provide any clarification on this issue.

E. The Weighted Average Moisture Content for Sand and Gravel is Stated to be 2.65%.

It is unclear where the values 213.75 and 123.75, found on pp. 2 and 8 in Section 6, used for the calculation of the weighted average moisture content for sand and gravel originate as they do not match the values stated in the Table. If the values are incorrect, the calculations on pp. 3, 4 and 9 in Section 6 would also be incorrect.

F. The Application Improperly Used Hourly Emission Factors Instead of Annual Emission Factors.

On p. 6 of Section 6, the applicant used hourly emission factors instead of using annual emission factors in Table 6-1. No justification for the use of these values was presented by the applicant.

G. The Maximum Haul Truck Emissions are not Supported.

Section 6, p. 7 of the application states that haul truck emissions decreased between November 2021 and the June 2021 submittals as a result of the vehicle miles traveled being decreased by one-half. No justification for this change was presented by the applicant.

H. The Application Did Not Justify the Use of Average Particle Densities.

Although the average particle densities were obtained from NMED accepted values, no justification was provided for this selection.

I. The Application Did Not Justify the Use for the Density Value of Cement.

The cement density value listed in the application does not match the NMED density values for cement (listed as either 2.85 g/cm3 or 3.12 g/cm3 for pure cement). In Section 16-M, it appears the applicant is using the density for lime silos (3.3 g/cm3) in place of cement. If the applicant were to use one of the NMED values for cement, it would have an effect on the dispersion of particles because particles with smaller densities generally travel further distances. Accordingly, the modeling values would change if the applicant used the NMED values listed for cement.

J. The Application Did Not Justify the Density Value Used for Fugitive Dust on Roads

The applicant identified the NMED density value for fugitive dust of paved roads (2.5 g/cm3 in Table 4, Section 16-M), when reporting the parameters are for unpaved road vehicle fugitive dust emissions.

K. The Application Failed to Include All Emission Sources.

The applicant failed to list Units 13 and 14 as emission sources in question 1, Section 16-O of the application and also failed to answer question 3.

L. The Application Incorrectly States the Type of Modeling Used.

The applicant answered "yes" to question number 1 in Section 16-T, which states that complex terrain modeling was used. This answer, however, is incorrect and conflicts with the application which states that the air dispersion model runs in non-default mode using flat terrain. *See* Section 16-F, question no. 1 in Section 2.1 of the dispersion model protocol.

M. The Particulate Matter Models are Out of Date.

The PM_{10} and $PM_{2.5}$ models were not updated to account for the revisions to haul road emissions listed in Table 2-E, Requested Allowable Emissions (posted November 18, 2021). This also results in the model being unreliable.

III. Eluid L. Martinez

Eluid L. Martinez is presently the owner of Water Resources Management Consultants, LLC, located at 1795 Paseo de Vista, Santa Fe, NM, 87501, which provides consulting services regarding water rights administration, water resources management and water use issues in the State of New Mexico. Mr. Martinez is an expert qualified by knowledge, skill, experience, training and education to provide opinions regarding water use issues and the administration and regulation of water rights in New Mexico.

Mr. Martinez holds a B.S. in civil engineering from New Mexico State University (1968). He is a registered Professional Engineer and Surveyor (No. 5124) in the State of New Mexico and was employed by the Office of the New Mexico State Engineer in various capacities from 1971 through 1994. In December 1990, Mr. Martinez was appointed New Mexico State Engineer by the Governor of New Mexico and was subsequently confirmed by the New Mexico State Senate. Mr. Martinez served in that position through 1994. During the summer of 1995, Mr. Martinez was nominated by President Clinton to be Commissioner of the United States Bureau of Reclamation of the U.S. Department of the Interior and was confirmed as Commissioner by the United States Senate in December of 1995. As Commissioner, Mr. Martinez oversaw the water resource management issues related to U.S. Bureau of Reclamation projects across the American west. Mr. Martinez served in that capacity until 2001. Mr. Martinez's testimony is anticipated to be thirty (30) minutes.

The following exhibits are submitted in connection with Mr. Martinez's testimony:

1. Curriculum vitae of Eluid L. Martinez, attached.

2. Ryan Roper and Roper Investments, Inc's Application for Permit to Use Underground Waters H-4700, attached.

3. Tables 2-A, 2-B, 2-C, 2-D, 2-E, 2-L, 2-M, Section 6, pp. 1 and 7, part of Record Proper.

Summary of Opinions

A. The Application is Incomplete Because of the Lack of Identification of the Source of Water That Constitutes the Majority of the Emissions Control Equipment.

The majority of the "Emissions Control Equipment" identified on Table 2-C is "Additional Moisture Content." However, Table 2-C does not identify the amount of water that comprises the "Additional Moisture Content" emission control equipment to control fugitive dust emissions from Unit 3, the Feed Hopper Conveyor, Unit 4, the Aggregate Bins, Unit 5, the Aggregate Weight Batcher, and Unit 6, the Aggregate Delivery Conveyor. Without a known supply and source of water, the ability of the applicant to control emissions at Units 3, 4, 5 and 6 renders the conclusions for emission controls unreliable and ineffective.

B. Trucking Water from an Off-Site Location is the Only Viable Option Based on the Information Supplied in the Application.

Based on my review of the application and my experience with water rights administration, the only potential sources of water that could be provided to the proposed concrete batch plant are: (1) an existing source on the property; (2) the delivery of water via pipeline; and (3) trucking water to the facility from an off-site location. The applicant applied for and received a permit on May 7, 2021 to drill a livestock watering well and to divert up to 3.0 ac-ft/yr. However, the permitted use of water for this well does not extend to diverting water from this source for the operation of a concrete batch plant, the water necessary for effective emissions control. An application seeking a permit for new appropriation of groundwater for the industrial uses at the facility would be rejected because the site of the proposed well would be located within the Hondo Underground Water Basin, which is now closed to new appropriations. The applicant could file an application to transfer water rights, but such a process is costly and takes a considerable amount of time before a final determination is made regarding whether the application will be granted or denied. A pipeline is impractical given the easement issues concomitant with constructing a pipeline crossing private and public lands. Accordingly, trucking water is the only viable option to provide water to the facility in the near future.

C. The Amount of Water Necessary for Operation of the Facility Will Cause Significantly Increased Truck Traffic and Emissions.

Table 2-M of the applications asserts that 3,900 gallons of water is required to produce 125 cubic yards of concrete. Therefore, 31.2 gallons of water is required to produce one (1) cubic yard of concrete. The application shows a maximum proposed output of 500,000 cubic yards per year, which would require 15,600,000 gallons, which is equal to 47.87 ac-ft/yr. That results in a 42,739 daily gallon requirement for the production of the concrete. This will require multiple truckloads of water just for the operation of the facility. This amount of water does not include the water necessary and which would be consumed for emissions control as identified in A.

D. Daily Delivery of Multiple of Water by Multiple Trucks is the Only Viable Option for Operation of the Facility Because the Applicant Has not Identified Any Water Storage Tanks.

The applicant has not identified the existence of water storage tanks at the facility. Accordingly, the water necessary for the operation of the facility and for emissions control must be delivered on a daily basis.

E. <u>The Application is Incomplete Because Water Trucks are Not Included in the Requested Permitted Capacity.</u>

In identifying the requested permitted capacity for a Regulated Emissions Source, the applicant failed to include water trucks as emission sources from Unit Number 1, the Haul Road. To the extent that the applicant will truck water to the concrete batch plant location for operational uses and emission control uses, the application is incomplete and unreliable because the requested permitted capacity of 20.3 trucks/hour does not include the trucks necessary to accomplish delivery of the water required for operation of the concrete batch plant and for the emission control measures identified by the applicant.

F. <u>The Application is Incomplete Because Calculations for Haul Road Fugitives Relating to Water Trucks Delivering Material to the Facility Were not Provided in Tables 2-A, 2-D and 2-E.</u>

Section 6, p. 1 of the application notes that calculations for haul road fugitives must be included in Tables 2-A, 2-D, and 2-E. As a material within the meaning of the application, water delivered to the proposed facility more frequently than one round trip per day must be included in the haul road fugitives calculation set forth in these tables. The omission of these calculation renders the application incomplete and unreliable.

G. <u>The Application is Incomplete Because it Does Not Identify the Amount of Water for the "Additional Moisture Content" Required to Obtain the Emissions Controls Necessary to Control Emissions at Units 3, 4, 5 and 6.</u>

Without an identification of the amount of water that will be consumed to effectuate the emission controls for these four (4) units, there is no way to determine the additional emissions caused by water trucks to the extent that water trucks are required to deliver water to the concrete batch plant location to achieve the emission controls identified in the application.

IV. David Paul Edler

David Paul Edler has twenty years of hands-on experience in the concrete industry. Mr. Edler's address is 160 Pronghorn Lane, Alto, NM, 88312. For a majority of his twenty years working in the concrete industry, Mr. Edler drove concrete mixer trucks for the ready-mix concrete operation of the Kienstra Concrete Inc. plant in Illinois. Kienstra is a company that owns and operates six concrete plants in Missouri and Illinois. Mr. Edler also has experience as a front-end loader operator at the Kienstra facilities as well as trucking materials for the Kienstra facilities. Based on his twenty-year experience working in and around concrete plants, Mr. Elder is familiar with the on-the-ground realities of what the operation of a concrete plant entails and is familiar with all of the equipment utilized at a concrete batch plant. Mr. Edler is an expert qualified by knowledge, skill, experience, and training to provide opinions regarding the reality of concrete batch plant operations. Mr. Edler's direct testimony is anticipated to be one hour.

The following exhibits are submitted in connection with Mr. Edler's Testimony:

1. NSR Minor Source Permit Application for Roper Construction, Inc. Alto CBP, including all revisions and modifications made by the applicant.

2. Table 2-C, Section 4, p. 1; Section 5; Section 6, pp. 2 and 8; Section 7 (13.2.4-1); Section 10; Section 14, part of Record Proper.

Summary of Opinions

A. <u>A 99.9% Efficiency Control of Emissions Using a Baghouse is Unrealistic.</u>

Table 2-C identifies three baghouse products as the emissions control equipment for Unit 7, the Truck Loading Area, Unit 9, the Cement Split Silo, and Unit 10, the Fly Ash Split Silo. As a practical matter, baghouse products do control virtually all emissions from these pieces of equipment. In fact, that fugitive dust emissions occur with regularity at these pieces of equipment

is evident from the appearance of virtually every concrete batch plant silo, which are invariably visibly streaked with fugitive dust residue. In Mr. Edler's experience, fugitive dust emissions occur in the following ways: (1) the air inside a baghouse is pressurized, forcing dust through any faulty seals and/or metal hinges; (2) the doors to the baghouse are opened regularly at least a couple of times per week to clean the filters located inside the baghouse, allowing dust to escape; and (3) the filters are replaced on a regular basis, at least twice a month and probably more often, and the baghouse doors are left open for an extended period of time during this process. A 99.9% efficiency control rate for baghouse control equipment is not realistic during the day-to-day operation of a concrete batch plant.

B. The Use of a Default Windspeed of NMED Default Windspeed of 11 MPH and 8.3 MPH Does Not Comport With the Actual Wind Conditions at the Facility Site.

Section 6, page 2 of the application notes that the applicant used the NMED default windspeed of 11 mph and 8.3 mph for the windspeed in Ruidoso based on data collected between 1996-2006 for its calculations. Based on Mr. Edler's experience living in this area, these windspeed values do not represent the reality of the wind conditions at the concrete batch plant site, where high sustained wind periods of 30-40 mph and wind gusts of 60-70 mph are not uncommon. Based on his experience working on concrete batch plant sites, high winds such as these will substantially increase the dust emissions identified by Mr. Edler.

C. The Applicant's Failure to Implement Emission Controls for the Aggregate Handling and Storage Piles Will Cause Significant Fugitive Dust Emissions.

Section 6, page 8 of the application reveals that the applicant is not going to implement any emissions control equipment or methodology to control fugitive dust emission from aggregate handling and storage piles. Apparently, this is based on the assumption in the application that the aggregate and sand piles have a weighted average moisture content of 2.65 %. In my experience, relying on the moisture content to control fugitive dust emissions is appropriate in areas where the relative humidity is higher and the average rainfall is more substantial than southern New Mexico. Even spraying the piles with water would not be sufficient to control dust emissions from the aggregate and sand piles. As noted in Section 7, 13.2.4-1, the "movement of trucks and loading equipment in the storage pile area is a substantial source of dust." In my experience, a significant amount of dust is emitted each time a loader digs into a storage pile and then moves material to feeder hopper.

D. The Claim in the Application that Fugitive Dust Can Be Controlled by Central Dust Control System is Unrealistic.

In Section 10, the applicant claims that fugitive dust created while loading the concrete trucks at the truck loading area will be controlled by "the central dust control system" and the dust "collected will be recycled back to the cement silo." While such a system is not clearly identified in the application, it appears the applicant is referring to the baghouses located at the truck loading area. There is certainly no identification of a closed system capable of collecting dust and returning the dust to the silo automatically. The reality of concrete batch plant operations is that the loading of concrete-mixer trucks is a significant source of fugitive dust emissions. Based on the pressurization of the air and the lack of a perfect seal between the loader chute and the mixer truck, the dust emissions during the loading of the trucks are substantial and are exacerbated during windy periods.

E. For the Operational Plan to Mitigate Emissions, the Application Incorrectly Identifies Asphalt Production Instead of Concrete Production.

Section 14 of the application incorrectly states that asphalt production will cease when equipment malfunctions. Asphalt production is an entirely different production process that includes petroleum products. In Mr. Edler's experience, it is not uncommon for owners/operators of concrete batch plants to incorporate asphalt production into their operations based on certain similarities of production. However, the applicant has not disclosed an intention of producing asphalt and such production should not be allowed under this application.

F. The Application is Incomplete Because it Does Not Identify the Emissions From the Cleaning Operations that are Necessary at a Concrete Batch Plant.

The Application fails to identify a wash out pit in the description of operations that constitute a potential source of emissions. A wash out pit is an essential area for the operation of concrete batch plant. At the end of each day, the mixer trucks must be washed out with water and possibly solvents of some sort. Typically, approximately 150 gallons of water is used to clean out the mixer trucks. The water mixture used to wash out the mixer trucks is dumped into a wash out pit. Dust from the tank that is washed out turns into cement dust once it dries and is a source of fugitive dust emissions.

Respectfully submitted,

HINKLE SHANOR LLP

/s/ Thomas M. Hnasko

Thomas M. Hnasko
Julie A. Sakura
218 Montezuma Ave
P.O. Box 2068
Santa Fe, NM 87504-2068
(505) 982-4554
thnasko@hinklelawfirm.com
jsakura@hinklelawfirm.com

Attorneys for Ranches of Sonterra Property Owners Association and Don R. and Kathleen Weems

CERTIFICATE OF SERVICE

I hereby certify that on January 19, 2022, I caused a true and correct copy of the foregoing pleading to be electronically served on the following:

Louis W. Rose
Kristen Burby
lrose@montand.com
kburby@montand.com

Counsel for Roper Construction, Inc.

Christopher J. Vigil
christopherj.vigil@state.nm.us

Attorney for New Mexico Environment Department Air Quality Bureau

/s/ Thomas M. Hnasko
Thomas M. Hnasko

TESTIMONY OF

CARLOS ITUARTE-VILLARREAL, PH. D.

EXHIBITS

CARLOS ITUARTE VILLARREAL, PH.D., AIR QUALITY AND MODELING SPECIALIST

Mr. Ituarte-Villarreal is an environmental specialist with significant experience in the areas of atmospheric dispersion modeling, fate and transport, emissions inventory, air quality permitting, and environmental compliance and engineering. Mr. Ituarte-Villarreal is an engineer with knowledge in electric generation in both renewable and tradition energy sectors, specialized in wind farm siting and sizing. Carlos holds a PhD in Environmental Science and Engineering and a MS in Industrial Engineering and has more than 10 years of experience in electric utility environmental and regulatory compliance.

YEARS OF EXPERIENCE

10

EXPERTISE

Engineering and Modeling

Emissions Inventory

Noise Impact Assessment

Wind Turbine Siting

Environmental Permitting

Environmental Impact Assessment

EDUCATION

Ph.D., Environmental Science & Engineering, Energy Science & Engineering; The University of Texas at El Paso; El Paso, Texas; 2015

M.S., Industrial Engineering; The University of Texas at El Paso; El Paso, Texas; 2010

B.S., Industrial Engineering; Instituto Tecnologico de Parral; Mexico; 2008

TRAININGS

Lean Manufacturing, TMAC

AERMOD Air Dispersion Modeling, Lakes Environmental

MEMBERSHIPS

Institute of Industrial Engineers (IIE)

American Wind Energy Association (AWEA)

Alpha Pi Mu honor society for Industrial and Systems Engineering

AWARDS

UTEP M.S.I.E. - Outstanding Student Award

LENGUAGES

Spanish– native language

English–high proficiency

RELATED WORK EXPERIENCE

SWCA Environmental Consultants (Aug 2013 – Present)
Air Quality and Modeling Specialist/Engineer
Provide permitting, modeling, engineering and compliance services to electric generation, industrial and oil & gas sectors.

El Paso Electric Company (Jan 2012 – August 2013)
Air Quality Engineer - Intern
Minimized regulatory compliance risk by analyzing, validating, and reporting CEMS emissions data. Maintained, developed, and improved environmental compliance tools, monitoring, sampling, and testing programs to demonstrate compliance with regulatory and permit limits.

EPA-UTEP Border Air Quality Internship Program (Jan 2012 – Dec 2012)
Intern
One year internship and education program to improve community air quality and public health and promote environmental justice.

The University of Texas at El Paso (May 2011 – Aug 2013)
Teaching Assistant
Collaborated on curriculum and exam development, met with students upon request, and graded all written work, including final exam papers.

The University of Texas at El Paso (Jan 2011 – May 2011)
Research Associate
Developed bio-inspired evolutionary algorithms for solving the renewable power integration problem.

The University of Texas at El Paso (Jun 2009 – Dec 2010)
Research Assistant
Conducted literature reviews, collection and analysis of data, preparation of materials for submission to granting agencies.

TEACHING EXPERIENCE

The University of Texas at El Paso (May 2011 – Aug 2013)
Teaching Assistant – to Professor Jose Espiritu
Production and Inventory Control
Reliability and Maintainability
Statistical Quality Control

PUBLICATIONS

Ph.D. Dissertation

Ituarte-Villarreal, Carlos M, "Wind farm optimization using evolutionary algorithms" (2015). ETD Collection for University of Texas, El Paso. AAI10000762.

Selected Publications

Espiritu, Jose F. and Carlos M. Ituarte-Villarreal. "Wind Farm Layout Optimization Using a Viral Systems Algorithm." IJAEC vol.4, no.4 (2013), pp.27-40.

Lopez, Nicolas and Carlos M. Ituarte-Villarreal. "Evolutionary Agent Based Microstorage Management for a Hybrid Power System." Complex Adaptive Systems (2012), pp. 350-355

Ituarte-Villarreal, Carlos M et al. "A viral system optimization algorithm to solve the wind farm layout problem considering reliability." IIE Annual Conference. Proceedings, 2012.

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Carlos M. Ituarte-Villarreal, Nicolas Lopez, Heidi A. Taboada and Jose F. Espiritu. (2013). Wind Farm Layout Optimization Considering Multiple-Objectives. Industrial Engineering Research Conference. San Juan, Puerto Rico. May 18-22, 2013.

Nicolas Lopez, Carlos M. Ituarte-Villarreal and Jose F. Espiritu. Evolutionary Agent Based Microstorage Management for a Hybrid Power System. Complex Adaptive Systems Conference. Washington D.C. November 14-16, 2012

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Carlos Ituarte-Villarreal, Nicolas Lopez and Jose F. Espiritu. Hybrid Power Systems Optimization using the Monkey Algorithm. Annual Industrial Engineering Research Conference and Expo. Orlando, Florida. May 19-23, 2012.

Carlos Ituarte-Villarreal, Claudia S. Valles and Jose F. Espiritu. Optimal Sitting of Wind Turbines Using Viral Systems Algorithm. In Proceedings of the 2nd Southwest Energy Science and Engineering Symposium. El Paso, TX. March 24, 2012.

Carlos M. Ituarte-Villarreal and Jose F. Espiritu. Optimization of wind turbine placement using a viral based optimization algorithm. In Proceedings of the Complex Adaptive Systems Conference. Chicago, Illinois. October 31- November 2, 2011

Carlos M. Ituarte-Villarreal and Jose F. Espiritu. A Decision Support System for the Level of Repair Analysis Problem. In Proceedings of the 41st International Conference on Computers & Industrial Engineering (CIE 41). Los Angeles, California. October 23-26, 2011

Carlos M. Ituarte-Villarreal and Jose F. Espiritu. Wind turbine placement in a wind farm using a viral based optimization algorithm. In Proceedings of the 41st International Conference on Computers & Industrial Engineering (CIE 41). Los Angeles, California. October 23-26, 2011

Carlos Ituarte-Villarreal and Jose F. Espiritu. A Solution Method for the Constrained Level of Repair Analysis Problem. Institute for Operations Research and Management Science Conference, Austin, Texas. November 2010

Carlos Ituarte-Villarreal, Jose F. Espiritu, Heidi A. Taboada & Oswaldo Aguirre. Level of Repair Analysis Modeling Using Genetic Algorithms. Institute for Operations Research and Management Science Conference, San Diego, California. October 2009.

RELATED PROJECT EXPERIENCE

Air Quality Services; El Paso, El Paso County, Texas. SWCA provided in-house Air Quality compliance services for four power generation facilities in El Paso County, Texas and Dona Ana County, New Mexico. *Role: Environmental Specialist. Provided specific services as they relate to the day-to-day monitoring, record keeping and reporting. Prepared State emissions inventories and GHG emissions inventories for CY2012, CY2013, CY2014 and CY2015. Provided additional support for permit compliance matters and the review and analysis of permit conditions.*

Mitchell County Power Facility Environmental Permitting; Mitchell County, Texas. SWCA conducted natural and cultural resource surveys of approximately 300 acres in Mitchell County, Texas, for compliance in preparation for a proposed power plant facility. *Role: Environmental Specialist. Assisted with screening level modeling and later with the preparation of an updated Air Quality Analysis to demonstrate compliance with all applicable ambient air quality standards.*

Air Quality Permitting; Cherokee County, Texas. SWCA provide air permitting services for a number of projects in Cherokee County, Texas including the preparation of a PSD permit application for a combined-cycle electric generating station. *Role: Air Quality and Modeling Specialist. Lead the preparation of an air dispersion modeling analysis and modeling result analysis in support of the PSD permit application to demonstrate compliance with applicable state and federal standards.*

Air Permitting Assistance; El Paso, El Paso County, Texas. SWCA prepared an application to obtain a Texas Commission of Environmental Quality Air Quality Standard Permit for pollution control projects in El Paso County, Texas. *Role: Air Quality Specialist. Responsible for writing the methodology section for the duct burner replacement application calculations. Performed a detailed emissions calculation for the existing and replacement duct burner system.*

Williamson County Power Project-Environmental Permitting; Williamson County, Texas. SWCA prepared a PSD permit for a new natural gas-fired power plant. *Role: Air Quality and Modeling Specialist. Assisted with the preparation of Emission calculations and report documentation. Provided modeling services for an initial screening simulation of a set of operating scenarios, and the subsequent refined model to consider terrain elevations and meteorological data.*

Environmental Planning and Compliance Service; Multiple Counties, CA. SWCA provided planning and permitting support for a dynamic reactive power support facility and associated 230-kilovolt (kV) transmission line near Alpine, CA. Services included routing and siting support; alternatives analysis; cultural, biological, and paleontological surveys; preparation of a Proponent's Environmental Assessment (PEA); and discretionary environmental permitting support. *Role: Environmental Specialist. Served as a noise and air quality analysist preparing the noise and air quality impact analysis sections using sophisticated sound and air dispersion modeling techniques along with software-based modeling programs.*

Sand Plant Expansion Air Permitting; Winkler County, Texas. SWCA prepared a TCEQ new source review permit amendment application to authorize a significant expansion to a sand washing, drying, sizing, and storage facility in Winkler County, Texas. The project included air dispersion modeling for five criteria pollutants and one toxic air pollutant. SWCA prepared a complete set of emission calculations that included over 100 emission points. *Role: Air Quality and Modeling Specialist. Assisted in the preparation of an air dispersion modeling analysis in support of the permit amendment application.*

Pipeline Expansion Project Environmental Services; Cochise County, Arizona. SWCA prepared an Air Quality and Noise Resource Report (Resource Report 9) addressing the air quality and noise resources associated with this proposed Expansion Project. *Role: Environmental Specialist. Responsible for the preparation of the baseline noise analysis and of the noise impact assessment modeling. Provided assistance in the preparation of an air dispersion impact analysis in order to demonstrate that this project will not cause an exceedance of the any National Ambient Air Quality Standards.*

Model Change Bulletin (MCB) 15
AERMOD version 21112 (April 22, 2021)

Changes are listed by type and with each change are the affected pollutants and source types:

Bug Fixes

Item	Modification	Pollutants	Source Types
1	Added capability to use flagpole receptor heights to buoyant line sources.	All	BUOYLINE
2	Updated subroutine DEBOPT to add a default debug filename, DEPOS.DBG that contains wet deposition information when deposition debug requested and model debug is not requested.	All	All
3	Updated subroutine METEXT to recognize MMIF data processed through AERMET as valid. Previously MMIF processed through AERMET was seen by AERMOD as possibly from an outdated version of AERMET.	All	All
4	Added error message when using ppb or ppm for background units unless pollutant is NO2, SO2, or CO. Other pollutants are assumed to be ug/m3 and do not have conversion factors built in.	All	All
5	Updated PFLCNV to remove duplicate sigma-v calculations when checking to see if adjust u* has been applied. Sigma-v is initially calculated from sigma-theta if wind speed is not missing. Duplicate code calculated sigma-v from sigma-theta even if wind speed was missing. This fix only affects meteorological data with site-specific turbulence measurements. Applications involving NWS data only are not affected.	All	All
6	Added check to determine if lines in a buoyant line group are parallel; differences in excess of 5 degrees generates a warning message and AERMOD will continue the model run.	All	BUOYLINE
7	Corrected BL_CALC to not reset key met parameters to rural values when no urban sources.	All	BUOYLINE
8	Updated RLINE.F to add local QEMIS for calculation of emissions when using EMISFACT keyword for time-varying emission factors with RLINE sources.	All	RLINE
9	Updated HRLOOP to set AO3CONC to missing when reading missing values from the hourly ozone data file so that MAXDCONT results will match base AERMOD run.	NO_2	All

10	Initialize logical variable AWMADWDBG to FALSE to avoid writing downwash debug output even when building downwash not being calculated.	All	POINT, POINTHOR, POINTCAP
11	Updated AWMA_DOWNWASH subroutine in COSET.F to change error message for AWMAUTURB and STREAMLINE to be 126 to avoid conflict with intended purpose of error message 125. Error message 125 is for situations where keyword FINISHED is not found. Updated modules.f to include error message 126 and error message 125.	All	All
12	Updated the SUMBACK_NO2 and EV_SUMBACK modules to properly convert background concentrations when the BACKUNIT keyword is used to convert output units.	NO2	All
13	Removed fatal error which would occur if processing INCLUDED files with RLINE or RLINEXT LOCATION inputs.	All	RLINE & RLINEXT

Enhancements

Item	Modification	Pollutants	Source Types
1	Added check to determine if lines in a buoyant line group are parallel; differences in excess of 5 degrees generates a warning message and AERMOD will continue the model run.	All	BUOYLINE
2	Added capability to process multiple buoyant line groups.	All	BUOYLINE
3	The warning message that has been associated with code 305 - 'Stack height > or = EPA formula height for SRCID: ' has been removed and AERMOD will no longer issue this message. This warning was added in version 11059 when the WAKEFLG setting based on the wind direction specific GEP calculation was disabled. The warning was originally added at the time to inform users that downwash would be applied even though stack height was above the direction specific GEP for the hour, calculated using the direction specific building dimension for the current hour the model is processing. The message has caused confusion implying that the stack height is > or = to the non-direction specific formula GEP height based on the building height and maximum projected building width.	All	POINT, POINTHOR, POINTCAP

4	Updated SOSET to allow users to enter a 0 for gas deposition parameters to use a default value for that parameter. Also updated SOSET to allow users to enter a 0 for fine mass fraction and/or mean particle diameter for certain pollutants.	AS, CD, PB, HG, HG0, HGII, POC, TCDD, BAP, POC, NO2, SO2	All
5	Add new keywords in ME pathway to set non-missing σ_θ or σ_w in profile file to missing for all hours, stable hours only, or convective hours only. Options are also available to set each one missing independently of the other.	All	All
6	Made changes to code to improve speed without affecting result (e.g., using integer exponent when possible).	All	RLINE and RLINEXT
7	Added PROG to metext.f and meset.f to include PROG as viable source of met in addition to MMIF. This is to accommodate the update to AERMET with a PROG pathway. The update ensures capability with previous versions of AERMET and future AERMET updates. This only affects cases with prognostic data.	All	All

Formulation updates – Regulatory

None

Formulation updates – BETA

None

Formulation updates – ALPHA

Item	Modification	Pollutants	Source Types
1	A 2-barrier algorithms (i.e., barriers on both sides of a roadway) was added for the RLINEXT source type. The input SO RBARRIER pathway now includes an option for a second barrier.	All	RLINEXT
2	The existing 1-barrier algorithms were updated for the RLINEXT source type based on Ahangar et al. 2017 and Venkatram et al. 2021.	All	RLINEXT

3	Added two new ALPHA options (AWMAENTRAIN and AWMAUTURBHX) that affect that affect the PRIME downwash algorithm. AWMAENTRAIN changes the beta entrainment coefficient for PRIME downwash referred to in the code as, beta0 and betap, from 0.60 to 0.35 in PRIME.f. AWMAUTURBHX enables enhanced calculation of tiz, tiy using subroutine wake_u_turb; it is also used to get a new value of velocity deficit like AWMAUTURB. With this option all enhanced calculations use the PRIME plume rise at each x value.	All	POINT, POINTHOR, POINTCAP
4	Add two new ALPHA low wind options (SWMIN and BIGT) which allow the user to override AERMOD's default values of minimum sigma-w and the time period used to calculate the time scale TRAN, respectively. AERMOD's default value for SWMIN is 0.02 m/s. With the SWMIN option, the user can specify a value within a range of 0.0 m/s to 3.0 m/s. AERMOD's default value for BIGT is 24.0 hours. With the BIGT option, the user can specify a value within a range of 0.5 hours to 48.0 hours.	All	All
5	Added the Generic Reaction Set Method (GRSM) for computing NO to NO2 conversion based on equilibrium chemistry between NO, NO2, and the reaction with ozone. Method requires ozone background through the OZONEVAL, O3VALUES, or OZONEFIL keyword and NOx background through new NOXVALUE, NOX_VALS, or NOX_FILE keyword.	NO2	POINT, VOLUME, and AREA
6	Added the Travel Time Reaction Method (TTRM) for computing NO to NO2 conversion based on the reaction with ozone and limitations of the travel time between the source and receptor. Method requires ozone background through the OZONEVAL, O3VALUES, or OZONEFIL keyword.	NO2	POINT, VOLUME, and AREA

Model Change Bulletin (MCB) 10
AERMET version 21112 (April 22, 2021), listed by change type

Listed with each change are the affected AERMET stages and data types (Upper air, National Weather Service (NWS), ONSITE, or MMIF[1].

Bug Fixes

Item	Modification	Stage	Data Type
1	Updated mod_AsosCommDates to correct anemometer height for Willimantic Airport from 1.21 to 7.92 m	All	SURFACE
2	Reset convective mixing height to missing if convective mixing height is zero in subroutine CBLHT. Change does not affect AERMOD results as other convective parameters are already missing	3	All
3	Update subroutine OSHRAV to average heights when sub-hourly site-specific data is read	1	ONSITE (sub-hourly)
4	Update format statement for writing missing variables at a level in subroutine UAQASM. Update is to allow 3 digits for the level instead of 2. The change does not affect data output, only reporting of data.	1	UPPERAIR
5	Update MPPBL to initialize the input albedo for subroutine NR_ANG when processing site-specific data when temperature available but no cloud cover or no temperature and no cloud cover.	3	ONSITE
6	Update subroutine RDISHD to not reset missing wind direction to 9990 from 999 in order for AERMET to not replace a valid observation with a missing observation.	1	SURFACE (ISHD only)
7	Update subroutine RDISHD to read the USAF ID in as character instead of integer to accommodate newer stations with non-numeric USAF IDs.	1	SURFACE (ISHD only)
8	Update subroutine RDISHD to check the date as well as the hour for potential duplicate observations to avoid losing an hour on a day when the next observation in the ISHD file is the same hour but a different day.	1	SURFACE (ISHD only)

[1] Unless stated otherwise, changes that affect ONSITE data also affect MMIF output data that is input to AERMET as ONSITE data.

9	Update subroutine OSQACK to only write out 2-digit years to avoid a format overflow when the site-specific data has 4-digit years. This change does not affect data output, only reporting the date to the screen.	1	ONSITE
10	Updated mod_AsosCommDates to correct WBAN numbers for Harriman (54768) and Ann Arbor (94889). Corrected coordinates for Harriman to 42.7 N, 73.17 W. Corrected coordinates for Ann Arbor to 42.22 N, 83.74 W	1	SURFACE
11	Updated mod_AsosCommDates to correct WBAN number for Francisco/Saipan International Airport to 41418.	1	SURFACE
12	Updated mod_AsosCommDates to correct latitude for Challis Airport to 44.52. Corrected longitude for Willow Run to 83.53 W. Corrected longitude for Oneida County Airport to 75.38 W.	1	SURFACE
13	Update MPPBL to only calculate mechanical mixing heights if ONSITE mixing heights are not provided.	3	ONSITE
14	Update SUBST to calculate station pressure from onsite elevation (if available) from standard atmosphere using SURFACE temperature, if available and ONSITE temperature is not available for the hour. This change makes the code consistent with the AERMET User's Guide, Section 5.6, bullet 2(h), page 5-13.	3	ONSITE
15	Updated SUMHF.FOR to check for missing heat flux values when checking for negative heat flux values throughout the day to determine the last convective hour of the day for heat flux integration to calculate convective mixing heights. Previously, AERMET did not check for missing values so a positive heat flux followed by two missing values early in the convective portion of the day could result in a short convective day.	3	SURFACE, ONSITE
16	Updated SUMHF.FOR to only interpolate missing heat flux values for convective hours if the hour is already determined to be convective based on solar angle in MPPBL.FOR. Previously, AERMET interpolated for any missing hour that was next to a convective hour, even if the interpolated hour was stable.	3	SURFACE, ONSITE

17	Updated MPPBL and SMTHZI to check that the previous hour is also the same day as the current hour when smoothing the mechanical mixing height	3	SURFACE, ONSITE

118. U.S. Environmental Protection Agency, 1984. Calms Processor (CALMPRO) User's Guide. Publication No. EPA–901/9–84–001. Office of Air Quality Planning and Standards, Region I, Boston, MA. (NTIS No. PB 84–229467).

Appendix A to Appendix W of Part 51—Summaries of Preferred Air Quality Models

Table of Contents

A.0 Introduction and Availability

(1) This appendix summarizes key features of refined air quality models preferred for specific regulatory applications. For each model, information is provided on availability, approximate cost (where applicable), regulatory use, data input, output format and options, simulation of atmospheric physics, and accuracy. These models may be used without a formal demonstration of applicability provided they satisfy the recommendations for regulatory use; not all options in the models are necessarily recommended for regulatory use.

(2) Many of these models have been subjected to a performance evaluation using comparisons with observed air quality data. Where possible, several of the models contained herein have been subjected to evaluation exercises, including: (1) Statistical performance tests recommended by the American Meteorological Society, and (2) peer scientific reviews. The models in this appendix have been selected on the basis of the results of the model evaluations, experience with previous use, familiarity of the model to various air quality programs, and the costs and resource requirements for use.

(3) Codes and documentation for all models listed in this appendix are available from the EPA's Support Center for Regulatory Air Models (SCRAM) Web site at *https://www.epa.gov/scram.* Codes and documentation may also available from the National Technical Information Service (NTIS), *http://www.ntis.gov,* and, when available, are referenced with the appropriate NTIS accession number.

A.1 AERMOD (AMS/EPA Regulatory Model)

References

U.S. Environmental Protection Agency, 2016. AERMOD Model Formulation. Publication No. EPA–454/B–16–014. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

Cimorelli, A., *et al.,* 2005. AERMOD: A Dispersion Model for Industrial Source Applications. Part I: General Model Formulation and Boundary Layer Characterization. *Journal of Applied Meteorology,* 44(5): 682–693.

Perry, S. *et al.,* 2005. AERMOD: A Dispersion Model for Industrial Source Applications. Part II: Model Performance against 17 Field Study Databases. *Journal of Applied Meteorology,* 44(5): 694–708.

U.S. Environmental Protection Agency, 2016. User's Guide for the AMS/EPA Regulatory Model (AERMOD). Publication No. EPA–454/B–16–011. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

U.S. Environmental Protection Agency, 2016. User's Guide for the AERMOD Meteorological Preprocessor (AERMET). Publication No. EPA–454/B–16–010. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

U.S. Environmental Protection Agency, 2016. User's Guide for the AERMOD Terrain Preprocessor (AERMAP). Publication No. EPA–454/B–16–012. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

Schulman, L. L., D.G. Strimaitis and J.S. Scire, 2000. Development and evaluation of the PRIME plume rise and building downwash model. *Journal of the Air and Waste Management Association,* 50: 378–390.

Schulman, L. L., and Joseph S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide. Document P–7304B. Environmental Research and Technology, Inc., Concord, MA. (NTIS No. PB 81–164642).

Availability

The model codes and associated documentation are available on EPA's SCRAM Web site (paragraph A.0(3)).

Abstract

AERMOD is a steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources. AERMOD simulates transport and dispersion from multiple point, area, or volume sources based on an up-to-date characterization of the atmospheric boundary layer. Sources may be located in rural or urban areas, and receptors may be located in simple or complex terrain. AERMOD accounts for building wake effects (*i.e.,* plume downwash) based on the PRIME building downwash algorithms. The model employs hourly sequential preprocessed meteorological data to estimate concentrations for averaging times from 1-hour to 1-year (also multiple years). AERMOD can be used to estimate the concentrations of nonreactive pollutants from highway traffic. AERMOD also handles unique modeling problems associated with aluminum reduction plants, and other industrial sources where plume rise and downwash effects from stationary buoyant line sources are important. AERMOD is designed to operate in concert with two pre-processor codes: AERMET processes meteorological data for input to AERMOD, and AERMAP processes terrain elevation data and generates receptor and hill height information for input to AERMOD.

a. Regulatory Use

(1) AERMOD is appropriate for the following applications:

- Point, volume, and area sources;
- Buoyant, elevated line sources (*e.g.,* aluminum reduction plants);
- Mobile sources;
- Surface, near-surface, and elevated releases;
- Rural or urban areas;
- Simple and complex terrain;
- Transport distances over which steady-state assumptions are appropriate, up to 50km;
- 1-hour to annual averaging times; and
- Continuous toxic air emissions.

(2) For regulatory applications of AERMOD, the regulatory default option should be set, *i.e.,* the parameter DFAULT should be employed in the MODELOPT record in the COntrol Pathway. The DFAULT option requires the use of meteorological data processed with the regulatory options in AERMET, the use of terrain elevation data processed through the AERMAP terrain processor, stack-tip downwash, sequential date checking, and does not permit the use of the model in the SCREEN mode. In the regulatory default mode, pollutant half-life or decay options are not employed, except in the case of an urban source of sulfur dioxide where a 4-hour half-life is applied. Terrain elevation data from the U.S. Geological Survey (USGS) 7.5-Minute Digital Elevation Model (DEM), or equivalent (approx. 30-meter resolution), (processed through AERMAP) should be used in all applications. Starting in 2011, data from the National Elevation Dataset (NED, *https://nationalmap.gov/elevation.html*) can also be used in AERMOD, which includes a range of resolutions, from 1-m to 2 arc seconds and such high resolution would always be preferred. In some cases, exceptions from the terrain data requirement may be made in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. Input Requirements

(1) Source data: Required inputs include source type, location, emission rate, stack height, stack inside diameter, stack gas exit velocity, stack gas exit temperature, area and volume source dimensions, and source base elevation. For point sources subject to the influence of building downwash, direction-specific building dimensions (processed through the BPIPPRM building processor) should be input. Variable emission rates are optional. Buoyant line sources require coordinates of the end points of the line, release height, emission rate, average line source width, average building width, average spacing between buildings, and average line source buoyancy parameter. For mobile sources, traffic volume; emission factor, source height, and mixing zone width are needed to determine appropriate model inputs.

(2) Meteorological data: The AERMET meteorological preprocessor requires input of surface characteristics, including surface roughness (zo), Bowen ratio, and albedo, as well as, hourly observations of wind speed between 7zo and 100 m (reference wind speed measurement from which a vertical profile can be developed), wind direction, cloud cover, and temperature between zo and 100 m (reference temperature measurement from which a vertical profile can be developed). Meteorological data can be in the

form of observed data or prognostic modeled data as discussed in paragraph 8.4.1(d). Surface characteristics may be varied by wind sector and by season or month. When using observed meteorological data, a morning sounding (in National Weather Service format) from a representative upper air station is required. Latitude, longitude, and time zone of the surface, site-specific (if applicable) and upper air meteorological stations are required. The wind speed starting threshold is also required in AERMET for applications involving site-specific data. When using prognostic data, modeled profiles of temperature and winds are input to AERMET. These can be hourly or a time that represents a morning sounding. Additionally, measured profiles of wind, temperature, vertical and lateral turbulence may be required in certain applications (*e.g.,* in complex terrain) to adequately represent the meteorology affecting plume transport and dispersion. Optionally, measurements of solar and/or net radiation may be input to AERMET. Two files are produced by the AERMET meteorological preprocessor for input to the AERMOD dispersion model. When using observed data, the surface file contains observed and calculated surface variables, one record per hour. For applications with multi-level site-specific meteorological data, the profile contains the observations made at each level of the meteorological tower (or remote sensor). When using prognostic data, the surface file contains surface variables calculated by the prognostic model and AERMET. The profile file contains the observations made at each level of a meteorological tower (or remote sensor), the one-level observations taken from other representative data (*e.g.,* National Weather Service surface observations), one record per level per hour, or in the case of prognostic data, the prognostic modeled values of temperature and winds at user-specified levels.

(i) Data used as input to AERMET should possess an adequate degree of representativeness to ensure that the wind, temperature and turbulence profiles derived by AERMOD are both laterally and vertically representative of the source impact area. The adequacy of input data should be judged independently for each variable. The values for surface roughness, Bowen ratio, and albedo should reflect the surface characteristics in the vicinity of the meteorological tower or representative grid cell when using prognostic data, and should be adequately representative of the modeling domain. Finally, the primary atmospheric input variables, including wind speed and direction, ambient temperature, cloud cover, and a morning upper air sounding, should also be adequately representative of the source area when using observed data.

(ii) For applications involving the use of site-specific meteorological data that includes turbulences parameters (*i.e.,* sigma-theta and/or sigma-w), the application of the ADJ_U* option in AERMET would require approval as an alternative model application under section 3.2.

(iii) For recommendations regarding the length of meteorological record needed to perform a regulatory analysis with AERMOD, *see* section 8.4.2.

(3) Receptor data: Receptor coordinates, elevations, height above ground, and hill height scales are produced by the AERMAP terrain preprocessor for input to AERMOD. Discrete receptors and/or multiple receptor grids, Cartesian and/or polar, may be employed in AERMOD. AERMAP requires input of DEM or NED terrain data produced by the USGS, or other equivalent data. AERMAP can be used optionally to estimate source elevations.

c. Output

Printed output options include input information, high concentration summary tables by receptor for user-specified averaging periods, maximum concentration summary tables, and concurrent values summarized by receptor for each day processed. Optional output files can be generated for: A listing of occurrences of exceedances of user-specified threshold value; a listing of concurrent (raw) results at each receptor for each hour modeled, suitable for post-processing; a listing of design values that can be imported into graphics software for plotting contours; a listing of results suitable for NAAQS analyses including NAAQS exceedances and culpability analyses; an unformatted listing of raw results above a threshold value with a special structure for use with the TOXX model component of TOXST; a listing of concentrations by rank (*e.g.,* for use in quantile-quantile plots); and a listing of concentrations, including arc-maximum normalized concentrations, suitable for model evaluation studies.

d. Type of Model

AERMOD is a steady-state plume model, using Gaussian distributions in the vertical and horizontal for stable conditions, and in the horizontal for convective conditions. The vertical concentration distribution for convective conditions results from an assumed bi-Gaussian probability density function of the vertical velocity.

e. Pollutant Types

AERMOD is applicable to primary pollutants and continuous releases of toxic and hazardous waste pollutants. Chemical transformation is treated by simple exponential decay.

f. Source-Receptor Relationships

AERMOD applies user-specified locations for sources and receptors. Actual separation between each source-receptor pair is used. Source and receptor elevations are user input or are determined by AERMAP using USGS DEM or NED terrain data. Receptors may be located at user-specified heights above ground level.

g. Plume Behavior

(1) In the convective boundary layer (CBL), the transport and dispersion of a plume is characterized as the superposition of three modeled plumes: (1) The direct plume (from the stack); (2) the indirect plume; and (3) the penetrated plume, where the indirect plume accounts for the lofting of a buoyant plume near the top of the boundary layer, and the penetrated plume accounts for the portion of a plume that, due to its buoyancy, penetrates above the mixed layer, but can disperse downward and re-enter the mixed layer. In the CBL, plume rise is superposed on the displacements by random convective velocities (Weil *et al.,* 1997).

(2) In the stable boundary layer, plume rise is estimated using an iterative approach to account for height-dependent lapse rates, similar to that in the CTDMPLUS model (*see* A.2 in this appendix).

(3) Stack-tip downwash and buoyancy induced dispersion effects are modeled. Building wake effects are simulated for stacks subject to building downwash using the methods contained in the PRIME downwash algorithms (Schulman, *et al.,* 2000). For plume rise affected by the presence of a building, the PRIME downwash algorithm uses a numerical solution of the mass, energy and momentum conservation laws (Zhang and Ghoniem, 1993). Streamline deflection and the position of the stack relative to the building affect plume trajectory and dispersion. Enhanced dispersion is based on the approach of Weil (1996). Plume mass captured by the cavity is well-mixed within the cavity. The captured plume mass is re-emitted to the far wake as a volume source.

(4) For elevated terrain, AERMOD incorporates the concept of the critical dividing streamline height, in which flow below this height remains horizontal, and flow above this height tends to rise up and over terrain (Snyder *et al.,* 1985). Plume concentration estimates are the weighted sum of these two limiting plume states. However, consistent with the steady-state assumption of uniform horizontal wind direction over the modeling domain, straight-line plume trajectories are assumed, with adjustment in the plume/receptor geometry used to account for the terrain effects.

h. Horizontal Winds

Vertical profiles of wind are calculated for each hour based on measurements and surface-layer similarity (scaling) relationships. At a given height above ground, for a given hour, winds are assumed constant over the modeling domain. The effect of the vertical variation in horizontal wind speed on dispersion is accounted for through simple averaging over the plume depth.

i. Vertical Wind Speed

In convective conditions, the effects of random vertical updraft and downdraft velocities are simulated with a bi-Gaussian probability density function. In both convective and stable conditions, the mean vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Gaussian horizontal dispersion coefficients are estimated as continuous functions of the parameterized (or measured) ambient lateral turbulence and also account for buoyancy-induced and building wake-induced turbulence. Vertical profiles of lateral turbulence are developed from measurements and similarity (scaling) relationships. Effective turbulence values are determined from the portion of the vertical profile of lateral turbulence between the plume height and the receptor height. The effective lateral turbulence is then used to estimate horizontal dispersion.

comprehensively prescribe which sources should be included as nearby sources.

c. For cumulative impact analyses of short-term and annual ambient standards, the nearby sources as well as the project source(s) must be evaluated using an appropriate appendix A model or approved alternative model with the emission input data shown in Table 8–1 or 8–2.

i. When modeling a nearby source that does not have a permit and the emissions limits contained in the SIP for a particular source category is greater than the emissions possible given the source's maximum physical capacity to emit, the ''maximum allowable emissions limit'' for such a nearby source may be calculated as the emissions rate representative of the nearby source's maximum physical capacity to emit, considering its design specifications and allowable fuels and process materials. However, the burden is on the permit applicant to sufficiently document what the maximum physical capacity to emit is for such a nearby source.

ii. It is appropriate to model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s) or could have impact on the averaging period of concern. Accordingly, it is not necessary to model impacts of a nearby source that does not, by its nature, operate at the same time as the primary source or could have impact on the averaging period of concern, regardless of an identified significant concentration gradient from the nearby source. The burden is on the permit applicant to adequately justify the exclusion of nearby sources to the satisfaction of the appropriate reviewing authority (paragraph 3.0(b)). The following examples illustrate two cases in which a nearby source may be shown not to operate at the same time as the primary source(s) being modeled: (1) Seasonal sources (only used during certain seasons of the year). Such sources would not be modeled as nearby sources during times in which they do not operate; and (2) Emergency backup generators, to the extent that they do not operate simultaneously with the sources that they back up. Such emergency equipment would not be modeled as nearby sources.

d. *Other sources.* That portion of the background attributable to all other sources (*e.g.,* natural sources, minor and distant major sources) should be accounted for through use of ambient monitoring data and determined by the procedures found in section 8.3.2 in keeping with eliminating or reducing the source-oriented impacts from nearby sources to avoid potential double-counting of modeled and monitored contributions.

8.4 Meteorological Input Data

8.4.1 Discussion

a. This subsection covers meteorological input data for use in dispersion modeling for regulatory applications and is separate from recommendations made for photochemical grid modeling. Recommendations for meteorological data for photochemical grid modeling applications are outlined in the latest version of EPA's *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$,* and *Regional Haze.*[60] In cases where Lagrangian models are applied for regulatory purposes, appropriate meteorological inputs should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. The meteorological data used as input to a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern. The representativeness of the measured data is dependent on numerous factors including, but not limited to: (1) The proximity of the meteorological monitoring site to the area under consideration; (2) the complexity of the terrain; (3) the exposure of the meteorological monitoring site; and (4) the period of time during which data are collected. The spatial representativeness of the data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area. Temporal representativeness is a function of the year-to-year variations in weather conditions. Where appropriate, data representativeness should be viewed in terms of the appropriateness of the data for constructing realistic boundary layer profiles and, where applicable, three-dimensional meteorological fields, as described in paragraphs (c) and (d) of this subsection.

c. The meteorological data should be adequately representative and may be site-specific data, data from a nearby National Weather Service (NWS) or comparable station, or prognostic meteorological data. The implementation of NWS Automated Surface Observing Stations (ASOS) in the early 1990's should not preclude the use of NWS ASOS data if such a station is determined to be representative of the modeled area.[93]

d. Model input data are normally obtained either from the NWS or as part of a site-specific measurement program. State climatology offices, local universities, FAA, military stations, industry, and pollution control agencies may also be sources of such data. In specific cases, prognostic meteorological data may be appropriate for use and obtained from similar sources. Some recommendations and requirements for the use of each type of data are included in this subsection.

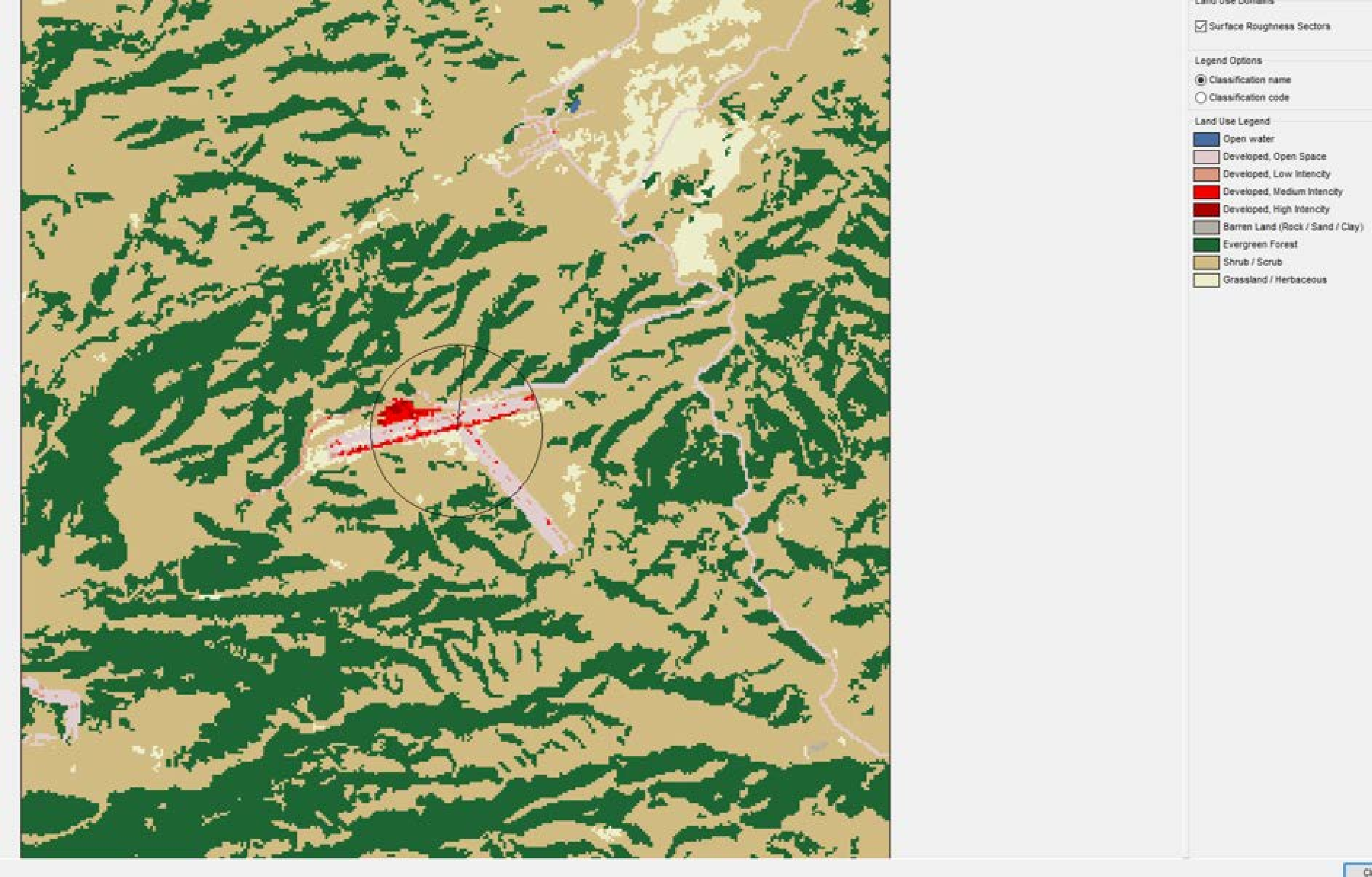
8.4.2 Recommendations and Requirements

a. AERMET [94] shall be used to preprocess all meteorological data, be it observed or prognostic, for use with AERMOD in regulatory applications. The AERMINUTE [95] processor, in most cases, should be used to process 1-minute ASOS wind data for input to AERMET when processing NWS ASOS sites in AERMET. When processing prognostic meteorological data for AERMOD, the Mesoscale Model Interface Program (MMIF) [103] should be used to process data for input to AERMET. Other methods of processing prognostic meteorological data for input to AERMET should be approved by the appropriate reviewing authority. Additionally, the following meteorological preprocessors are recommended by the EPA: PCRAMMET,[96] MPRM,[97] and METPRO.[98] PCRAMMET is the recommended meteorological data preprocessor for use in applications of OCD employing hourly NWS data. MPRM is the recommended meteorological data preprocessor for applications of OCD employing site-specific meteorological data. METPRO is the recommended meteorological data preprocessor for use with CTDMPLUS.[99]

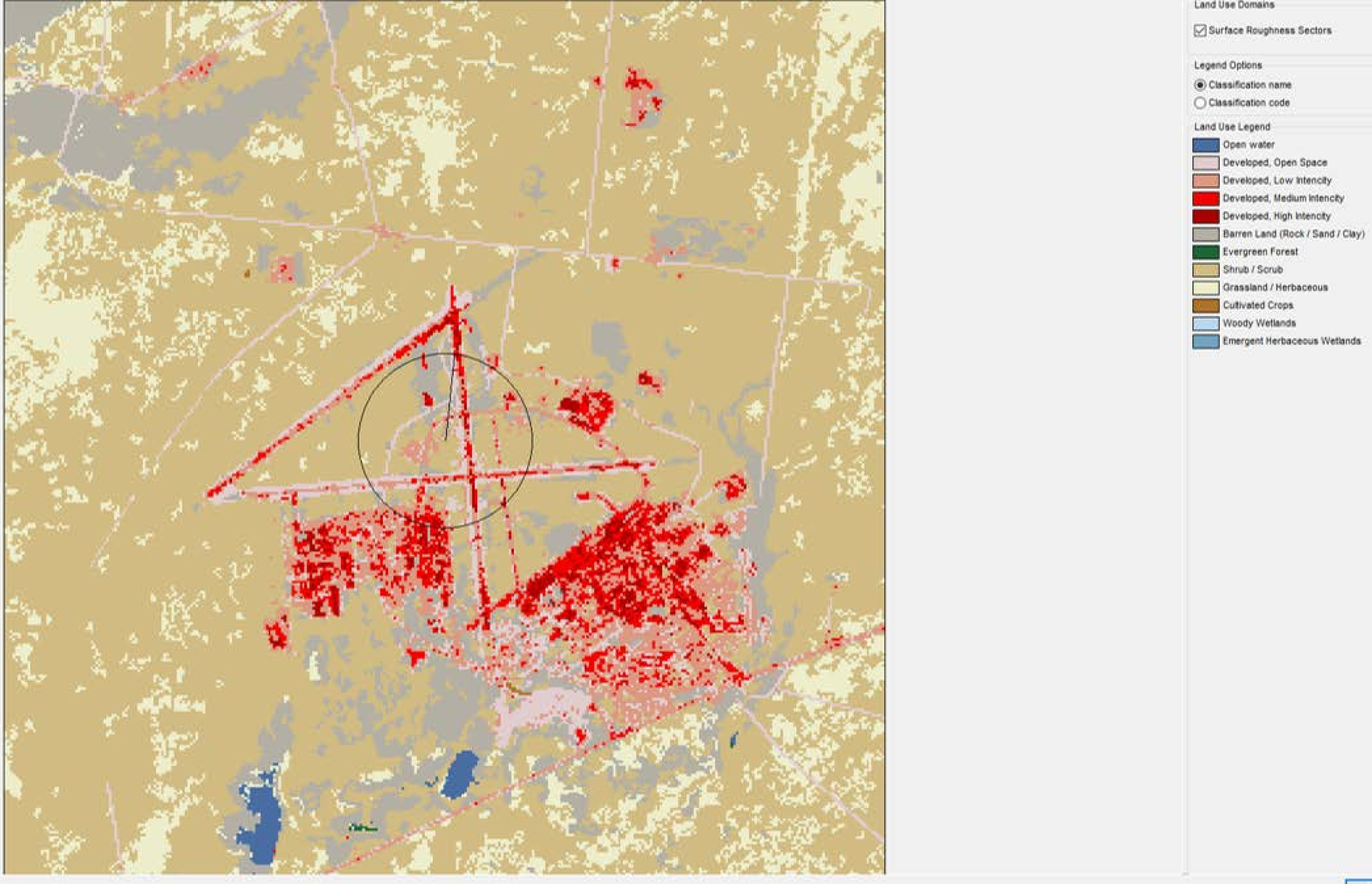
b. Regulatory application of AERMOD necessitates careful consideration of the meteorological data for input to AERMET. Data representativeness, in the case of AERMOD, means utilizing data of an appropriate type for constructing realistic boundary layer profiles. Of particular importance is the requirement that all meteorological data used as input to AERMOD should be adequately representative of the transport and dispersion within the analysis domain. Where surface conditions vary significantly over the analysis domain, the emphasis in assessing representativeness should be given to adequate characterization of transport and dispersion between the source(s) of concern and areas where maximum design concentrations are anticipated to occur. The EPA recommends that the surface characteristics input to AERMET should be representative of the land cover in the vicinity of the meteorological data, *i.e.,* the location of the meteorological tower for measured data or the representative grid cell for prognostic data. Therefore, the model user should apply the latest version AERSURFACE,[100 101] where applicable, for determining surface characteristics when processing measured meteorological data through AERMET. In areas where it is not possible to use AERSURFACE output, surface characteristics can be determined using techniques that apply the same analysis as AERSURFACE. In the case of prognostic meteorological data, the surface characteristics associated with the prognostic meteorological model output for the representative grid cell should be used.[102 103] Furthermore, since the spatial scope of each variable could be different, representativeness should be judged for each variable separately. For example, for a variable such as wind direction, the data should ideally be collected near plume height to be adequately representative, especially for sources located in complex terrain. Whereas, for a variable such as temperature, data from a station several kilometers away from the source may be considered to be adequately representative. More information about meteorological data, representativeness, and surface characteristics can be found in the AERMOD Implementation Guide.[76]

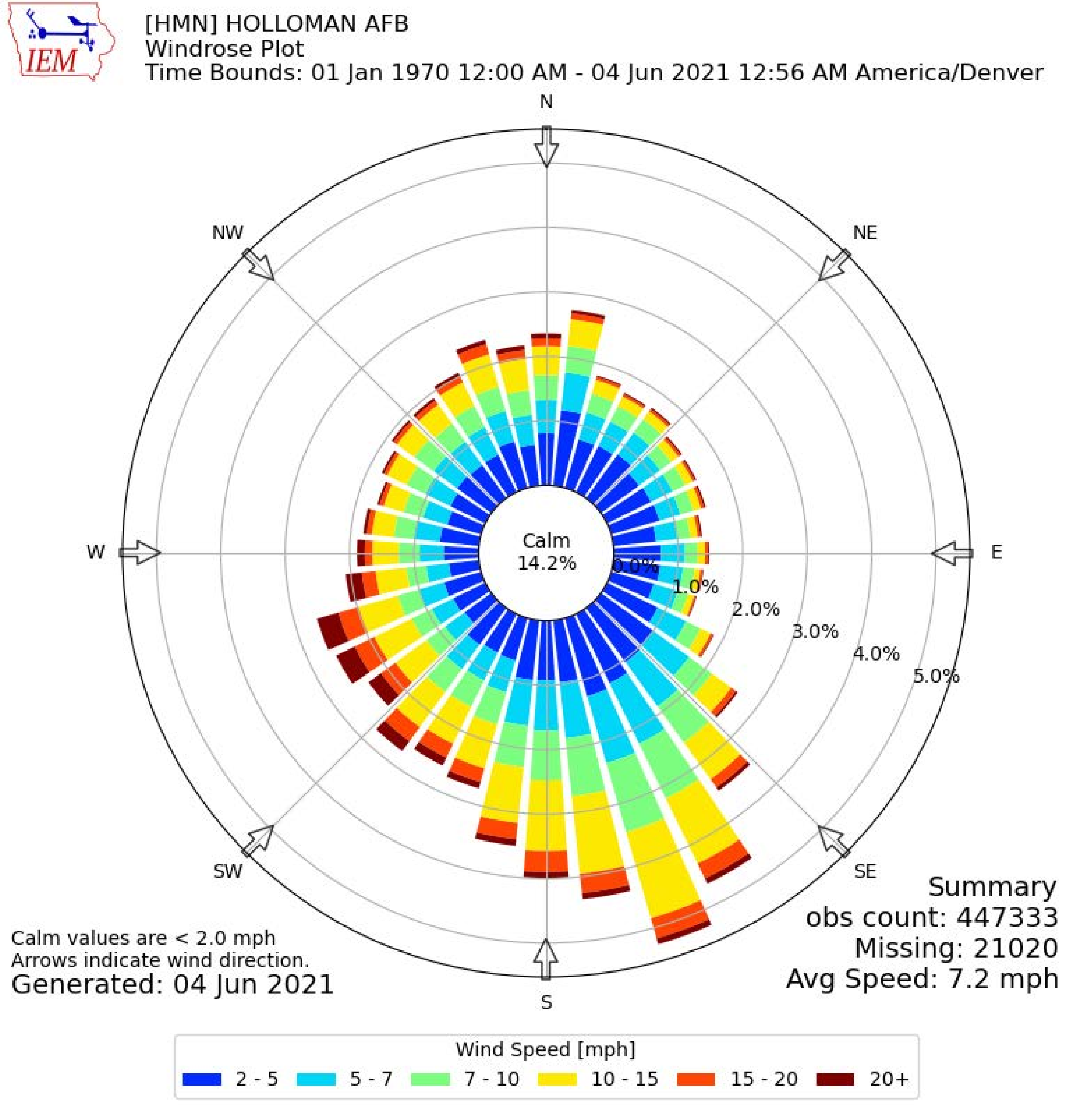
c. Regulatory application of CTDMPLUS requires the input of multi-level measurements of wind speed, direction, temperature, and turbulence from an appropriately sited meteorological tower. The measurements should be obtained up to the representative plume height(s) of interest. Plume heights of interest can be determined by use of screening procedures such as CTSCREEN.

d. Regulatory application of OCD requires meteorological data over land and over water.

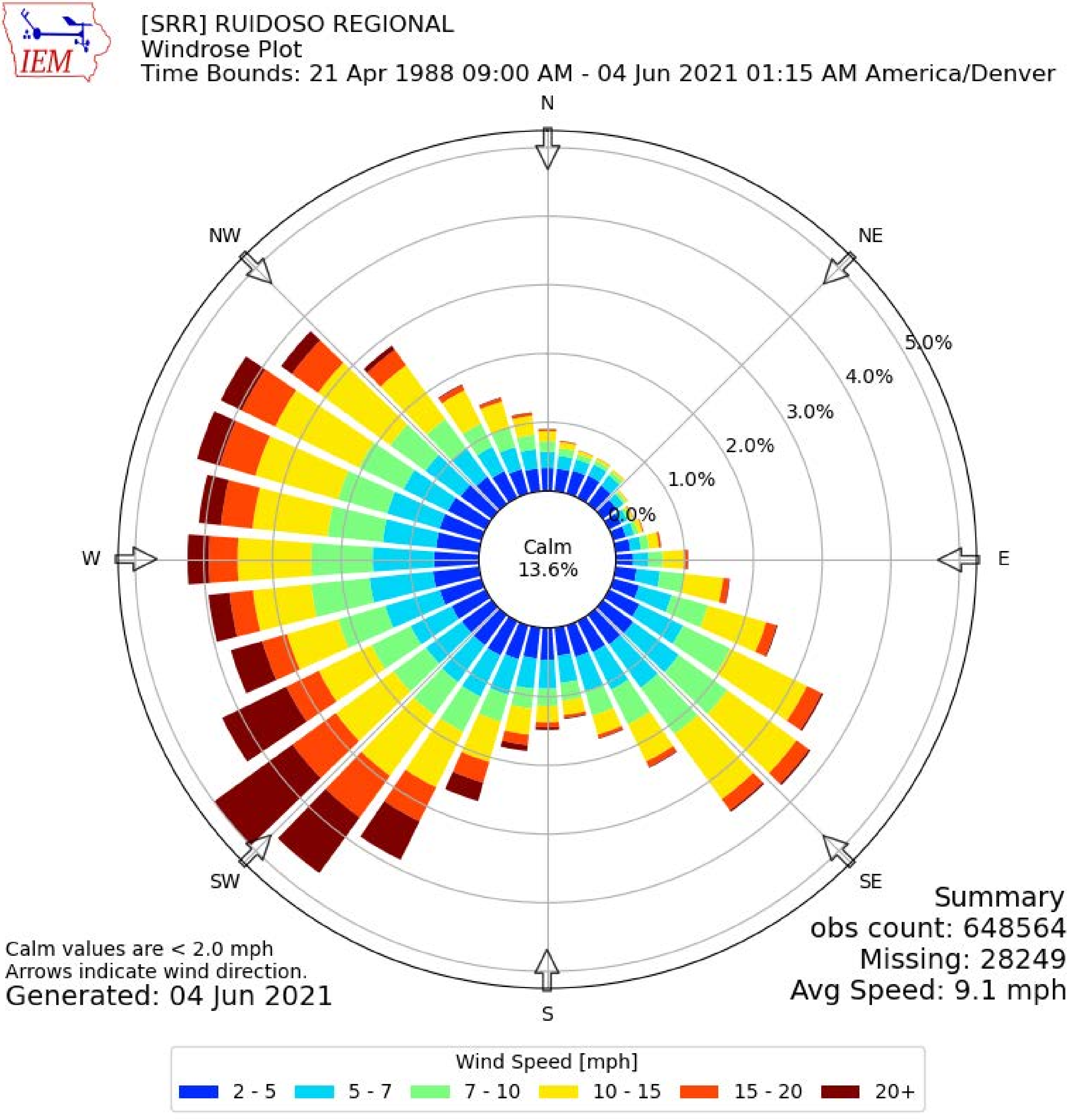

Surface Roughness Sectors
Legend Options
Classification name
Classification code
Land Use Legend
Open water
Developed, Open Space
Developed, Low Intencity
Developed, Medium Intencity
Developed, High Intencity
Barren Land (Rock / Sand / Clay)
Evergreen Forest
Shrub / Scrub
Grassland / Herbaceous


Land Use Domains
Surface Roughness Sectors
Legend Options
Classification name
Classification code
Land Use Legend
Open water
Developed, Open Space
Developed, Low Intencity
Developed, Medium Intencity
Developed, High Intencity
Barren Land (Rock / Sand / Clay)
Evergreen Forest
Shrub / Scrub
Grassland / Herbaceous


Land Use Domains
Surface Roughness Sectors
Legend Options
Classification name
Classification code
Land Use Legend
Open water
Developed, Open Space
Developed, Low Intencity
Developed, Medium Intencity
Developed, High Intencity
Barren Land (Rock / Sand / Clay)
Evergreen Forest
Shrub / Scrub
Grassland / Herbaceous
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands



[HMN] HOLLOMAN AFB
Windrose Plot
Time Bounds: 01 Jan 1970 12:00 AM - 04 Jun 2021 12:56 AM America/Denver
N
NE
E
SE
S
SW
W
NW
Calm
14.2%
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
Summary
obs count: 447333
Missing: 21020
Avg Speed: 7.2 mph
Calm values are < 2.0 mph
Arrows indicate wind direction.
Generated: 04 Jun 2021
Wind Speed [mph]
2 - 5
5 - 7
7 - 10
10 - 15
15 - 20
20+


[SRR] RUIDOSO REGIONAL
Windrose Plot
Time Bounds: 21 Apr 1988 09:00 AM - 04 Jun 2021 01:15 AM America/Denver
IEM
N
NE
E
SE
S
SW
W
NW
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
Calm
13.6%
Calm values are < 2.0 mph
Arrows indicate wind direction.
Generated: 04 Jun 2021
Summary
obs count: 648564
Missing: 28249
Avg Speed: 9.1 mph
Wind Speed [mph]
2 - 5
5 - 7
7 - 10
10 - 15
15 - 20
20+

Windrose Data Table (Percent Frequency) for RUIDOSO REGIONAL (SRR)
Observations Used/Missing/Total: 633354/28264/661618
21 Apr 1988 09:00 AM - 10 Dec 2021 02:15 PM America/Denver
Hour Limiter: All included
Month Limiter: All included
Wind Speed Units: miles per hour
Generated 10 Dec 2021 21:37 UTC, contact: akrherz@iastate.edu
First value in table is CALM

Direction	Calm	2.0 4.9	5.0 6.9	7.0 9.9	10.0 14.9	15.0 19.9	20.0+
355-004	13.54	0.336	0.236	0.155	0.152	0.022	0.007
005-014		0.331	0.195	0.108	0.09	0.014	0.005
015-024		0.351	0.175	0.076	0.052	0.006	0.001
025-034		0.367	0.183	0.064	0.039	0.005	0.001
035-044		0.334	0.191	0.067	0.033	0.003	0
045-054		0.255	0.126	0.043	0.028	0.003	0.001
055-064		0.197	0.106	0.047	0.038	0.008	0.002
065-074		0.192	0.125	0.064	0.067	0.014	0.002
075-084		0.214	0.161	0.114	0.147	0.029	0.005
085-094		0.251	0.224	0.205	0.311	0.052	0.007
095-104		0.306	0.343	0.358	0.562	0.086	0.011
105-114		0.388	0.493	0.545	0.878	0.154	0.018
115-124		0.488	0.704	0.764	1.244	0.233	0.027
125-134		0.544	0.818	0.878	1.254	0.221	0.032
135-144		0.532	0.786	0.845	1.192	0.2	0.028
145-154		0.502	0.613	0.568	0.61	0.088	0.015
155-164		0.477	0.518	0.372	0.294	0.049	0.012
165-174		0.415	0.402	0.258	0.212	0.04	0.016
175-184		0.461	0.42	0.251	0.236	0.072	0.035
185-194		0.45	0.446	0.29	0.38	0.15	0.086
195-204		0.515	0.535	0.405	0.607	0.309	0.274
205-214		0.56	0.669	0.569	0.9	0.546	0.614
215-224		0.552	0.672	0.593	1.097	0.747	0.994
225-234		0.546	0.655	0.587	1.04	0.776	1.394
235-244		0.556	0.666	0.635	0.851	0.521	1.027
245-254		0.631	0.824	0.714	0.772	0.371	0.471
255-264		0.674	0.93	0.857	0.845	0.338	0.3
265-274		0.651	0.898	0.894	1.065	0.411	0.307
275-284		0.627	0.792	0.809	1.085	0.455	0.318
285-294		0.636	0.802	0.745	1.244	0.532	0.342
295-304		0.618	0.723	0.717	1.356	0.535	0.338
305-314		0.569	0.638	0.631	1.293	0.466	0.194
315-324		0.491	0.521	0.525	0.97	0.277	0.076
325-334		0.436	0.401	0.376	0.542	0.082	0.015
335-344		0.371	0.335	0.291	0.398	0.049	0.012
345-354		0.334	0.28	0.21	0.281	0.042	0.008

Station Identifier:	SRR
Station Name:	RUIDOSO REGIONAL
Network:	NM_ASOS
County:	Lincoln
State:	NM
Latitude:	33.46285
Longitude:	-105.53475
Elevation [m]:	2076
Time Zone:	America/Denver

https://mesonet.agron.iastate.edu/sites/windrose.phtml?station=SRR&network=NM_ASOS

Windrose Data Table (Percent Frequency) for HOLLOMAN AFB (HMN)
Observations Used/Missing/Total: 430118/21000/451118
01 Jan 1970 01:00 AM - 10 Dec 2021 12:58 PM America/Denver
Hour Limiter: All included
Month Limiter: All included
Wind Speed Units: miles per hour
Generated 10 Dec 2021 22:11 UTC, contact: akrherz@iastate.edu
First value in table is CALM

Direction	Calm	2.0 4.9	5.0 6.9	7.0 9.9	10.0 14.9	15.0 19.9	20.0+
355-004	14.24	0.804	0.513	0.378	0.452	0.123	0.073
005-014		1.174	0.591	0.41	0.417	0.089	0.054
015-024		0.778	0.437	0.296	0.225	0.048	0.023
025-034		0.796	0.418	0.263	0.168	0.039	0.024
035-044		0.838	0.424	0.254	0.15	0.043	0.028
045-054		0.729	0.407	0.215	0.138	0.043	0.027
055-064		0.757	0.371	0.22	0.133	0.036	0.026
065-074		0.777	0.337	0.213	0.125	0.046	0.032
075-084		0.661	0.332	0.2	0.117	0.043	0.028
085-094		0.727	0.374	0.198	0.113	0.04	0.024
095-104		0.731	0.358	0.179	0.092	0.035	0.013
105-114		0.683	0.391	0.17	0.099	0.026	0.014
115-124		0.874	0.494	0.255	0.175	0.043	0.016
125-134		1.005	0.689	0.438	0.381	0.092	0.038
135-144		1.039	0.85	0.7	0.724	0.159	0.064
145-154		1.188	1.046	0.947	1.138	0.26	0.091
155-164		1.255	1.082	1.112	1.394	0.324	0.094
165-174		0.963	0.878	0.901	1.213	0.302	0.095
175-184		0.922	0.779	0.775	1.096	0.326	0.094
185-194		0.926	0.715	0.644	0.867	0.255	0.1
195-204		0.681	0.515	0.519	0.707	0.222	0.103
205-214		0.665	0.48	0.458	0.64	0.238	0.134
215-224		0.704	0.467	0.438	0.673	0.269	0.189
225-234		0.513	0.382	0.352	0.592	0.277	0.239
235-244		0.554	0.371	0.346	0.642	0.337	0.321
245-254		0.597	0.4	0.346	0.632	0.325	0.34
255-264		0.467	0.354	0.308	0.478	0.214	0.249
265-274		0.541	0.375	0.323	0.408	0.115	0.12
275-284		0.606	0.409	0.313	0.346	0.078	0.054
285-294		0.544	0.391	0.313	0.322	0.065	0.037
295-304		0.607	0.431	0.323	0.339	0.055	0.039
305-314		0.655	0.451	0.369	0.332	0.065	0.038
315-324		0.638	0.451	0.34	0.366	0.078	0.047
325-334		0.643	0.477	0.366	0.405	0.105	0.056
335-344		0.745	0.494	0.387	0.526	0.159	0.072
345-354		0.636	0.466	0.382	0.489	0.136	0.074

Station Identifier:	HMN
Station Name:	HOLLOMAN AFB
Network:	NM_ASOS
County:	Otero
State:	NM
Latitude:	32.85186
Longitude:	-106.10854
Elevation [m]:	1248
Time Zone:	America/Denver

https://mesonet.agron.iastate.edu/sites/windrose.phtml?station=HMN&network=NM_ASOS

TESTIMONY OF

BREANNA BERNAL

EXHIBITS

SWCA | Resume

BREANNA BERNAL, B.S., AIR QUALITY SPECIALIST

As an Air Quality Specialist, Ms. Bernal is highly experienced in conducting the air quality permitting, compliance, and reporting driven by state, federal, and local air quality rules and regulations. Ms. Bernal has a demonstrated ability to evaluate project impacts with respect to PSD, Title V, FERC and NEPA projects. She is familiar with technical aspects of air quality analysis including air quality impact assessment and emission inventory methodologies.

YEARS OF EXPERIENCE

3.5

EXPERTISE

Air quality analysis and permitting

Due diligence

Emissions inventory

Clean Air Act (CAA) compliance

CAA PSD/NNSR permitting

Noise Survey Following ASTM Standards

Regulatory agency coordination

EDUCATION

B.S., Environmental Geoscience; Texas A&M University, College Station, Texas; 2017

A.A., Liberal Arts; San Antonio College, San Antonio, Texas; 2014

RELATED WORK EXPERIENCE

SWCA Environmental Consultants (July 2021 – Present)
Air Quality Specialist
Provide permitting and compliance services to electric generation, industrial and oil & gas sectors.

Westward Environmental, Inc. (April 2018 – July 2021)
Environmental Specialist
Provided permitting and compliance services for a wide range of facilities including aggregate and agricultural operations, asphalt plants, concrete batch plants, frac sand facilities, and more. Assisted in staff safety training and public notice for air quality permitting.

SELECTED PROJECT EXPERIENCE (* denotes project experience prior to SWCA)

PSD/NSR Permitting; Dallas/Fort Worth, Texas – Assisted with PSD Permitting analyses and NSR permitting throughout career. Worked in many industries including general manufacturing, oil and gas, power generation and aggregate. Knowledgeable in the many Texas NSR permitting mechanisms, including construction permits, standard permits, and permits by rule (PBRs). *Role: Air Quality Specialist*

Title V Permitting; Dallas/Fort Worth, Texas – Assisted with Title V permitting projects throughout career. Worked with aspects of the TCEQ Title V operating permits program including SOPs, minor and significant revisions, and off-permit changes. *Role: Air Quality Specialist*

Painted Desert Power, LLC; Air Quality and Noise Threshold Determination; Coconino County, Nevada – SWCA prepared threshold determination reports for a solar field. Evaluated baseline conditions for air quality and noise levels at the project site, as well as the relevant regulatory programs. Performed air quality emission and noise calculations for the proposed project. Prepared an impacts evaluation to demonstrate compliance with all state and federal standards. *Role: Air Quality Specialist*

The Bureau of Land Management (BLM) and Gold Standard Ventures; Air Quality Environmental Report, Elko County, Nevada: SWCA prepared an environmental impact statement meeting the requirements of NEPA and the policies and standards of the Council on Environmental Quality CEQ and the BLM for mining operations. Evaluated baseline conditions for air quality at the project site, as well as the relevant regulatory programs. Analyzed potential environmental consequences and impacts to the local and regional quality as a result of the project by evaluating the results from air dispersion modeling and emission calculations. *Role: Air Quality Specialist*

***Potter Ready Mix, LLC; Air Quality Permitting, Multiple Counties, Texas –** Served as one of the primary air quality consultants for multiple concrete batch plant projects across Texas for three years. Assisted with preparing documentation and calculations for standard permits, alterations, and relocations for concrete batch plants. *Role: Environmental Specialist*

NMED Plume Depletion Parameters

Coal Handling Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-2.5	1.57	1	1.5
	PM10		
0-2.5	1.57	0.078	1.5
2.5-5	3.88	0.27	1.5
5-10	7.77	0.652	1.5
	TSP		
0-2.5	1.57	0.03	1.5
2.5-5	3.88	0.1	1.5
5-10	7.77	0.24	1.5
10-20	15.54	0.38	1.5
20-30	25.33	0.25	1.5

Source:
Figure 6, July 1983, American Mining Congress Report:
"Fugitive Dust Emission Factors for the Mining Industry"

Limestone and Gypsum Handling Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-2.5	1.57	1	2.7
	PM10		
0-2.5	1.57	0.078	2.7
2.5-5	3.88	0.27	2.7
5-10	7.77	0.652	2.7
	TSP		
0-2.5	1.57	0.03	2.7
2.5-5	3.88	0.1	2.7
5-10	7.77	0.24	2.7
10-20	15.54	0.38	2.7
20-30	25.33	0.25	2.7

Source:
Figure 6, July 1983, American Mining Congress Report:
"Fugitive Dust Emission Factors for the Mining Industry"

	density(g/cm3)
Limestone Dust	1.11
Gypsum	0.86

Cooling Tower Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-2.5	1.57	1	2.5
	PM10		
0-2.5	1.57	0.078	2.5
2.5-5	3.88	0.27	2.5
5-10	7.77	0.652	2.5
	TSP		
0-2.5	1.57	0.03	2.5
2.5-5	3.88	0.1	2.5
5-10	7.77	0.24	2.5
10-20	15.54	0.38	2.5
20-30	25.33	0.25	2.5

Source:
Figure 6, July 1983, American Mining Congress Report:
"Fugitive Dust Emission Factors for the Mining Industry"

Vehicle Fugitive Dust Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-2.5	1.57	1	2.5
	PM10		
0-2.5	1.57	0.25	2.5
2.5-10	6.91	0.75	2.5
	TSP		

Source:
AP-42 Particle size k factors for paved roads.

0-2.5	1.57	0.05	2.5
2.5-10	6.91	0.15	2.5
10-15	12.63	0.05	2.5
15-30	23.23	0.75	2.5

Fly Ash Handling Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-2.5	1.57	1	1.04
	PM10		
0-2.5	1.57	0.14	1.04
2.5-5	3.88	0.33	1.04
5-10	7.77	0.53	1.04
	TSP		
0-2.5	1.57	0.06	1.04
2.5-5	3.88	0.13	1.04
5-10	7.77	0.21	1.04
10-20	15.54	0.36	1.04
20-30	25.33	0.24	1.04

Source:
Particle Distribution:
Fly ash classification analysis of San Juan Generating Station
for Phoenix Cement.
Density:
http://www.powderandbulk.com/resources/bulk_density/material_bulk_density_chart_f.htm

Cement Handling Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
	1.5	1	2.85
	PM10		
	1.5	0.26	2.85
	3	0.25	2.85
	6	0.48	2.85
	TSP		
	1.5	0.11	2.85
	3	0.11	2.85
	6	0.21	2.85
	12	0.26	2.85
	24	0.23	2.85
	30	0.08	2.85

Source:
http://ciks.cbt.nist.gov/~garbocz/nist6883/nistir6883.htm

Density:
Analysis of the ASTM Round-Robin Test on Particle Size Distribution of Portland Cement: Phase II,
Page A-36
For pure cement, use 3.12 g/cm3 density.

Combustion Stack Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-2.5	1.57	1	1.5
	PM10		
0-2.5	1.57	1	1.5
	TSP		
0-2.5	1.57	1	1.5

Wood Dust Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-2.5		1	0.56
	PM10		
	1.5		0.56
	3		0.56
	6		0.56
	TSP		

Source: Steve Dubyk, "The specific gravity of wood dust is 0.56, according to this tome.

1.5	0.56	"Tenth Report on Carcinogens"
3	0.56	
6	0.56	
12	0.56	
24	0.56	
30	0.56	

Lime Silo Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-2.5	1.57	1	3.30
	PM10		
0-2.5	1.57	0.25	3.30
2.5-10	6.91	0.75	3.30
	TSP		
0-2.5	1.57	0.174	3.30
2.5-10	6.91	0.521	3.30
10-30	21.54	0.305	3.30

Source:
Particle Distribution:
particle size distribution for lime silo emissions is based on a fly ash classification analysis plus a bag house that controls to 98.8% of particles less than 2.5 micrometers, 99.4% of particles between 2.5 and ten micrometers , and 99.8% of particles between ten and 30 micrometers.
Note: Particle size distribution of lime may differ from fly ash. Use this only if better information is not available.
Density:
CRC, "Handbook of Chemistry and Physics", 80th Edition.

Asphalt Baghouse Stack Depletion Parameters

Particle Size Category	Mass Mean Particle Diameter (um)	Mass Weighted Size Fraction	Density (g/cm3)
	PM2.5		
0-1.0	0.63	0.72	1.50
1.0-2.5	1.85	0.28	1.50
	PM10		
0-1.0	0.63	0.5	1.50
1.0-2.5	1.85	0.19	1.50
2.5-10	6.92	0.31	1.50
	TSP		
0-1.0	0.63	0.15	1.50
1.0-2.5	1.85	0.06	1.50
2.5-10	6.92	0.09	1.50
10.0-15.0	12.66	0.05	1.50
15.0-30.0	23.3	0.65	1.50

Source:
Particle Distribution:
Particle size distribution for asphalt baghouse emissions is based on Table 11.1-3 in AP-42, section 11.1 (version 3/04) .

Density:
CRC, "Handbook of Chemistry and Physics", 80th Edition.

Current Tier I BACT Requirements: Mechanical, Agricultural, and Construction Sources (TCEQ January 2021)

Last Revision Date: January, 2021

Instructions: Use the small arrow (filter symbol) in cell A5 to sort

Unit Type	Date of Last Update	MSS	PM
Material handling: aggregate	10/1/2018	Best management practices (conducting system maintenance in a manner which minimizes emissions) employed during handling system maintenance. No bypassing of controls. Opacity requirement same as normal operation BACT requirements. No downtime since: fabric filters should be in good repair with an acceptable pressure drop prior to the start of operations, all aggregate should be prewashed, suction shroud for truck drop point should be in good repair with minimum flow rate.	Concrete batch plant: 70% reduction, all aggregate material prewashed prior to delivery Rock/aggregate handling: 70% reduction, typically water sprays
Material handling: conveyor	10/1/2018	Best management practices (conducting system maintenance in a manner which minimizes emissions) employed during handling system maintenance. No bypassing of controls. Fabric filters should be in good repair with an acceptable pressure drop prior to the start of operation. Removal of spent filters in such a manner to minimize PM emissions and placing the spent filters in sealable bags or other sealable containers prior to removal from the site. Bags or containers shall be kept closed at all times except when adding spent filters.	Grain elevator: Mechanical conveying: enclosed conveying or equivalent. Pneumatic conveying: 99% reduction, outlet grain loading ≤ 0.01 gr/dscf. Typically achieved with a baghouse. Specify technique. Iron and steel raw materials: 99% reduction, outlet grain loading ≤ 0.01 gr/dscf, typically achieved when dry powdery materials are conveyed by pneumatic or enclosed system and stored in silos with emissions exhausted to a fabric filter. Provide technique. Maximum of 5% opacity at stack Coal handling: 90% reduction, typically enclosed (50-90% reduction); chemical sprays (80-90% reduction; or full enclosure (90+%). Specify technique. Rock/aggregate: 70% reduction, typically water sprays
Material handling: drop point	10/1/2018	Best management practices (conducting system maintenance in a manner which minimizes emissions) employed during handling system maintenance. No bypassing of controls. Suction shroud should be in good repair with minimum flow rate.	Concrete: Truck drop 99% reduction or 0.01 gr/dscf, suction shroud, minimum 5000 acfm Rock/aggregate: 70% reduction, typically water sprays

13.2.4 Aggregate Handling And Storage Piles

13.2.4.1 General

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage.

Dust emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents, and loadout from the pile. The movement of trucks and loading equipment in the storage pile area is also a substantial source of dust.

13.2.4.2 Emissions And Correction Parameters

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Emissions also depend on 3 parameters of the condition of a particular storage pile: age of the pile, moisture content, and proportion of aggregate fines.

When freshly processed aggregate is loaded onto a storage pile, the potential for dust emissions is at a maximum. Fines are easily disaggregated and released to the atmosphere upon exposure to air currents, either from aggregate transfer itself or from high winds. As the aggregate pile weathers, however, potential for dust emissions is greatly reduced. Moisture causes aggregation and cementation of fines to the surfaces of larger particles. Any significant rainfall soaks the interior of the pile, and then the drying process is very slow.

Silt (particles equal to or less than 75 micrometers [µm] in diameter) content is determined by measuring the portion of dry aggregate material that passes through a 200-mesh screen, using ASTM-C-136 method.[1] Table 13.2.4-1 summarizes measured silt and moisture values for industrial aggregate materials.

Table 13.2.4-1. TYPICAL SILT AND MOISTURE CONTENTS OF MATERIALS AT VARIOUS INDUSTRIES[a]

Industry	No. Of Facilities	Material	Silt Content (%)			Moisture Content (%)		
			No. Of Samples	Range	Mean	No. Of Samples	Range	Mean
Iron and steel production	9	Pellet ore	13	1.3 - 13	4.3	11	0.64 - 4.0	2.2
		Lump ore	9	2.8 - 19	9.5	6	1.6 - 8.0	5.4
		Coal	12	2.0 - 7.7	4.6	11	2.8 - 11	4.8
		Slag	3	3.0 - 7.3	5.3	3	0.25 - 2.0	0.92
		Flue dust	3	2.7 - 23	13	1	—	7
		Coke breeze	2	4.4 - 5.4	4.9	2	6.4 - 9.2	7.8
		Blended ore	1	—	15	1	—	6.6
		Sinter	1	—	0.7	0	—	—
		Limestone	3	0.4 - 2.3	1.0	2	ND	0.2
Stone quarrying and processing	2	Crushed limestone	2	1.3 - 1.9	1.6	2	0.3 - 1.1	0.7
		Various limestone products	8	0.8 - 14	3.9	8	0.46 - 5.0	2.1
Taconite mining and processing	1	Pellets	9	2.2 - 5.4	3.4	7	0.05 - 2.0	0.9
		Tailings	2	ND	11	1	—	0.4
Western surface coal mining	4	Coal	15	3.4 - 16	6.2	7	2.8 - 20	6.9
		Overburden	15	3.8 - 15	7.5	0	—	—
		Exposed ground	3	5.1 - 21	15	3	0.8 - 6.4	3.4
Coal-fired power plant	1	Coal (as received)	60	0.6 - 4.8	2.2	59	2.7 - 7.4	4.5
Municipal solid waste landfills	4	Sand	1	—	2.6	1	—	7.4
		Slag	2	3.0 - 4.7	3.8	2	2.3 - 4.9	3.6
		Cover	5	5.0 - 16	9.0	5	8.9 - 16	12
		Clay/dirt mix	1	—	9.2	1	—	14
		Clay	2	4.5 - 7.4	6.0	2	8.9 - 11	10
		Fly ash	4	78 - 81	80	4	26 - 29	27
		Misc. fill materials	1	—	12	1	—	11

[a] References 1-10. ND = no data.

13.2.4.3 Predictive Emission Factor Equations

Total dust emissions from aggregate storage piles result from several distinct source activities within the storage cycle:

1. Loading of aggregate onto storage piles (batch or continuous drop operations).
2. Equipment traffic in storage area.
3. Wind erosion of pile surfaces and ground areas around piles.
4. Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

Either adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front-end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

The quantity of particulate emissions generated by either type of drop operation, per kilogram (kg) (ton) of material transferred, may be estimated, with a rating of A, using the following empirical expression:[11]

$$E = k(0.0016) \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \quad \text{(kg/megagram [Mg])}$$

$$E = k(0.0032) \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \quad \text{(pound [lb]/ton)} \qquad (1)$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

[a] Multiplier for < 2.5 µm taken from Reference 14.

The equation retains the assigned quality rating if applied within the ranges of source conditions that were tested in developing the equation, as follows. Note that silt content is included, even though silt content does not appear as a correction parameter in the equation. While it is reasonable to expect that silt content and emission factors are interrelated, no significant correlation between the 2 was found during the derivation of the equation, probably because most tests with high silt contents were conducted under lower winds, and vice versa. It is recommended that estimates from the equation be reduced 1 quality rating level if the silt content used in a particular application falls outside the range given:

Ranges Of Source Conditions For Equation 1			
Silt Content (%)	Moisture Content (%)	Wind Speed	
		m/s	mph
0.44 - 19	0.25 - 4.8	0.6 - 6.7	1.3 - 15

To retain the quality rating of the equation when it is applied to a specific facility, reliable correction parameters must be determined for specific sources of interest. The field and laboratory procedures for aggregate sampling are given in Reference 3. In the event that site-specific values for correction parameters cannot be obtained, the appropriate mean from Table 13.2.4-1 may be used, but the quality rating of the equation is reduced by 1 letter.

For emissions from equipment traffic (trucks, front-end loaders, dozers, etc.) traveling between or on piles, it is recommended that the equations for vehicle traffic on unpaved surfaces be used (see Section 13.2.2). For vehicle travel between storage piles, the silt value(s) for the areas among the piles (which may differ from the silt values for the stored materials) should be used.

Worst-case emissions from storage pile areas occur under dry, windy conditions. Worst-case emissions from materials-handling operations may be calculated by substituting into the equation appropriate values for aggregate material moisture content and for anticipated wind speeds during the worst case averaging period, usually 24 hours. The treatment of dry conditions for Section 13.2.2, vehicle traffic, "Unpaved Roads", follows the methodology described in that section centering on parameter p. A separate set of nonclimatic correction parameters and source extent values corresponding to higher than normal storage pile activity also may be justified for the worst-case averaging period.

13.2.4.4 Controls[12-13]

Watering and the use of chemical wetting agents are the principal means for control of aggregate storage pile emissions. Enclosure or covering of inactive piles to reduce wind erosion can also reduce emissions. Watering is useful mainly to reduce emissions from vehicle traffic in the storage pile area. Watering of the storage piles themselves typically has only a very temporary slight effect on total emissions. A much more effective technique is to apply chemical agents (such as surfactants) that permit more extensive wetting. Continuous chemical treating of material loaded onto piles, coupled with watering or treatment of roadways, can reduce total particulate emissions from aggregate storage operations by up to 90 percent.[12]

References For Section 13.2.4

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2. R. Bohn, *et al.*, *Fugitive Emissions From Integrated Iron And Steel Plants*, EPA-600/2-78-050, U. S. Environmental Protection Agency, Cincinnati, OH, March 1978.

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4. *Evaluation Of Open Dust Sources In The Vicinity Of Buffalo, New York*, EPA Contract No. 68-02-2545, Midwest Research Institute, Kansas City, MO, March 1979.

5. C. Cowherd, Jr., and T. Cuscino, Jr., *Fugitive Emissions Evaluation*, MRI-4343-L, Midwest Research Institute, Kansas City, MO, February 1977.

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7. *Improved Emission Factors For Fugitive Dust From Western Surface Coal Mining Sources*, 2 Volumes, EPA Contract No. 68-03-2924, PEDCo Environmental, Kansas City, MO, and Midwest Research Institute, Kansas City, MO, July 1981.

8. *Determination Of Fugitive Coal Dust Emissions From Rotary Railcar Dumping*, TRC, Hartford, CT, May 1984.

9. *PM-10 Emission Inventory Of Landfills In the Lake Calumet Area*, EPA Contract No. 68-02-3891, Midwest Research Institute, Kansas City, MO, September 1987.

10. *Chicago Area Particulate Matter Emission Inventory — Sampling And Analysis*, EPA Contract No. 68-02-4395, Midwest Research Institute, Kansas City, MO, May 1988.

11. *Update Of Fugitive Dust Emission Factors In AP-42 Section 11.2*, EPA Contract No. 68-02-3891, Midwest Research Institute, Kansas City, MO, July 1987.

12. G. A. Jutze, *et al.*, *Investigation Of Fugitive Dust Sources Emissions And Control*, EPA-450/3-74-036a, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

13. C. Cowherd, Jr., *et al.*, *Control Of Open Fugitive Dust Sources*, EPA-450/3-88-008, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1988.

14. C. Cowherd, *Background Document for Revisions to Fine Fraction Ratios &sed for AP-42 Fugitive Dust Emission Factors*. Prepared by Midwest Research Institute for Western Governors Association, Western Regional Air Partnership, Denver, CO, February 1, 2006.

13.2.1 Paved Roads

13.2.1.1 General

Particulate emissions occur whenever vehicles travel over a paved surface such as a road or parking lot. Particulate emissions from paved roads are due to direct emissions from vehicles in the form of exhaust, brake wear and tire wear emissions and resuspension of loose material on the road surface. In general terms, resuspended particulate emissions from paved roads originate from, and result in the depletion of, the loose material present on the surface (i.e., the surface loading). In turn, that surface loading is continuously replenished by other sources. At industrial sites, surface loading is replenished by spillage of material and trackout from unpaved roads and staging areas. Figure 13.2.1-1 illustrates several transfer processes occurring on public streets.

Various field studies have found that public streets and highways, as well as roadways at industrial facilities, can be major sources of the atmospheric particulate matter within an area.[1-9] Of particular interest in many parts of the United States are the increased levels of emissions from public paved roads when the equilibrium between deposition and removal processes is upset. This situation can occur for various reasons, including application of granular materials for snow and ice control, mud/dirt carryout from construction activities in the area, and deposition from wind and/or water erosion of surrounding unstabilized areas. In the absence of continuous addition of fresh material (through localized track out or application of antiskid material), paved road surface loading should reach an equilibrium value in which the amount of material resuspended matches the amount replenished. The equilibrium surface loading value depends upon numerous factors. It is believed that the most important factors are: mean speed of vehicles traveling the road; the average daily traffic (ADT); the number of lanes and ADT per lane; the fraction of heavy vehicles (buses and trucks); and the presence/absence of curbs, storm sewers and parking lanes.[10]

The particulate emission factors presented in a previous version of this section of AP-42, dated October 2002, implicitly included the emissions from vehicles in the form of exhaust, brake wear, and tire wear as well as resuspended road surface material. EPA included these sources in the emission factor equation for paved roads since the field testing data used to develop the equation included both the direct emissions from vehicles and emissions from resuspension of road dust.

This version of the paved road emission factor equation only estimates particulate emissions from resuspended road surface material[28]. The particulate emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOVES[29] model. This approach eliminates the possibility of double counting emissions. Double counting results when employing the previous version of the emission factor equation in this section and MOVES to estimate particulate emissions from vehicle traffic on paved roads. It also incorporates the decrease in exhaust emissions that has occurred since the paved road emission factor equation was developed. Earlier versions of the paved road emission factor equation includes estimates of emissions from exhaust, brake wear, and tire wear based on emission rates for vehicles in the 1980 calendar year fleet. The amount of PM released from vehicle exhaust has decreased since 1980 due to lower new vehicle emission standards and changes in fuel characteristics.

13.2.1.2 Emissions And Correction Parameters

Dust emissions from paved roads have been found to vary with what is termed the "silt loading" present on the road surface. In addition, the average weight and speed of vehicles traveling the road influence road dust emissions. The term silt loading (sL) refers to the mass of silt-size material (equal to or less than 75 micrometers [µm] in physical diameter) per unit area of the travel surface. The total road surface dust loading consists of loose material that can be collected by broom sweeping and vacuuming of the traveled portion of the paved road. The silt fraction is determined by measuring the proportion of the loose dry surface dust that passes through a 200-mesh screen, using the ASTM-C-136 method. Silt loading is the product of the silt fraction and the total loading, and is abbreviated "sL". Additional details on the sampling and analysis of such material are provided in AP-42 Appendices C.1 and C.2.

The surface sL provides a reasonable means of characterizing seasonal variability in a paved road emission inventory. In many areas of the country, road surface loadings [11-21] are heaviest during the late winter and early spring months when the residual loading from snow/ice controls is greatest. As noted earlier, once replenishment of fresh material is eliminated, the road surface loading can be expected to reach an equilibrium value, which is substantially lower than the late winter/early spring values.

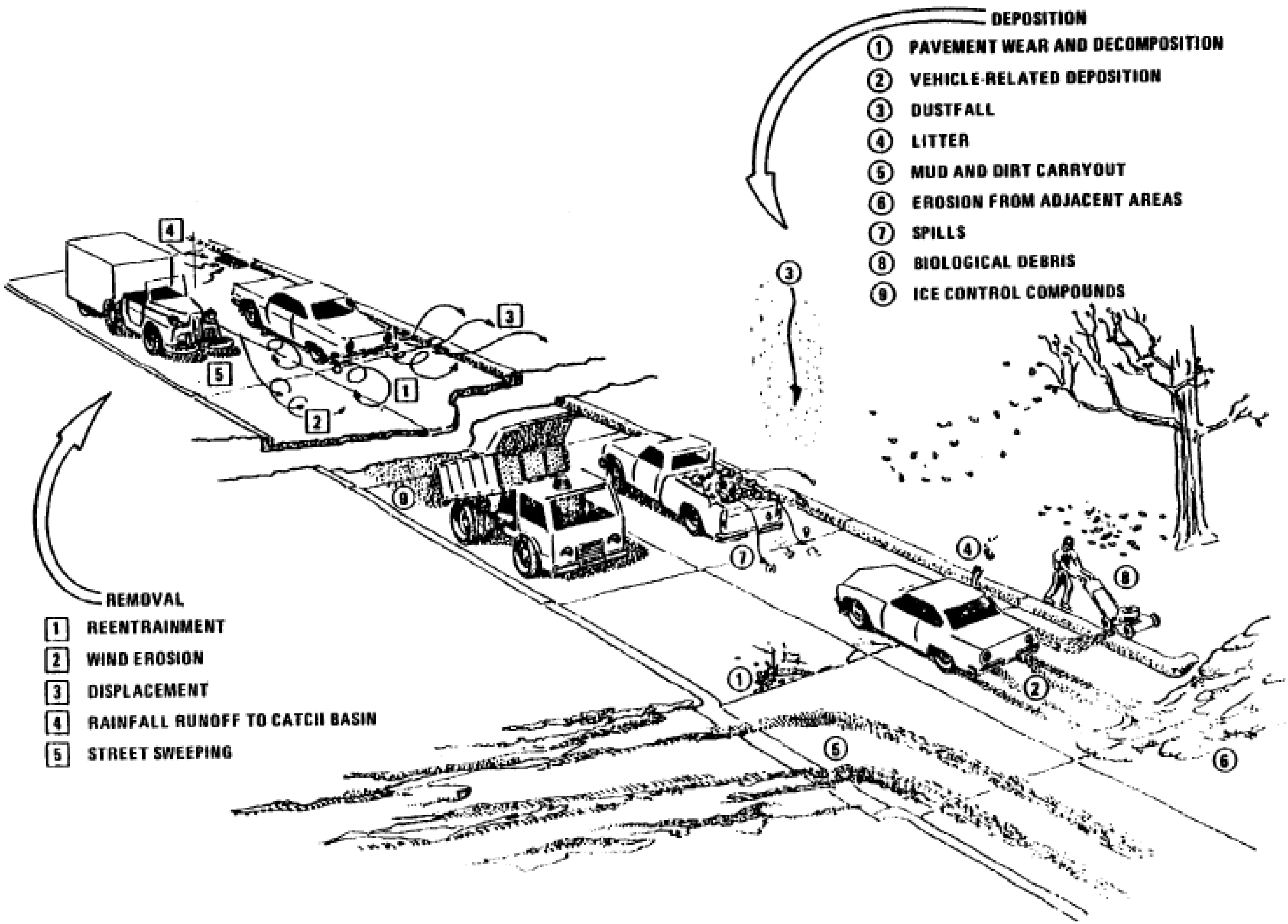

Figure 13.2.1-1. Deposition and removal processes.

13.2.1.3 Predictive Emission Factor Equations[10,29]

The quantity of particulate emissions from resuspension of loose material on the road surface due to vehicle travel on a dry paved road may be estimated using the following empirical expression:

$$E = k\,(sL)^{0.91} \times (W)^{1.02} \qquad (1)$$

where:
- E = particulate emission factor (having units matching the units of k),
- k = particle size multiplier for particle size range and units of interest (see below),
- sL = road surface silt loading (grams per square meter) (g/m^2), and
- W = average weight (tons) of the vehicles traveling the road.

It is important to note that Equation 1 calls for the average weight of all vehicles traveling the road. For example, if 99 percent of traffic on the road are 2 ton cars/trucks while the remaining 1 percent consists of 20 ton trucks, then the mean weight "W" is 2.2 tons. More specifically, Equation 1 is *not* intended to be used to calculate a separate emission factor for each vehicle weight class. Instead, only one emission factor should be calculated to represent the "fleet" average weight of all vehicles traveling the road.

The particle size multiplier (k) above varies with aerodynamic size range as shown in Table 13.2.1-1. To determine particulate emissions for a specific particle size range, use the appropriate value of k shown in Table 13.2.1-1.

To obtain the total emissions factor, the emissions factors for the exhaust, brake wear and tire wear obtained from either EPA's MOBILE6.2 [27] or most recent MOVES [29] software model should be added to the emissions factor calculated from the empirical equation.

Table 13.2.1-1. PARTICLE SIZE MULTIPLIERS FOR PAVED ROAD EQUATION

Size range[a]	Particle Size Multiplier k[b]		
	g/VKT	g/VMT	lb/VMT
PM-2.5[c]	0.15	0.25	0.00054
PM-10	0.62	1.00	0.0022
PM-15	0.77	1.23	0.0027
PM-30[d]	3.23	5.24	0.011

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.

[b] Units shown are grams per vehicle kilometer traveled (g/VKT), grams per vehicle mile traveled (g/VMT), and pounds per vehicle mile traveled (lb/VMT). The multiplier k includes unit conversions to produce emission factors in the units shown for the indicated size range from the mixed units required in Equation 1.

[c] The k-factors for $PM_{2.5}$ were based on the average $PM_{2.5}$:PM_{10} ratio of test runs in Reference 30.

[d] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

Equation 1 is based on a regression analysis of 83 tests for PM-10.[3, 5-6, 8, 27-29, 31-36] Sources tested include public paved roads, as well as controlled and uncontrolled industrial paved roads. The majority of tests involved freely flowing vehicles traveling at constant speed on relatively level roads. However, 22 tests of slow moving or "stop-and-go" traffic or vehicles under load were available for inclusion in the data base.[32-36] Engine exhaust, tire wear and break wear were subtracted from the emissions measured in the test programs prior to stepwise regression to determine Equation 1.[37, 39] The equations retain the quality rating of A (D for PM-2.5), if applied within the range of source conditions that were tested in developing the equation as follows:

Silt loading:	0.03 - 400 g/m^2 0.04 - 570 grains/square foot (ft^2)
Mean vehicle weight:	1.8 - 38 megagrams (Mg) 2.0 - 42 tons
Mean vehicle speed:	1 - 88 kilometers per hour (kph) 1 - 55 miles per hour (mph)

The upper and lower 95% confidence levels of equation 1 for PM_{10} is best described with equations using an exponents of 1.14 and 0.677 for silt loading and an exponents of 1.19 and 0.85 for weight. Users are cautioned that application of equation 1 outside of the range of variables and operating conditions specified above, e.g., application to roadways or road networks with speeds above 55 mph and average vehicle weights of 42 tons, will result in emission estimates with a higher level of uncertainty. In these situations, users are encouraged to consider an assessment of the impacts of the influence of extrapolation to the overall emissions and alternative methods that are equally or more plausible in light of local emissions data and/or ambient concentration or compositional data.

To retain the quality rating for the emission factor equation when it is applied to a specific paved road, it is necessary that reliable correction parameter values for the specific road in question be determined. With the exception of limited access roadways, which are difficult to sample, the collection and use of site-specific silt loading (sL) data for public paved road emission inventories are strongly recommended. The field and laboratory procedures for determining surface material silt content and surface dust loading are summarized in Appendices C.1 and C.2. In the event that site-specific values cannot be obtained, an appropriate value for a paved public road may be selected from the values in Table 13.2.1-2, but the quality rating of the equation should be reduced by 2 levels.

Equation 1 may be extrapolated to average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual (or other long-term) average emissions are inversely proportional to the frequency of measurable (> 0.254 mm [0.01 inch]) precipitation by application of a precipitation correction term. The precipitation correction term can be applied on a daily or an hourly basis [26, 38].

For the daily basis, Equation 1 becomes:

$$E_{ext} = [\, k\,(sL)^{0.91} \times (W)^{1.02}\,]\,(1 - P/4N) \qquad (2)$$

where k, sL, W, and S are as defined in Equation 1 and

E_{ext} = annual or other long-term average emission factor in the same units as k,

P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period, and

N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).

Note that the assumption leading to Equation 2 is based on analogy with the approach used to develop long-term average unpaved road emission factors in Section 13.2.2. However, Equation 2 above incorporates an additional factor of "4" in the denominator to account for the fact that paved roads dry more quickly than unpaved roads and that the precipitation may not occur over the complete 24-hour day.

For the hourly basis, equation 1 becomes:

$$E_{ext} = [\ k\ (sL)^{0.91} \times (W)^{1.02}\ ]\ (1 - 1.2P/N) \qquad (3)$$

where k, sL, W, and S are as defined in Equation 1 and

E_{ext} = annual or other long-term average emission factor in the same units as k,

P = number of hours with at least 0.254 mm (0.01 in) of precipitation during the averaging period, and

N = number of hours in the averaging period (e.g., 8760 for annual, 2124 for season 720 for monthly)

Note: In the hourly moisture correction term (1-1.2P/N) for equation 3, the 1.2 multiplier is applied to account for the residual mitigative effect of moisture. For most applications, this equation will produce satisfactory results. Users should select a time interval to include sufficient "dry" hours such that a reasonable emissions averaging period is evaluated. For the special case where this equation is used to calculate emissions on an hour by hour basis, such as would be done in some emissions modeling situations, the moisture correction term should be modified so that the moisture correction "credit" is applied to the first hours following cessation of precipitation. In this special case, it is suggested that this 20% "credit" be applied on a basis of one hour credit for each hour of precipitation up to a maximum of 12 hours.

Note that the assumption leading to Equation 3 is based on analogy with the approach used to develop long-term average unpaved road emission factors in Section 13.2.2.

Figure 13.2.1-2 presents the geographical distribution of "wet" days on an annual basis for the United States. Maps showing this information on a monthly basis are available in the *Climatic Atlas of the United States*[23] . Alternative sources include other Department of Commerce publications (such as local climatological data summaries). The National Climatic Data Center (NCDC) offers several products that provide hourly precipitation data. In particular, NCDC offers *Solar and Meteorological Surface Observation Network 1961-1990* (SAMSON) CD-ROM, which contains 30 years worth of hourly meteorological data for first-order National Weather Service locations. Whatever meteorological data are used, the source of that data and the averaging period should be clearly specified.

It is emphasized that the simple assumption underlying Equations 2 and 3 has not been verified in any rigorous manner. For that reason, the quality ratings for Equations 2 and 3 should be downgraded one letter from the rating that would be applied to Equation 1.

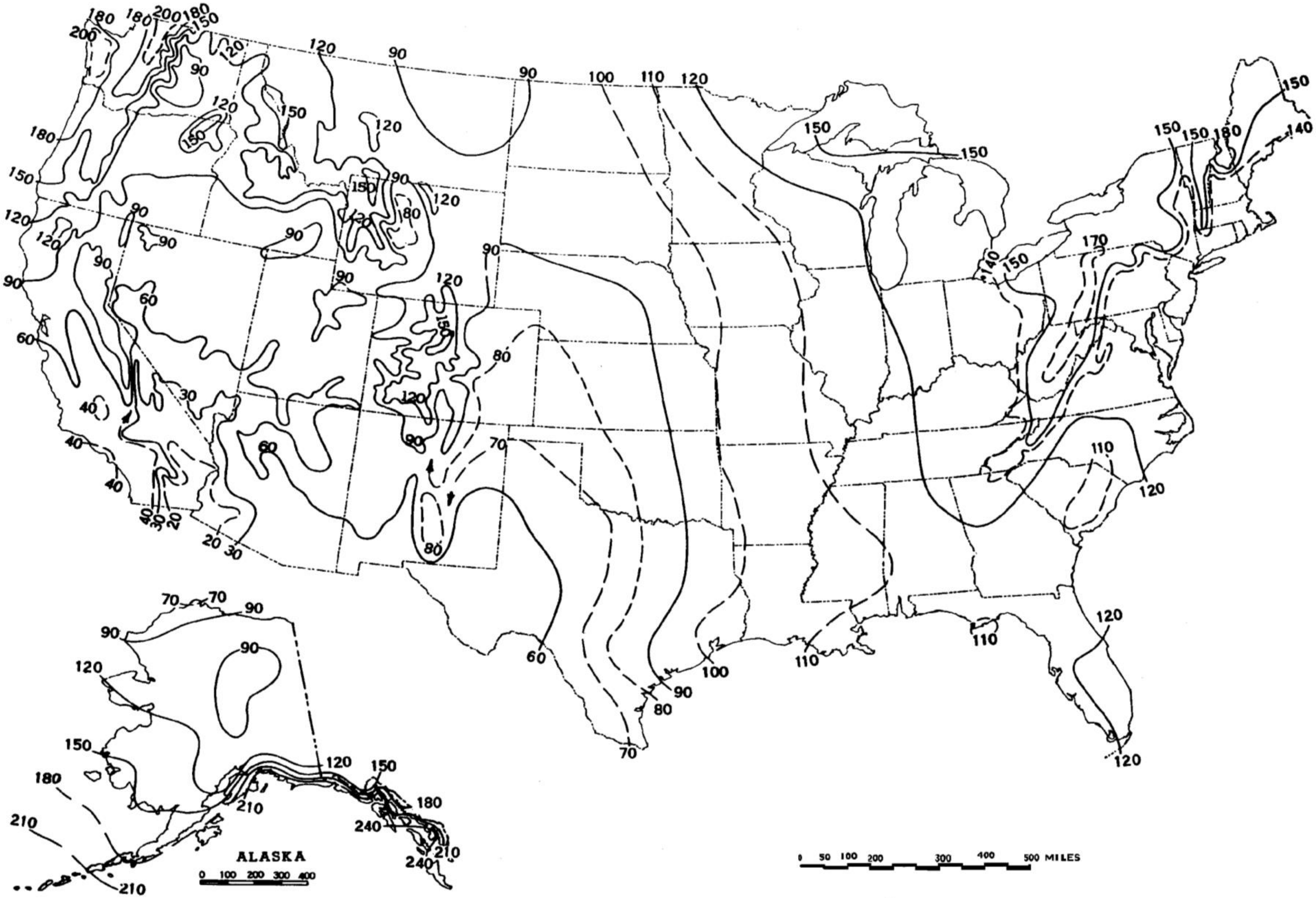

Figure 13.2.1-2. Mean number of days with 0.01 inch or more of precipitation in the United States.

Table 13.2.1-2 presents recommended default silt loadings for normal baseline conditions and for wintertime baseline conditions in areas that experience frozen precipitation with periodic application of antiskid material[24]. The winter baseline is represented as a multiple of the non-winter baseline, depending on the ADT value for the road in question. As shown, a multiplier of 4 is applied for low volume roads (< 500 ADT) to obtain a wintertime baseline silt loading of 4 X 0.6 = 2.4 g/m^2.

Table 13.2.1-2. Ubiquitous Silt Loading Default Values with Hot Spot Contributions from Anti-Skid Abrasives (g/m^2)

ADT Category	< 500	500-5,000	5,000-10,000	> 10,000
Ubiquitous Baseline g/m^2	0.6	0.2	0.06	0.03 0.015 limited access
Ubiquitous Winter Baseline Multiplier during months with frozen precipitation	X4	X3	X2	X1
Initial peak additive contribution from application of antiskid abrasive (g/m^2)	2	2	2	2
Days to return to baseline conditions (assume linear decay)	7	3	1	0.5

It is suggested that an additional (but temporary) silt loading contribution of 2 g/m^2 occurs with each application of antiskid abrasive for snow/ice control. This was determined based on a typical application rate of 500 lb per lane mile and an initial silt content of 1 % silt content. Ordinary rock salt and other chemical deicers add little to the silt loading, because most of the chemical dissolves during the snow/ice melting process.

To adjust the baseline silt loadings for mud/dirt trackout, the number of trackout points is required. It is recommended that in calculating PM_{10} emissions, six additional miles of road be added for each active trackout point from an active construction site, to the paved road mileage of the specified category within the county. In calculating $PM_{2.5}$ emissions, it is recommended that three additional miles of road be added for each trackout point from an active construction site.

It is suggested the number of trackout points for activities other than road and building construction areas be related to land use. For example, in rural farming areas, each mile of paved road would have a specified number of trackout points at intersections with unpaved roads. This value could be estimated from the unpaved road density (mi/sq. mi.).

The use of a default value from Table 13.2.1-2 should be expected to yield only an order-of-magnitude estimate of the emission factor. Public paved road silt loadings are dependent upon: traffic characteristics (speed, ADT, and fraction of heavy vehicles); road characteristics (curbs, number of lanes, parking lanes); local land use (agriculture, new residential construction) and regional/seasonal factors (snow/ice controls, wind blown dust). As a result, the collection and use of site-specific silt loading data is highly recommended. In the event that default silt loading values are used, the quality ratings for the equation should be downgraded 2 levels.

Limited access roadways pose severe logistical difficulties in terms of surface sampling, and few silt loading data are available for such roads. Nevertheless, the available data do not suggest great variation in silt loading for limited access roadways from one part of the country to another. For annual conditions, a default value of 0.015 g/m^2 is recommended for limited access roadways.[9,22] Even fewer of the available data correspond to worst-case situations, and elevated loadings are observed to be quickly depleted because of high traffic speeds and high ADT rates. A default value of 0.2 g/m^2 is recommended for short periods of time following application of snow/ice controls to limited access roads.[22]

The limited data on silt loading values for industrial roads have shown as much variability as public roads. Because of the variations of traffic conditions and the use of preventive mitigative controls, the data probably do not reflect the full extent of the potential variation in silt loading on industrial roads. However, the collection of site specific silt loading data from industrial roads is easier and safer than for public roads. Therefore, the collection and use of site-specific silt loading data is preferred and is highly recommended. In the event that site-specific values cannot be obtained, an appropriate value for an industrial road may be selected from the mean values given in Table 13.2.1-3, but the quality rating of the equation should be reduced by 2 levels.

The predictive accuracy of Equation 1 requires thorough on-site characterization of road silt loading. Road surface sampling is time-consuming and potentially hazardous because of the need to block traffic lanes. In addition, large number of samples is required to represent spatial and temporal variations across roadway networks. Mobile monitoring is a new alternative silt loading or road dust emission characterization method for either paved or unpaved roads. It utilizes a test vehicle that generates and monitors its own dust plume concentration (mass basis) at a fixed sampling probe location. A calibration factor is needed for each mobile monitoring configuration (test vehicle and sampling system), to convert the relative dust emission intensity to an equivalent silt loading or emission factor. Typically, portable continuous particle concentration monitors do not comply with Federal Reference Method (FRM) standards. Therefore, a controlled study must be performed to correlate the portable monitor response to the road silt loading or size specific particle concentration measured with an approved FRM sampling system. In the calibration tests, multiple test conditions should be performed to provide an average correlation with known precision and to accommodate variations in road silt loading, vehicle speed, road dust characteristics and other road conditions that may influence mobile monitoring measurements or emissions characteristics. Because the paved road dust emissions are also dependent on the average vehicle weight for the road segment, it is important that the weight of the test vehicle correspond closely to the average vehicle weight for the road segment or be adjusted using the average vehicle weight relationship in Equation 1. In summary, it is believed that the Mobile Monitoring Method will provide improved capabilities to provide reliable temporally and spatially resolved silt loading or emissions factors with increased coverage, improved safety, reduced traffic interference and decreased cost.[40, 41, 42]

Table 13.2.1-3 (Metric And English Units). TYPICAL SILT CONTENT AND LOADING VALUES FOR PAVED ROADS AT INDUSTRIAL FACILITIES [a]

Industry	No. of Sites	No. Of Samples	Silt Content (%)		No. of Travel Lanes	Total Loading x 10^{-3}			Silt Loading (g/m^2)	
			Range	Mean		Range	Mean	Units[b]	Range	Mean
Copper smelting	1	3	15.4-21.7	19.0	2	12.9 - 19.5	15.9	kg/km	188-400	292
						45.8 - 69.2	55.4	lb/mi		
Iron and steel production	9	48	1.1-35.7	12.5	2	0.006 - 4.77	0.495	kg/km	0.09-79	9.7
						0.020 -16.9	1.75	lb/mi		
Asphalt batching	1	3	2.6 - 4.6	3.3	1	12.1 - 18.0	14.9	kg/km	76-193	120
						43.0 - 64.0	52.8	lb/mi		
Concrete batching	1	3	5.2 - 6.0	5.5	2	1.4 - 1.8	1.7	kg/km	11-12	12
						5.0 - 6.4	5.9	lb/mi		
Sand and gravel processing	1	3	6.4 - 7.9	7.1	1	2.8 - 5.5	3.8	kg/km	53-95	70
						9.9 - 19.4	13.3	lb/mi		
Municipal solid waste landfill	2	7		-	2	-			1.1-32.0	7.4
Quarry	1	6		-	2	-			2.4-14	8.2
Corn wet mills	3	15		-	2	-			0.05 – 2.9	1.1

[a] References 1-2,5-6,11-13. Values represent samples collected from *industrial* roads. Public road silt loading values are presented in Table-13.2.1-2. Dashes indicate information not available.[b] Multiply entries by 1000 to obtain stated units; kilograms per kilometer (kg/km) and pounds per mile (lb/mi).

13.2.1.4 Controls[6,25]

Because of the importance of the silt loading, control techniques for paved roads attempt either to prevent material from being deposited onto the surface (preventive controls) or to remove from the travel lanes any material that has been deposited (mitigative controls). Covering of loads in trucks, and the paving of access areas to unpaved lots or construction sites, are examples of preventive measures. Examples of mitigative controls include vacuum sweeping, water flushing, and broom sweeping and flushing. Actual control efficiencies for any - of these techniques can be highly variable. Locally measured silt loadings before and after the application of controls is the preferred method to evaluate controls. It is particularly important to note that street sweeping of gutters and curb areas may actually increase the silt loading on the traveled portion of the road. Redistribution of loose material onto the travel lanes will actually produce a short-term increase in the emissions.

In general, preventive controls are usually more cost effective than mitigative controls. The cost-effectiveness of mitigative controls falls off dramatically as the size of an area to be treated increases. The cost-effectiveness of mitigative measures is also unfavorable if only a short period of time is required for the road to return to equilibrium silt loading condition. That is to say, the number and length of public roads within most areas of interest preclude any widespread and routine use of mitigative controls. On the other hand, because of the more limited scope of roads at an industrial site, mitigative measures may be used quite successfully (especially in situations where truck spillage occurs). Note, however, that public agencies could make effective use of mitigative controls to remove sand/salt from roads after the winter ends.

Because available controls will affect the silt loading, controlled emission factors may be obtained by substituting controlled silt loading values into the equation. (Emission factors from controlled industrial roads were used in the development of the equation.) The collection of surface loading samples from treated, as well as baseline (untreated), roads provides a means to track effectiveness of the controls over time. The use of Mobile Monitoring Methodologies provide an improved means to track progress in controlling silt loading values.

13.2.1.5 Changes since Fifth Edition

The following changes were made since the publication of the Fifth Edition of AP-42:

October 2002

1) The particle size multiplier for $PM_{2.5}$ was revised to 25% of PM_{10}. The approximately 55% reduction was a result of emission testing using FRM monitors. The monitoring was specifically intended to evaluate the PM-2.5 component of the emissions.

2) Default silt loading values were included in Table 13.2.1-2 replacing the Tables and Figures containing silt loading statistical information.

3) Editorial changes within the text were made indicating the possible causes of variations in the silt loading between roads within and among different locations. The uncertainty of using the default silt loading value was discussed.

4) Section 13.2.1.1 was revised to clarify the role of dust loading in resuspension. Additional minor text changes were made.

5) Equations 2 and 3, Figure 13.2.1-2, and text were added to incorporate natural mitigation into annual or other long-term average emission factors.

December 2003

1) The emission factor equation was adjusted to remove the component of particulate emissions- from exhaust, brake wear, and tire wear. A parameter C representing these emissions was included in the predictive equation. The parameter C varied with aerodynamic size range of the particulate matter. Table 13.2.1-2 was added to present the new coefficients.

2) The default silt loading values in Table 13.2.1-3 were revised to incorporate the results from a recent analysis of silt loading data.

November 2006

1) The $PM_{2.5}$ particle size multiplier was revised to 15% of PM_{10} as the result of wind tunnel studies of a variety of dust emitting surface materials.

2) References were rearranged and renumbered.

January 2011

1) The empirical predictive equation was revised. The revision is based upon stepwise regression of 83 profile emissions tests and an adjustment of individual test data for the exhaust; break wear and tire wear emissions prior to regression of the data.

2) The C term is removed from the empirical predictive equation and Table 13.2.1-2 with the C term values is removed since the exhaust; break wear and tire wear emissions were no longer part of the regressed data.

3) The $PM_{2.5}$ particle size multiplier was revised to 25% of PM_{10} since the PM_{10} test data used to develop the equation did not meet the necessary PM_{10} concentrations for a ratio of 15%.

4) The lower speed of the vehicle speed range supported by the empirical predictive equation was revised to 1 mph.

5) Information was added on an improved methodology to develop spatially and temporally resolved silt loadings or emissions factors by Mobile Monitoring Methodologies.

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11.19.2 Crushed Stone Processing and Pulverized Mineral Processing

11.19.2.1 Process Description [24, 25]

Crushed Stone Processing

Major rock types processed by the crushed stone industry include limestone, granite, dolomite, traprock, sandstone, quartz, and quartzite. Minor types include calcareous marl, marble, shell, and slate. Major mineral types processed by the pulverized minerals industry, a subset of the crushed stone processing industry, include calcium carbonate, talc, and barite. Industry classifications vary considerably and, in many cases, do not reflect actual geological definitions.

Rock and crushed stone products generally are loosened by drilling and blasting and then are loaded by power shovel or front-end loader into large haul trucks that transport the material to the processing operations. Techniques used for extraction vary with the nature and location of the deposit. Processing operations may include crushing, screening, size classification, material handling and storage operations. All of these processes can be significant sources of PM and PM-10 emissions if uncontrolled.

Quarried stone normally is delivered to the processing plant by truck and is dumped into a bin. A feeder is used as illustrated in Figure 11.19.2-1. The feeder or screens separate large boulders from finer rocks that do not require primary crushing, thus reducing the load to the primary crusher. Jaw, impactor, or gyratory crushers are usually used for initial reduction. The crusher product, normally 7.5 to 30 centimeters (3 to 12 inches) in diameter, and the grizzly throughs (undersize material) are discharged onto a belt conveyor and usually are conveyed to a surge pile for temporary storage or are sold as coarse aggregates.

The stone from the surge pile is conveyed to a vibrating inclined screen called the scalping screen. This unit separates oversized rock from the smaller stone. The undersized material from the scalping screen is considered to be a product stream and is transported to a storage pile and sold as base material. The stone that is too large to pass through the top deck of the scalping screen is processed in the secondary crusher. Cone crushers are commonly used for secondary crushing (although impact crushers are sometimes used), which typically reduces material to about 2.5 to 10 centimeters (1 to 4 inches). The material (throughs) from the second level of the screen bypasses the secondary crusher because it is sufficiently small for the last crushing step. The output from the secondary crusher and the throughs from the secondary screen are transported by conveyor to the tertiary circuit, which includes a sizing screen and a tertiary crusher.

Tertiary crushing is usually performed using cone crushers or other types of impactor crushers. Oversize material from the top deck of the sizing screen is fed to the tertiary crusher. The tertiary crusher output, which is typically about 0.50 to 2.5 centimeters (3/16th to 1 inch), is returned to the sizing screen. Various product streams with different size gradations are separated in the screening operation. The products are conveyed or trucked directly to finished product bins, to open area stock piles, or to other processing systems such as washing, air separators, and screens and classifiers (for the production of manufactured sand).

Some stone crushing plants produce manufactured sand. This is a small-sized rock product with a maximum size of 0.50 centimeters (3/16 th inch). Crushed stone from the tertiary sizing screen is sized in a vibrating inclined screen (fines screen) with relatively small mesh sizes.

Oversized material is processed in a cone crusher or a hammermill (fines crusher) adjusted to produce small diameter material. The output is returned to the fines screen for resizing.

In certain cases, stone washing is required to meet particulate end product specifications or demands.

Pulverized Mineral Processing

Pulverized minerals are produced at specialized processing plants. These plants supply mineral products ranging from sizes of approximately 1 micrometer to more than 75 micrometers aerodynamic diameter. Pharmaceutical, paint, plastics, pigment, rubber, and chemical industries use these products. Due to the specialized characteristics of the mineral products and the markets for these products, pulverized mineral processing plants have production rates that are less than 5% of the production capacities of conventional crushed stone plants. Two alternative processing systems for pulverized minerals are summarized in Figure 11-19.2-2.

In dry processing systems, the mineral aggregate material from conventional crushing and screening operations is subject to coarse and fine grinding primarily in roller mills and/or ball mills to reduce the material to the necessary product size range. A classifier is used to size the ground material and return oversized material that can be pulverized using either wet or dry processes. The classifier can either be associated with the grinding operation, or it can be a stand-alone process unit. Fabric filters control particulate matter emissions from the grinding operation and the classifier. The products are stored in silos and are shipped by truck or in bags.

In wet processing systems, the mineral aggregate material is processed in wet mode coarse and fine grinding operations. Beneficiation processes use flotation to separate mineral impurities. Finely ground material is concentrated and flash dried. Fabric filters are used to control particulate matter emissions from the flash dryer. The product is then stored in silos, bagged, and shipped.

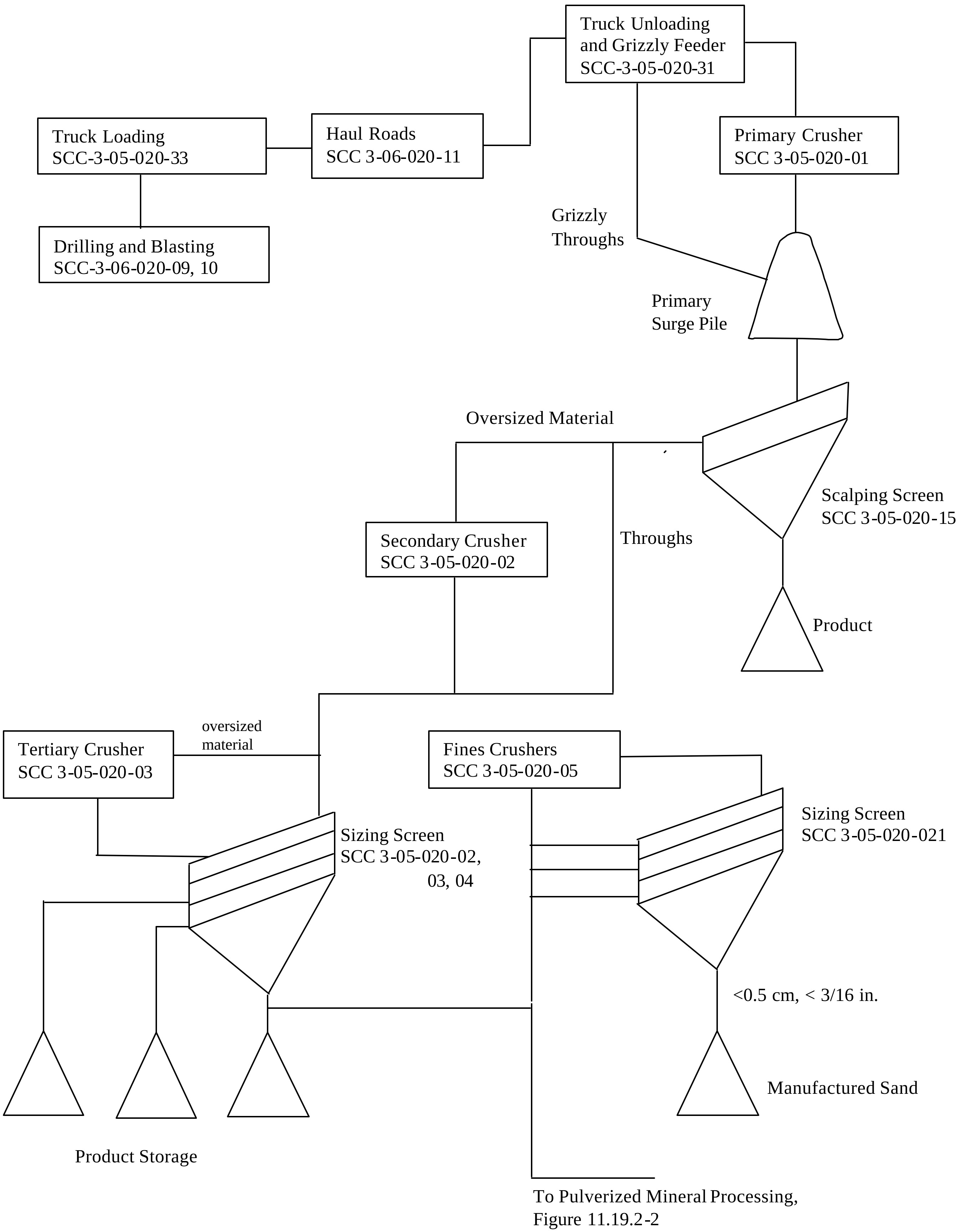

Figure 11.19.2-1. Typical stone processing plant

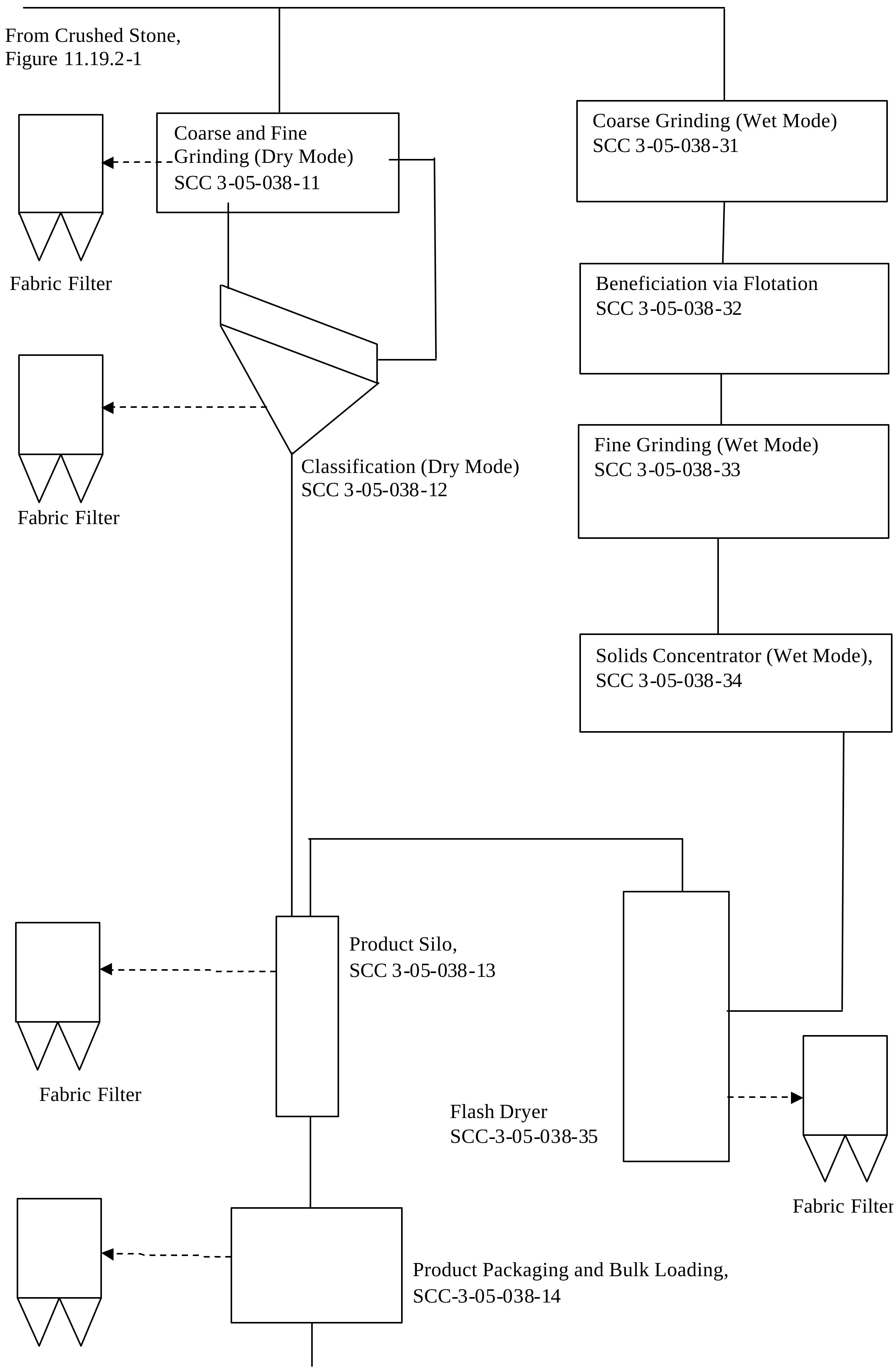

Figure 11.19.2-2 Flowchart for Pulverized Mineral Processing

11.19.2.2 Emissions and Controls [10, 11, 12, 13, 14, and 26]

Crushed Stone Processing

Emissions of PM, PM-10, and PM-2.5 occur from a number of operations in stone quarrying and processing. A substantial portion of these emissions consists of heavy particles that may settle out within the plant. As in other operations, crushed stone emission sources may be categorized as either process sources or fugitive dust sources. Process sources include those for which emissions are amenable to capture and subsequent control. Fugitive dust sources generally involve the reentrainment of settled dust by wind or machine movement. Emissions from process sources should be considered fugitive unless the sources are vented to a baghouse or are contained in an enclosure with a forced-air vent or stack. Factors affecting emissions from either source category include the stone size distribution and the surface moisture content of the stone processed, the process throughput rate, the type of equipment and operating practices used, and topographical and climatic factors.

Of graphical and seasonal factors, the primary variables affecting uncontrolled PM emissions are wind and material moisture content. Wind parameters vary with geographical location, season, and weather. It can be expected that the level of emissions from unenclosed sources (principally fugitive dust sources) will be greater during periods of high winds. The material moisture content also varies with geographical location, season, and weather. Therefore, the levels of uncontrolled emissions from both process emission sources and fugitive dust sources generally will be greater in arid regions of the country than in temperate ones and greater during the summer months because of a higher evaporation rate.

The moisture content of the material processed can have a substantial effect on emissions. This effect is evident throughout the processing operations. Surface wetness causes fine particles to agglomerate on or to adhere to the faces of larger stones, with a resulting dust suppression effect. However, as new fine particles are created by crushing and attrition and as the moisture content is reduced by evaporation, this suppressive effect diminishes and may disappear. Plants that use wet suppression systems (spray nozzles) to maintain relatively high material moisture contents can effectively control PM emissions throughout the process. Depending on the geographical and climatic conditions, the moisture content of mined rock can range from nearly zero to several percent. Because moisture content is usually expressed on a basis of overall weight percent, the actual moisture amount per unit area will vary with the size of the rock being handled. On a constant mass-fraction basis, the per-unit area moisture content varies inversely with the diameter of the rock. The suppressive effect of the moisture depends on both the absolute mass water content and the size of the rock product. Typically, wet material contains >1.5 percent water.

A variety of material, equipment, and operating factors can influence emissions from crushing. These factors include (1) stone type, (2) feed size and distribution, (3) moisture content, (4) throughput rate, (5) crusher type, (6) size reduction ratio, and (7) fines content. Insufficient data are available to present a matrix of rock crushing emission factors detailing the above classifications and variables. Available data indicate that PM-10 and PM-2.5 emissions from limestone and granite processing operations are similar. Therefore, the emission factors developed from the emissions data gathered at limestone and granite processing facilities are considered to be representative of typical crushed stone processing operations. Emission factors for filterable PM, PM-10, and PM-2.5 emissions from crushed stone processing operations are presented in Tables 11.19.2-1 (Metric units) and 11.19.2-2 (English units.)

Table 11.19.2-1 (Metric Units). EMISSION FACTORS FOR CRUSHED STONE PROCESSING OPERATIONS (kg/Mg)[a]

Source [b]	Total Particulate Matter [r,s]	EMISSION FACTOR RATING	Total PM-10	EMISSION FACTOR RATING	Total PM-2.5	EMISSION FACTOR RATING
Primary Crushing (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Primary Crushing (controlled) (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Secondary Crushing (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Secondary Crushing (controlled) (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Tertiary Crushing (SCC 3-050030-03)	0.0027[d]	E	0.0012[o]	C	ND[n]	
Tertiary Crushing (controlled) (SCC 3-05-020-03)	0.0006[d]	E	0.00027[p]	C	0.00005[q]	E
Fines Crushing (SCC 3-05-020-05)	0.0195[e]	E	0.0075[e]	E	ND	
Fines Crushing (controlled) (SCC 3-05-020-05)	0.0015[f]	E	0.0006[f]	E	0.000035[q]	E
Screening (SCC 3-05-020-02, 03)	0.0125[c]	E	0.0043[l]	C	ND	
Screening (controlled) (SCC 3-05-020-02, 03)	0.0011[d]	E	0.00037[m]	C	0.000025[q]	E
Fines Screening (SCC 3-05-020-21	0.15[g]	E	0.036[g]	E	ND	
Fines Screening (controlled) (SCC 3-05-020-21)	0.0018[g]	E	0.0011[g]	E	ND	
Conveyor Transfer Point (SCC 3-05-020-06)	0.0015[h]	E	0.00055[h]	D	ND	
Conveyor Transfer Point (controlled) (SCC 3-05-020-06)	0.00007[i]	E	2.3×10^{-5}[i]	D	6.5×10^{-6}[q]	E
Wet Drilling - Unfragmented Stone (SCC 3-05-020-10)	ND		4.0×10^{-5}[j]	E	ND	
Truck Unloading - Fragmented Stone (SCC 3-05-020-31)	ND		8.0×10^{-6}[j]	E	ND	
Truck Loading - Conveyor, crushed stone (SCC 3-05-020-32)	ND		5.0×10^{-5}[k]	E	ND	

a. Emission factors represent uncontrolled emissions unless noted. Emission factors in kg/Mg of material throughput. SCC = Source Classification Code. ND = No data.

b. Controlled sources (with wet suppression) are those that are part of the processing plant that employs current wet suppression technology similar to the study group. The moisture content of the study group without wet suppression systems operating (uncontrolled) ranged from 0.21 to 1.3 percent, and the same facilities operating wet suppression systems (controlled) ranged from 0.55 to 2.88 percent. Due to carry over of the small amount of moisture required, it has been shown that each source, with the exception of crushers, does not need to employ direct water sprays. Although the moisture content was the only variable measured, other process features may have as much influence on emissions from a given source. Visual observations from each source under normal operating conditions are probably the best indicator of which emission factor is most appropriate. Plants that employ substandard control measures as indicated by visual observations should use the uncontrolled factor with appropriate control efficiency that best reflects the effectiveness of the controls employed.

c. References 1, 3, 7, and 8

d. References 3, 7, and 8

e. Reference 4

f. References 4 and 15

g. Reference 4

h. References 5 and 6

i. References 5, 6, and 15

j. Reference 11

k. Reference 12

l. References 1, 3, 7, and 8

m. References 1, 3, 7, 8, and 15

n. No data available, but emission factors for PM-10 for tertiary crushers can be used as an upper limit for primary or secondary crushing

o. References 2, 3, 7, 8

p. References 2, 3, 7, 8, and 15

q. Reference 15

r. PM emission factors are presented based on PM-100 data in the Background Support Document for Section 11.19.2

s. Emission factors for PM-30 and PM-50 are available in Figures 11.19.2-3 through 11.19.2-6.

Note: Truck Unloading - Conveyor, crushed stone (SCC 3-05-020-32) was corrected to Truck Loading - Conveyor, crushed stone (SCC 3-05-020-32). October 1, 2010.

Table 11.19.2-2 (English Units). EMISSION FACTORS FOR CRUSHED STONE PROCESSING OPERATIONS (lb/Ton)[a]

Source [b]	Total Particulate Matter [r,s]	EMISSION FACTOR RATING	Total PM-10	EMISSION FACTOR RATING	Total PM-2.5	EMISSION FACTOR RATING
Primary Crushing (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Primary Crushing (controlled) (SCC 3-05-020-01)	ND		ND[n]		ND[n]	
Secondary Crushing (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Secondary Crushing (controlled) (SCC 3-05-020-02)	ND		ND[n]		ND[n]	
Tertiary Crushing (SCC 3-050030-03)	0.0054[d]	E	0.0024[o]	C	ND[n]	
Tertiary Crushing (controlled) (SCC 3-05-020-03)	0.0012[d]	E	0.00054[p]	C	0.00010[q]	E
Fines Crushing (SCC 3-05-020-05)	0.0390[e]	E	0.0150[e]	E	ND	
Fines Crushing (controlled) (SCC 3-05-020-05)	0.0030[f]	E	0.0012[f]	E	0.000070[q]	E
Screening (SCC 3-05-020-02, 03)	0.025[c]	E	0.0087[l]	C	ND	
Screening (controlled) (SCC 3-05-020-02, 03)	0.0022[d]	E	0.00074[m]	C	0.000050[q]	E
Fines Screening (SCC 3-05-020-21)	0.30[g]	E	0.072[g]	E	ND	
Fines Screening (controlled) (SCC 3-05-020-21)	0.0036[g]	E	0.0022[g]	E	ND	
Conveyor Transfer Point (SCC 3-05-020-06)	0.0030[h]	E	0.00110[h]	D	ND	
Conveyor Transfer Point (controlled) (SCC 3-05-020-06)	0.00014[i]	E	4.6×10^{-5}[i]	D	1.3×10^{-5}[q]	E
Wet Drilling - Unfragmented Stone (SCC 3-05-020-10)	ND		8.0×10^{-5}[j]	E	ND	
Truck Unloading -Fragmented Stone (SCC 3-05-020-31)	ND		1.6×10^{-5}[j]	E	ND	
Truck Loading - Conveyor, crushed stone (SCC 3-05-020-32)	ND		0.00010[k]	E	ND	

a. Emission factors represent uncontrolled emissions unless noted. Emission factors in lb/Ton of material of throughput. SCC = Source Classification Code. ND = No data.

b. Controlled sources (with wet suppression) are those that are part of the processing plant that employs current wet suppression technology similar to the study group. The moisture content of the study group without wet suppression systems operating (uncontrolled) ranged from 0.21 to 1.3 percent, and the same facilities operating wet suppression systems (controlled) ranged from 0.55 to 2.88 percent. Due to carry over of the small amount of moisture required, it has been shown that each source, with the exception of crushers, does not need to employ direct water sprays. Although the moisture content was the only variable measured, other process features may have as much influence on emissions from a given source. Visual observations from each source under normal operating conditions are probably the best indicator of which emission factor is most appropriate. Plants that employ substandard control measures as indicated by visual observations should use the uncontrolled factor with an appropriate control efficiency that best reflects the effectiveness of the controls employed.

c. References 1, 3, 7, and 8

d. References 3, 7, and 8

e. Reference 4

f. References 4 and 15

g. Reference 4

h. References 5 and 6

i. References 5, 6, and 15

j. Reference 11

k. Reference 12

l. References 1, 3, 7, and 8

m. References 1, 3, 7, 8, and 15

n. No data available, but emission factors for PM-10 for tertiary crushers can be used as an upper limit for primary or secondary crushing

o. References 2, 3, 7, 8

p. References 2, 3, 7, 8, and 15

q. Reference 15

r. PM emission factors are presented based on PM-100 data in the Background Support Document for Section 11.19.2

s. Emission factors for PM-30 and PM-50 are available in Figures 11.19.2-3 through 11.19.2-6.

Note: Truck Unloading - Conveyor, crushed stone (SCC 3-05-020-32) was corrected to Truck Loading - Conveyor, crushed stone (SCC 3-05-020-32). October 1, 2010.

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Emission factor estimates for stone quarry blasting operations are not presented because of the sparsity and unreliability of available tests. While a procedure for estimating blasting emissions is presented in Section 11.9, Western Surface Coal Mining, that procedure should not be applied to stone quarries because of dissimilarities in blasting techniques, material blasted, and size of blast areas. Emission factors for fugitive dust sources, including paved and unpaved roads, materials handling and transfer, and wind erosion of storage piles, can be determined using the predictive emission factor equations presented in AP-42 Section 13.2.

The data used in the preparation of the controlled PM calculations was derived from the individual A-rated tests for PM-2.5 and PM-10 summarized in the Background Support Document. For conveyor transfer points, the controlled PM value was derived from A-rated PM-2.5, PM-10, and PM data summarized in the Background Support Document.

The extrapolation line was drawn through the PM-2.5 value and the mean of the PM-10 values. PM emission factors were calculated for PM-30, PM-50, and PM-100. Each of these particle size limits is used by one or more regulatory agencies as the definition of total particulate matter. The graphical extrapolations used in calculating the emission factors are presented in Figures 11.19.2-3, -4, -5, and -6.

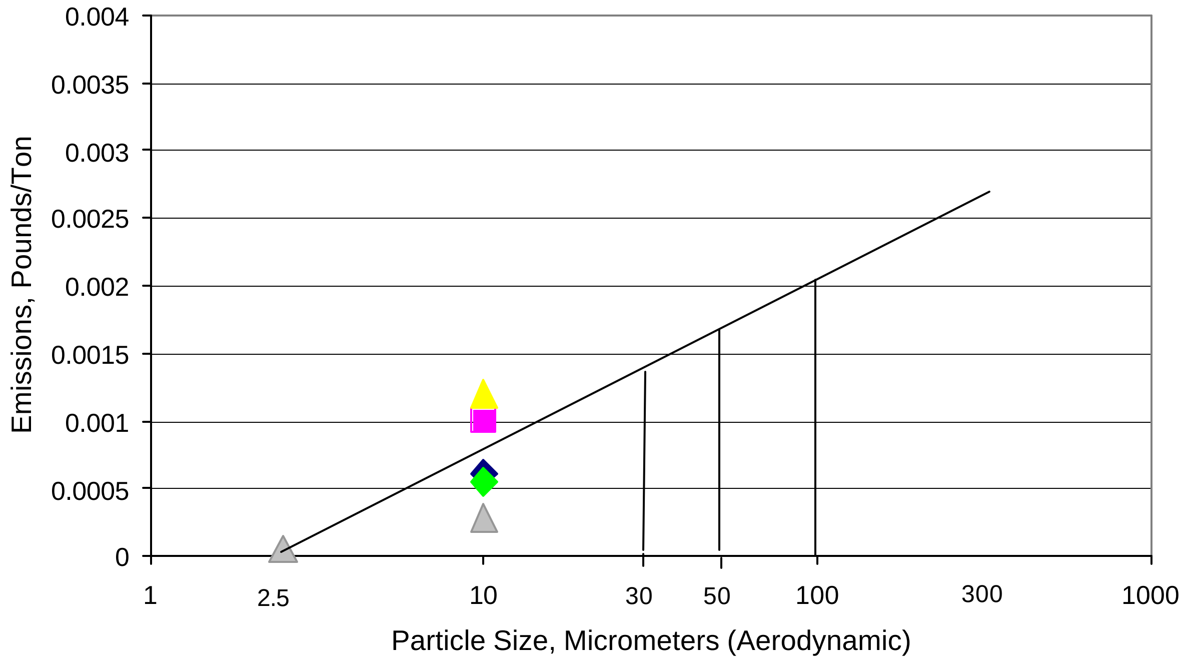

Figure 11-19-3. PM Emission Factor Calculation, Screening (Controlled)

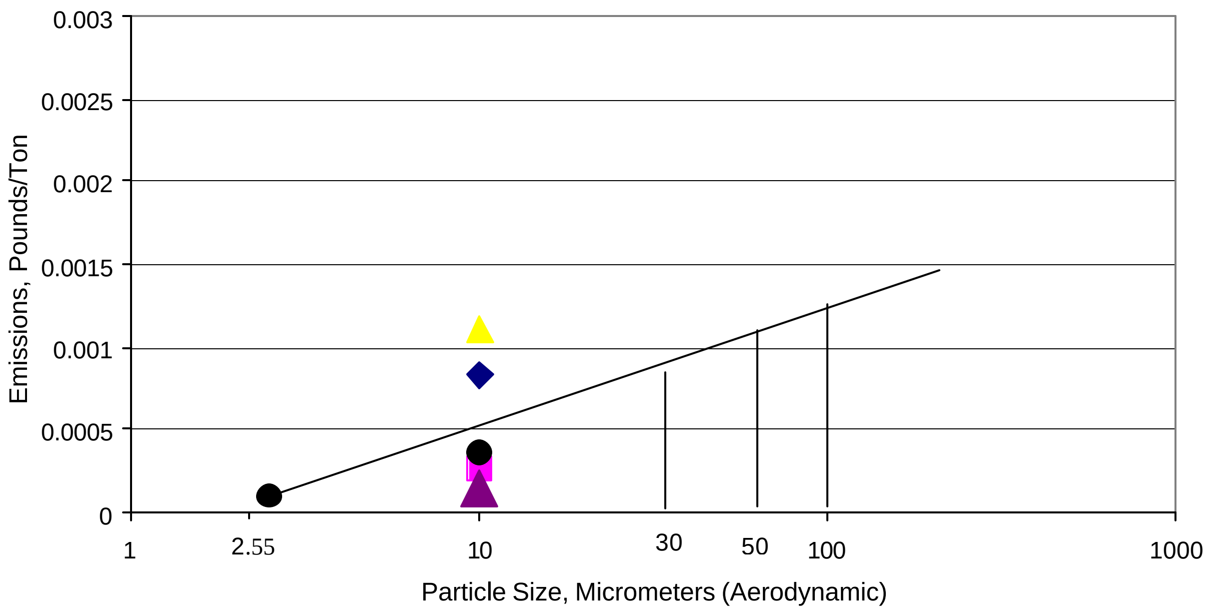

Figure 11.19-4. PM Emission Factor Calculation, Tertiary Crushing (Controlled)

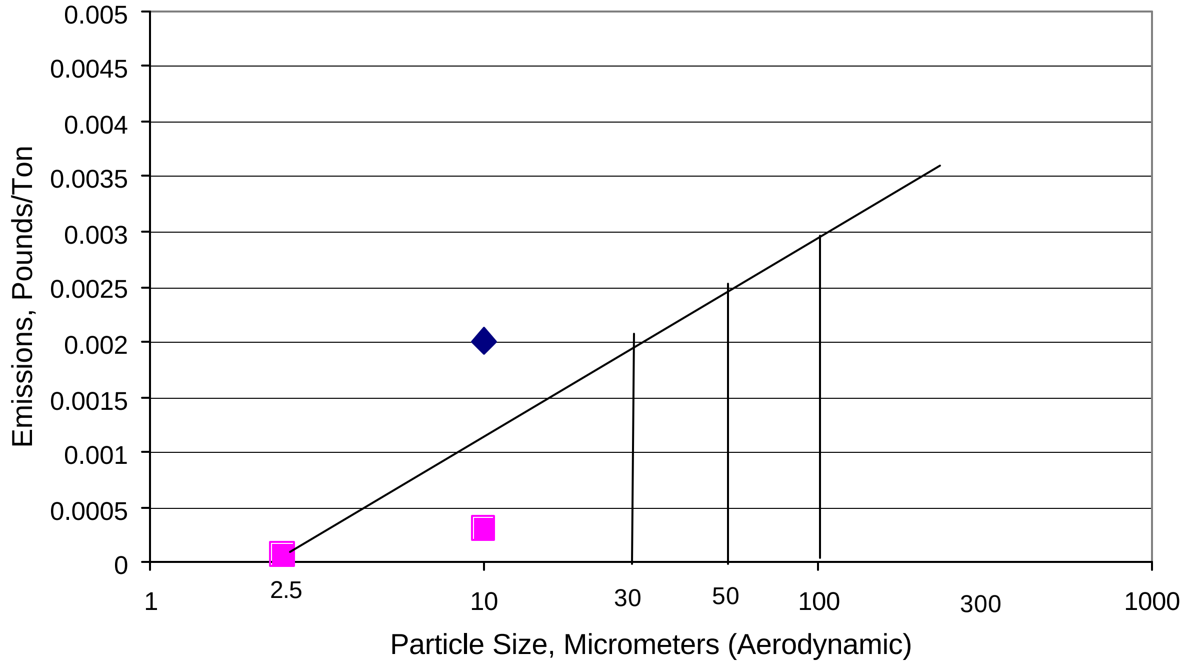

Figure 11-19.5. PM Emission Factor Calculation, Fines Crushing (Controlled)

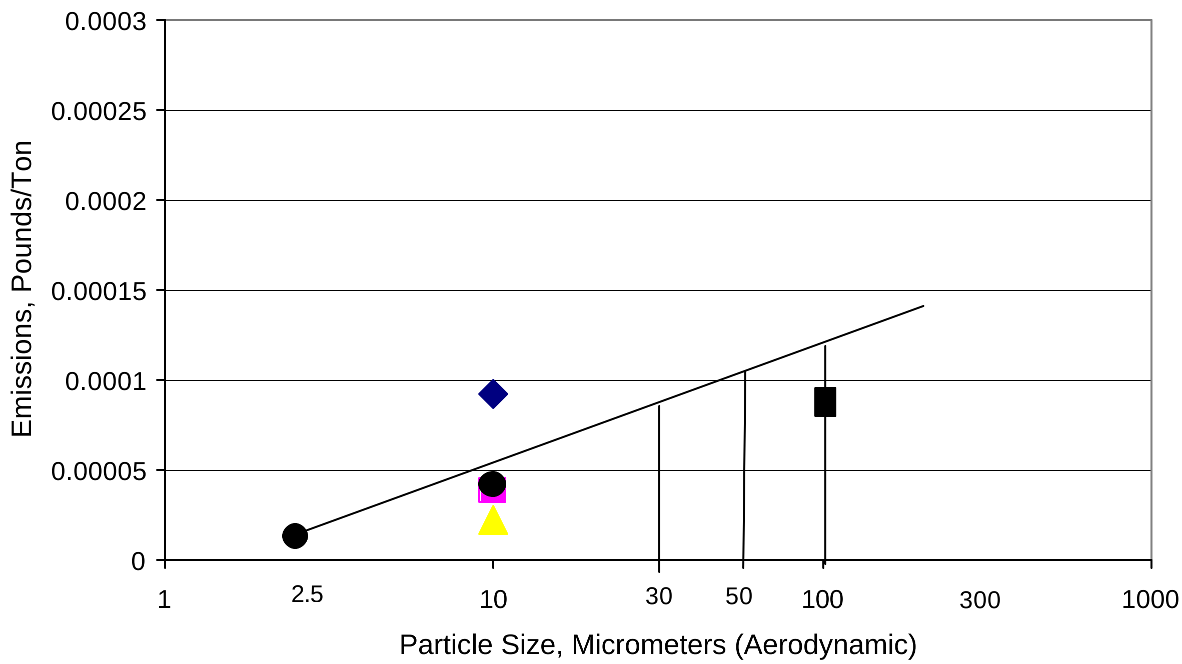

Figure 11.19-6. PM Emission Factor Calculation, Conveyor Transfer Points (Controlled)

The uncontrolled PM emission factors have been calculated from the controlled PM emission factors calculated in accordance with Figures 11.19.2-3 through 11.19.2-6. The PM-10 control efficiencies have been applied to the PM controlled emission factor data to calculate the uncontrolled PM emission rates.

Screening PM-10

Controlled = 0.00073 Lbs./Ton.

Uncontrolled = 0.00865 Lbs./Ton.

Efficiency = 91.6%

Tertiary Crushing PM-10

Controlled = 0.00054

Uncontrolled = 0.00243

Efficiency = 77.7%

Fines Crushing PM-10:

Controlled = 0.0012

Uncontrolled = 0.015

Efficiency = 92.0%

Conveyor Transfer Points PM-10

Controlled = 0.000045

Uncontrolled = 0.0011

Efficiency = 95.9%

The uncontrolled total particulate matter emission factor was calculated from the controlled total particulate matter using Equation 1:

$$\text{Uncontrolled emission factor} = \frac{\text{Controlled total particulate emission factor}}{(100\% - \text{PM-10 Efficiency } \%)/100\%}$$

Equation 1

The Total PM emission factors calculated using Figures 11.19.2-3 through 11.19.2-6 were developed because (1) there are more A-rated test data supporting the calculated values and (2) the extrapolated values provide the flexibility for agencies and source operators to select the most appropriate definition for Total PM. All of the Total PM emission factors have been rated as E due to the limited test data and the need to estimate emission factors using extrapolations of the PM-2.5 and PM-10 data.

Pulverized Mineral Processing

Emissions of particulate matter from dry mode pulverized mineral processing operations are controlled by pulse jet and envelope type fabric filter systems. Due to the low-to-moderate gas temperatures generated by the processing equipment, conventional felted filter media are used. Collection efficiencies for fabric filter-controlled dry process equipment exceed 99.5%. Emission factors for pulverized mineral processing operations are presented in Tables 11.19.2-3 and 11.19.2-4.

Table 11.19.2-3 (Metric Units). EMISSION FACTORS FOR PULVERIZED MINERAL PROCESSING OPERATIONS [a]

Source [b]	Total Particulate Matter	EMISSION FACTOR RATING	Total PM-10	EMISSION FACTOR RATING	Total PM-2.5	EMISSION FACTOR RATING
Grinding (Dry) with Fabric Filter Control (SCC 3-05-038-11)	0.0202	D	0.0169	B	0.0060	B
Classifiers (Dry) with Fabric Filter Control (SCC 3-05-038-12)	0.0112	E	0.0052	E	0.0020	E
Flash Drying with Fabric Filter Control (SCC 3-05-038-35)	0.0134	C	0.0073	C	0.0042	C
Product Storage with Fabric Filter Control (SCC 3-05-38-13)	0.0055	E	0.0008	E	0.0003	E

a. Emission factors represent controlled emissions unless noted. Emission factors are in kg/Mg of material throughput.

b. Date from references 16 through 23

Table 11.19.2-4 (English Units). EMISSION FACTORS FOR PULVERIZED MINERAL PROCESSING OPERATIONS [a]

Source [b]	Total Particulate Matter	EMISSION FACTOR RATING	Total PM-10	EMISSION FACTOR RATING	Total PM-2.5	EMISSION FACTOR RATING
Grinding (Dry) with Fabric Filter Control (SCC 3-05-038-11)	0.0404	D	0.0339	B	0.0121	B
Classifiers (Dry) with Fabric Filter Control (SCC 3-05-038-12)	0.0225	E	0.0104	E	0.0041	E
Flash Drying with Fabric Filter Control (SCC 3-05-038-35)	0.0268	C	0.0146	C	0.0083	C
Product Storage with Fabric Filter Control (SCC 3-05-038-13)	0.0099	E	0.0016	E	0.0006	E

a. Emission factors represent controlled emissions unless noted. Emission factors are in lb/Ton of material throughput.

b. Data from references 16 through 23

References for Section 11.19.2[1]

1. J. Richards, T. Brozell, and W. Kirk, *PM-10 Emission Factors for a Stone Crushing Plant Deister Vibrating Screen*, EPA Contract No. 68-Dl-0055, Task 2.84, U. S. Environmental Protection Agency, Research Triangle Park, NC, February 1992.

2. J. Richards, T. Brozell, and W. Kirk, *PM-10 Emission Factors for a Stone Crushing Plant Tertiary Crusher,* EPA Contract No. 68-D1-0055, Task 2.84, U. S. Environmental Protection Agency, Research Triangle Park, NC, February 1992.

3. W. Kirk, T. Brozell, and J. Richards, *PM-10 Emission Factors for a Stone Crushing Plant Deister Vibrating Screen and Crusher,* National Stone Association, Washington DC, December 1992.

4. T. Brozell, J. Richards, and W. Kirk, *PM-10 Emission Factors for a Stone Crushing Plant Tertiary Crusher and Vibrating Screen*, EPA Contract No. 68-DO-0122, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 1992.

5. T. Brozell, *PM-10 Emission Factors for Two Transfer Points at a Granite Stone Crushing Plant,* EPA Contract No. 68-DO-0122, U. S. Environmental Protection Agency, Research Triangle Park, NC, January 1994.

6. T. Brozell, *PM-10 Emission Factors for a Stone Crushing Plant Transfer Point*, EPA Contract No. 68-DO-0122, U. S. Environmental Protection Agency, Research Triangle Park, NC, February 1993.

7. T. Brozell and J. Richards, *PM-10 Emission Factors for a Limestone Crushing Plant Vibrating Screen and Crusher for Bristol, Tennessee,* EPA Contract No. 68-D2-0163, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 1993.

8. T. Brozell and J. Richards, *PM-10 Emission Factors for a Limestone Crushing Plant Vibrating Screen and Crusher for Marysville, Tennessee,* EPA Contract No. 68-D2-0163, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 1993.

9. *Air Pollution Control Techniques for Nonmetallic Minerals Industry*, EPA-450/3-82-014, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 1982.

10. *Review Emission Data Base and Develop Emission Factors for the Construction Aggregate Industry,* Engineering-Science, Inc., Arcadia, CA, September 1984.

11. P. K. Chalekode *et al.*, *Emissions from the Crushed Granite Industry: State of the Art*, EPA-600/2-78-021, U. S. Environmental Protection Agency, Washington, DC, February 1978.

12. T. R. Blackwood *et al.*, *Source Assessment: Crushed Stone*, EPA-600/2-78-004L, U. S. Environmental Protection Agency, Washington, DC, May 1978.

13. *An Investigation of Particulate Emissions from Construction Aggregate Crushing Operations and Related New Source Performance Standards,* National Crushed Stone Association, Washington, DC, December 1979.

[1] References 1 through 23 are identical to References 1 through 23 in the Background Support Document for AP-42, Section 11.19-2.

14. F. Record and W. T. Harnett, *Particulate Emission Factors for the Construction Aggregate Industry, Draft Report*, GCA-TR-CH-83-02, EPA Contract No. 68-02-3510, GCA Corporation, Chapel Hill, NC, February 1983.

15. T. Brozell, T. Holder, and J. Richards, *Measurement of PM-10 and PM2.5 Emission Factors at a Stone Crushing Plant*, National Stone Association, December 1996.

16. T. Brozell, and J. Richards, *$PM_{10}/PM_{2.5}$ Emission Factor Testing for the Pulverized Mineral Division of the National Stone, Sand and Gravel Association*. Report to the National Stone, Sand and Gravel Association; October 2001.

17. Frank Ward & Company, *A Report of Particulate Source Sampling Performed for Franklin Industrial Minerals Located in Sherwood, Tennessee,* Report to Franklin Industrial Minerals, August 1994.

18. Advanced Industrial Resources, LLC. *Performance Test Report of Baghouse No. 37 at Franklin Industrial Minerals, Report to Franklin Industrial Minerals,* November 1999.

19. Advanced Industrial Resources, LLC. *Performance Test Report of BH-750Limestone System at Franklin Industrial Minerals, Report to Franklin Industrial Minerals,* May 2000.

20. Air Quality Technical Services, *Performance Testing for Flash Dryer #1, Omya, Inc. Plant in Florence, Vermont*. June 1997.

21. Air Quality Technical Services, *Performance Testing for Flash Dryer #2, Omya, Inc. Plant in Florence, Vermont*, March 1998.

22. Air Quality Technical Services. *Performance Testing for Flash Dryer #3, Omya, Inc. Plant in Florence, Vermont,* August 2000.

23. Air Quality Technical Services. *Performance Testing for Flash Dryer #3, Omya, Inc. Plant in Florence, Vermont,* September 2000.

24. *Air Pollution Control Techniques for Nonmetallic Minerals Industry*, EPA-450/3-82-014, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 1982.

25. Written communication from J. Richards, Air Control Techniques, P.C. to B. Shrager, MRI, March 18, 1994.

26. C. Cowherd, Jr. et. al., *Development of Emission Factors For Fugitive Dust Sources*, EPA-450/3-74-037, U.S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

11.12 Concrete Batching

11.12.1 Process Description [1-5]

Concrete is composed essentially of water, cement, sand (fine aggregate) and coarse aggregate. Coarse aggregate may consist of gravel, crushed stone or iron blast furnace slag. Some specialty aggregate products could be either heavyweight aggregate (of barite, magnetite, limonite, ilmenite, iron or steel) or lightweight aggregate (with sintered clay, shale, slate, diatomaceous shale, perlite, vermiculite, slag pumice, cinders, or sintered fly ash). Supplementary cementitious materials, also called mineral admixtures or pozzolan minerals may be added to make the concrete mixtures more economical, reduce permeability, increase strength, or influence other concrete properties. Typical examples are natural pozzolans, fly ash, ground granulated blast-furnace slag, and silica fume, which can be used individually with portland or blended cement or in different combinations. Chemical admixtures are usually liquid ingredients that are added to concrete to entrain air, reduce the water required to reach a required slump, retard or accelerate the setting rate, to make the concrete more flowable or other more specialized functions.

Approximately 75 percent of the U.S. concrete manufactured is produced at plants that store, convey, measure and discharge these constituents into trucks for transport to a job site. At most of these plants, sand, aggregate, cement and water are all gravity fed from the weight hopper into the mixer trucks. The concrete is mixed on the way to the site where the concrete is to be poured. At some of these plants, the concrete may also be manufactured in a central mix drum and transferred to a transport truck. Most of the remaining concrete manufactured are products cast in a factory setting. Precast products range from concrete bricks and paving stones to bridge girders, structural components, and panels for cladding. Concrete masonry, another type of manufactured concrete, may be best known for its conventional 8 x 8 x 16-inch block. In a few cases concrete is dry batched or prepared at a building construction site. Figure 11.12-1 is a generalized process diagram for concrete batching.

The raw materials can be delivered to a plant by rail, truck or barge. The cement is transferred to elevated storage silos pneumatically or by bucket elevator. The sand and coarse aggregate are transferred to elevated bins by front end loader, clam shell crane, belt conveyor, or bucket elevator. From these elevated bins, the constituents are fed by gravity or screw conveyor to weigh hoppers, which combine the proper amounts of each material.

11.12.2 Emissions and Controls [6-8]

Particulate matter, consisting primarily of cement and pozzolan dust but including some aggregate and sand dust emissions, is the primary pollutant of concern. In addition, there are emissions of metals that are associated with this particulate matter. All but one of the emission points are fugitive in nature. The only point sources are the transfer of cement and pozzolan material to silos, and these are usually vented to a fabric filter or "sock". Fugitive sources include the transfer of sand and aggregate, truck loading, mixer loading, vehicle traffic, and wind erosion from sand and aggregate storage piles. The amount of fugitive emissions generated during the transfer of sand and aggregate depends primarily on the surface moisture content of these materials. The extent of fugitive emission control varies widely from plant to plant. Particulate emission factors for concrete batching are give in Tables 11.12-1 and 11.12-2.

Types of controls used may include water sprays, enclosures, hoods, curtains, shrouds, movable and telescoping chutes, central duct collection systems, and the like. A major source of potential emissions, the movement of heavy trucks over unpaved or dusty surfaces in and around the plant, can be controlled by good maintenance and wetting of the road surface.

Predictive equations that allow for emission factor adjustment based on plant specific conditions are given in the Background Document for Chapter 11.12 and Chapter 13. Whenever plant specific data are available, they should be used with these predictive equations (e.g. Equations 11.12-1 through 11.12-3) in lieu of the general fugitive emission factors presented in Table 11.12-1, 11.12-2, and 11.12-5 through11.12-8 in order to adjust to site specific conditions, such as moisture levels and localized wind speeds.

11.12.3 Updates since the 5th Edition.

October 2001

– This major revision of the section replaced emissions factors based upon engineering judgment and poorly documented and performed source test reports with emissions tests conducted at modern operating truck mix and central mix facilities. Emissions factors for both total PM and total PM_{10} were developed from this test data.

June 2006

– This revision of the section supplemented the two source tests with several additional source tests of central mix and truck mix facilities. The measurement of the capture efficiency, local wind speed and fines material moisture level was improved over the previous two source tests. In addition to quantifying total PM and PM_{10}, $PM_{2.5}$ emissions were quantified at all of the facilities. Single value emissions factors for truck mix and central mix operations were revised using all of the data. Additionally, parameterized emissions factor equations using local wind speed and fines material moisture content were developed from the newer data.

February 2011

– This is an editorial revision of the section. Emissions factors in Tables 11.12-1, 11.12-2, 11.12-7 and 11.12-8 were corrected to agree with the emissions factors presented in the background report.

August 2011

- Equation 11.12-2 was corrected. An explanation was added under the equation.

January 2012

- This is an editorial revision of the section. Emissions factors for Uncontrolled factors in Table 11.12-3 for Total PM, PM_{10} and $PM_{10\text{-}2.5}$ were corrected to agree with the emissions factors presented in Table 11.12-2 and the emissions factors presented in the background report.

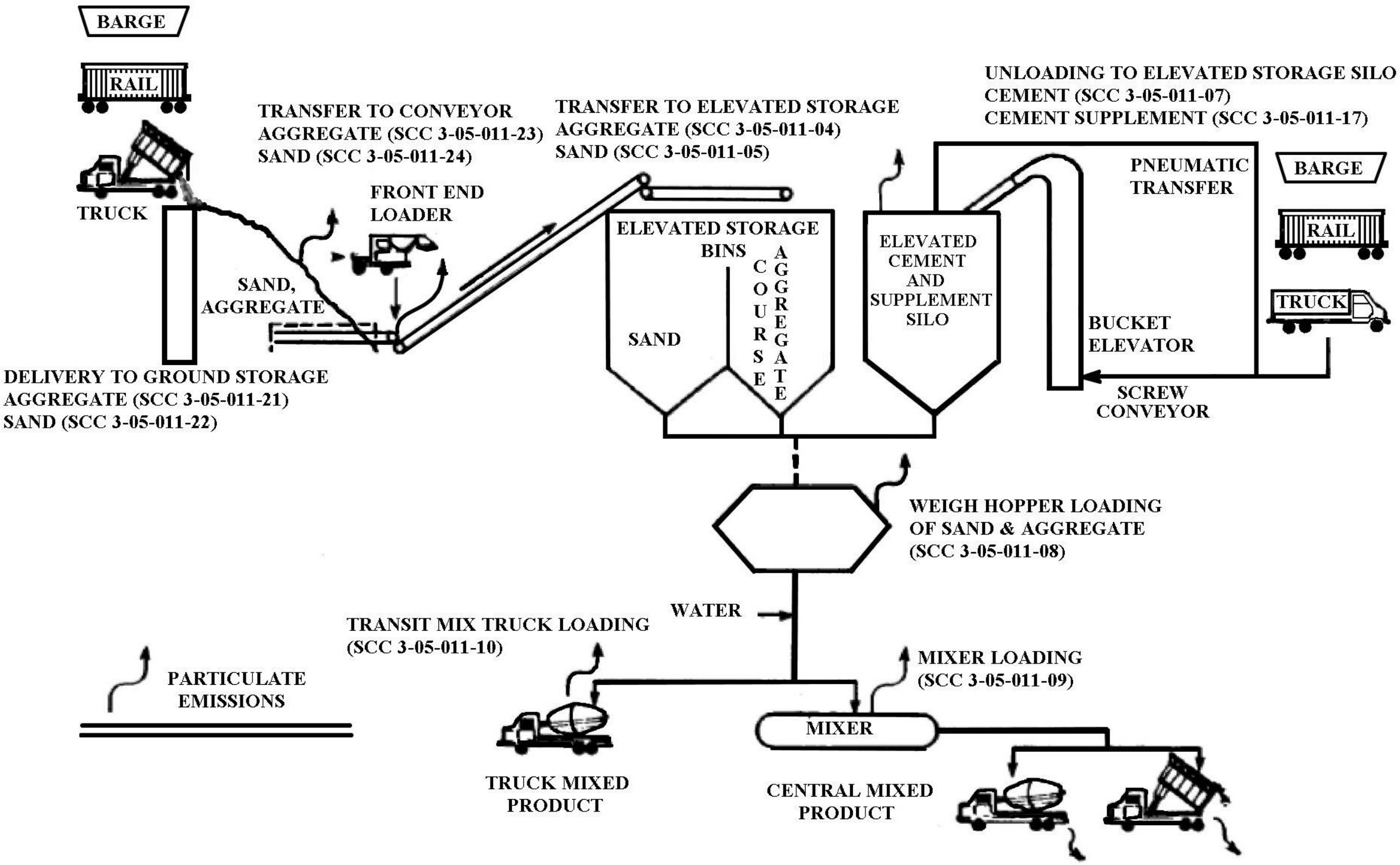

Figure 11.12-1. Typical Concrete Batching Process.

TABLE 11.12-1 (METRIC UNITS)
EMISSION FACTORS FOR CONCRETE BATCHING [a]

Source (SCC)	Uncontrolled				Controlled			
	Total PM	Emission Factor Rating	Total PM_{10}	Emission Factor Rating	Total PM	Emission Factor Rating	Total PM_{10}	Emission Factor Rating
Aggregate transfer [b] (3-05-011-04,-21,23)	0.0035	D	0.0017	D	ND		ND	
Sand transfer [b] (3-05-011-05,22,24)	0.0011	D	0.00051	D	ND		ND	
Cement unloading to elevated storage silo (pneumatic)[c] (3-05-011-07)	0.36	E	0.24	E	0.00050	D	0.00017	D
Cement supplement unloading to elevated storage silo (pneumatic)[d] (3-05-011-17)	1.57	E	0.65	E	0.0045	D	0.0024	E
Weigh hopper loading [e] (3-05-011-08)	0.0026	D	0.0013	D	ND		ND	
Mixer loading (central mix)[f] (3-05-011-09)	0.286 or Eqn. 11.12-1	B	0.078 or Eqn. 11.12-1	B	0.0092 or Eqn. 11.12-1	B	0.0028 or Eqn. 11.12-1	B
Truck loading (truck mix)[g] (3-05-011-10)	0.559	B	0.155	B	0.049 or Eqn. 11.12-1	B	0.0131 or Eqn. 11.12-1	B
Vehicle traffic (paved roads)	See AP-42 Section 13.2.1, Paved Roads							
Vehicle traffic (unpaved roads)	See AP-42 Section 13.2.2, Unpaved Roads							
Wind erosion from aggregate and sand storage piles	See AP-42 Section 13.2.5, Industrial Wind Erosion							

ND = No data

[a] All emission factors are in kg of pollutant per Mg of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 846 kg course aggregate, 648 kg sand, 223 kg cement and 33kg cement supplement. Approximately 75 liters of water was added to this solid material to produce 1826 kg of concrete.

[b] Reference 9 and 10. Emission factors are based upon an equation from AP-42, section 13.2.4 Aggregate Handling And Storage Piles, equation 1 with k_{PM-10} =.35, k_{PM} = .74, U = 10mph, $M_{aggregate}$ =1.77%, and M_{sand} = 4.17%. These moisture contents of the materials ($M_{aggregate}$ and M_{sand}) are the averages of the values obtained from Reference 9 and Reference 10.

[c] The uncontrolled PM & PM-10 emission factors were developed from Reference 9. The controlled emission factor for PM was developed from References 9, 10, 11, and 12. The controlled emission factor for PM-10 was developed from References 9 and 10.

[d] The controlled PM emission factor was developed from Reference 10 and Reference 12, whereas the controlled PM-10 emission factor was developed from only Reference 10.

[e] Emission factors were developed by using the AP-42 Section 13.2.4, Aggregate and Sand Transfer Emission Factors in conjunction with the ratio of aggregate and sand used in an average $yard^3$ of concrete. The unit for these emission factors is kg of pollutant per Mg of aggregate and sand.

[f] References 9, 10, and 14. The emission factor units are kg of pollutant per Mg of cement and cement supplement. The general factor is the arithmetic mean of all test data.

[g] Reference 9, 10, and 14. The emission factor units are kg of pollutant per Mg of cement and cement supplement. The general factor is the arithmetic mean of all test data.

TABLE 11.12-2 (ENGLISH UNITS)
EMISSION FACTORS FOR CONCRETE BATCHING [a]

Source (SCC)	Uncontrolled				Controlled			
	Total PM	Emission Factor Rating	Total PM_{10}	Emission Factor Rating	Total PM	Emission Factor Rating	Total PM_{10}	Emission Factor Rating
Aggregate transfer [b] (3-05-011-04,-21,23)	0.0069	D	0.0033	D	ND		ND	
Sand transfer [b] (3-05-011-05,22,24)	0.0021	D	0.00099	D	ND		ND	
Cement unloading to elevated storage silo (pneumatic)[c] (3-05-011-07)	0.73	E	0.47	E	0.00099	D	0.00034	D
Cement supplement unloading to elevated storage silo (pneumatic)[d] (3-05-011-17)	3.14	E	1.10	E	0.0089	D	0.0049	E
Weigh hopper loading [e] (3-05-011-08)	0.0048	D	0.0028	D	ND		ND	
Mixer loading (central mix)[f] (3-05-011-09)	0.572 or Eqn. 11.12-1	B	0.156 or Eqn. 11.12-1	B	0.0184 or Eqn. 11.12-1	B	0.0055 or Eqn. 11.12-1	B
Truck loading (truck mix)[g] (3-05-011-10)	1.118	B	0.310	B	0.098 or Eqn. 11.12-1	B	0.0263 or Eqn. 11.12-1	B
Vehicle traffic (paved roads)	See AP-42 Section 13.2.1, Paved Roads							
Vehicle traffic (unpaved roads)	See AP-42 Section 13.2.2, Unpaved Roads							
Wind erosion from aggregate and sand storage piles	See AP-42 Section 13.2.5, Industrial Wind Erosion							

ND = No data

[a] All emission factors are in lb of pollutant per ton of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 1865 lbs course aggregate, 1428 lbs sand, 491 lbs cement and 73 lbs cement supplement. Approximately 20 gallons of water was added to this solid material to produce 4024 lbs (one cubic yard) of concrete.

[b] Reference 9 and 10. Emission factors are based upon an equation from AP-42, section 13.2.4 Aggregate Handling And Storage Piles, equation 1 with k_{PM-10} =.35, k_{PM} = .74, U = 10mph, $M_{aggregate}$ =1.77%, and M_{sand} = 4.17%. These moisture contents of the materials ($M_{aggregate}$ and M_{sand}) are the averages of the values obtained from Reference 9 and Reference 10.

[c] The uncontrolled PM & PM-10 emission factors were developed from Reference 9. The controlled emission factor for PM was developed from References 9, 10, 11, and 12. The controlled emission factor for PM-10 was developed from References 9 and 10.

[d] The controlled PM emission factor was developed from Reference 10 and Reference 12, whereas the controlled PM-10 emission factor was developed from only Reference 10.

[e] Emission factors were developed by using the Aggregate and Sand Transfer Emission Factors in conjunction with the ratio of aggregate and sand used in an average $yard^3$ of concrete. The unit for these emission factors is lb of pollutant per ton of aggregate and sand.

[f] References 9, 10, and 14. The emission factor units are lb of pollutant per ton of cement and cement supplement. The general factor is the arithmetic mean of all test data.

[g] Reference 9, 10, and 14. The emission factor units are lb of pollutant per ton of cement and cement supplement. The general factor is the arithmetic mean of all test data.

The particulate matter emissions from truck mix and central mix loading operations are calculated in accordance with the values in Tables 11.12-1 or 11.12-2 or by Equation 11.12-1[14] when site specific data are available.

$$E = k\,(0.0032)\left[\frac{U^{a}}{M^{b}}\right] + c \qquad \text{Equation 11.12-1}$$

E	=	Emission factor in lbs./ton of cement and cement supplement
k	=	Particle size multiplier (dimensionless)
U	=	Wind speed at the material drop point, miles per hour (mph)
M	=	Minimum moisture (% by weight) of cement and cement supplement
a, b	=	Exponents
c	=	Constant

The parameters for Equation 11.12-1 are summarized in Tables 11.12-3 and 11.12-4.

Table 11.12-3. Equation Parameters for Truck Mix Operations

Condition	Parameter Category	k	a	b	c
Controlled[1]	Total PM	0.8	1.75	0.3	0.013
	PM_{10}	0.32	1.75	0.3	0.0052
	$PM_{10-2.5}$	0.288	1.75	0.3	0.00468
	$PM_{2.5}$	0.048	1.75	0.3	0.00078
Uncontrolled[1]	Total PM	1.118			
	PM_{10}	0.310			
	$PM_{10-2.5}$	0.260			
	$PM_{2.5}$	0.050			

Table 11.12-4. Equation Parameters for Central Mix Operations

Condition	Parameter Category	k	a	b	c
Controlled[1]	Total PM	0.19	0.95	0.9	0.0010
	PM_{10}	0.13	0.45	0.9	0.0010
	$PM_{10-2.5}$	0.12	0.45	0.9	0.0009
	$PM_{2.5}$	0.03	0.45	0.9	0.0002
Uncontrolled[1]	Total PM	5.90	0.6	1.3	0.120
	PM_{10}	1.92	0.4	1.3	0.040
	$PM_{10-2.5}$	1.71	0.4	1.3	0.036
	$PM_{2.5}$	0.38	0.4	1.3	0

1. Emission factors expressed in lbs/tons of cement and cement supplement

To convert from units of lbs/ton to units of kilograms per mega gram, the emissions calculated by Equation 11.12-1 should be divided by 2.0.

Particulate emission factors per yard of concrete for an average batch formulation at a typical facility are given in Tables 11.12-5 and 11.12-6. For truck mix loading and central mix loading, the emissions of PM, PM-10, PM-10-2.5, and PM-2.5 are calculated by multiplying the emission factor calculated using Equation 11.12-2 by a factor of 0.282 to convert from emissions per ton of cement and cement supplement to emissions per yard of concrete. This equation is based on a typical concrete formulation of 564 pounds of cement and cement supplement in a total of 4,024 pounds of material (including aggregate, sand, and water). This calculation is summarized in Equation 11.12-2.

$$\text{PM, PM10, PM10-2.5, PM2.5 emissions}\left(\frac{\text{pounds}}{\text{yd}^3\text{ of concrete}}\right) = 0.282 * \quad (\text{Equation 11.12}-1\text{ factor or Table 11.12-2 Factor})$$

Equation 11.12-2

*NOTE: August 8, 2011. The equation was corrected.
The basis of this conversion constant is:

EF (pounds / ton *cem*) * (ton *cem* / 2,000 pounds *cem*) * (564 pounds *cem* / yd^3 concrete) = EF (pounds / yd^3 concrete)

Where:

cem is the sum of cement (491 pounds) and cement supplement (73 pounds).

Metals emission factors for concrete batching are given in Tables 11.12-7 and 11.12-8. Alternatively, the metals emissions from ready mix plants can be calculated based on (1) the weighted average concentration of the metal in the cement and the cement supplement (i.e. flyash) and (2) on the total particulate matter emission factors calculated in accordance with Equation 11.12-3. Emission factors calculated using Equation 11.12-3 are rated D.

$$\text{Metal}_{EF} = \text{PM}_{EF}\left(\frac{aC + bS}{C + S}\right)$$

Equation 11.12-3

Where:

Metal_{EF}	=	Metal Emissions, Lbs. As per Ton of Cement and Cement Supplement
PM_{EF}	=	Controlled Particulate Matter Emission Factor (PM, PM10, or PM2.5) Lbs. per Ton of Cement and Cement Supplement
a	=	ppm of Metal in Cement
C	=	Quantity of Cement Used, Lbs. per hour
b	=	ppm of Metal in Cement Supplement
S	=	Quantity of Cement Supplement Used, Lbs. per hour

This equation is based on the assumption that 100% of the particulate matter emissions are material entrained from the cement and cement supplement streams. Equation 11.12-3 over-estimates total metal emissions to the extent that sand and fines from aggregate contribute to the total particulate matter emissions.

TABLE 11.12-5 (ENGLISH UNITS)
PLANT WIDE EMISSION FACTORS PER YARD OF TRUCK MIX CONCRETE [a]

	Uncontrolled		Controlled	
	PM (lb/yd^3)	PM-10 (lb/yd^3)	PM (lb/yd^3)	PM-10 (lb/yd^3)
Aggregate delivery to ground storage (3-05-011-21)	0.0064	0.0031	0.0064	0.0031
Sand delivery to ground storage (3-05-011-22)	0.0015	0.0007	0.0015	0.0007
Aggregate transfer to conveyor (3-05-011-23)	0.0064	0.0031	0.0064	0.0031
Sand transfer to conveyor (3-05-011-24)	0.0015	0.0007	0.0015	0.0007
Aggregate transfer to elevated storage (3-05-011-04)	0.0064	0.0031	0.0064	0.0031
Sand transfer to elevated storage (3-05-011-05)	0.0015	0.0007	0.0015	0.0007
Cement delivery to Silo (3-05-011-07 controlled)	0.0002	0.0001	0.0002	0.0001
Cement supplement delivery to Silo (3-05-011-17 controlled)	0.0003	0.0002	0.0003	0.0002
Weigh hopper loading (3-05-011-08)	0.0079	0.0038	0.0079	0.0038
Truck mix loading (3-05-011-10)	See Equation 11.12-2			

TABLE 11.12-6 (ENGLISH UNITS)
PLANT WIDE EMISSION FACTORS PER YARD OF CENTRAL MIX CONCRETE [a]

	Uncontrolled		Controlled	
	PM (lb/yd^3)	PM-10 (lb/yd^3)	PM (lb/yd^3)	PM-10 (lb/yd^3)
Aggregate delivery to ground storage (3-05-011-21)	0.0064	0.0031	0.0064	0.0031
Sand delivery to ground storage (3-05-011-22)	0.0015	0.0007	0.0015	0.0007
Aggregate transfer to conveyor (3-05-011-23)	0.0064	0.0031	0.0064	0.0031
Sand transfer to conveyor (3-05-011-24)	0.0015	0.0007	0.0015	0.0007
Aggregate transfer to elevated storage (3-05-011-04)	0.0064	0.0031	0.0064	0.0031
Sand transfer to elevated storage (3-05-011-05)	0.0015	0.0007	0.0015	0.0007
Cement delivery to Silo (3-05-011-07 controlled)	0.0002	0.0001	0.0002	0.0001
Cement supplement delivery to Silo (3-05-011-17 controlled)	0.0003	0.0002	0.0003	0.0002
Weigh hopper loading (3-05-011-08)	0.0079	0.0038	0.0079	0.0038
Central mix loading (3-05-011-09)	See Equation 11.12-2			

[a] Total facility emissions are the sum of the emissions calculated in Tables 11.12-4 or 11.12-5. Total facility emissions do not include road dust and wind blown dust. The emission factors in Tables 11.12-5 and 11.12-6 are based upon the following composition of one yard of concrete.

Coarse Aggregate	1865. pounds
Sand	1428. pounds
Cement	491. pounds
Cement Supplement	73. pounds
Water	20. gallons (167 pounds)

TABLE 11.12-7 (METRIC UNITS)
CONCRETE BATCH PLANT METAL EMISSION FACTORS [a]

	Arsenic	Beryllium	Cadmium	Total Chromium	Lead	Manganese	Nickel	Total Phosphorus	Selenium	Emission Factor Rating
Cement Silo Filling [b] (SCC 3-05-011-07) w/ Fabric Filter	8.38e-07 2.12e-09	8.97e-09 2.43e-10	1.17e-07 ND	1.26e-07 1.45e-08	3.68e-07 5.46e-09	1.01e-04 5.87e-08	8.83e-06 2.09e-08	5.88e-05 ND	ND ND	E E
Cement Supplement Silo Filling [c] (SCC 3-05-011-17) w/ Fabric Filter	ND 5.02e-07	ND 4.52e-08	ND 9.92e-09	ND 6.10e-07	ND 2.60e-07	ND 1.28e-07	ND 1.14e-06	ND 1.77e-06	ND 3.62e-08	E E
Central Mix Batching [d] (SCC 3-05-011-09) w/ Fabric Filter	4.19e-06 1.48e-07	ND ND	5.92e-09 3.55e-10	7.11e-07 6.34e-08	1.91e-07 1.83e-08	3.06e-05 1.89e-06	1.64e-06 1.24e-07	1.01e-05 6.04e-07	ND ND	E E
Truck Loading [e] (SCC 3-05-011-10) w/ Fabric Filter	6.09e-06 3.01e-07	1.22e-07 5.18e-08	1.71e-08 4.53e-09	5.71e-06 2.05e-06	1.81e-06 7.67e-07	3.06e-05 1.04e-05	5.99e-06 2.39e-06	1.92e-05 6.16e-06	1.31e-06 5.64e-08	E E

ND=No data

[a] All emission factors are in kg of pollutant per Mg of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 846 Kg course aggregate, 648 kg sand, 223 kg cement and 33kg cement supplement. Approximately 75 liters of water was added to this solid material to produce 1826 kg of concrete.

[b] The uncontrolled emission factors were developed from Reference 9. The controlled emission factors were developed form Reference 9 and 10. Although controlled emissions of phosphorous compounds were below detection, it is reasonable to assume that the effectiveness is comparable to the average effectiveness (98%) for the other metals.

[c] Reference 10.

[d] Reference 9. The emission factor units are kg of pollutant per Mg of cement and cement supplement. Emission factors were developed from a typical central mix operation. The average estimate of the percent of emissions captured during each run is 94%.

[e] Reference 9 and 10. The emission factor units are kg of pollutant per Mg of cement and cement supplement. Emission factors were developed from two typical truck mix loading operations. Based upon visual observations of every loading operation during the two test programs, the average capture efficiency during the testing was 71%.

TABLE 11.12-8 (ENGLISH UNITS)
CONCRETE BATCH PLANT METAL EMISSION FACTORS [a]

	Arsenic	Beryllium	Cadmium	Total Chromium	Lead	Manganese	Nickel	Total Phosphorus	Selenium	Emission Factor Rating
Cement Silo Filling [b] (SCC 3-05-011-07)	1.68e-06	1.79e-08	2.34e-07	2.52e-07	7.36e-07	2.02e-04	1.76e-05	1.18e-05	ND	E
w/ Fabric Filter	4.24e-09	4.86e-10	ND	2.90e-08	1.09e-08	1.17e-07	4.18e-08	ND	ND	E
Cement Supplement Silo Filling [c] (SCC 3-05-011-17)	ND	ND	ND	ND	ND	ND	ND	ND	ND	E
w/ Fabric Filter	1.00e-06	9.04e-08	1.98e-10	1.22e-06	5.20e-07	2.56e-07	2.28e-06	3.54e-06	7.24e-08	E
Central Mix Batching [d] (SCC 3-05-011-09)	8.38e-06	ND	1.18e-08	1.42e-06	3.82e-07	6.12e-05	3.28e-06	2.02e-05	ND	E
w/ Fabric Filter	2.96e-07	ND	7.10e-10	1.27e-07	3.66e-08	3.78e-06	2.48e-07	1.20e-06	ND	E
Truck Loading [e] (SCC 3-05-011-10)	1.22e-05	2.44e-07	3.42e-08	1.14e-05	3.62e-06	6.12e-05	1.19e-05	3.84e-05	2.62e-06	E
w/ Fabric Filter	6.02e-07	1.04e-07	9.06e-09	4.10e-06	1.53e-06	2.08e-05	4.78e-06	1.23e-05	1.13e-07	E

ND=No data

[a] All emission factors are in lb of pollutant per ton of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 1865 lbs course aggregate, 1428 lbs sand, 491 lbs cement and 73 lbs cement supplement. Approximately 20 gallons of water was added to this solid material to produce 4024 lbs (one cubic yard) of concrete.

[b] The uncontrolled emission factors were developed from Reference 9. The controlled emission factors were developed form Reference 9 and 10. Although controlled emissions of phosphorous compounds were below detection, it is reasonable to assume that the effectiveness is comparable to the average effectiveness (98%) for the other metals.

[c] Reference 10.

[d] Reference 9. The emission factor units are lb of pollutant per ton of cement and cement supplement. Emission factors were developed from a typical central mix operation. The average estimate of the percent of emissions captured during each test run is 94%.

[e] Reference 9 and 10. The emission factor units are lb of pollutant per ton of cement and cement supplement. Emission factors were developed from two typical truck mix loading operations. Based upon visual observations of every loading operation during the two test programs, the average capture efficiency during the testing was 71%.

References for Section 11.12

1. *Air Pollutant Emission Factors*, APTD-0923, U.S. Environmental Protection Agency, Research Triangle Park, NC, April 1970.

2. *Air Pollution Engineering Manual*, 2nd Edition, AP-40, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1974. Out of Print.

3. Telephone and written communication between Edwin A. Pfetzing, PEDCo Environmental., Inc., Cincinnati, OH, and Richards Morris and Richard Meininger, National Ready Mix Concrete Association, Silver Spring, MD, May 1984.

4. *Development Document for Effluent Limitations Guidelines and Standards of Performance, The Concrete Products Industries, Draft*, U.S. Environmental Protection Agency, Washington, DC, August 1975.

5. Portland Cement Association. (2001). Concrete Basics. Retrieved August 27, 2001 from the World Wide Web: http://www.portcement.org/cb/

6. *Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions*, EPA-450/3-77-010, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1977.

7. *Fugitive Dust Assessment at Rock and Sand Facilities in the South Coast Air Basin*, Southern California Rock Products Association and Southern California Ready Mix Concrete Association, Santa Monica, CA, November 1979.

8. Telephone communication between T.R. Blackwood, Monsanto Research Corp., Dayton, OH, and John Zoller, PEDCo Environmental, Inc., Cincinnati, OH, October 18, 1976.

9. *Final Test Report for USEPA* [sic] *Test Program Conducted at Chaney Enterprises Cement Plant*, ETS, Inc., Roanoke, VA April 1994.

10. *Final Test Report for USEPA* [sic] *Test Program Conducted at Concrete Ready Mixed Corporation*, ETS, Inc., Roanoke, VA April 1994.

11. *Emission Test for Tiberi Engineering Company*, Alar Engineering Corporation, Burbank, IL, October, 1972.

12. *Stack Test "Confidential"* (Test obtained from State of Tennessee), Environmental Consultants, Oklahoma City, OK. February 1976.

13. *Source Sampling Report, Particulate Emissions from Cement Silo Loading*, Specialty Alloys Corporation, Gallaway, Tennessee, Reference number 24-00051-02, State of Tennessee, Department of Health and Environment, Division of Air Pollution Control, June 12, 1984.

14. Richards, J. and T. Brozell. "*Ready Mixed Concrete Emission Factors, Final Report*" Report to the Ready Mixed Concrete Research Foundation, Silver Spring, Maryland. August 2004.

TESTIMONY OF

ELUID L. MARTINEZ

EXHIBITS

ELUID L. MARTINEZ
P.O. Box 31066
Santa Fe, NM 87594-1066
Telephone: (505) 984-9817
E-mail: eluid@excite.com

EXPERIENCE:

2001 – Present	Water Resources Management Consultants, LLC Mailing Address: P.O. Box 31066, Santa Fe, NM 87594-1066 Physical Address: 505 Don Gaspar Ave, Santa Fe, NM 87505 *President, Water Resources Management Consultants, LLC*
12/1995 – 01/2001	Commissioner of Reclamation, United States Bureau of Reclamation, Department of the Interior, United States Presidential Appointment, confirmed by the United States Senate.
12/1990 – 12/1994	New Mexico State Engineer and Secretary of the New Mexico Interstate Stream Commission, appointed by the governor and confirmed by the State Senate. Served as the New Mexico Compact Commissioner/Representative to the following: Rio Grande Compact Colorado River Compact La Plata River Compact Costilla Creek Compact Member of the New Mexico Water Quality Control Commission, New Mexico Coal Surface Mining Commission and the New Mexico Hardrock Mining Commission.
04/1984 – 11/1990	Chief of Technical Division, New Mexico State Engineer's Office. Also served as a State Engineer's Water Rights Hearing Examiner/Officer.
09/1971 – 04/1984	Office of the New Mexico State Engineer, Chief of the Hydrographic Survey Section; Acting Chief, Water Use and Reports Section; Acting Chief, Administrative Services Section

PROFESSIONAL PUBLICATIONS:

E.g., Colorado River Basin Water Management: Evaluating and Adjusting for Hydroclimatic Variability (Co-author) (National Research Council of the National Academics).

PROFESSIONAL ACTIVITIES:

2002 – Present

Principal, Water Resources Management Consultant, LLC. I am a registered Professional Engineer and Land Surveyor and consult in water rights, water rights administration and water management issues.

I have testified several times as an expert in contested water right application hearings before State Engineer appointed Hearing Examiners.

I have testified in court and/or prepared expert reports or affidavits as follows:

I prepared an expert witness report and testified for the City of Alamogordo in the matter of the City of Alamogordo and David and Julia Christopher and Tularosa Community Ditch Corporation, Dan C. Abercrombie, Else I. Baily, Laymon Hightower, David Rankin and Allen (Bill) Trammell vs. New Mexico State Engineer, John R. D'Antonio, Jr. and HFR

Corporation and Three Rivers Cattle Ltd Co. in the Twelfth Judicial District Court, County of Otero, State of New Mexico.

I prepared an expert Affidavit for the Defendant in the Matter of Henry G. Coors and South Hills Water Company, Plaintiff v. Albuquerque Bernalillo County Water Utility Authority, Defendant, in Cause No. CV-2010-04258, Second Judicial District Court, County of Bernalillo, State of New Mexico.

I prepared an expert Affidavit for the Defendant in the matter of Harper Cattle L.L.C. Plaintiff vs. The Mora Trust and Harold Daniels, Individually, Defendants, Fourth Judicial District Court, County of Mora, State of New Mexico.

I prepared expert Affidavits for the Albuquerque-Bernalillo County Water Utility Authority in the case of Albuquerque-Bernalillo County Water Utility Authority vs. New Mexico State Engineer John D'Antonio and Herk Rodriguez D.B.A. New Mexico Land and Water Conservancy, LLC.

I prepared expert witness reports for Tri-State Electric Generation and Transmission Association, Inc. with respect to Past and Present Use Water Rights of Pueblos Acoma and Laguna.

I prepared an expert Affidavit and a Statement of Opinions for the City of Las Cruces in the Lower Rio Grande Stream System and Underground Water Basin Adjudication, Stream System related to the claims of the United States with respect to the Rio Grande Project.

HONORS:

Member:
Sigma Tau-National Engineering Honor Society
Chi Epsilon-National Civil Engineering Honor Society
Sigma Chi Rho-NMSU Civil Engineering Honor Society

MEMBERSHIPS:

Present Member, Board of Directors, National Water Resources Association

Past Member, New Mexico Supreme Court Appointee to the Judicial Performance Evaluation Commission

Past Member, Western States Water Council

Past Member, National Drought Policy Commission

Past Member, National Research Council, National Academy, Committee on the Scientific Basis of Colorado River Basin Water Management

Past Member, City of Santa Fe Board of Education
City of Santa Fe Redevelopment Commission
City of Santa Fe Urban Policy Board
City of Santa Fe Historical Styles Committee
City of Santa Fe Planning Commission
City/County of Santa Fe Planning and Zoning Commission
City/County of Santa Fe Extra Territorial Zoning Commission

EDUCATION:

Bachelor of Science-Civil Engineering
New Mexico State University 1968

File H-4700

NEW MEXICO OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO USE UNDERGROUND WATERS IN ACCORDANCE WITH SECTIONS 72-12-1.1, 72-12-1.2, OR 72-12-1.3 NEW MEXICO STATUTES

For fees, see State Engineer website: http://www.ose.state.nm.us/

1. APPLICANT(S)

Name: RYAN ROPER, ROPER INVESTMENTS LLC	Name:
Contact or Agent: check here if Agent ☐	Contact or Agent: check here if Agent ☐
Mailing Address: PO BOX 969	Mailing Address:
City: ALTO	City:
State: NM Zip Code: 88312	State: Zip Code:
Phone: 575-973-0440 ☐ Home ■ Cell Phone (Work): 575-973-0440	Phone: ☐ Home ☐ Cell Phone (Work):
E-mail (optional): RYAN@ROPER-NM.COM	E-mail (optional):

☐ Check here if existing well. Enter OSE File No. ____________

2. WELL LOCATION Required: Coordinate location must be New Mexico State Plane (NAD 83), UTM (NAD 83), or Lat/Long (WGS84). District II (Roswell) and District VII (Cimarron) customers, provide a PLSS location in addition to above.

NM State Plane (NAD83) - In feet	NM West Zone ☐ NM Central Zone ☐ NM East Zone ☐	X (in feet): Y (in feet): OSE DII MAY 6 2021 PM1:55					
UTM (NAD83) - In meters	UTM Zone 13N ☐ UTM Zone 12N ☐	Easting (in meters): Northing (in meters):					
Lat/Long (WGS84) - To 1/10th of second ■ Check if seconds are decimal format	Lat: 33 deg	25	min	8.93	sec		
	Long: 105 deg	39	min	52.67	sec		

Other Location Information (complete the below, if applicable):

PLSS Quarters or Halves: NE, NW, NE (2,1,2) Section: 27 Township: 10S Range: 13E

County: LINCOLN

Land Grant Name (if applicable):

Lot No: Block No: Unit/Tract: Subdivision:

Hydrographic Survey: Map: Tract:

Other description relating well to common landmarks, streets, or other:

Well is on Land Owned by (Required): ROPER INVESTMENTS LLC

FOR OSE INTERNAL USE

Application for Permit, Form wr-01, Rev 6/30/17

File No.: H-4700-POD1	Trn. No.: 694824	Receipt No.: 2-43330
Well Tag ID No. (if applicable): 20E74	Sub-Basin: HRR	Log Due Date: 05-07-2022

3. PURPOSE OF USE

- ☐ Domestic use for one household
- ☒ Livestock watering
- ☐ Domestic use for more than one household. Number of households _____ Note: List each lot and owner contact information.
- ☐ Drinking and sanitary uses that are incidental to the operations of a governmental, commercial, or non-profit facility
- ☐ Prospecting, mining or drilling operations to discover or develop natural resources
- ☐ Construction of public works, highways and roads
- ☐ Domestic use for one household and livestock watering
- ☐ Domestic use for multiple households and livestock watering
- ☐ Domestic well to accompany a house or other dwelling unit constructed for sale
- ☐ New well (with new purpose)
- ☐ Amend purpose of use on existing well
- ☐ No change in purpose

4. WELL INFORMATION: CHECK THOSE THAT APPLY ☐ Existing Well ☐ Known Artesian

File Information: (If existing well, provide OSE no. & indicate below if well is to be replacement, repaired or deepened, or supplemental. If new well, leave blank, as OSE must assign no.)		
OSE Well No.(If Existing)	New Well No. (provided by OSE)	
Well Driller Name: KD HUEY CO., LLC	**Well Driller License Number:** WD68	
Approximate Depth of Well (feet): 400	Outside Diameter of Well Casing (inches): 5.5	
☐ Replacement well (List all existing wells if more than one):	☐ Repair or Deepen: ☐ Clean out well to original depth ☐ Deepen well from _____ to _____ ft. ☐ Other (Explain):	☐ Supplemental well (List OSE No. for all wells this will supplement):

5. ADDITIONAL STATEMENTS OR EXPLANATIONS (Use additional sheets if necessary)

OSE DII MAY 6 2021 PM1:55

ACKNOWLEDGEMENT

I, We (name of applicant(s)), RYAN ROPER, ROPER INVESTMENTS LLC
Print Name(s)

affirm that the foregoing statements are true to the best of (my, our) knowledge and belief.

[signature]
Applicant Signature

Applicant Signature

ACTION OF THE OFFICE OF THE STATE ENGINEER (FOR OSE USE ONLY)

This application is approved subject to the attached general and specific conditions of approval.

Witness my hand and seal this 7th day of May 20 21, for the New Mexico State Engineer,

By: [signature]
Signature

[signature]
Print

FOR OSE INTERNAL USE

Well Tag ID Issued? ☒ Yes ☐ No

Application for Permit, Form wr-01, Rev 6/30/17

File No.: H-4700-POD1	Trn No.: 694824	Well ID Tag No.: 20E74

NEW MEXICO STATE ENGINEER OFFICE
APPLICATION FOR PERMIT TO USE UNDERGROUND WATERS
IN ACCORDANCE WITH SECTION 72-12-1 NEW MEXICO STATUTES

GENERAL CONDITIONS OF APPROVAL (A thru R)

17-A The maximum combined diversion of all wells that may be appropriated under this permit is 3.000 acre-feet in any year (One acre-foot equals 325,851 gallons).

17-B The well shall be drilled by a driller licensed in the State of New Mexico in accordance with 72-12-12 NMSA 1978. A licensed driller shall not be required for the construction of a well driven without the use of a drill rig; provided that the casing shall not exceed two and three-eighths (2 3/8) inches outside diameter.

17-C The well driller must file the well record with the State Engineer and the applicant within 30 days after the well is drilled or driven. It is the well owner's responsibility to ensure that the well driller files the well record. The well driller may obtain the well record form from any District Office or the Office of the State Engineer website.

17-D The production casing shall not exceed 7 inches outside diameter except under specific conditions in which reasons satisfactory to the State Engineer are shown.

17-E To request a change to the purpose of use of water authorized under this permit, the permittee shall file an application with the State Engineer.

17-F An application for a new 72-12-1.1 NMSA 2003 domestic well permit where the proposed point of diversion is to be located on the same legal lot of record as an operational 72-12-1.1 NMSA domestic well shall be treated as an application for a supplemental well and the combined diversion may not exceed the maximum annual diversion permitted.

17-G If artesian water is encountered, the well driller shall comply with all rules and regulations pertaining to the drilling and casing of artesian wells.

17-H The drilling of the well and amount and uses of water permitted are subject to such limitations as may be imposed by a court or by lawful municipal or county ordinance which are more restrictive than the conditions of this permit and applicable State Engineer regulations.

GENERAL CONDITIONS OF APPROVAL (Continued)

17-I The permittee shall utilize the highest and best technology available to ensure conservation of water to the maximum extent practical.

17-J The well shall be set back a minimum of 50 ft. from an existing well of other ownership unless a variance has been granted by the State Engineer. The State Engineer may grant a variance for a replacement well or to allow for maximum spacing of the well from a source of groundwater contamination. The well shall be set back from potential sources of contamination in accordance with federal, state, and local requirements.

17-K Pursuant to section 72-8-1 NMSA 1978, the permittee shall allow the State Engineer and OSE representatives entry upon private property for the performance of their respective duties, including access to the ditch or acequia to measure flow and also to the well for meter reading and water level measurement.

17-L The permit is subject to cancellation for non-compliance with the conditions of approval or if otherwise not exercised in accordance with the terms of the permit.

17-M The right to divert water under this permit is subject to curtailment by priority administration as implemented by the State Engineer or a court.

17-N In the event of any change of ownership to this permit the new owner shall file a change of ownership form with the State Engineer in accordance with Section 72-1-2.1 NMSA 1978.

17-O This well permit shall automatically expire unless the well is completed and the well record is filed with the State Engineer within one year of the date of issuance of the permit.

17-P The well shall be constructed, maintained, and operated to prevent inter-aquifer exchange of water and to prevent loss of hydraulic head between hydrogeologic zones.

17-Q The State Engineer retains jurisdiction over this permit.

NEW MEXICO STATE ENGINEER OFFICE
APPLICATION FOR PERMIT TO USE UNDERGROUND WATERS
IN ACCORDANCE WITH SECTION 72-12-1 NEW MEXICO STATUTES

GENERAL CONDITIONS OF APPROVAL (Continued)

17-R The State Engineer shall supply a well identification tag for the well driller to firmly affix to the well casing or cap with a steel band upon completion in accordance with Subsection M of 19.27.4.29 NMAC.
The permit holder is responsible for maintaining the well identification tag.

Well Tag(s) associated with this permit:
20E74

SPECIFIC CONDITIONS OF APPROVAL

17-10 Total diversion from all wells under this permit number shall not exceed 3.000 acre-feet per annum.

17-14 This permit authorizes the diversion of water for watering livestock. The total diversion of water under this permit shall not exceed 3.000 acre-feet per year.

LOG This permit will automatically expire unless the well H 04700 POD1 is completed and the well record filed on or before 05/07/2022.

ACTION OF STATE ENGINEER

This application is approved for the use indicated, subject to all general conditions and to specific conditions listed above.

Witness my hand and seal this 07 day of May A.D., 2021

John R. D Antonio, Jr., P.E. , State Engineer

By: [signature]
MARET AMARAL

Trn Desc: H 04700 POD1
Log Due Date: 05/07/2022
Form: wr-01

File Number: H 04700
Trn Number: 694824