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Michigan Department of Natural Resources & Environment
Air Quality Division
P.O. Box 30473
Lansing, MI 48909

May 7, 2010
NTH Project No. 16-060556

RE: Response to Request for Information
Holland Board of Public Works
Application 25-07

Dear Ms. Dolehanty:

In response to your letter dated March 10, 2010 and as a result of comments received during the open public comment period, the Holland Board of Public Works (HBPW) has requested that NTH Consultants, Ltd. (NTH) perform an ambient impact analysis demonstrating that the proposed project will meet the national ambient air quality standard (NAAQS) for emissions of $PM_{2.5}$. As part of this analysis, NTH has completed a modeling protocol for your review that describes the methodology that will be used in performing the dispersion modeling analysis.

Upon your review and acceptance of this protocol, NTH will submit the modeling analysis for emissions of $PM_{2.5}$ from the proposed project.

If you have any further questions, please feel free to contact us at (517) 484-6900.

Sincerely,

NTH Consultants, Ltd.

Jeffrey P. Jaros
Project Manager

Delbert Rector, P.E.
Senior Vice President

Enclosure

cc: Mr. Vrajesh Patel, Michigan Department of Environmental Quality
Mr. David Koster, Holland Board of Public Works
Charles Denton, Esquire, Barnes & Thornburg LLP
Mr. Daniel Mitas, HDR|CB

JPJ/DR/mjb

MODELING PROTOCOL

$PM_{2.5}$ Air Dispersion Modeling

In Response to Comments on Draft Permit 25-07

HOLLAND BOARD OF PUBLIC WORKS

James DeYoung Facility

Holland, Michigan

May 7, 2010

NTH Project Number: 16-050556

Prepared by:
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A Site Map and Preliminary Drawings

B Land Use Designations

C Estimation of CFB Project $PM_{2.5}$ Emissions

1.0 INTRODUCTION

The Holland Board of Public Works ("HBPW") is seeking an air use permit to install for a new circulating fluidized bed ("CFB") boiler to be constructed at the existing James DeYoung Facility. To this end, HBPW has previously submitted an application and technical support document that includes an ambient impact analysis for all affected new source review (NSR) pollutants for which there will be a significant increase in emissions. Specifically, a dispersion modeling analysis was conducted for PM_{10}, CO, Pb and toxic air contaminants. As part of the application review process, MDNRE held an open public comment period that included a public hearing. During this time, MDNRE accepted comments on the draft permit proposed by MDNRE.

Some of the public comments on the draft permit expressed the need to ensure that the emissions from the plant will not interfere with attainment of the National Ambient Air Quality Standard for $PM_{2.5}$. While the use of PM_{10} as a surrogate for $PM_{2.5}$ is still necessary and appropriate, and MDNRE's policy to that effect is still in effect, in response to a letter from MDNRE dated March 10, 2010, HBPW requested that NTH Consultants, Ltd. ("NTH") prepare and submit this modeling protocol, and subsequent $PM_{2.5}$ modeling to assist the MDNRE in responding to such comments. This protocol has been prepared according to Section 9 of the Michigan Air Use Permit Technical Manual and 40 CFR Part 51 Appendix W. Except as noted, this protocol is identical to that prepared and submitted to MDNRE in January, 2006 for PM_{10} modeling supporting the draft permit.

1.1 Project Description

HBPW is proposing to construct and install a new circulating fluidized bed ("CFB") boiler to be constructed at the existing James DeYoung Facility located in Holland, MI. The application and draft permit is identified as Permit to Install No. 25-07.

The preliminary site drawings related to the proposed project were included in Appendix A of the original application, and with the modeling protocol submitted on January 18, 2006, and are included with this protocol.

2.0 MODEL PROPOSED

The ambient impact analysis will utilize the AERMOD dispersion model version 09292.

2.1 AERMOD

On November 9, 2005, the U.S. Environmental Protection Agency promulgated the use of the **A**MS/**E**PA **R**egulatory **M**odel **I**mprovement **C**ommittee (AERMIC) **Mod**el (AERMOD) for all regulatory applications requiring an ambient impact demonstration.

AERMOD is a steady-state Gaussian model capable of handling multiple source inputs and producing concentration impacts from point, area, volume, and open-pit sources. AERMOD is also capable of handling numerous source configurations, building inputs, receptor grids and elevated terrain.

For this project, HBPW proposes to use the most current version of the AERMOD source code (version 09292).

2.2 Proprietary Model Information

NTH has license agreements with both Trinity Consultants and Lakes Environmental Software, Inc. For this application, the most recent version of the Lakes Environmental's ISC-AERMOD View will be used. The current version of this program is Version 6.5.0. This software is a graphical user interface (GUI) to the AERMOD model and provides the user with input screens for ease in setting up the model runstream, and viewing inputs and outputs through a graphical viewer. The textual input and output files, as well as the ISCView file (*.isc) if requested, will be provided electronically to the MDNRE.

3.0 METEOROLOGICAL DATA

Actual surface meteorological (MET) data is required for use in the AERMOD modeling system. Raw meteorological data obtained in the SAMSON format can be readily obtained from any number of sources. Prior to use with the model, the meteorological data must be processed through the AERMET pre-processor with certain site characteristics, including vegetative cover, friction velocity, etc. In addition, deposition modeling requires that the pre-processed MET data include values for precipitation codes, precipitation rates, relative humidity, surface pressure, and cloud cover, along with the normal parameters required for dispersion modeling. The description of the meteorological data that will be used for this project is provided below.

3.1 Source Location

The James DeYoung Facility is located at 64 Pine Avenue in Holland, Michigan on the shores of Lake Macatawa in southern Ottawa County. The facility consists of 3 active coal fired boilers (Units 3, 4 and 5). Unit 3 will be shut down and razed to accommodate the installation of the CFB boiler, to be known as Unit 10.

3.2 Available Meteorological Data

The Air Quality Division (AQD) has provided processed meteorological (MET) data for 57 stations in Michigan for the AERMOD model via the MDNRE website to use when using the model in dispersion mode. This available surface data has been pre-processed with available upper air meteorological data from rawinsonde soundings. NTH will use the same 5-year (2003-2007) dataset from Tulip City Airport, Station #12636, previously provided by the MDNRE for this project.

3.3 Site Specific Features And Meteorological Data

Meteorological data for use in AERMOD must be processed through the AERMET pre-processing program available from U.S. EPA. As part of processing the MET files, the user must specify certain site-specific surface features and characteristics and can, therefore, tailor any MET file to the site-specific conditions at the facility site. The AQD recently completed the process of determining representative surface characteristics for use in preparing pre-processed "AERMOD-ready" MET data. This data has been posted via their website.

4.0 PROPOSED RECEPTOR SYSTEM AND TERRAIN ELEVATIONS

Currently, no formal guidance exists for establishing a receptor grid. Instead, EPA states that the ambient impact analysis needs to be sufficient such that the maximum impact is obtained through the use of air quality models.

4.1 Receptor Grid System

In performing the ambient impact analysis for $PM_{2.5}$ for use in comparing ground level impacts to the NAAQS, a multi-tiered receptor grid will be used. This grid will be most dense within close proximity to the facility site and will gradually become less dense traveling out from the source. Consistent with the GAQM and MDNRE – AQD recommendations, the ambient air impact analyses (criteria pollutant and TAC modeling) utilized the following receptor grid configuration:

- Fence Line Receptors: Receptors were placed on the facility fence line at 25 meter spacing.
- Near-field Cartesian Receptor Grid: Receptors were placed at 50 meter spacing from the fence line outward to 1 km from the center of the facility sources (572,490.92, 4,738,257.70).
- Mid-field Cartesian Receptor Grid: Receptors were placed at 100 meter spacing from the boundary of the Near-field grid out to 3 km from the center point.
- Far-field Cartesian Receptor Grid: Receptors were placed at 250 meter spacing from the boundary of the Mid-field grid outward to 5 km. As a result, the overall grid occupies a 10 km by 10 km area. The southwest corner of the far-field grid in the UTM coordinate system is (567,490.92 Easting, 4,733,257.70 Northing.

The combination of these receptor grids provides a more dense (50m) grid close to the facility, while expanding the grid out 5 km in each direction from the facility center with wider receptor spacing (up to 250-m spacing). The use of this receptor grid configuration contains a total of 6,032 receptors. A printout of the dispersion modeling receptor grid was provided in Appendix D of the original modeling protocol. There are no proposed changes to the receptor grid.

4.2 AERMAP

AERMOD requires the use of an elevated terrain data file for use in establishing elevations for all sources, buildings and receptors. The AERMAP pre-processor is used to process digital elevation maps with location points for all sources, structures, and receptors. The 7.5-minute digitized topographic files for the area surrounding the facility will be used to obtain elevations and hill heights as required by the AERMOD model. The following NAD27 based Digital Elevation Models (DEMs) will be incorporated into the AERMOD model via the AERMAP pre-processor:

- Holland East
- Holland West
- Hamilton East
- Hamilton West
- Borculo
- Hudsonville West
- Port Sheldon
- Saugatuck

5.0 SOURCES TO BE MODELED

Detailed emission rate and modeled emission information for $PM_{2.5}$ are provided in Attachment C.

5.1 Sources For Dispersion Modeling

Dispersion modeling is used for the ambient impact analysis to demonstrate compliance with the $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS). This is being done as requested to assist MDNRE in responding to public comments. Consistent with recent EPA guidance[1] regarding the use of the PM_{10} Surrogate Policy, PSD increment modeling will not be performed.

Modeling involves the development of an appropriate emission inventory in order to show compliance with the applicable standards. NTH will use the existing James DeYoung sources, the proposed new CFB Boiler and associated ancillary equipment, and the same offsite sources provided by the MDNRE for the PM_{10} modeling. The $PM_{2.5}$ hourly emission rates summarized in Attachment C will be used in the proposed $PM_{2.5}$ modeling. Since there are minor design changes to stacks, NTH will re-perform the PM_{10} NAAQS analysis to confirm that the CFB

[1] US EPA Region IV, Gregg Worley Memo Re Trimble County Kentucky Unit 2 Project, October 2, 2009

project will not be culpable for any predicted exceedances of the NAAQS should the modeling predict a potential violation of the NAAQS.

6.0 MODELING OPTIONS

The following is a brief discussion of the modeling options that will be employed in the dispersion and deposition modeling.

6.1 Default and Non-Default Options

The use of the default options will be used for the NAAQS demonstration.

6.2 Rural/Urban Dispersion Option

Historically, only sources located in the Detroit city area in Southeast Michigan and in the Grand Rapids area in West Michigan have been modeled by the AQD using the URBAN dispersion option. Although there are some areas of fairly dense population within the central Holland area, there is not a significant amount of industrial manufacturing and the population density rapidly decreases outside a 1-2 mile radius of the central city area. Based upon these observations, NTH is proposing to conduct all modeling analyses utilizing the RURAL source option

7.0 PROPOSED CAVITY CALCULATIONS

The U.S. EPA regulations require that all modeling demonstrations address pollutant impacts within the cavity region. With the development of the PRIME algorithms, which is now directly incorporated into AERMOD, a separate analysis to address cavity concentrations is unnecessary. Use of AERMOD is determined to demonstrate compliance with the requirement to address concentrations within a cavity region.

8.0 MODELING APPROACH

The initial modeling runs will be conducted to determine if the significant impact levels (SILs) will be exceeded. If not, no further modeling is required. If the SILs are exceeded, the NAAQS modeling runs will determine the receptors, if any, with predicted concentrations above the difference of the NAAQS value and the background values for $PM_{2.5}$. The background data from 2006-2008 show that the background concentrations are 30.1 µg/m^3 for the 24-hour NAAQS and 11.0 µg/m^3 for the annual average NAAQS. The target values that will define the critical isopleths will, therefore be:

- 4.9 µg/m^3 (24-hour)
- 4.0 µg/m^3 (Annual)

The NAAQS runs will yield a 24-hour 8th high averaged for a five year period, and a 1st high annual average.

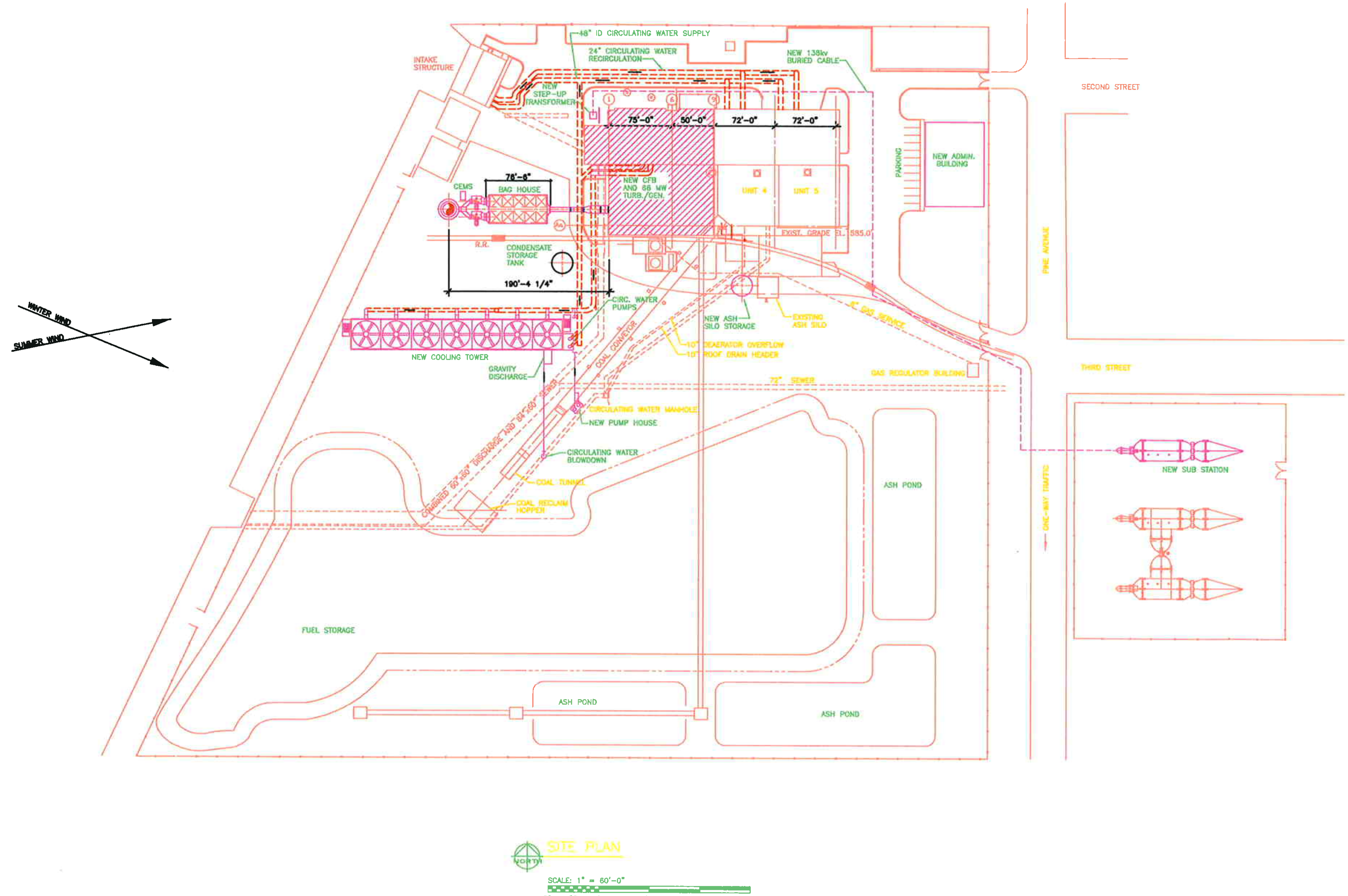
The previous PM_{10} modeling predicted an exceedance of the PM_{10} NAAQS. In the event that an exceedance of the $PM_{2.5}$ NAAQS is predicted, NTH will perform a culpability analysis to demonstrate that the CFB project does not contribute to the exceedance. This will require year-by-year modeling of only the CFB project sources to determine the receptors for annual average and the receptor-days for the 24-hour average that are above the SILs. Unless there are final regulations or guidance to the contrary, NTH will utilize the lowest U.S. EPA proposed SILs of 1.2 µg/m^3 on a 24-hour basis and 0.3 µg/m^3 on an annual basis for this culpability analysis.

The culpability analysis will be done by determining if there is any overlap of the isopleths of 1st high values from the modeling of the CFB Project sources with the predicted exceedance area. If there is an overlap for the 24-hr NAAQS, then NTH will do an analysis that compares all receptor-day combinations with concentrations at or above 1.2 µg/m^3 in the predicted exceedance area for the ASCPC project sources with receptor-days for all sources above 4.9 µg/m^3.

U.S. EPA has not published any guidance for States' or applicants to use when performing a culpability analysis for the 24-hour $PM_{2.5}$ NAAQS. Using the approach outlined above is believed to be a conservative approach since there is currently no method for determining culpability of a source to an averaged value. This will be conservative because not all receptor days with predicted concentrations above 4.9 µg/m^3 in each year will contribute to an average above 4.9 µg/m^3.

Attachment A

Site Map and Preliminary Drawings



NOT TO BE USED FOR CONSTRUCTION

CUMMINS & BARNARD INC.

CONSULTING ENGINEERS

SINCE 1932

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REVISIONS	DATE
REVIEW	07 MAR 03
REVIEW	18 MAR 03
FINAL REPORT	30 MAY 03
PHASE 2	15 JUL 04

SITE PLAN

DRAWN TJB
CHECKED
APPROVED
SCALE 1" = 60'-0"
JOB NO.

SHEET M1

REVISION D
LAST EDITED 07-22-200

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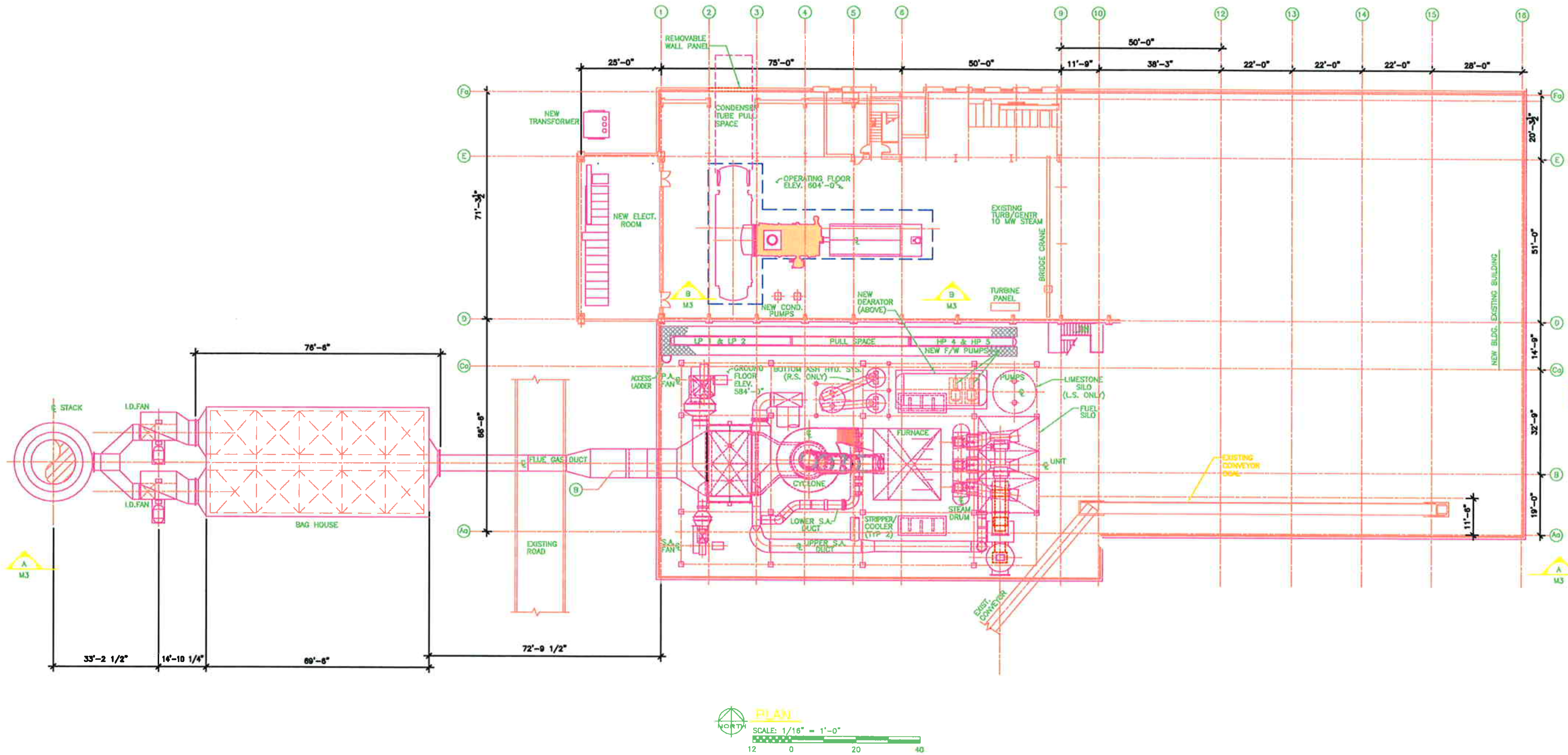

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REVISIONS	DATE
REVIEW	07 MAR 03
REVIEW	18 MAR 03
FINAL REPORT	30 MAY 03

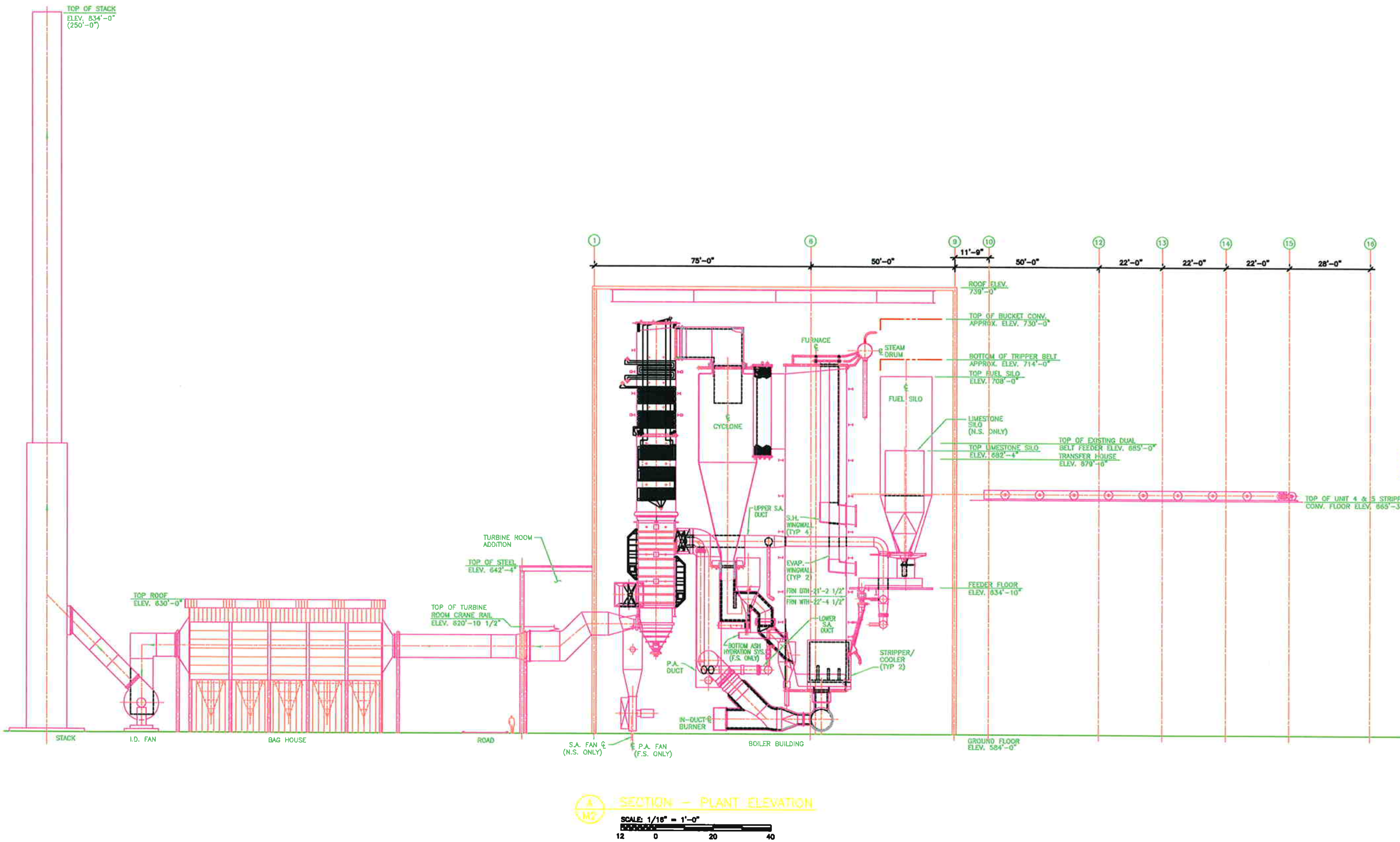
NEW PLANT EQUIPMENT ARRANGEMENT PLAN VIEW

DRAWN	JHP/TJB
CHECKED	
APPROVED	
SCALE	1/16"=1'-0"
JOB NO.	

SHEET M2

REVISION	LAST EDITED
C	07-08-200

DATE 07-08-2004 TIME 13:31 SCALE 1:192 USER LBS NAME c:\4540.03\9_Drawings\4540M2.dwg



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REVISIONS	DATE
A REVIEW	07 MAR 03
B REVIEW	18 MAR 03
C FINAL REPORT	30 MAY 03

NEW PLANT EQUIPMENT ARRANGEMENT CROSS SECTION

DRAWN	JHP/TJB
CHECKED	
APPROVED	
SCALE	1/16"=1'-0"
JOB NO.	

SHEET M3

REVISION	LAST EDITED
C	07-06-200

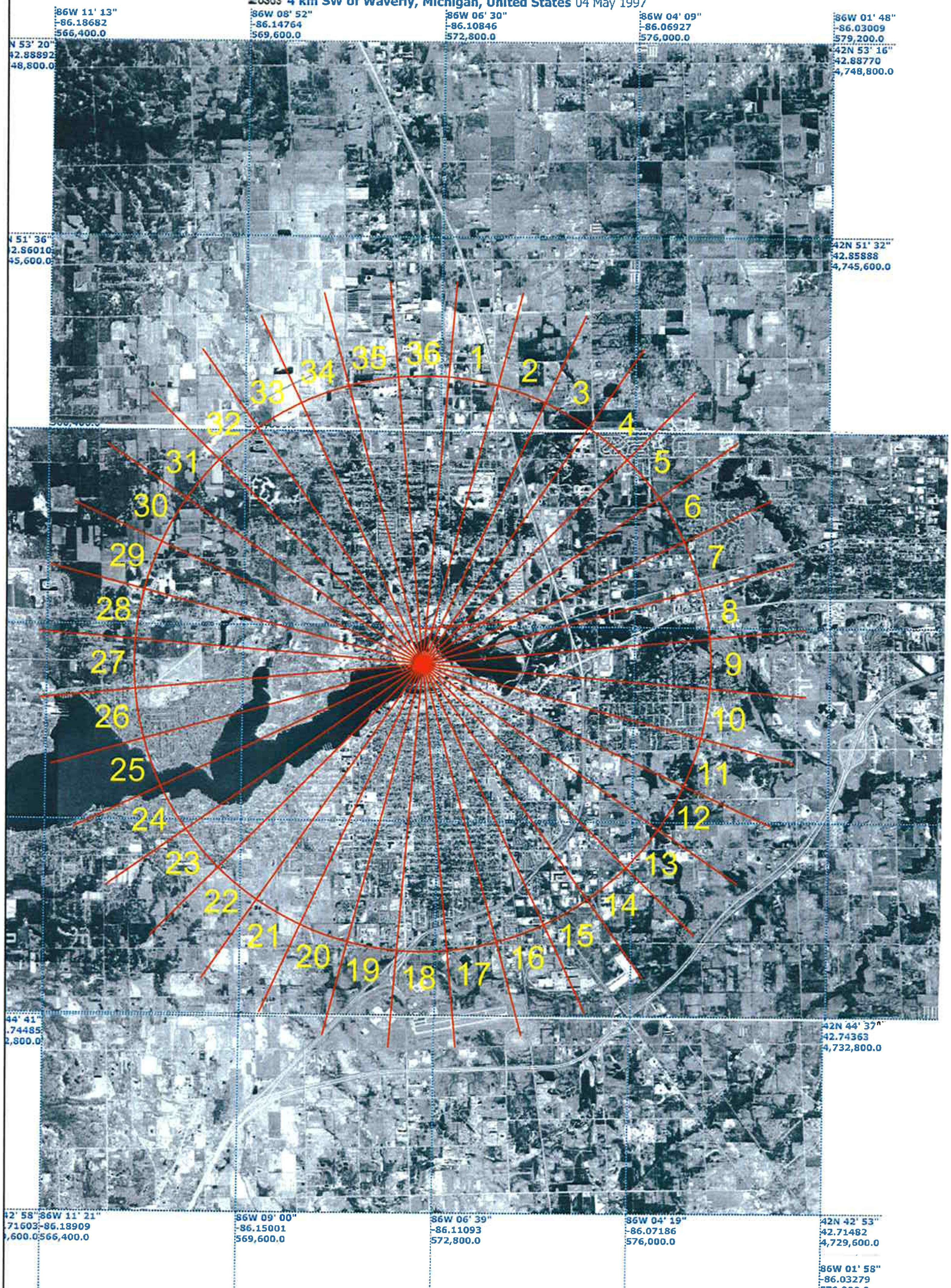
DATE 07-06-2004 TIME 15:32 SCALE 1:192 USER LBS DWG d:\4540.03\9_Drawings\4540M3.dwg

Attachment B

Land Use Designations

Send To Printer Back To TerraServer Change to 8.5x11 Print Size Remove Grid Lines Change to Landscape

USGS 4 km SW of Waverly, Michigan, United States 04 May 1997



0 2Km 0 1Mi 4 = 1 mile

Image courtesy of the U.S. Geological Survey

1 SHTTYPE	TITLE1 TITLE2	NTH PROJECT No.: PROJNO	CAD FILE NAME: XX000000000	NTH Consultants, Ltd. Infrastructure Engineering and Environmental Services
	PROJECT HOLLAND	DESIGNED BY: XXX	INCEP DATE: MODAYR	
		DRAWN BY: XXX	DRAWING SCALE: SCALE	
		CHECKED BY: XXX	PLOT DATE: MODAYR	

Attachment C

Estimation of CFB Project $PM_{2.5}$ Emissions

ATTACHMENT C
Estimation of CFB Project $PM_{2.5}$ Emissions
May 3, 2010

The purpose of this attachment is to document the updated $PM_{2.5}$ and PM_{10} emission calculations and other modeling parameters for the $PM_{2.5}$ NAAQS modeling and the updated PM_{10} modeling.

Attachment C-1 summarizes the changes to the design and operation of the material handling equipment that lead to the final modeling parameters. Attachments C-2 through C-9 are documents relating to material handling sources that have been updated since the November 2008 update.

Attachment C-2, titled "Post Modification Particulate Emissions Summary - Coal Handling Fugitives and Associated Control Releases", which is a summary of the revisions to Tables B-12 through B-19 which were previously in the application. Changes to these tables are as follows:

1. **Table B-12.** Coal Drop from Barge. $PM_{2.5}$ emission estimates have been added. These are based on using the $PM_{2.5}$ "k" multiplier as specified in AP-42, 13.2.4-3.
2. **Table B-13.** Fugitives from Bulldozer Activity. $PM_{2.5}$ emission estimates have been added. These are based on the $PM_{2.5}$ "a" and "b" factors from AP-42, Table 13.2.2-2. Also, 75% control efficiency was applied as representing a comprehensive fugitive emission program for these types of operations.
3. **Table B-14.** Drop into underground hopper. These are based on using the $PM_{2.5}$ "k" multiplier as specified in AP-42, 13.2.4-3. The hours of operation has been reduced to 1-hour per day. While the reclaim hopper (volume source) will operate 12 hours per day during coal transfer through the transfer house and into the inside coal hoppers, the underground hopper is in an "open" position for not more than 1 hour per day. During this hour the bulldozer will fill the hopper with coal and will continue to pile coal on the ground directly above the hopper. Since there is no air space into which coal can drop into the hopper, emissions from the drop into the hopper are precluded.
4. **Table B-15.** New Transfer/Crusher House Baghouse. For modeling purposes, it is conservatively assumed that the $PM_{2.5}$ emission rate (pounds per hour) will be the same as the PM_{10} emission rate. Using AP-42, Appendix B, Category 3, it has been calculated that the expected $PM_{2.5}$ emissions for coal dust from a fabric filter would only be 0.588 of the PM_{10} emissions. See Attachment C-8. This lower emission rate is shown for illustrative purposes, but has not been used in the model. The hours of operation have been reduced to 12-hours per day.
5. **Table B-16.** Unit 10 Coal Storage Silos (3) with Baghouse Control. For modeling purposes, it is conservatively assumed that the $PM_{2.5}$ emission rate (pounds per hour) will be the same as the PM_{10} emission rate. Using AP-42, Appendix B, Category 3, it has been calculated that the expected $PM_{2.5}$ emissions for coal dust from a fabric filter would only be 0.588 of the PM_{10} emissions. This lower emission rate is shown for

illustrative purposes, but has not been used in the model. The hours of operation have been reduced to 12-hours per day.

6. **Table B-17.** Unit 10 Limestone Feed Storage Baghouse. Holland BPW has determined that venting this silo to the Unit 10 baghouse is a better engineering design. Therefore, this is no longer a source of direct emissions.
7. **Table B-18.** New Fly Ash Silo Baghouse. Holland BPW has determined that venting this silo to the Unit 10 baghouse is a better engineering design. Therefore, this is no longer a source of direct emissions.
8. **Table B-19.** Existing Flyash Silo. No changes.

Attachment C-3 titled Wind Erosion Summary has 9 tables. There have not been any new wind erosion calculations made since November 2008, therefore the uncontrolled emission rates for both existing and new piles are the same as previously provided. Instead, a control efficiency has been applied to these pile activities, 75% for active areas and 80% to long term storage areas, consistent with the control factors used in the Consumers Energy application 341-07. Since the new piles are not really new piles, but an expansion of the existing piles, the "new source" is represented by the increase in emissions from these pile "area" sources. These tables also show the net change in emissions from existing to future, and the negative emission rates indicate that while the piles will be expanding, the improved fugitive dust control will result in lower estimated emissions.

Attachment C-4 contains Tables B-9, B-10 and B-11. Table B-9 is a summary table of Table B-12 through B-19, with wind erosion summary data added.

Table B-10 is the summary of existing emissions from existing sources. For the coal drop from the barge and the drop to the underground hopper, the hourly and daily emissions will not change from what they are today. Than annual emission estimate is based on the ratio of current annual coal use to future annual coal use (0.354), so there will be a change in emission on an annual basis for these two sources. For the dozer activity, there will be more dozer hours in the future than there are currently, but the future dozer activity will also be controlled; whereas the existing activity is not controlled. The estimate of the hourly and daily emissions for existing dozer activity could be estimated based on daily dozer operating hours, which translates to a ratio (0.524) of vehicle miles traveled.

Table B-11presents the net changes in emissions for the material handling sources. The emission rate in each cell is the difference between the future and the present emission rates in the corresponding cells.

Attachment C-5 provides the $PM_{2.5}$ modeling parameters for the material handling sources. Except for the wind erosion from the piles, the emissions are linked to the Tables B-11. The wind erosion emissions are taken from the wind erosion files, and selected the lowest net change for the 5-year period.

ATTACHMENT C
Estimation of CFB Project $PM_{2.5}$ Emissions
May 3, 2010

Attachment C-6 provides the PM_{10} modeling parameters for the material handling sources. Except for the wind erosion from the piles, the emissions are linked to the Tables B-11. The wind erosion emissions are taken from the wind erosion files, and selected the lowest net change for the 5 year period.

Attachment C-7 provides the estimate of $PM_{2.5}$ emissions from the cooling tower. These have been estimated using the data and methods provided in the paper *"Calculating Realistic PM_{10} Emissions from Cooling Towers"* by Reisman and Frisbie. A copy of the paper is included as part of Attachment C-7. The results are shown in the worksheet as 0.197 % of total particulate emissions are $PM_{2.5}$ and 38.085 % are PM_{10}. While these values are deemed realistic, NTH conservatively used the total PM emission rate of 0.0039 g/s as the PM_{10} emission rate, as was done in the original application, and calculated the $PM_{2.5}$ emission rate by multiplying 0.0039 g/s by 0.197/38.085. This results in a $PM_{2.5}$ emission rate of 0.00002 g/s per cell.

The $PM_{2.5}$ emissions from the proposed CFB Boiler have been assumed to be equal to the BACT/MACT level of PM_{10}, which is based on 0.024 lb/MMBtu.

Attachment C-8 provides the estimations of the $PM_{2.5}$ fraction of PM_{10} for coal dust, ash and limestone dust from fabric filters.

Attachment C-9 provides the $PM_{2.5}$ and the PM_{10} fugitive dust emissions from the roads.

Attachment C-1
Estimation of CFB Project $PM_{2.5}$ Emissions
May 7, 2010

Source	Source Description	Basis for $PM_{2.5}$ Emission Estimate
ACT_PILE	Coal Drop From Ship	Used k factor ratio for drop equation $PM_{2.5}$ = 0.15*PM_{10}, AP-42, 13.2.4-3
ACT_PILE	Dozer Activity	Used k factor ratio for unpaved roads $PM_{2.5}$= 0.10*PM_{10}, AP-42, Table 13.2.2-2, Control Factor = 75% for future operations.
ACT_PILE	Wind Erosion - Active Pile	Used k factor ratio for wind erosion $PM_{2.5}$ = 0.15*PM_{10}, AP-42, page 13.2.5-3. Control Factor = 75% for future operations.
ACT_PILE	Wind Erosion - After Shipments	Used k factor ratio for wind erosion $PM_{2.5}$ = 0.15*PM_{10}, AP-42, page 13.2.5-3. Control Factor = 75% for future operations.
ACT_PILE	Coal Drop, Dozer, Wind Erosion from Active and After Shipment Piles	The net from the existing active pile to the new active pile with control is negative, therefore not modeled.
ALTFUEL	Fuel Delivery Road	Used k factor ratio for paved roads $PM_{2.5}$= 0.15*PM_{10}, AP-42, Table 13.2-1.1. Deliveries of 25 trucks per day.
BH_STACK	Unit 10 Boiler	$PM_{2.5}$ = PM_{10} = 0.025 lb/MMBtu
COALSILO	Unit 10 Coal Storage Silos Baghouse	Reduce hours of operation to 12. Raised stack from 164 to 225 feet.
COMPPILE	Wind Erosion - Inactive Pile	Used k factor ratio for wind erosion $PM_{2.5}$= 0.15*PM_{10}, AP-42, page 13.2.5-3. Net is negative from existing to new controlled pile.
EMP	Employee Traffic	Used k factor ratio for paved roads $PM_{2.5}$ = 0.15*PM_{10}, AP-42, Table 13.2-1.1.
HOPPER	Drop Emissions at Underground Hopper	Used k factor ratio for drop equation $PM_{2.5}$ = 0.15*PM_{10}, AP-42, 13.2.4-3, AND reduced hours of opening exposure to 1 hour.
LIMEASHP	Limestone and Ash Hauling Traffic	Used k factor ratio for paved roads $PM_{2.5}$ = 0.15*PM_{10}, AP-42, Table 13.2-1.1.
MAINRD	Main Entrance Road	Used k factor ratio for paved roads $PM_{2.5}$ = 0.15*PM_{10}, AP-42, Table 13.2-1.1.

Attachment C-1
Estimation of CFB Project $PM_{2.5}$ Emissions
May 7, 2010

Source	Source Description	Basis for $PM_{2.5}$ Emission Estimate
TCBH_STK	Trans/Crush House Baghouse Stk	Reduce hours of operation to 12. Raised stack from 85 to 120 feet.
TRWCWL1-7	Cooling Tower	Used Technical Paper *"Calculating Realistic PM_{10} Emissions from Cooling Towers"*, by Reisman and Frisbie. Conservatively used ration of $PM_{2.5}$ to PM_{10} from this paper, rather than absolute value.
U10_LIME	Unit 10 Limestone Bin Filter	REMOVED
U10ASHVT	Unit 10 Fly Ash Silo Vent	REMOVED
PACSILO	Powdered Activated Carbon (PAC) Silo	4 hours operation per day. Normally fills in 2 hours.

The detailed calculations based on these assumptions follow.

**Holland Board of Public Works Fugitives
Summary and Working Emissions for
150-day Coal Supply
Revised May 3, 2010**

Table B-12. Coal Drop from Barge

Annual Operation (day /yr)	365	
Annual Coal Usage (ton /yr)	503,262	
Barge Capacity (tons/trip)	13,000	From C&B
Average Number of Barge Trips (annually)	39.0	
Barge Unloading Rate (tons /hr)	3000	From C&B 3,000 - 4,000 tph
Barge Unload Time (hr/trip)	4.33	Assuming 3,000 tph
E=k*0.0032*(U/5)^1.3/(M/2)^1.4		
Where, k= Particle size multiplier (AP42 13.2.4-3)		
k, PM	0.74	
k, PM_{10}	0.35	
k, $PM_{2.5}$	0.053	
U= mean wind speed @ BIV (m/s)	4.84	
U= mean wind speed @ BIV (mph)	10.8	
(U/5)^1.3=	2.73	
M = Moisture (%)	6.0	From C&B
(M/2)^1.4=	4.66	
$E_{PM,}$ uncontrolled (lb/ton)	0.00139	
$E_{PM10,}$ uncontrolled (lb/ton)	0.00066	
$E_{PM2.5,}$ uncontrolled (lb/ton)	0.00010	
Control efficiency	90%	Wetting of material while off-loading
E_{PM} , controlled (lb/ton)	0.00014	
E_{PM10} , controlled (lb/ton)	0.000066	
$E_{PM2.5}$, controlled (lb/ton)	0.000010	
PM Emission Rate, uncontrolled (lb/hr)	4.17	Max lb/hr
PM Emission Rate, uncontrolled (lb/day)	18.05	
PM Emission Rate, uncontrolled (tpy)	0.35	
PM_{10} Emission Rate, uncontrolled (lb/hr)	1.97	Max lb/hr
PM_{10} Emission Rate, uncontrolled (lb/day)	8.54	
PM_{10} Emission Rate, uncontrolled (tpy)	0.17	
$PM_{2.5}$ Emission Rate, uncontrolled (lb/hr)	0.30	Max lb/hr
$PM_{2.5}$ Emission Rate, uncontrolled (lb/day)	1.29	
$PM_{2.5}$ Emission Rate, uncontrolled (tpy)	0.025	
PM Emission Rate, controlled (lb/hr)	0.42	
PM Emission Rate, controlled (lb/day)	1.81	
PM Emission Rate, controlled (tpy)	0.03	
PM_{10} Emission Rate, controlled (lb/hr)	0.20	
PM_{10} Emission Rate, controlled (lb/day)	0.85	
PM_{10} Emission Rate, controlled (tpy)	0.02	
$PM_{2.5}$ Emission Rate, controlled (lb/hr)	0.030	
$PM_{2.5}$ Emission Rate, controlled (lb/day)	0.13	
$PM_{2.5}$ Emission Rate, controlled (tpy)	0.00250	

Table B-13. Fugitives from Bulldozer Activity

Unpaved Roads
AP-42 13.2

E = k (s/12)^a (W/3)^b [(365-P)/365] (AP42 13.2.2-4)
Where W = average vehicle wt.

Bulldozer loads underground hopper 8 hour/day
Bulldozer maintains pile for 24 hours after each Shipment

	Dozer #1 loading hopper			Dozer #2 works the pile		
	PM	**PM-10**	**PM-2.5**	**PM**	**PM-10**	**PM-2.5**
k (lb/VMT) from Tab. 13.2.2-2, AP-42	4.9	1.5	0.15	4.9	1.5	0.15
a dimensionless, from Tab. 13.2.2-2, AP-42	0.7	0.9	0.9	0.7	0.9	0.9
b dimensionless, from Tab. 13.2.2-2, AP-42	0.45	0.45	0.45	0.45	0.45	0.45
s = silt content	2.2	2.2	2.2	2.2	2.2	2.2
W= Average weight of vehicle (tons)	20	20	20	20	20	20
Mdry= Average moisture content of rec'd mat'l	6.0	6.0	6.0	6.0	6.0	6.0
p=days of precip>0.01 inches	120	120	120	120	120	120
Eext (lb/VMT)	2.36	0.51	0.05	2.36	0.51	0.05
Operating Days (Day/Year)	365	365	365	365	365	365
Average Operating Hours (Hours/Day)	16.0	16.0	16.0	10.7	10.7	10.7
Distance-Feet Per Day	42240	42240	42240	28160	28160	28160
Distance-Miles Per Day	8.0	8.0	8.0	5.3	5.3	5.3
VMT_{hr}=Dist/Operating Hours (miles/hr)	0.5	0.5	0.5	0.5	0.5	0.5
VMT_{ann}=Dist*Operating Days (miles/yr)	2920	2920	2920	1947	1947	1947
Uncontrolled Emiss.= E*VMT_{hr} (lb/hr)	1.18	0.26	0.026	1.18	0.26	0.026
Uncontrolled Emiss.= E*VMT_{hr} (lb/day)	18.84	4.11	0.41	12.56	2.74	0.27
Uncontrolled Emiss.= E*VMT_{ann}/2000 (tpy)	3.44	0.75	0.07	2.29	0.50	0.05
Control Factor	75%	75%	75%	75%	75%	75%
Controlled Hourly Emissions (lb/hr)	0.29	0.06	0.0064	0.29	0.06	0.0064
Controlled Emiss.= E*VMT_{hr} (lb/day)	4.71	1.03	0.10	3.14	0.68	0.069
Controlled Annual Emissions (tpy)	0.86	0.19	0.019	0.57	0.12	0.013

Holland Board of Public Works Fugitives
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Table B-14. Drop Emissions at Underground Hopper

Operating Time (hr/day)	1	
Annual Operation (day /yr)	365	
Maximum Coal Loading Rate (ton/hr)	344.7	based on a maximum loading of a 36-hr supply in 6 hours
Maximum Coal Loading Rate (ton/day)	2068.2	based on a 36-hour supply
Annual Coal Usage (ton /yr)	503,262	
AP-42 13.2.4-3 Eqn (1)		
E=k*0.0032*(U/5)^1.3/(M/2)^1.4		
Where, k= Particle size multiplier		
k, PM	0.74	
k, PM_{10}	0.35	
k, $PM_{2.5}$	0.053	
U= mean wind speed @ BIV (m/s)	4.84	
U= mean wind speed @ BIV (mph)	10.83	
(U/5)^1.3=	2.73	
M= Moisture	6.0	
(M/2)^1.4=	4.66	
$E_{PM,}$ uncontrolled (lb/ton)	0.001389	
$E_{PM10,}$ uncontrolled (lb/ton)	0.000657	
$E_{PM2.5,}$ uncontrolled (lb/ton)	0.000099	
Control efficiency [1]	75%	
E_{PM} , controlled (lb/ton)	0.000347	
E_{PM10} , controlled (lb/ton)	0.000164	
$E_{PM2.5,}$ controlled (lb/ton)	0.00000116	
PM Emission Rate, uncontrolled (lb/hr)	0.48	
PM Emission Rate, uncontrolled (lb/day)	0.4787	
PM Emission Rate, uncontrolled (tpy)	0.35	
PM_{10} Emission Rate, uncontrolled (lb/hr)	0.23	
PM_{10} Emission Rate, uncontrolled (lb/day)	0.2264	
PM_{10} Emission Rate, uncontrolled (tpy)	0.17	
$PM_{2.5}$ Emission Rate, uncontrolled (lb/hr)	0.0343	
$PM_{2.5}$ Emission Rate, uncontrolled (lb/day)	0.0343	
$PM_{2.5}$ Emission Rate, uncontrolled (tpy)	0.03	
PM Emission Rate, controlled (lb/hr)	0.120	
PM Emission Rate, controlled (lb/day)	0.1197	
PM Emission Rate, controlled (tpy)	0.09	
PM_{10} Emission Rate, controlled (lb/hr)	0.057	
PM_{10} Emission Rate, controlled (lb/day)	0.0566	
PM_{10} Emission Rate, controlled (tpy)	0.04	
PM2.5 Emission Rate, controlled (lb/hr)	0.00857	
PM2.5 Emission Rate, controlled (lb/day)	0.0086	
PM2.5 Emission Rate, controlled (tpy)	0.0063	

[1] Sierra Research 2003. Final BACM Technological and Economic Feasibility Analysis. This report demonstrates a control efficiency of 75% for a 3-sided enclosure with 50% porosity. Therefore, an underground hopper (4-sided enclosure with 0.0% porosity) is expected to have at least 75% control efficiency.

Modeling Protocol
Attachment C-2

Holland Board of Public Works Fugitives
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150-day Coal Supply
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Table B-15. New Transfer/Crusher House Baghouse

Baghouse (scfm)	10,000	
Baghouse PM10 (gr /scf)	**0.004**	**BACT**
Emissions PM10(lb /hr)	0.34	
Emissions PM2.5(lb /hr) = PM10	0.34	
Emissions PM2.5(lb /hr) From AP-42 App B, Category 3	0.20	
Operating Time (hr /day)	**12**	**NTH**
Operating Time (day/ year)	**365**	
Baghouse Emissions (lb/day)	4.11	
Daily Baghouse Emissions (lb/hr)	0.17	
Baghouse Emissions (tpy)	0.75	

Table B-16. Unit 10 Coal Storage Silos (3) with Baghouse Control

Flow Rate of Baghouse (scfm)	15,000	
Baghouse PM10 (gr /scf)	**0.004**	**BACT**
Emissions PM10(lb /hr)	0.51	
Emissions PM2.5(lb /hr) = PM10	0.51	
Emissions PM2.5(lb /hr) From AP-42 App B, Category 3	0.30	
Operating Time (hr /day)	**12**	**NTH**
Operating Time (day/ year)	**365**	
Baghouse Emissions (lb/day)	6.17	
Daily Baghouse Emissions (lb/hr)	0.26	
Emissions (tpy)	1.13	

Table B-17. Unit 10 Limestone Feed Storage Baghouse - REMOVED

Flow Rate of Baghouse (scfm)	5000	
Baghouse PM10 (gr /scf)	**0.004**	**BACT**
Emissions PM10(lb /hr)	0.17	
Emissions PM2.5(lb /hr) = PM10	0.17	
Emissions PM2.5(lb /hr) From AP-42 Page 11.19-12	0.050	
Operating Time (hr /day)	**6**	**NTH**
Operating Time (day/ year)	**365**	
Baghouse Emissions (lb/day)	1.03	
Emissions (tpy)	0.19	

Note: The Limestone Feed Storage will be vented to the Unit 10 Baghouse.

Table B-18. New Fly Ash Silo Baghouse (Unit 10 Only) - REMOVED

Flow Rate of Baghouse (scfm)	1100	
Baghouse PM10 (gr /scf)	**0.004**	**BACT**
Emissions PM10(lb /hr)	0.038	
Emissions PM2.5(lb /hr) = PM10	0.038	
Emissions PM2.5(lb /hr) From AP-42 Table 1.1-6	0.022	
Operating Time (hr /day)	**16**	**NTH**
Operating Time (day/ year)	**365**	
Baghouse Emissions (lb/day)	0.60	
Emissions (tpy)	0.11	

REMOVED

Note: The New Ash Silo Storage will be vented to the Unit 10 Baghouse.

Table B-19. Existing Fly Ash Bin Filter (Units 4 & 5)

Size of Silo (ft^3)	**8,482**	20 ft diam by 27 ft tall storage capacity
Density of ash (lb/ft3)	**37**	from MAERS
Bin Filter (gr /scf)	**0.02**	
Bin Filter Emissions (lb /hr)	0.00052	
pm2.5 Emissions (lb /hr)	0.00030	
Operating Hours	24	
Bin Filter Emissions (lb/day)	0.0124	
Bin Filter Emissions (tpy)	0.0023	

REMOVED

Table B-20. PAC Silo Baghouse

Flow Rate of Baghouse (scfm)	1100
Baghouse PM10 (gr /scf)	**0.004**
Emissions PM10(lb /hr)	0.038
Emissions PM2.5(lb /hr) = PM10	0.038
Emissions PM2.5(lb /hr) From AP-42 Table 1.1-6	0.022
Operating Time (hr /day)	**4**
Operating Time (day/ year)	**365**
Baghouse Emissions (lb/day)	0.15
Daily Baghouse Emissions (lb/hr)	0.01
Emissions (tpy)	0.03

Attachment C-3
Wind Erosion Summary

Wind Erosion Emissions for Active Portion of the New Pile

Year	Pollutant	Avr. Hour (lbs0	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	0.0060	52.8	0.026
2004	PM	0.00605	53.0	0.026
2005	PM	0.00638	55.9	0.028
2006	PM	0.00573	50.2	0.025
2007	PM	0.00602	52.8	0.026
2003	PM10	0.00302	26.4	0.013
2004	PM10	0.00302	26.5	0.013
2005	PM10	0.00319	27.9	0.014
2006	PM10	0.00286	25.1	0.013
2007	PM10	0.00301	26.4	0.013
2003	PM2.5	0.00045	3.96	0.0020
2004	PM2.5	0.00045	3.97	0.0020
2005	PM2.5	0.00048	4.19	0.0021
2006	PM2.5	0.00043	3.76	0.0019
2007	PM2.5	0.00045	3.96	0.0020

[1] The average hour is based on the annual emissions.

Wind Erosion Control Efficiency **75.0%**

Wind Erosion Emissions for Active Portion of the Existing Pile

Year	Pollutant	Avg. Hour [1]	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	0.0107	93.7	0.047
2004	PM	0.0107	93.9	0.047
2005	PM	0.0113	99.0	0.050
2006	PM	0.0102	89.0	0.044
2007	PM	0.0107	93.5	0.047
2003	PM10	0.0053	46.8	0.023
2004	PM10	0.0054	46.9	0.023
2005	PM10	0.0057	49.5	0.025
2006	PM10	0.0051	44.5	0.022
2007	PM10	0.0053	46.8	0.023
2003	PM2.5	0.00080	7.0	0.0035
2004	PM2.5	0.00080	7.0	0.0035
2005	PM2.5	0.00085	7.4	0.0037
2006	PM2.5	0.00076	6.7	0.0033
2007	PM2.5	0.00080	7.0	0.0035

Wind Erosion Control Efficiency **0.00%**

Wind Erosion Emissions for Active Portion Pile (Net)

Year	Pollutant	Avg. Hour [1]	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	-0.0047	-40.8	-0.020
2004	PM	-0.0047	-40.9	-0.020
2005	PM	-0.0049	-43.2	-0.022
2006	PM	-0.0044	-38.8	-0.019
2007	PM	-0.0047	-40.8	-0.020
2003	PM10	-0.0023	-20.4	-0.010
2004	PM10	-0.0023	-20.5	-0.010
2005	PM10	-0.0025	-21.6	-0.011
2006	PM10	-0.0022	-19.4	-0.010
2007	PM10	-0.0023	-20.4	-0.010
2003	PM2.5	-0.00035	-3.1	-0.0015
2004	PM2.5	-0.00035	-3.1	-0.0015
2005	PM2.5	-0.00037	-3.2	-0.0016
2006	PM2.5	-0.00033	-2.9	-0.0015
2007	PM2.5	-0.00035	-3.1	-0.0015

Wind Erosion Emissions for Idle Portion of the New Pile

Year	Pollutant	Avg. Hour [1]	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	0.029	253.7	0.13
2004	PM	0.029	252.8	0.13
2005	PM	0.030	266.6	0.13
2006	PM	0.028	241.7	0.12
2007	PM	0.029	252.4	0.13
2003	PM_{10}	0.014	126.8	0.063
2004	PM_{10}	0.014	126.4	0.06
2005	PM_{10}	0.015	133.3	0.07
2006	PM_{10}	0.014	120.9	0.06
2007	PM_{10}	0.014	126.2	0.06
2003	PM2.5	0.0022	19.0	0.0095
2004	PM2.5	0.0022	19.0	0.0095
2005	PM2.5	0.0023	20.0	0.0100
2006	PM2.5	0.0021	18.1	0.0091
2007	PM2.5	0.0022	18.9	0.0095

Wind Erosion Control Efficiency **80%**

Wind Erosion Emissions for Idle Portion of the Existing Pile

Year	Pollutant	Avg. Hour [1]	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	0.0649	568.5	0.284
2004	PM	0.0641	561.2	0.281
2005	PM	0.0674	590.1	0.295
2006	PM	0.0611	535.4	0.268
2007	PM	0.0638	558.9	0.279
2003	PM10	0.0324	284.3	0.142
2004	PM10	0.0320	280.6	0.140
2005	PM10	0.0337	295.1	0.148
2006	PM10	0.0306	267.7	0.134
2007	PM10	0.0319	279.4	0.140
2003	PM2.5	0.00487	42.6	0.0213
2004	PM2.5	0.00480	42.1	0.0210
2005	PM2.5	0.00505	44.3	0.0221
2006	PM2.5	0.00458	40.2	0.0201
2007	PM2.5	0.00479	41.9	0.0210

Wind Erosion Control Efficiency **0.00%**

Wind Erosion Emissions for Idle Portion Pile (Net)

Year	Pollutant	Avg. Hour [1]	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	-0.0359	-314.9	-0.157
2004	PM	-0.0352	-308.3	-0.154
2005	PM	-0.0369	-323.6	-0.162
2006	PM	-0.0335	-293.7	-0.147
2007	PM	-0.0350	-306.5	-0.153
2003	PM10	-0.0180	-157.4	-0.079
2004	PM10	-0.0176	-154.2	-0.077
2005	PM10	-0.0185	-161.8	-0.081
2006	PM10	-0.0168	-146.9	-0.073
2007	PM10	-0.0175	-153.2	-0.077
2003	PM2.5	-0.00270	-23.6	-0.0118
2004	PM2.5	-0.00264	-23.1	-0.0116
2005	PM2.5	-0.00277	-24.3	-0.0121
2006	PM2.5	-0.00251	-22.0	-0.0110
2007	PM2.5	-0.00262	-23.0	-0.0115

Wind Erosion Emissions for Pile After Shipment

Year	Pollutant	Avr. Hour (lbs0	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	0.0181	158.5	0.079
2004	PM	0.01814	158.9	0.079
2005	PM	0.01913	167.6	0.084
2006	PM	0.01719	150.6	0.075
2005	PM	0.01807	158.3	0.079
2003	PM_{10}	0.00905	79.3	0.040
2004	PM_{10}	0.00907	79.4	0.040
2005	PM_{10}	0.00956	83.8	0.042
2006	PM_{10}	0.00859	75.3	0.038
2005	PM_{10}	0.00903	79.1	0.040
2003	PM2.5	0.00136	11.9	0.006
2004	PM2.5	0.00136	11.9	0.006
2005	PM2.5	0.00143	12.6	0.006
2006	PM2.5	0.00129	11.3	0.006
2007	PM2.5	0.00135	11.87	0.006

Wind Erosion Control Efficiency **75.00%**

Wind Erosion Emissions for Existing Pile After Shipment

Year	Pollutant	Avg. Hour [1]	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	0.0321	281.0	0.141
2004	PM	0.0321	281.6	0.141
2005	PM	0.0339	297.0	0.149
2006	PM	0.0305	266.9	0.133
2007	PM	0.0320	280.5	0.140
2003	PM10	0.0160	140.5	0.070
2004	PM10	0.0161	140.8	0.070
2005	PM10	0.0170	148.5	0.074
2006	PM10	0.0152	133.4	0.067
2007	PM10	0.0160	140.3	0.070
2003	PM2.5	0.00241	21.1	0.0105
2004	PM2.5	0.00241	21.1	0.0106
2005	PM2.5	0.00254	22.3	0.0111
2006	PM2.5	0.00229	20.0	0.0100
2007	PM2.5	0.00240	21.0	0.0105

Wind Erosion Control Efficiency **0.00%**

Wind Erosion Emissions for Pile After Shipment (Net)

Year	Pollutant	Avg. Hour [1]	Total Annual	
		(lbs)	(lbs)	(tons)
2003	PM	-0.0140	-122.47	-0.061
2004	PM	-0.0140	-122.73	-0.061
2005	PM	-0.0148	-129.45	-0.065
2006	PM	-0.0133	-116.32	-0.058
2007	PM	-0.0140	-122.26	-0.061
2003	PM10	-0.0070	-61.237	-0.031
2004	PM10	-0.0070	-61.366	-0.031
2005	PM10	-0.0074	-64.727	-0.032
2006	PM10	-0.0066	-58.162	-0.029
2007	PM10	-0.0070	-61.132	-0.031
2003	PM2.5	-0.00105	-9.1855	-0.0046
2004	PM2.5	-0.00105	-9.2049	-0.0046
2005	PM2.5	-0.00111	-9.7090	-0.0049
2006	PM2.5	-0.00100	-8.7242	-0.0044
2007	PM2.5	-0.00105	-9.1698	-0.0046

Attachment C-4

Holland BPW - Coal Handling Operations (Fugitive and Point Source) PM Emissions

Revised May 3, 2010

Table B-9. Post Modification Particulate Emissions Summary - Coal Handling Fugitives and Associated Control Releases

Operation	Max Hourly PM (lb/hr)	PM (lb/day)	Daily Average Hourly PM (lb/hr) [1]	PM (tpy)	Max Hourly PM_{10} (lb/hr)	PM_{10} (lb/day)	Daily Average Hourly PM_{10} (lb/hr) [1]	PM_{10} (tpy)	Max Hourly $PM_{2.5}$ (lb/hr)	$PM_{2.5}$ (lb/day)	Daily Average Hourly $PM_{2.5}$ (lb/hr) [1]	$PM_{2.5}$ (tpy)
Coal Drop from Barge	0.42	1.81	0.075	0.03	0.20	0.85	0.036	0.02	0.030	0.13	0.0054	0.0025
Fugitives from Bulldozer Activity	0.59	7.85	0.327	1.43	0.13	1.71	0.071	0.31	0.01	0.17	0.0071	0.03
Drop Emissions at Underground Hopper	0.12	0.12	0.005	0.09	0.06	0.06	0.002	0.04	0.0086	0.0086	0.00036	0.0063
New Transfer/Crusher House Baghouse	0.34	4.11	0.171	0.75	0.34	4.11	0.171	0.75	0.34	4.11	0.171	1.50
Unit 10 Storage Silos (3) with Baghouse Control	0.51	6.17	0.257	1.13	0.51	6.17	0.257	1.13	0.51	6.17	0.257	2.25
PAC Silo	0.0377	0.1509	0.0063	0.0275	0.0377	0.1509	0.0063	0.0275	0.0377	0.1509	0.0063	0.0275
Existing Fly Ash Bin Filter (Units 4 & 5)	0.00052	0.0124	0.0005	0.0023	0.0005	0.0124	0.0005	0.0023	0.0003	0.0072	0.0003	0.0023
Wind Erosion From Daily Active Pile (2003-2007)	N/A	N/A	0.0064	0.028	N/A	N/A	0.0032	0.014	N/A	N/A	0.00048	0.002
Wind Erosion From Pile After Shipment (2003-2007)	N/A	N/A	0.019	0.084	N/A	N/A	0.010	0.042	N/A	N/A	0.0014	0.006
Wind Erosion From Compacted Pile Area (2003-2007)	N/A	N/A	0.030	0.133	N/A	N/A	0.015	0.067	N/A	N/A	0.0023	0.010
Total Emissions	N/A	N/A	N/A	**3.71**	N/A	N/A	N/A	**2.40**	N/A	N/A	N/A	**3.84**

	Tons/year		75%	
Coal Usage (Potential) - Post Modification	503,262	Ratio:	0.354	Pre-Mod / Post Mod
Coal Usage (Past Actual) - Pre Modification	178,263			
Dozer Hours Per Day - Post Modification	26.7	Ratio:	0.524	
Dozer Hours Per Day - Pre Modification	14			

Table B-10. Pre Modification Particulate Emissions Summary - Coal Handling Fugitives and Associated Control Releases

Operation	Max Hourly PM (lb/hr)	PM (lb/day)	Daily Average Hourly PM (lb/hr) [1]	PM (tpy)	Max Hourly PM_{10} (lb/hr)	PM_{10} (lb/day)	Daily Average Hourly PM_{10} (lb/hr) [1]	PM_{10} (tpy)	Max Hourly $PM_{2.5}$ (lb/hr)	$PM_{2.5}$ (lb/day)	Daily Average Hourly $PM_{2.5}$ (lb/hr) [1]	$PM_{2.5}$ (tpy)
Coal Drop from Barge	0.42	1.8	0.075	0.01	0.20	0.85	0.036	0.01	0.030	0.129	0.0054	0.00089
Fugitives from Bulldozer Activity	1.24	16.47	0.686	2.03	0.27	3.59	0.150	0.44	0.03	0.36	0.0150	0.0443
Drop Emissions at Underground Hopper	0.12	0.12	0.005	0.03	0.06	0.06	0.002	0.01	0.0086	0.0086	0.00036	0.0022
New Transfer/Crusher House Baghouse												
Unit 10 Storage Silos (3) with Baghouse Control												
PAC Silo												
Existing Fly Ash Bin Filter (Units 4 & 5)	0.0005	0.0124	0.0005	0.0023	0.0005	0.0124	0.0005	0.0023	0.0003	0.0072	0.0003	0.0023
Wind Erosion From Daily Active Pile (2003-2007)	N/A	N/A	0.011	0.05	N/A	N/A	0.0057	0.02	N/A	N/A	0.00085	0.0037
Wind Erosion From Pile After Shipment (2003-2007)	N/A	N/A	0.034	0.15	N/A	N/A	0.017	0.074	N/A	N/A	0.00254	0.01114
Wind Erosion From Compacted Pile Area (2003-2007)	N/A	N/A	0.067	0.30	N/A	N/A	0.034	0.15	N/A	N/A	0.0051	0.0221
Total Emissions	N/A	N/A	N/A	**2.57**	N/A	N/A	N/A	**0.71**	N/A	N/A		

Table B-11. Net Particulate Emissions Summary - Coal Handling Fugitives and Associated Control Releases

Operation	Max Hourly PM (lb/hr)	PM (lb/day)	Daily Average Hourly PM (lb/hr) [1]	PM (tpy)	Max Hourly PM_{10} (lb/hr)	PM_{10} (lb/day)	Daily Average Hourly PM_{10} (lb/hr) [1]	PM_{10} (tpy)	Max Hourly $PM_{2.5}$ (lb/hr)	$PM_{2.5}$ (lb/day)	Daily Average Hourly $PM_{2.5}$ (lb/hr) [1]	$PM_{2.5}$ (tpy)
Coal Drop from Barge	0.00	0.0	0.000	0.02	0.00	0.00	0.000	0.011	0.000	0.000	0.0000	0.0016
Fugitives from Bulldozer Activity	-0.65	-8.62	-0.359	-0.60	-0.14	-1.88	-0.078	-0.13	-0.01	-0.19	-0.0078	-0.01
Drop Emissions at Underground Hopper	0.00	0.00	0.000	0.06	0.00	0.00	0.00000	0.027	0.0000	0.0000	0.0000	0.0040
New Transfer/Crusher House Baghouse	0.34	4.11	0.171	0.75	0.34	4.11	0.171	0.75	0.34	4.11	0.171	1.50
Unit 10 Storage Silos (3) with Baghouse Control	0.51	6.17	0.257	1.13	0.51	6.17	0.257	1.13	0.51	6.17	0.257	2.25
PAC Silo	0.0377	0.1509	0.0063	0.0275	0.0377	0.1509	0.0063	0.0275	0.0377	0.1509	0.0063	0.0275
Existing Fly Ash Bin Filter (Units 4 & 5)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wind Erosion From Daily Active Pile (2003-2007)	N/A	N/A	-0.005	-0.02	N/A	N/A	-0.002	-0.011	N/A	N/A	-0.00037	-0.0016
Wind Erosion From Pile After Shipment (2003-2007)	N/A	N/A	-0.015	-0.06	N/A	N/A	-0.007	-0.032	N/A	N/A	-0.0011	-0.0049
Wind Erosion From Compacted Pile Area (2003-2007)	N/A	N/A	-0.037	-0.16	N/A	N/A	-0.018	-0.081	N/A	N/A	-0.0028	-0.0121
Total Emissions	N/A	N/A	N/A	**1.14**	N/A	N/A	N/A	**1.69**	N/A	N/A	N/A	**3.76**

Attachment C-6

PM10 Modeling - Fugitive and Coal Handling Emission Sources

PM2.5 Run Description: PM2.5 Net Rates Run
Control Scenarios: 30 mph wind restrictions on After Shipment & Compacted Pile Fugitives

Point Source Release Parameters

Description of Source	X Coordinate (meters)	Y Coordinate (meters)	Elevation (meters)	Emission Rate (g/sec)	Release Ht. (meters)	Temp (K)	Velocity (meter/sec)	Diam (m)	PM2.5 PM Rate (lb/hr)
Unit 10 Coal Storage Silos Baghouse	572496.02	4738251.13	178.3	0.0324	49.99	294.26	15.523	0.762	0.257
PAC Silo	572464.79	4738229.37	178.3	0.0008	7.62	294.26	27.329	0.305	6.29E-03
Existing Fly Ash Silo Vent	572526.06	4738220.62	178.3	0.00E+00	24.38	294.26	0.086	0.203	0.00E+00
Trans/Crush House Baghouse Stk	572500.93	4738060.10	178.3	2.16E-02	15.24	294.26	16.170	0.610	0.171

Area (Polygon) Source Release Parameters

Description of Source	X Coordinate (meters)	Y Coordinate (meters)	Elevation (meters)	Emission Rate (g/sec/m2)	Release Ht. (meters)	X Length (meters)	Y Length (meters)	Angle (degrees)	Plume Ht. (meters)	PM2.5 Emission Rates Hourly (lb/hour)
Active Coal Area			178		7.62	0.00	0.00	0	0	
Coal Drop From Ship				0.000E+00						0.0000
Dozer Activity				-1.122E-07						-0.0078
Wind Erosion - Active Pile				-4.752E-09						-0.00033
Wind Erosion - After Shipments				-1.425E-08						-0.0010
Total Emission Rate				**-1.312E-07**						-0.0092
Compacted Coal Area			178	**-2.629E-08**	9.14	0.00	0.00	0	0	-0.00277

Volume Source Release Parameters

Description of Source	X Coordinate (meters)	Y Coordinate (meters)	Elevation (meters)	Emission Rate (g/sec)	Release Ht. (meters)	Init. Lat. (meters)	Init. Vert. (meters)	PM2.5 Emission Rates Hourly (lb/hour)
Drop Emissions at Underground Hopper	572392.98	4738119.64	178.3	0.000E+00	0.00	3.6576	0.5671	0.00000

Attachment C-6

PM10 Modeling - Fugitive and Coal Handling Emission Sources

PM10 Run Description: PM10 Net Rates Run
Control Scenarios: 30 mph wind restrictions on After Shipment & Compacted Pile Fugitives

Point Source Release Parameters

Description of Source	X Coordinate (meters)	Y Coordinate (meters)	Elevation (meters)	Emission Rate (g/sec)	Release Ht. (meters)	Temp (K)	Velocity (meter/sec)	Diam (m)	PM10 PM Rate (lb/hr)
Unit 10 Coal Storage Silos Baghouse	572496.02	4738251.13	178.3	0.0324	49.99	294.26	15.523	0.762	0.257
PAC Silo	572464.79	4738229.37	178.3	0.0008	7.62	294.26	27.329	0.305	6.29E-03
Existing Fly Ash Silo Vent	572526.06	4738220.62	178.3	0.00E+00	24.38	294.26	0.086	0.203	0.00E+00
Trans/Crush House Baghouse Stk	572500.93	4738060.10	178.3	2.16E-02	15.24	294.26	16.170	0.610	0.171

Area (Polygon) Source Release Parameters

Description of Source	X Coordinate (meters)	Y Coordinate (meters)	Elevation (meters)	Emission Rate (g/sec/m2)	Release Ht. (meters)	X Length (meters)	Y Length (meters)	Angle (degrees)	Plume Ht. (meters)	PM10 Emission Rates Hourly (lb/hour)
Active Coal Area			178		7.62	0.00	0.00	0	0	
Coal Drop From Ship				0.000E+00						0.0000
Dozer Activity				-1.120E-06						-0.0783
Wind Erosion - Active Pile				-3.525E-08						-0.00246
Wind Erosion - After Shipments				-1.058E-07						-0.0074
Total Emission Rate				**-1.261E-06**						-0.0881
Compacted Coal Area			178	**-1.753E-07**	9.14	0.00	0.00	0	0	-0.01847

Volume Source Release Parameters

Description of Source	X Coordinate (meters)	Y Coordinate (meters)	Elevation (meters)	Emission Rate (g/sec)	Release Ht. (meters)	Init. Lat. (meters)	Init. Vert. (meters)	PM10 Emission Rates Hourly (lb/hour)
Drop Emissions at Underground Hopper	572392.98	4738119.64	178.3	0.000E+00	0.00	3.6576	0.5671	0.00000

Attachment C-7
Holland BPW Unit 10 Cooling Tower
PM Emissions

There will be 1 mechanical cooling tower, with 7cells. Data for the tower is as follows:								Table 1				
Pumping rate of recirculation pumps (gal/min)		**70,000**				EPRI Droplet Diameter (µm)	EPRI % Mass Smaller	Droplet Volume (µm³) [2]	Droplet Mass (µg) [3]	Particle Mass (Solids) (µg) [4]	Solid Particle Volume (µm³) [5]	Solid Particle Diameter (µm) [7]
Flow of cooling water (lbs/hr)		34,986,000				10	0.000	524	5.24E-04	2.09E-06	9.52E-01	1.223
TDS of blowdown (mg/l or ppmw)		4,000				20	0.196	4189	4.19E-03	1.68E-05	7.62E+00	2.446
Flow of dissolved solids (lbs/hr)		139,944				20.43999	0.197	4471	4.47E-03	1.79E-05	8.13E+00	2.500
Fraction of flow producing drift[1]		0.31				30	0.226	14137	1.41E-02	5.65E-05	2.57E+01	3.669
Control efficiency of drift eliminators (gal drift/gal flow)		**0.000005**				40	0.514	33510	3.35E-02	1.34E-04	6.09E+01	4.892
Particulate emissions per tower (lbs/hr)		0.22				50	1.816	65450	6.54E-02	2.62E-04	1.19E+02	6.115
Particulate emissions per tower (tpy)		0.95				60	5.702	113097	1.13E-01	4.52E-04	2.06E+02	7.339
Particulate emissions per tower (g/sec)		0.027				70	21.348	179594	1.80E-01	7.18E-04	3.27E+02	8.562
Particulate emissions from each of 7 tower cells (g/sec)		0.0039				81.75998	38.085	286168	2.86E-01	1.14E-03	5.20E+02	10.000
Air flow per cell (ACFM)		810000				90	49.812	381703	3.82E-01	1.53E-03	6.94E+02	11.008
Annual emissions for 70%/35% CF Scenario						110	70.509	696909	6.97E-01	2.79E-03	1.27E+03	13.454
All tower fans will operate half of the year and half the tower fans will operate the remainder of the year.						130	82.203	1150346	1.15E+00	4.60E-03	2.09E+03	15.900
Annual particulate emissions (tons/year)		0.71				150	88.012	1767144	1.77E+00	7.07E-03	3.21E+03	18.346
Average annual emissions (g/sec)		0.02				180	91.032	3053625	3.05E+00	1.22E-02	5.55E+03	22.016
Temperature (F)		98				110	70.509	696909	6.97E-01	2.79E-03	1.27E+03	13.454
						130	82.023	1150346	1.15E+00	4.60E-03	2.09E+03	15.900
Note:						150	88.012	1767144	1.77E+00	7.07E-03	3.21E+03	18.346
[1] Technical Report EPA-600-7-79-251a, p63						180	91.032	3053625	3.05E+00	1.22E-02	5.55E+03	22.016
Effects of Pathogenic and Toxic Materials Transported Via Cooling Device Drift - Volume 1.						210	92.468	4849044	4.85E+00	1.94E-02	8.82E+03	25.685
						240	94.091	7238223	7.24E+00	2.90E-02	1.32E+04	29.354
						270	94.689	10305986	1.03E+01	4.12E-02	1.87E+04	33.023
Drift water droplet density (ρ_w)	1	g/cm3 or	1.00E-06	µg/µm³		300	96.288	14137155	1.41E+01	5.65E-02	2.57E+04	36.693
Solid particle density (NaCl) (ρ_{tds})	2.2	g/cm3	2.20E-06	µg/µm³		350	97.011	22449279	2.24E+01	8.98E-02	4.08E+04	42.808
Volume of Drift droplet	$(4/3)\pi(D_d/2)^3$		[2]			400	98.340	33510293	3.35E+01	1.34E-01	6.09E+04	48.924
Mass of Solid in Drift Droplets	(TDS) (ρ_w) (volume of drift droplet)		[3]			450	99.071	47712898	4.77E+01	1.91E-01	8.68E+04	55.039
Mass of Solids in Drift	(TDS) (ρ_w) $(4/3)\pi(D_d/2)^3$		[4]			500	99.071	65449792	6.54E+01	2.62E-01	1.19E+05	61.155
Mass of Solids in Drift	(ρ_{tds})(solid particle volume) = (ρ_{tds})$(4/3)\pi(D_p/2)^3$		[5]			600	100.000	113097240	1.13E+02	4.52E-01	2.06E+05	73.386
Solving for $D_{p=}$	$D_d[(TDS)(\rho_w)/(\rho_{tds})]^{1/3}$		[7]									
					PM2.5 Emissions		7.70424E-06	g/sec				
					PM10 Emissions		0.001486997	g/sec				

Calculating Realistic PM_{10} Emissions from Cooling Towers

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ABSTRACT

Particulate matter less than 10 micrometers in diameter (PM_{10}) emissions from wet cooling towers may be calculated using the methodology presented in EPA's AP-42[1] , which assumes that all total dissolved solids (TDS) emitted in "drift" particles (liquid water entrained in the air stream and carried out of the tower through the induced draft fan stack.) are PM_{10}. However, for wet cooling towers with medium to high TDS levels, this method is overly conservative, and predicts significantly higher PM_{10} emissions than would actually occur, even for towers equipped with very high efficiency drift eliminators (e.g., 0.0006% drift rate). Such over-prediction may result in unrealistically high PM_{10} modeled concentrations and/or the need to purchase expensive Emission Reduction Credits (ERCs) in PM_{10} non-attainment areas. Since these towers have fairly low emission points (10 to 15 m above ground), over-predicting PM_{10} emission rates can easily result in exceeding federal Prevention of Significant Deterioration (PSD) significance levels at a project's fenceline. This paper presents a method for computing realistic PM_{10} emissions from cooling towers with medium to high TDS levels.

INTRODUCTION

Cooling towers are heat exchangers that are used to dissipate large heat loads to the atmosphere. Wet, or evaporative, cooling towers rely on the latent heat of water evaporation to exchange heat between the process and the air passing through the cooling tower. The cooling water may be an integral part of the process or may provide cooling via heat exchangers, for example, steam condensers. Wet cooling towers provide direct contact between the cooling water and air passing through the tower, and as part of normal operation, a very small amount of the circulating water may be entrained in the air stream and be carried out of the tower as "drift" droplets. Because the drift droplets contain the same chemical impurities as the water circulating through the tower, the particulate matter constituent of the drift droplets may be classified as an emission. The magnitude of the drift loss is influenced by the number and size of droplets produced within the tower, which are determined by the tower fill design, tower design, the air and water patterns, and design of the drift eliminators.

AP-42 METHOD OF CALCULATING DRIFT PARTICULATE

EPA's AP-42[1] provides available particulate emission factors for wet cooling towers, however, these values only have an emission factor rating of "E" (the lowest level of confidence acceptable). They are also rather high, compared to typical present-day manufacturers' guaranteed drift rates, which are on the order of 0.0006%. (Drift emissions are typically expressed as a percentage of the cooling tower water circulation rate). AP-42 states that "a *conservatively high* PM_{10} emission factor can be obtained by (a) multiplying the total liquid drift factor by the TDS fraction in the circulating water, and (b) assuming that once the water evaporates, all remaining solid particles are within the PM_{10} range." (Italics per EPA).

If TDS data for the cooling tower are not available, a source-specific TDS content can be estimated by obtaining the TDS for the make-up water and multiplying it by the cooling tower cycles of concentration. [The cycles of concentration is the ratio of a measured parameter for the cooling tower water (such as conductivity, calcium, chlorides, or phosphate) to that parameter for the make-up water.]

Using AP-42 guidance, the total particulate emissions (PM) (after the pure water has evaporated) can be expressed as:

$$PM = \text{Water Circulation Rate} \times \text{Drift Rate} \times \text{TDS} \qquad [1]$$

For example, for a typical power plant wet cooling tower with a water circulation rate of 146,000 gallons per minute (gpm), drift rate of 0.0006%, and TDS of 7,700 parts per million by weight (ppmw):

$$PM = 146{,}000 \text{ gpm} \times 8.34 \text{ lb water/gal} \times 0.0006/100 \times 7{,}700 \text{ lb solids}/10^6 \text{ lb water} \times 60 \text{ min/hr} = \underline{3.38 \text{ lb/hr}}$$

On an annual basis, this is equivalent to almost 15 tons per year (tpy). Even for a state-of-the-art drift eliminator system, this is not a small number, especially if assumed to all be equal to PM_{10}, a regulated criteria pollutant. However, as the following analysis demonstrates, only a very small fraction is actually PM_{10}.

COMPUTING THE PM_{10} FRACTION

Based on a representative drift droplet size distribution and TDS in the water, the amount of solid mass in each drop size can be calculated. That is, for a given initial droplet size, assuming that the mass of dissolved solids condenses to a spherical particle after all the water evaporates, and assuming the density of the TDS is equivalent to a representative salt (e.g., sodium chloride), the diameter of the final solid particle can be calculated. Thus, using the drift droplet size distribution, the percentage of drift mass containing particles small enough to produce PM_{10} can be calculated. This method is conservative as the final particle is assumed to be perfectly spherical; hence as small a particle as can exist.

The droplet size distribution of the drift emitted from the tower is critical to performing the analysis. Brentwood Industries, a drift eliminator manufacturer, was contacted and agreed to provide drift eliminator test data from a test conducted by Environmental Systems Corporation (ESC) at the Electric Power Research Institute (EPRI) test facility in Houston, Texas in 1988 (Aull[2], 1999). The data consist of water droplet size distributions for a drift eliminator that achieved a tested drift rate of 0.0003 percent. As we are using a 0.0006 percent drift rate, it is reasonable to expect that the 0.0003 percent drift rate would produce smaller droplets, therefore, this size distribution data can be assumed to be <u>conservative</u> for predicting the fraction of PM_{10} in the total cooling tower PM emissions.

In calculating PM_{10} emissions the following assumptions were made:

- Each water droplet was assumed to evaporate shortly after being emitted into ambient air, into a single, solid, spherical particle.
- Drift water droplets have a density (ρ_w) of water; 1.0 g/cm^3 or $1.0 * 10^{-6}$ $\mu g / \mu m^3$.
- The solid particles were assumed to have the same density (ρ_{TDS}) as sodium chloride, (i.e., 2.2 g/cm^3).

Using the formula for the volume of a sphere, $V = 4\pi r^3/3$, and the density of pure water, $\rho_w = 1.0$ g/cm^3, the following equations can be used to derive the solid particulate diameter, D_p, as a function of the TDS, the density of the solids, and the initial drift droplet diameter, D_d :

$$\text{Volume of drift droplet} = (4/3)\pi(D_d/2)^3 \quad [2]$$

$$\text{Mass of solids in drift droplet} = (TDS)(\rho_w)(\text{Volume of drift droplet}) \quad [3]$$

substituting,

$$\text{Mass of solids in drift} = (TDS)(\rho_w)(4/3)\pi(D_d/2)^3 \quad [4]$$

Assuming the solids remain and coalesce after the water evaporates, the mass of solids can also be expressed as:

$$\text{Mass of solids} = (\rho_{TDS})(\text{solid particle volume}) = (\rho_{TDS})(4/3)\pi(D_p/2)^3 \quad [5]$$

Equations [4] and [5] are equivalent:

$$(\rho_{TDS})(4/3)\pi(D_p/2)^3 = (TDS)(\rho_w)(4/3)\pi(D_d/2)^3 \quad [6]$$

Solving for D_p:

$$D_p = D_d\,[(TDS)(\rho_w/\rho_{TDS})]^{1/3} \quad [7]$$

Where,

TDS is in units of ppmw
D_p = diameter of solid particle, micrometers (μm)
D_d = diameter of drift droplet, μm

Using formulas [2] – [7] and the particle size distribution test data, Table 1 can be constructed for drift from a wet cooling tower having the same characteristics as our example; 7,700 ppmw TDS and a 0.0006% drift rate. The first and last columns of this table are the particle size distribution derived from test results provided by Brentwood Industries. Using straight-line interpolation for a solid particle size 10 μm in diameter, we conclude that approximately <u>14.9 percent</u> of the mass emissions are equal to or smaller than PM_{10}. The balance of the solid particulate are particulate greater than 10 μm. Hence, PM_{10} emissions from this tower would be equal to PM emissions x 0.149, or 3.38 lb/hr x 0.149 = 0.50 lb/hr. The process is repeated in Table 2, with all parameters equal except that the TDS is 11,000 ppmw. The result is that approximately 5.11 percent are smaller at 11,000 ppm. Thus, while total PM emissions are larger by virtue of a higher TDS, overall PM_{10} emissions are actually lower, because more of the solid particles are larger than 10 μm.

Table 1. Resultant Solid Particulate Size Distribution (TDS = 7700 ppmw)

EPRI Droplet Diameter (μm)	Droplet Volume (μm^3) [2][1]	Droplet Mass (μg) [3]	Particle Mass (Solids) (μg) [4]	Solid Particle Volume (μm^3)	Solid Particle Diameter (μm) [7]	EPRI % Mass Smaller
10	524	5.24E-04	4.03E-06	1.83	1.518	0.000
20	4189	4.19E-03	3.23E-05	14.66	3.037	0.196
30	14137	1.41E-02	1.09E-04	49.48	4.555	0.226
40	33510	3.35E-02	2.58E-04	117.29	6.073	0.514
50	65450	6.54E-02	5.04E-04	229.07	7.591	1.816
60	113097	1.13E-01	8.71E-04	395.84	9.110	5.702
70	179594	1.80E-01	1.38E-03	628.58	10.628	21.348
90	381704	3.82E-01	2.94E-03	1335.96	13.665	49.812
110	696910	6.97E-01	5.37E-03	2439.18	16.701	70.509
130	1150347	1.15E+00	8.86E-03	4026.21	19.738	82.023
150	1767146	1.77E+00	1.36E-02	6185.01	22.774	88.012
180	3053628	3.05E+00	2.35E-02	10687.70	27.329	91.032
210	4849048	4.85E+00	3.73E-02	16971.67	31.884	92.468
240	7238229	7.24E+00	5.57E-02	25333.80	36.439	94.091
270	10305995	1.03E+01	7.94E-02	36070.98	40.994	94.689
300	14137167	1.41E+01	1.09E-01	49480.08	45.549	96.288
350	22449298	2.24E+01	1.73E-01	78572.54	53.140	97.011
400	33510322	3.35E+01	2.58E-01	117286.13	60.732	98.340
450	47712938	4.77E+01	3.67E-01	166995.28	68.323	99.071
500	65449847	6.54E+01	5.04E-01	229074.46	75.915	99.071
600	113097336	1.13E+02	8.71E-01	395840.67	91.098	100.000

[1] Bracketed numbers refer to equation number in text.

The percentage of PM_{10}/PM was calculated for cooling tower TDS values from 1000 to 12000 ppmw and the results are plotted in Figure 1. Using these data, Figure 2 presents predicted PM_{10} emission rates for the 146,000 gpm example tower. As shown in this figure, the PM emission rate increases in a straight line as TDS increases, however, the PM_{10} emission rate increases to a maximum at around a TDS of 4000 ppmw, and then begins to decline. The reason is that at higher TDS, the drift droplets contain more solids and therefore, upon evaporation, result in larger solid particles for any given initial droplet size.

CONCLUSION

The emission factors and methodology given in EPA's AP-42[1] Chapter 13.4 *Wet Cooling Towers*, do not account for the droplet size distribution of the drift exiting the tower. This is a critical factor, as more than 85% of the mass of particulate in the drift from most cooling towers will result in solid particles larger than PM_{10} once the water has evaporated. Particles larger than PM_{10} are no longer a regulated air pollutant, because their impact on human health has been shown to be insignificant. Using reasonable, conservative assumptions and a realistic drift droplet size distribution, a method is now available for calculating realistic PM_{10} emission rates from wet mechanical draft cooling towers equipped with modern, high-efficiency drift eliminators and operating at medium to high levels of TDS in the circulating water.

Table 2. Resultant Solid Particulate Size Distribution (TDS = 11000 ppmw)

EPRI Droplet Diameter (μm)	Droplet Volume (μm^3) [2][1]	Droplet Mass (μg) [3]	Particle Mass (Solids) (μg) [4]	Solid Particle Volume (μm^3)	Solid Particle Diameter (μm) [7]	EPRI % Mass Smaller
10	524	5.24E-04	5.76E-06	2.62	1.710	0.000
20	4189	4.19E-03	4.61E-05	20.94	3.420	0.196
30	14137	1.41E-02	1.56E-04	70.69	5.130	0.226
40	33510	3.35E-02	3.69E-04	167.55	6.840	0.514
50	65450	6.54E-02	7.20E-04	327.25	8.550	1.816
60	113097	1.13E-01	1.24E-03	565.49	10.260	5.702
70	179594	1.80E-01	1.98E-03	897.97	11.970	21.348
90	381704	3.82E-01	4.20E-03	1908.52	15.390	49.812
110	696910	6.97E-01	7.67E-03	3484.55	18.810	70.509
130	1150347	1.15E+00	1.27E-02	5751.73	22.230	82.023
150	1767146	1.77E+00	1.94E-02	8835.73	25.650	88.012
180	3053628	3.05E+00	3.36E-02	15268.14	30.780	91.032
210	4849048	4.85E+00	5.33E-02	24245.24	35.909	92.468
240	7238229	7.24E+00	7.96E-02	36191.15	41.039	94.091
270	10305995	1.03E+01	1.13E-01	51529.97	46.169	94.689
300	14137167	1.41E+01	1.56E-01	70685.83	51.299	96.288
350	22449298	2.24E+01	2.47E-01	112246.49	59.849	97.011
400	33510322	3.35E+01	3.69E-01	167551.61	68.399	98.340
450	47712938	4.77E+01	5.25E-01	238564.69	76.949	99.071
500	65449847	6.54E+01	7.20E-01	327249.23	85.499	99.071
600	113097336	1.13E+02	1.24E+00	565486.68	102.599	100.000

Figure 1: Percentage of Drift PM that Evaporates to PM10

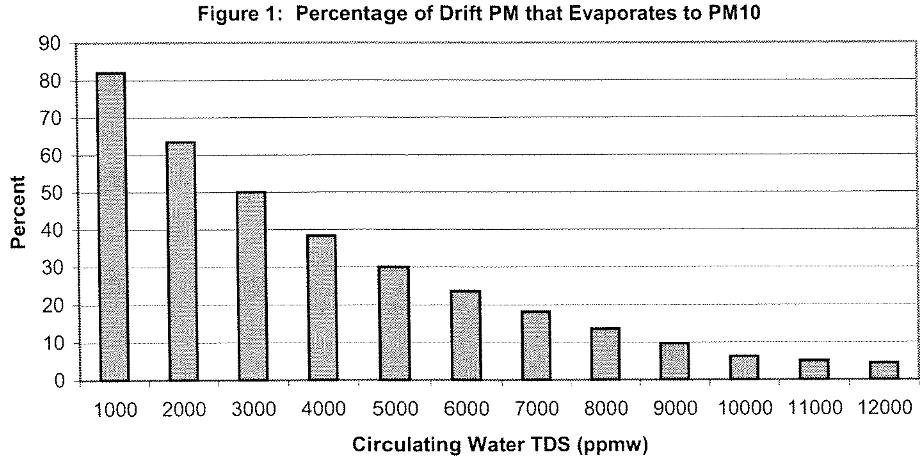
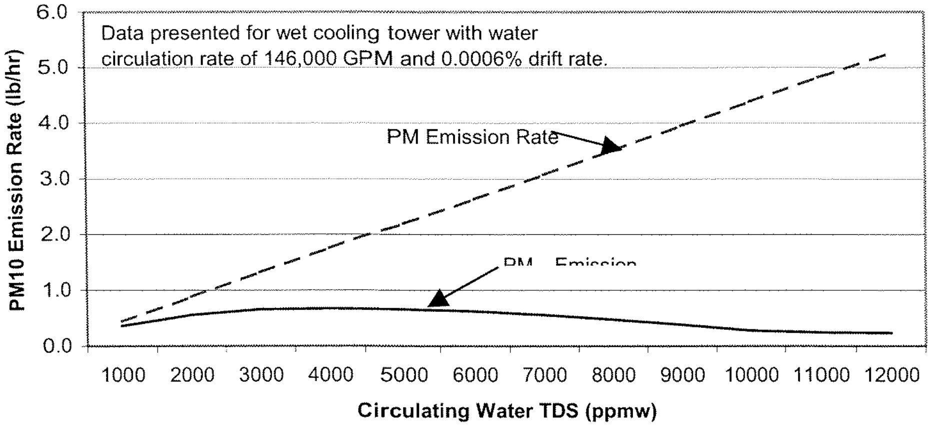


Figure 2: PM_{10} Emission Rate vs. TDS



REFERENCES

1. EPA, 1995. Compilation of Air pollutant Emission Factors, AP-42 Fifth edition, Volume I: *Stationary Point and Area Sources*, Chapter 13.4 Wet Cooling Towers, http://www.epa.gov/ttn/chief/ap42/, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, January.

2. Aull, 1999. Memorandum from R. Aull, Brentwood Industries to J. Reisman, Greystone, December 7, 1999.

KEY WORDS

Drift
Drift eliminators
Cooling tower
PM_{10} emissions
TDS

ATTACHMENT C-8

Estimation of Holland BPW $PM_{2.5}$ Coal Handling Fabric Filter Emission Rates Using AP-42, Appendix B.2 Generalized Particle Size Distributions

The proposed CFB project will install 4 new fabric filters for material handling processes, 2 which will collect coal dust, one used for the flyash silo and one used for a limestone silo. In AP-42, Appendix B.2, Category 3 - Mechanically Generated/Aggregated, Unprocessed Ores would conservatively represent coal dust. The cumulative particle size distribution for uncontrolled emissions is given as:

Particle Size, µm	Cumulative % < Stated Size
1.0[a]	4
2.0[a]	11
2.5	15
3.0[a]	18
4.0[a]	25
5.0[a]	30
6	34
10	51

[a] Value calculated from data reported at 2.5, 6.0, and 10.0 µm.

The collection efficiency for low temperature fabric filters is given as:

Particle size (µm)	0-2.5	2.5-6	6-10
Collection efficiency (Table B.2-3):	99.0	99.5	99.5

From this data the controlled particle size fraction can be calculated. If it assumed that the overall control is 99.5% by weight, then the uncontrolled loading would be estimated to be 0.004/0.005=0.80 gr/dscf. The fractional loading of the other particle sizes can be calculated by multiplying the cumulative fraction (%/100) times the total grain loading of 0.80. The results are shown in the Table C-1 below. As can be seen, while the $PM_{2.5}$ fraction is 0.12/0.408 =0.294 of the uncontrolled emissions, it is estimated to represent 58.8% (0.00120/0.00204=0.588) of the controlled emissions.

ATTACHMENT C-8

Table C-1. Fractional Emission Rates

Particle Size, µm	Cumulative % < Stated Size	Uncontrolled emiss @99.5% control and outlet of 0.004 gr gr/dscf	Controlled Emission Rates gr/dscf
1.0[a]	4	0.032	0.00032
2.0[a]	11	0.088	0.00088
2.5	15	0.12	0.00120
3.0[a]	18	0.144	0.00072
4.0[a]	25	0.20	0.00100
5.0[a]	30	0.24	0.00120
6	34	0.272	0.00136
10	51	0.408	0.00204
’10-30	100	0.80	0.00400

Attachment C-9
Road Fugitive Emissions

Table B-26. Summary of Fugitive Emissions from Roads

Emission Source	PM (lb/hr)	PM (tpy)	PM_{10} (lb/hr)	PM_{10} (tpy)	$PM_{2.5}$ (lb/hr)	$PM_{2.5}$ (tpy)
Paved Main Entrance Road	4.57E-02	2.00E-01	8.90E-03	3.90E-02	1.33E-03	5.82E-03
Paved Employee Driveway	5.98E-03	2.62E-02	1.14E-03	5.01E-03	1.55E-04	6.79E-04
Paved Limestone and PAC Delivery Road	1.64E-02	7.19E-02	3.20E-03	1.40E-02	4.79E-04	2.10E-03
Paved Alternate Fuels Delivery Road	1.69E-01	7.40E-01	3.30E-02	1.44E-01	4.93E-03	2.16E-02
Total Fugitive Emissions from Roads	**2.37E-01**	**1.04E+00**	**4.62E-02**	**2.02E-01**	**6.90E-03**	**3.02E-02**

AP-42 Equations for Paved Roads

Equation 1, for short-term emissions

$$E = \left(k \left(\frac{sL}{2} \right)^{0.65} \left(\frac{W}{3} \right)^{1.5} - C \right)$$

Equation 2, for annual emissions

$$E = \left(k \left(\frac{sL}{2} \right)^{0.65} \left(\frac{W}{3} \right)^{1.5} - C \right) \left(1 - \frac{P}{4N} \right)$$

Parameter	PM	PM_{10}	$PM_{2.5}$	
k, Particle size multiplier for PM	0.082	0.016	0.0024	From Table 13.2.1-1
C, Exhaust, brake wear, and tire wear for PM	0.00047	0.00047	0.00036	From Table 13.2.1-2
sL, silt loading	7.4	7.4	7.4	From Table 13.2.1-4 for MSWLF
$(sL/2)^{0.65}$ =	2.34	2.34	2.34	
W, mean vehicle weight (tons)	Shown Below			From HBPW
P, number of days of precipitation in one year	120	120	120	From Figure 13.2.1-2
N, number of days in the averageing period	365	365	365	
Control Efficiency	80%	80%	80%	

Attachment C-9
Road Fugitive Emissions

Main Entrance Road

Vehicle Type	Length Traveled (feet)	Vehicle weight (tons)	Vehicle Miles Traveled (VMT)	Vehicles (trips) per day	Percentage of Total Vehicles	Percent times Vehicle Weight	VMT per day
Limestone Trucks (Full)	131.2	40	0.02	1.0	0.9%	0.35	0.02
Limestone Trucks (Empty)	131.2	15	0.02	1.0	0.9%	0.13	0.02
PAC Trucks (Full)	131.2	34	0.02	1.0	0.9%	0.30	0.02
PAC Trucks (Empty)	131.2	12	0.02	1.0	0.9%	0.11	0.02
Alternative Fuels Trucks (Full)	131.2	40	0.02	25.0	21.9%	8.77	0.62
Alternative Fuel Trucks (Empty)	131.2	15	0.02	25.0	21.9%	3.29	0.62
Visitor/Employee/Maintenance Vehicles	131.2	2	0.02	60	52.6%	1.05	1.49

Mean Vehicle Weight, W (tons)	14.0
Total Miles Traveled on Paved Roads	2.8

Parameter	PM	PM_{10}	$PM_{2.5}$
Short-term emission factor (lb/VMT)	3.87E-01	7.54E-02	1.13E-02
Long-term emission factor (lb/VMT)	3.55E-01	6.92E-02	1.03E-02
Short-term Emissions (lb/hr)	**4.57E-02**	**8.90E-03**	**1.33E-03**
Long-term Emissions (tpy)	**2.00E-01**	**3.90E-02**	**5.82E-03**

Employee Road

Vehicle Type	Length Traveled (feet)	Vehicle weight (tons)	Vehicle Miles Traveled (VMT)	Vehicles (trips) per day	Percentage of Total Vehicles	Percent times Vehicle Weight	VMT per day
Visitor/Employee/Maintenance Vehicles	606.8	2	0.11	60.0	100.0%	2.00	6.90

Mean Vehicle Weight, W (tons)	2.0
Total Miles Traveled on Paved Roads	6.9

Parameter	PM	PM_{10}	$PM_{2.5}$
Short-term emission factor (lb/VMT)	2.08E-02	3.98E-03	5.40E-04
Long-term emission factor (lb/VMT)	1.91E-02	3.66E-03	4.95E-04
Short-term Emissions (lb/hr)	**5.98E-03**	**1.14E-03**	**1.55E-04**
Long-term Emissions (tpy)	**2.62E-02**	**5.01E-03**	**6.79E-04**

Limestone and PAC Delivery Road

Vehicle Type	Length Traveled (feet)	Vehicle weight (tons)	Vehicle Miles Traveled (VMT)	Vehicles (trips) per day	Percentage of Total Vehicles	Percent times Vehicle Weight	VMT per day
Limestone Trucks (Full)	387	40	0.07	1.0	25.0%	10.00	0.07
Limestone Trucks (Empty)	722	15	0.14	1.0	25.0%	3.75	0.14
PAC Trucks (Full)	387	34	0.07	1.0	25.0%	8.50	0.07
PAC Trucks (Empty)	722	12	0.14	1.0	25.0%	3.00	0.14

Mean Vehicle Weight, W (tons)	25.3
Total Miles Traveled on Paved Roads	0.4

Parameter	PM	PM_{10}	$PM_{2.5}$
Short-term emission factor (lb/VMT)	9.37E-01	1.83E-01	2.74E-02
Long-term emission factor (lb/VMT)	8.60E-01	1.68E-01	2.51E-02
Short-term Emissions (lb/hr)	**1.64E-02**	**3.20E-03**	**4.79E-04**
Long-term Emissions (tpy)	**7.19E-02**	**1.40E-02**	**2.10E-03**

Alternative Fuels Delivery Road

Vehicle Type	Length Traveled (feet)	Vehicle weight (tons)	Vehicle Miles Traveled (VMT)	Vehicles (trips) per day	Percentage of Total Vehicles	Percent times Vehicle Weight	VMT per day
Alternative Fuels Trucks (Full)	377	40	0.07	25.0	50.0%	20.00	1.79
Alternative Fuel Trucks (Empty)	427	15	0.08	25.0	50.0%	7.50	2.02

Mean Vehicle Weight, W (tons)	27.5
Total Miles Traveled on Paved Roads	3.8

Parameter	PM	PM_{10}	$PM_{2.5}$
Short-term emission factor (lb/VMT)	1.07E+00	2.08E-01	3.11E-02
Long-term emission factor (lb/VMT)	9.78E-01	1.91E-01	2.86E-02
Short-term Emissions (lb/hr)	**1.69E-01**	**3.30E-02**	**4.93E-03**
Long-term Emissions (tpy)	**7.40E-01**	**1.44E-01**	**2.16E-02**