AIR DISPERSION MODELING PROTOCOL
WESTMORELAND SANITY LANDFILL LEACHATE EVAPORATOR

CEC PROJECT 313-688

PREPARED BY
CIVIL & ENVIRONMENTAL CONSULTANTS, INC.
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PITTSBURGH, PA 15202

PREPARED FOR
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BELLE VERNON PA 15012

JUNE 24, 2021

Revised August 11, 2021

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APPENDICES

1.0 INTRODUCTION

Noble Environmental, Inc. (Noble) submitted a Plan Approval to the Pennsylvania Department of Environmental Protection (PADEP) in 2020 for the installation of a leachate evaporator at the Westmoreland Sanitary Landfill (WSL) located in Belle Vernon, Westmoreland County, PA. In correspondence dated May 7, 2021, PADEP requested additional information regarding the selection of monitoring locations and potential effects of the elevated landfill cell(s) topography on monitoring radionuclide emissions. Subsequently, Noble proposed an air dispersion modeling analysis to estimate ambient air concentrations of radionuclides. A telephone conference was held with PADEP on June 8, 2021 to discuss the proposed air dispersion modeling.

This air dispersion modeling analysis will be conducted in accordance with US EPA's Guidelines on Air Quality Models (40 CFR 51 Appendix W) and PADEP's recommendations from our discussions.

2.0 PROJECT SUMMARY

Perma-Fix Environmental Services, Inc. (Perma-Fix) has provided Noble with calculations to estimate the maximum radium-226 (Ra-226) and radium-228 (Ra-228) in the evaporator sludge material and emitted through the evaporation process. These calculations assume the influent radium is emitted as a particulate during the evaporation process. The calculations assume a total dissolved solids (TDS) reduction of 99%. This reduction occurs through removal of TDS within the evaporator mist elimination system.

While radium is in the form of particulate matter (PM), this dispersion modeling analysis will not include special model processing for PM (i.e. PM10 or PM2.5) as this is not intended to be a National Ambient Air Quality (NAAQS) analysis. Since this is not a NAAQS analysis, the following have been excluded from consideration and/or analysis:

- PM10 and PM2.5 NAAQS standards;
- PM10 and PM2.5 Significant Impact Levels;
- Nearby Sources;
- Background Concentrations; and
- Secondary Formation of PM 2.5.

2.1 PROJECT LOCATION

The location of emission sources, structures, and receptors are represented in the Universal Transverse Mercator (UTM) coordinate system. The datum for the Westmoreland Sanitary Landfill modeling analysis is based on World Geodic System (WGS84). UTM coordinates for this analysis are all located within UTM Zone 17. A map of the surrounding area and property boundary Appendix A.

The evaporator is located at the Westmoreland Sanitary Landfill, on an approximate 300-acre parcel.

The approximate UTM coordinates of the evaporator are 597,393 meters Easting and 4,444,662 meters Northing. The project will be located at a base elevation of about 290 meters above mean sea level. The evaporator is located at an active landfill. Landfill elevations range from about 290 meters to 335 meters.

2.2 MODEL SELECTION

CEC proposes to use the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD, v21112) for this dispersion modeling analysis. AERMOD also incorporates the Plume Rise Model Enhancement (PRIME) downwash algorithm. AERMOD is an EPA-approved and required dispersion model for evaluating impacts of land-based stationary sources as outlined in EPA's "Guideline on Air Quality Models" (40 CFR 51, Appendix W).

AERMOD is capable of modeling receptors both in the near-building wake (cavity) region as well as far-building wake regions. The PRIME algorithm accounts for the distance from each structure to potentially affected sources in that structure's region of influence.

Default AERMOD control options are proposed. Consistent with EPA recommendations, these include the following:

- Stack-tip downwash; and
- Effects of elevated terrain (simple and complex).

2.2.1 Urban / Rural Classification

In accordance with Section 7.2.1.1 of EPA's Guideline on Air Quality Models, Appendix W, for any dispersion modeling exercise the "urban" or "rural" determination of the location surrounding the subject source is important in determining the applicable boundary layer characteristics that affect the modeled calculation of ambient concentrations. The land use methodology in Section 7.2.1.1(b)(i) of Appendix W was used to determine the urban or rural status of the area around the Westmoreland Sanitary Landfill. This methodology examines the various land uses within 3 km of the source and quantifies the percentage of area in various land use categories. Following this guidance, 2016 National Land Cover Data was used to determine land use categories within a 3-km radius circle inscribed electronically around the landfill. The land use analysis shows the area is ~80% rural. Therefore, no urban model option was selected.

2016 NLCD Land Cover Classification		Auer Land-Use Classification			
Category ID	Category Description	Category ID	Category Description	Urban / Rural	Percent
11	Open Water	A5	Water Surfaces	Rural	4.36%
21	Developed, Open Space	A1	Metropolitan Natural	Rural	11.30%
22	Developed, Low Intensity	R1	Common Residential	Rural	18.49%
23	Developed, Medium Intensity	R2, R3, C1, I1, I2	Compact Residential / Commercial / Industrial	Urban	14.77%
24	Developed, High Intensity	R2, R3, C1, I1, I2	Compact Residential / Commercial / Industrial	Urban	5.31%
31	Barren Land (Rock/Sand/Clay)	A3	Undeveloped (uncultivated, wasteland)	Rural	2.16%
41	Deciduous Forest	A4	Undeveloped (rural)	Rural	19.09%
42	Evergreen Forest	A4	Undeveloped (rural)	Rural	0.04%
43	Mixed Forest	A4	Undeveloped (rural)	Rural	14.46%
52	Shrub/Scrub	A3	Undeveloped (uncultivated, wasteland)	Rural	0.02%
71	Grasslands/Herbaceous	A3	Undeveloped (uncultivated, wasteland)	Rural	0.78%
81	Pasture/Hay	A2	Agricultural (rural)	Rural	7.60%
82	Cultivated Crops	A2	Agricultural (rural)	Rural	1.61%
95	Emergent Herbaceous Wetland	A3	Undeveloped (uncultivated, wasteland)	Rural	0.00%
					100.0%
				Urban	20.08%
				Rural	79.92%

2.3 PROJECT SOURCE AND STACK PARAMETERS

This dispersion modeling analysis will estimate ambient air concentrations from the evaporator stack. A unit emission rate (1 g/s) is proposed to be used in this modeling analysis.

The stack parameters provided in engineering drawings and previous emission calculations (attached) are as follows:

Stack Height: 39 feet
Stack Diameter: 48 inches
Stack Exhaust Flow Rate: 30,400 scfm (22% moisture)

Stack Exhaust Flow Rate: 36,012 acfm

Stack parameter calculations are further detailed in Appendix B.

2.4 GOOD ENGINEERING PRACTICE (GEP) STACK HEIGHT AND BUILDING DOWNWASH

The roof elevation of the one significant building was provided by Noble. Building dimensions were estimated from the most recent landfill drawing, also provided by Noble. The UTM coordinates for the building were determined by overlaying the site plan on Google Earth satellite imagery, ensuring that the surrounding landmarks were adequately aligned. The building was processed using the EPA Building Profile Input Program (BPIP-PRIME v04274) to determine the Good Engineering Practice (GEP) stack heights, direction-specific building heights, and widths for each 10- degree direction for the emission source included in this air dispersion analysis.

2.5 TERRAIN AND RECEPTOR DATA

A discrete Cartesian receptor grid will be generated in AERMOD. Receptor spacing is proposed as follows:

- 25-meter spacing along property boundary;
- 50-meter spacing from the property boundary to a distance of 2,000 meters;
- 100-meter spacing from the property boundary to a distance of 5,000 meters;
- Special receptors to be located at residences identified nearby; and
- 10-meter spacing in the area of identified “hot spots”.

Receptor terrain data will be determined in a two-step process. First, a 10,000 meter x 10,000 meter receptor grid with spacing specified above, will be set up centered on the landfill property, with 30 meter spacing within the property boundaries. U.S. Geologic Survey’s (USGS) 3D Elevation Program (3DEP) data will be imported into AERMOD’s terrain processor AERMAP (v18081) in GeoTIFF format. The GeoTIFF files will have a one-third arc-second (~10 meter) resolution.

AERMAP will be used to calculate hill height scales using the TERRHGTS PROVIDED keywords in the input file CO pathway. Elevations within the landfill property boundary will be considered with regard to assigning hill heights to boundary and nearby ambient receptors. We propose two modeling scenarios. One modeling scenario will incorporate current landfill elevations. The second modeling scenario will incorporate elevations from plans for the final cover grade including a potential berm to be installed at the landfill. Elevations for model receptors at the landfill that are not captured by USGS 3DEP data will be entered into AERMAP to calculate hill height scales for these receptors.

2.6 METEOROLOGICAL DATA

The DEP has provided an AERMOD ready five year meteorological data set for the years 2016 through 2020. Both upper air and surface data were collected from the Pittsburg International Airport (KPIT). The elevation of the KPIT station is 367 meters. The KPIT data was processed by the DEP with AERMET (v21112), AERMINUTE (v15272), and AERSURFACE (v20060).

In order to evaluate the representativeness of KPIT data to the location of the evaporator at the Westmoreland Sanitary Landfill, AERSURFACE (v. 20060) was used to determine the surface characteristics albedo, bowen ratio, and surface roughness within a one-kilometer radius of the location of the evaporator and the KPIT meteorological station. Details of the surface characteristics comparison have been provided electronically (Appendix E). Maximum concentrations are expected near the location of the evaporator. With north equal to 0 degrees, maximum offsite impacts are expected occur between approximately 135° and 338°.

We propose to use meteorological data processed with the adjust u* option. Receptor concentrations have the potential to be overestimated in low wind conditions, as the evaporator stack is fairly short (39 feet).

2.7 EMISSIONS DATA AND MODEL RESULTS

A unit emission rate (1 g/s) will be used in the air dispersion model. Radium is assumed to be emitted in particulate form. Concentrations predicted by the air dispersion model will be converted to ug/m^3 radium using a unit multiplier, then to units of microCuries per milliliter (µCi/ml).

2.7.1 Calculations

The output concentrations of the air dispersion model (µg/m3) will be converted into µCi/ml and used to determine the total effective dose equivalent (i.e. dose) at the potential receptor locations.

To convert from µg/m3 to µCi/ml for Ra-226, the following conversion will be used:

$$\frac{\mu g}{m^3} \times \frac{m^3}{1 \times 10^6\, ml} \div 9.89 \times 10^{-1} \frac{\mu g}{\mu Ci} (226^{Ra})$$

To convert from µg/m3 to µCi/ml for Ra-228, the following conversion will be used:

$$\frac{\mu g}{m^3} \times \frac{m^3}{1 \times 10^6\, ml} \div 2.73 \times 10^{2} \frac{\mu g}{\mu Ci} (228^{Ra})$$

2.7.2 Calculation Assumptions

The emissions concentrations of Ra-226 and Ra-228 were provided to CEC by Perma-Fix and were based on calculations prepared by Perma-Fix using the following assumptions:

- Radium is assumed to be emitted in particulate form.
- 45,000 gal/day processed through system (maximum system capacity).
- The entire 45,000 gal/day is emitted through evaporation (conservative assumption).
- 99% of radium is removed by the evaporator mist elimination system through TDS reduction which goes into the sludge. The remaining 1% gets evaporated with the 45,000 gal/day (based on 99% TDS reduction manufacturer specification).

As part of the permitting process for the proposed leachate evaporation system, Westmoreland Sanitary Landfill collected representative samples of the facility's leachate to test for radium-226 and radium-228. The maximum concentrations of Ra-226 and Ra-228 from the laboratory results were utilized in the emissions calculations prepared by Perma-Fix and provided to CEC for use in this dispersion modeling analysis. Westmoreland Sanitary Landfill does not anticipate any significant changes to future incoming waste streams and therefore does not anticipate any significant changes to the radionuclide content of the leachate.

2.7.3 Regulatory and Technical Thresholds

The dose will be determined using the methodology in Appendix B to 10CRF20 of the U.S. Nuclear Regulatory Commission (NRC) regulations (Annual Limits on Intake and Derived Air Concentrations of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage).

Table 2 in Appendix B to 10 CFR 20 is relevant to the assessment of dose to the public. The concentration values in Table 2 are equivalent to the radionuclide concentrations, which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 50 millirem. Because more than one radionuclide is present, a unity rule calculation will be performed to account for the dose contribution of Ra-226 and Ra-228.

Calculations quantifying maximum radium content of the sludge have previously been submitted to the DEP and are included as Appendix D. These calculations demonstrate the incoming leachate concentrations of Ra-226 and Ra-228 would each have to be greater than 60 times the previously measured maximum concentrations, while the evaporator is operating at full capacity, to exceed the unity rule.

Following installation and startup of the HRT pre-treatment and leachate evaporation systems, the site will collect representative samples (before and after pre-treatment) in accordance with the landfill's Solid Waste Permit. Resulting radium-226 and radium-228 concentrations will be compared with the calculated concentrations that would exceed the unity rule. This process will enable Westmoreland Sanitary Landfill to establish a database of Ra-226 and Ra-228 concentrations for tracking potential concentration changes, as well as to demonstrate compliance with NRC Limits.

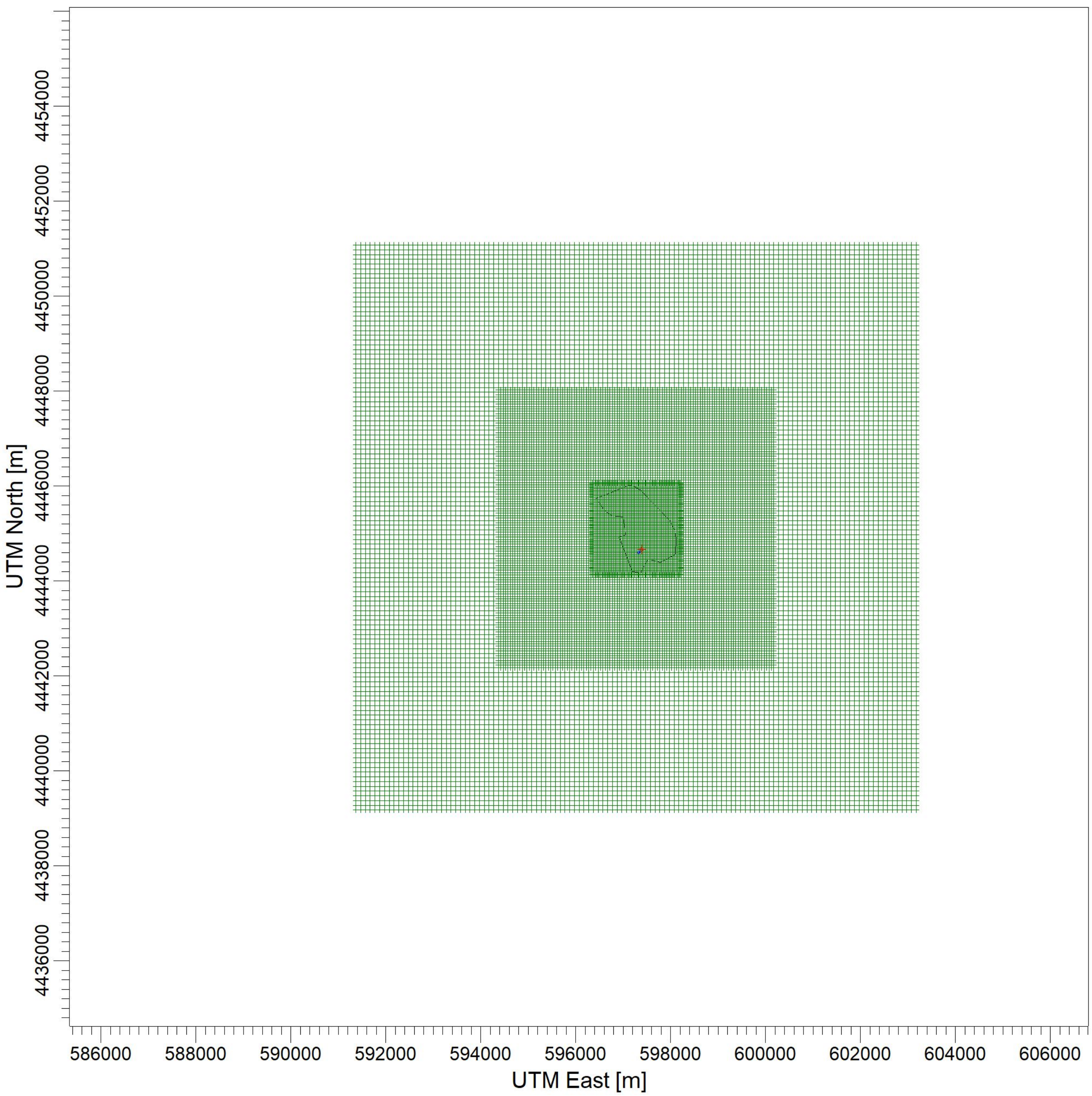
2.8 MODEL RESULTS

Results of the air dispersion modeling will be documented in a final written report that will detail the model outputs and include all input and output files associated with the EPA's AERMOD Modeling System. The final modeling will be submitted electronically to the DEP. The report will include an analysis of the resultant ambient air concentration of Ra-226 and Ra-228 radionuclides in µCi/ml. Model output concentrations contours will be used to assist in locating potentially impacted areas, including potential sensitive receptor locations. This information will be used to select air monitoring locations and update, as needed, the monitoring plan previously submitted to the DEP by Noble.

APPENDIX A
SITE PLAN AND RECEPTOR GRID

PROJECT TITLE:

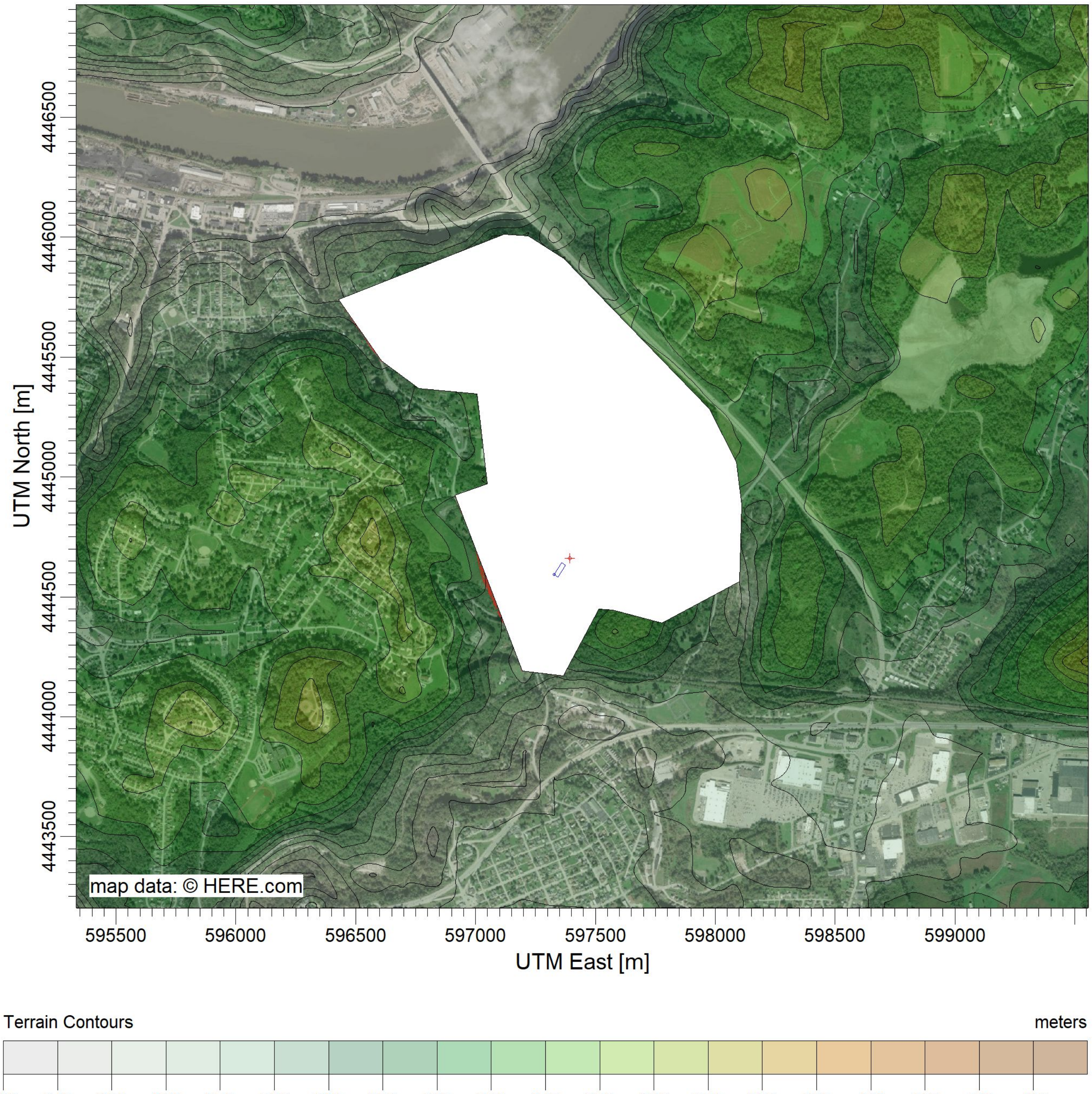
Appendix A Receptor Grid
Leachate Evaporator



COMMENTS:	**1**	COMPANY NAME: **Civil & Environmental Consultants, Inc.**	
	RECEPTORS: **27535**		
		SCALE: 1:134,977 0 5 km	
		DATE: **6/23/2021**	PROJECT NO.: **313-688**

PROJECT TITLE:

Appendix A Site Layout
Leachate Evaporator



COMMENTS:	1	COMPANY NAME: **Civil & Environmental Consultants, Inc.**	
	RECEPTORS: **27535**		
		SCALE: 1:26,557 0 — 1 km	
		DATE: **6/23/2021**	PROJECT NO.: **313-688**

APPENDIX B
STACK PARAMETERS

APPENDIX B - STACK PARAMETERS

Modeling Parameters			Referance
Stack height	39	ft	Stack Drawing.pdf
	11.89	m	
Stack diameter	4	ft	Stack Drawing.pdf
	1.22	m	
Exit flow rate	30,400	scfm 22% H2O	WSL-Air-Plan-Approval-RTC-1.pdf
	36,012	acfm	
	17.00	m3/sec	
Exit temperature	165	°F	
	347.0	K	

1 ft =	0.3048	m
1 cf =	0.028317	m3
1 min =	60	sec
F =	[(F-32) x (5/9) +273.15]	K
Ps =	14.5	psia
Pb =	14.5	psia
Pa =	14.5	psia
RHs =	22%	
RHa =	22%	
PVs =	0.3391	psi
PVa =	0.3887	psi
Ts =	528	R
Ta =	625	R

$$ACFM = SCFM \cdot \frac{P_S - (RH_S \cdot PV_S)}{P_B - (RH_A \cdot PV_A)} \cdot \frac{T_A}{T_S} \cdot \frac{P_B}{P_A}$$

where:

P_S = Standard pressure (PSIA)

P_B = Atmospheric pressure – barometer (PSIA)

P_A = Actual pressure (PSIA)

RH_S = Standard relative humidity

RH_A = Actual relative humidity

PV_S = Saturated vapor pressure of water at standard temperature (PSI)1

PV_A = Saturated vapor pressure of water at actual temperature (PSI)1

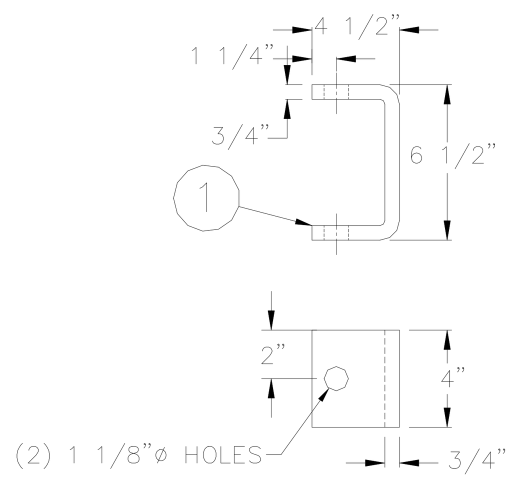
T_S = Standard temperature (°R) NOTE: °R =°F+460

T_A = Actual temperature (°R)1: See vapor pressure chart >

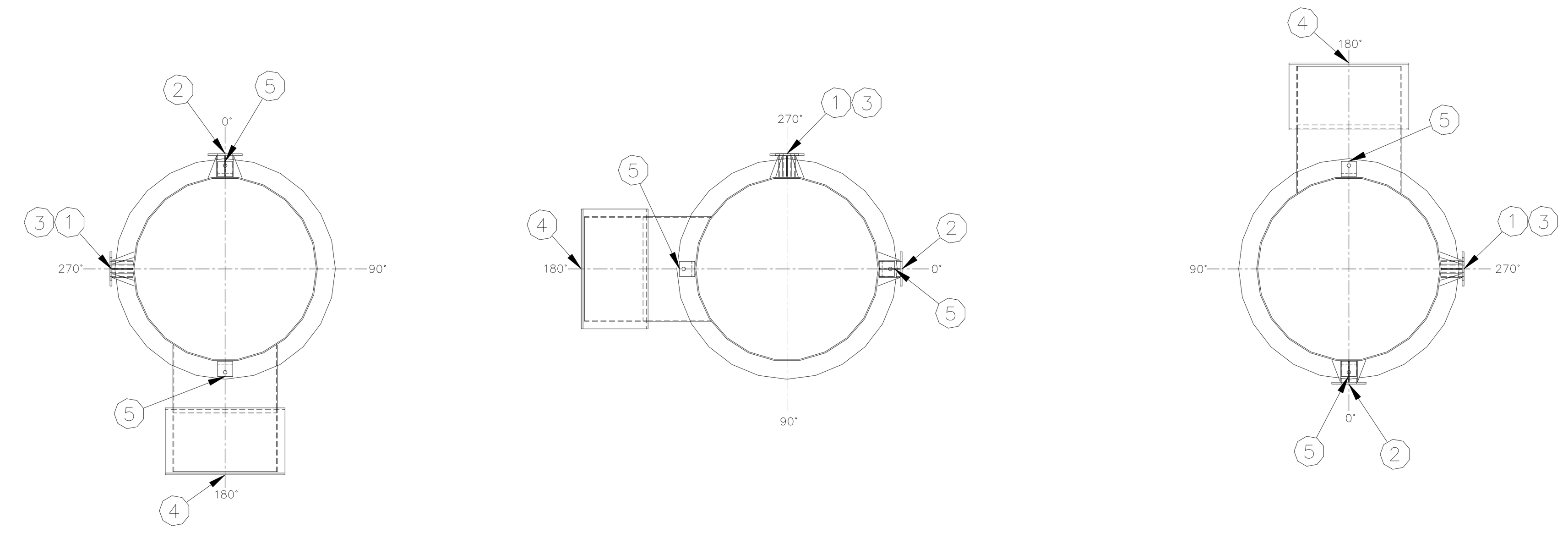
https://www.pdblowers.com/tech-talk/scfm-standard-cfm-vs-acfm-actual-cfm/

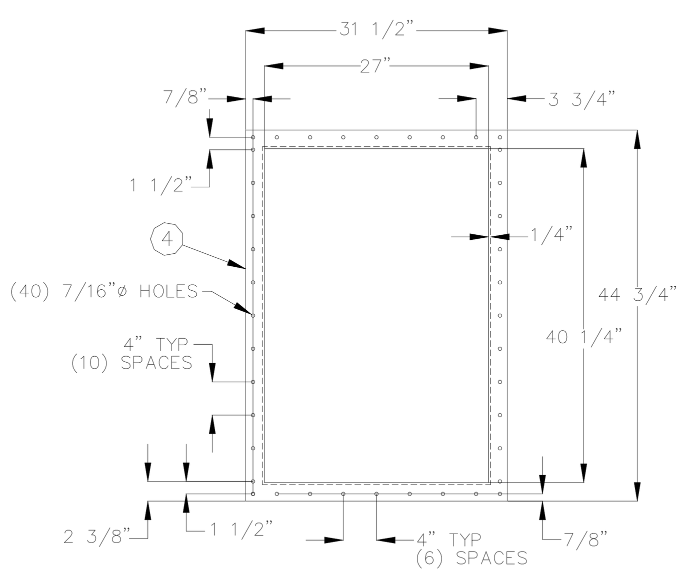
APPENDIX C
STACK DIAGRAM

ITEM	QTY	DESCRIPTION	REF.			
1	1	4"ø FRP FLANGED NOZZLE W/GUSSETS				
2	1	4"ø FRP FLANGED NOZZLE W/GUSSETS				
3	1	2"ø FRP FLANGED NOZZLE W/GUSSETS				
4	1	27" x 40 1/4" RECTANGULAR FLANGED FITTING				
5	2	LIFTING LUGS – #304 STAINLESS STEEL				

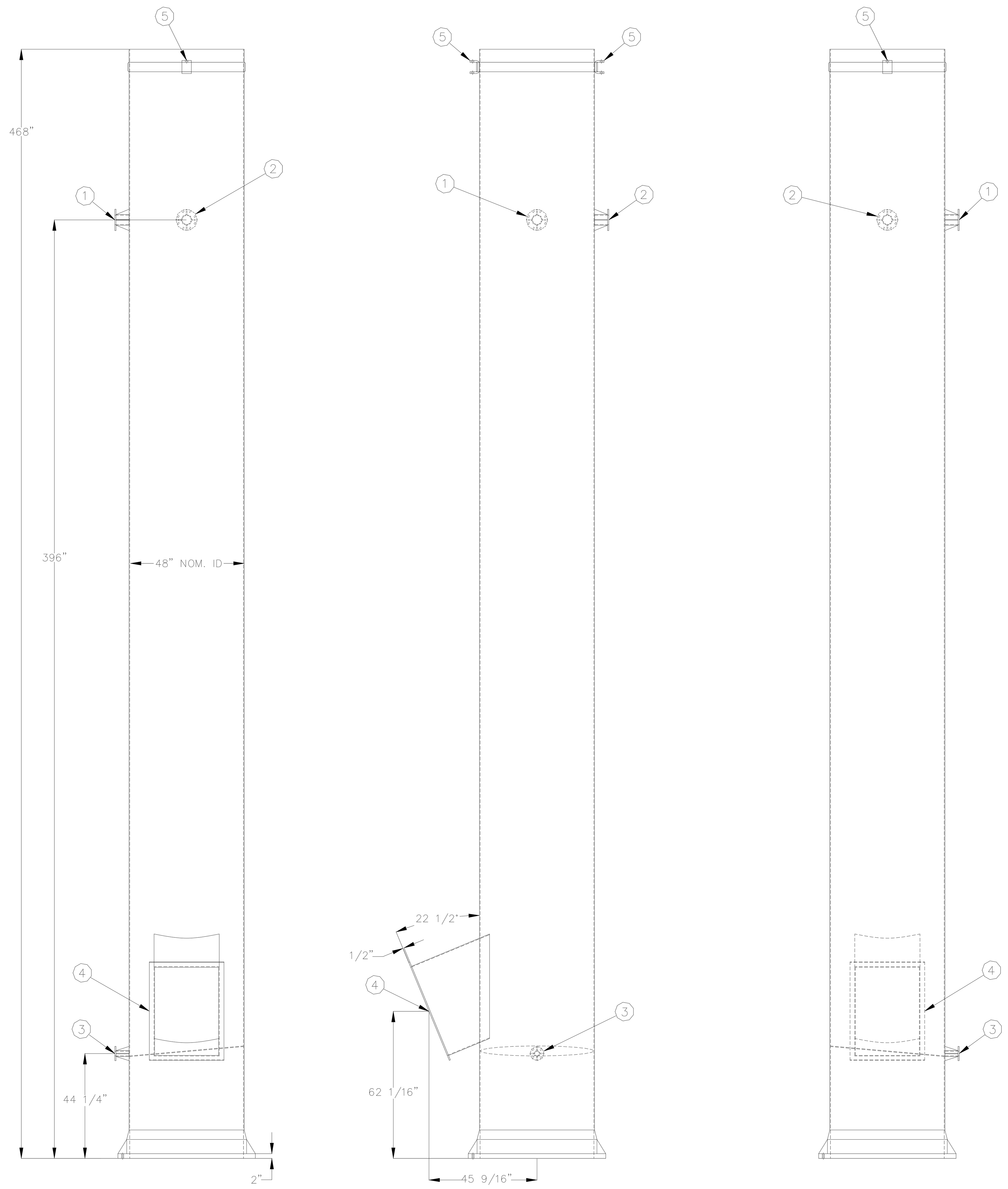


LIFT LUG DETAIL

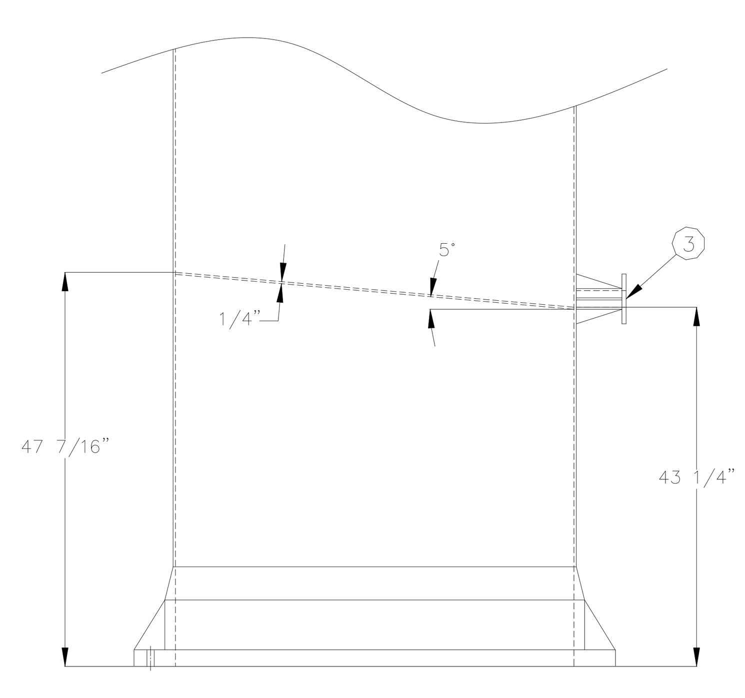




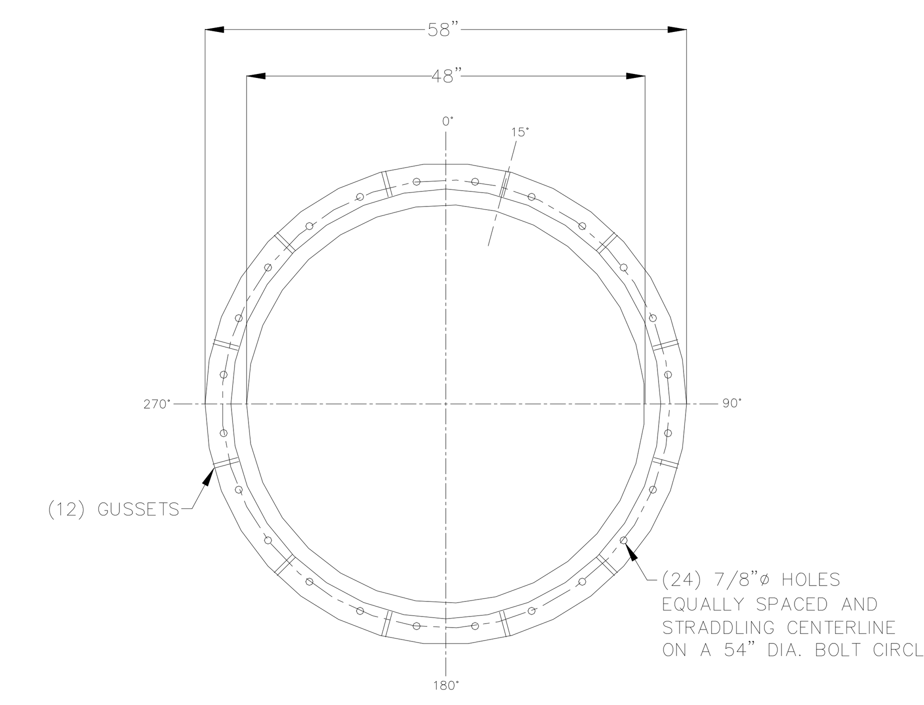
ITEM #4 FLANGE DETAIL



ELEVATION VIEW ELEVATION VIEW ELEVATION VIEW



INTERNAL PLATE DETAIL



BOTTOM FLANGE

MATERIAL & GENERAL NOTES

–RESIN: DERAKANE 441 VINYL ESTER RESIN – 100 MIL CORROSION BARRIER – MEKP CURE
DERAKANE 441 VINYL ESTER RESIN BACKUP – MEKP CURE
–VEIL: NEXUS FILAMENT WIND 90° (90° = HOOP)
–EXTERIOR FINISH: RAL #7042 TRAFFIC GREY A GEL COAT w/U.V. INHIBITOR.
–STACK DESIGNED FOR A SPECIFIC GRAVITY OF 1.2, OUTDOORS & 20 PSF SNOW LOAD.
–WIND LOADS ARE PER ASCE 7–10 WITH 115 MPH WIND LOAD AND EXPOSURE C.
–STACK DESIGNED FOR +5"/–0" w.c. PRESSURE AT 200° F. TEMPERATURE.
–STACK DESIGNED IN ACCORDANCE WITH ASTM D 3299 WHERE APPLICABLE. ITEMS NOT ADDRESSED BY ASTM D 3299 ARE DESIGNED IN ACCORDANCE WITH GPI STANDARDS OR OUR SUPPLIERS STANDARDS.
–THE CHEMICAL SERVICE MUST BE COMPATIBLE WITH THE MATERIALS OF CONSTRUCTION AT THE DESIGN CONDITIONS.
–MAXIMUM FLUID LEVEL IS 3".
–STACK ESTIMATED WEIGHT EMPTY: 2,100 LB.
–ALL HARDWARE TO BE 18–8 S.S. UNLESS SPECIFIED OTHERWISE.
–ALL EXPOSED C.S. TO BE PAINTED WITH GRAY PRIMER.
–TRUE ORIENTATION SHOWN IN PLAN VIEW ONLY FOR CLARITY.
–SEE GPI HANDLING & INSTALLATION INSTRUCTIONS & GENERAL OPERATING INSTRUCTIONS.
–ALL STANDARD NOZZLES HAVE A 150# BOLT PATTERN PER ANSI B16.5, 50 PSI RATING, WITH HOLES STRADDLING THE CENTER LINES.
–ALL STANDARD FLANGED FITTINGS ARE TO EXTEND 6" FROM FLANGE FACE TO CLOSEST POINT ON TANK UNLESS SPECIFIED OTHERWISE.
–SHIPPING ORIENTATION: 90° DOWN

PART NUMBER: ST16–1

REVISIONS				
NO.	DESCRIPTION	BY DATE:	CHK'D:	COPIES:
1.	–	–		
2.				
3.				
4.				
5.				

HEARTLAND
GPI Corp.
101 Northern Rd. Schofield, WI 54476 (715)–359–6123

DRAWN BY: KJZ	SCALE:	HDL'G. INST.	# ORIG. PRINTS.
CHECKER:	DATE: OCT. 15, 2019	DRAWING NO: D19–10–15–01	
CHK'D:	GPI JOB# 7888		

APPENDIX D
RADIUM EMISSION CALCULATIONS (PERMA-FIX)

29 April 2021

Alexander Sulkowski
Director
Noble Environmental Inc.
m. 412.979.5493
asulkowski@nobleenviro.com

RE: Westmoreland Sanitary Landfill, Radium Throughput, ***Rev. 4***

Dear Mr. Sulkowski,

Noble Environmental Inc. (Noble) reached out to Perma-Fix Environmental Services, Inc. (Perma-Fix) requesting assistance with determining total radium concentrations at the Westmoreland Sanitary Landfill in Westmoreland, PA. This letter provides the calculations and assumptions to determine the *maximum* radium-226 (Ra-226) and radium-228 (Ra-228) in the sludge material and emitted through the evaporation process, based on limited knowledge of the process and sample results along with the manufacturer specifications. This letter has been revised to show the corrected minutes per day and includes a total dissolved solids (TDS) reduction of 99% (consistent with the evaporator manufacturer's specifications). This calculation assumes the influent radium is emitted as a particulate during the evaporation process.

Radium: Data based on analytical results provided to Perma-Fix showing maximum results of 8.74 pico-Curies per Liter (pCi/L) Ra-226 and 4.09 pCi/L Ra-228. This assumes no radium removal from the upstream HRT system prior to fluids entering the evaporator.

Assumptions:

- 45,000 gal/day processed through system (maximum system capacity)
- The entire 45,000 gal/day is emitted through evaporation (conservative assumption)
- 99% of radium is removed by the evaporator mist elimination system through TDS reduction which goes into the sludge. The remaining 1% gets evaporated with the 45,000 gal/day (based on 99% TDS reduction manufacturer specification). It is important to note, the HRT system upstream of the evaporator provides a manufacturer's guarantee (demonstrated through laboratory bench scale testing) to provide greater than 99% TSS reduction which may contribute to upstream reduction in radium that would otherwise enter the evaporator.
- 30,400 scfm vapor flow rate from stack (including 22% moisture content)

$$\frac{pCi}{day}\ of\ Ra226 = \frac{8.74pCi}{L} Ra226 \times \frac{3.78L}{gal} \times \frac{45{,}000gal}{day} = \mathbf{1.487E^6 pCi/day}$$

$$\frac{pCi}{L} of\ Ra226\ after\ evap. = \frac{1.487E^6 pCi}{day} \times 0.01 \times \left(\frac{min}{30{,}400cf}\right) \times \frac{day}{1{,}440min} \times \frac{1cf}{28.31L} = \mathbf{1.20E^{-5} pCi/L}$$

$$\frac{pCi}{day} \; of \; Ra228 = \frac{4.09pCi}{L} Ra228 \times \frac{3.78L}{gal} \times \frac{45{,}000gal}{day} = \mathbf{6.957E^5 pCi/day}$$

$$\frac{pCi}{L} of \; Ra228 \; after \; evap. = \frac{6.957E^5 pCi}{day} \times 0.01 \times \left(\frac{min}{30{,}400cf}\right) \times \frac{day}{1{,}440min} \times \frac{1cf}{28.31L} = \mathbf{5.61E^{-6} pCi/L}$$

$$\frac{pCi}{L} of \; Ra226 \; in \; sludge = \frac{1.487E^6 pCi}{day} \times 0.99 \times \left(\frac{day}{4{,}500gal}\right) \times \frac{gal}{3.78L} = \mathbf{86.5 pCi/L}$$

$$\frac{pCi}{L} of \; Ra228 \; in \; sludge = \frac{6.957E^5 pCi}{day} \times 0.99 \times \left(\frac{day}{4{,}500gal}\right) \times \frac{gal}{3.78L} = \mathbf{40.5 pCi/L}$$

The Nuclear Regulatory Commission (NRC) Ra-226 air discharge limit is 9E-4 pCi/L, which assumes, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 50 millirem. Similarly, the Ra-228 air discharge limit is 2E-3 pCi/L. The calculated Ra-226 and Ra-228 emission concentrations of 1.20E-5 pCi/L and 5.61E-6 pCi/L, respectively, are below the NRC Ra-226 and Ra-228 limits. Compliance is demonstrated using a unity rule calculation, the result of which is required to be <1. The unity rule calculation is as follows:

$$\frac{1.2E^{-5}\frac{pCi}{L}}{9E^{-4}\frac{pCi}{L}} + \frac{5.6E^{-6}\frac{pCi}{L}}{2E^{-3}\frac{pCi}{L}} = \mathbf{0.016}$$

Using the same assumptions in the calculations shown on page 1 the incoming Ra-226 and Ra-228 concentrations were evaluated to determine what the incoming concentrations in the water would need to be to exceed the NRC air discharge limits. When evaluated individually, the incoming Ra-226 concentration would need to be more than 393 pCi/L, and the Ra-228 concentration would need to be more than 1,460 pCi/L. Assuming the incoming water contains both radium isotopes in the same ratio as the maximum concentrations ratio (8.74:4.09 pCi/L Ra-226:Ra-228), the incoming concentrations would need to be more than 542 pCi/L Ra-226 and 253 pCi/L Ra-228 to exceed the unity rule calculation.

Please contact me if you have any questions or require further information.

Sincerely,

Alejandro Lopez, CHP
Director- Health Physics Operations
(724) 728-3960
alopez@perma-fix.com

APPENDIX E
SURFACE CHARACTERISTICS COMPARISON CHARTS
(Submitted Electronically)