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DRAFT MEMORANDUM

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Date: February 10, 2010

To: Brian Rakvica, NDEP

RE: Site-Specific Input Parameters for the Johnson & Ettinger Model

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This memorandum summarizes the approach used to identify site-specific values for the following input parameters to be used in the Johnson and Ettinger (J&E) Soil Gas Model to evaluate vapor intrusion at the Tronox site:

- Soil type
- Soil dry bulk density, soil total porosity, soil water-filled porosity
- Soil vapor permeability
- Average soil temperature
- Air exchange rate
- Enclosed space floor length and width
- Vapor flow rate into building

The rationale for each recommended value is described in the following sections.

Soil Type

Soil type was determined based on laboratory-measured grain size distributions of 15 samples collected across the Tronox site in 2009. These samples were all taken at 10 feet below ground surface (bgs), except for one sample at 15 feet bgs and one sample at 9 feet bgs. Figure A-1 shows the locations of these samples. Particle size analysis was performed for both coarser grains, according to ASTM D422, and finer grains, according to ASTM D4464M. The weight percent of gravel, sand, silt, and clay in these samples was determined, as defined by the USDA. To classify the soil type, the normalized weight percent of sand, silt, and clay was plotted on the U.S. Soil Conservation Service Classification Chart provided in the J&E Model User's Guide (EPA 2004). The result is shown in Figure A-2. According to this classification, seven samples are "sand," seven samples are "loamy sand," and one sample is "sandy loam;" however, the 14 samples classified as sand or loamy sand are clustered together along the boundary between these two soil types. Table A-1 summarizes these results. Figure A-3 shows the mean of all samples, which falls slightly inside the boundary of loamy sand. Removing the sandy loam sample from the mean gives a classification that is nearly directly on top of the loamy sand and sand boundary, as shown in Figure A-4. In addition, the soil classification was mapped for the various sample locations, shown in Figure A-1. Although it might appear that some regions of the site consist of sand and other regions consist of loamy sand, we believe that the entire site should be considered to be of a single soil type because the grain size distribution in Figure A-2 is very tightly clustered. While this cluster happens to cross the chart's boundary for sand and loamy sand, there are not two distinct clusters.

Soil Dry Bulk Density, Soil Total Porosity, Soil Water-Filled Porosity

Site-specific values for soil dry bulk density, soil total porosity, and soil water-filled porosity were estimated based on measurements from the same 15 soil samples collected in 2009 described above and an additional sample collected in 2008, although this later sample lacked laboratory data for total porosity. Soil dry bulk density was measured according to ASTM D2937, soil total porosity was measured according to API RP 40[1]. The results for these analyses are shown in Table A-2. The site-specific input values were taken as the arithmetic mean of the samples because of the uniform soil stratum identified in the above discussion.

Due to the uncertainty associated with water-filled porosity, we conducted an additional evaluation of percent moisture data from every soil sampling location. Although this is a less accurate test, averaged over all soil samples taken on the site, percent moisture should be close to the laboratory measured soil water-filled porosity if the 16 samples are representative of the site-wide water-filled porosity. Percent moisture was converted to a volumetric water content using a mean wet density from the 16 soil samples. The result was that the laboratory-measured value for soil water-filled porosity matched up very well with the site-wide mean percent moisture data. Table A-3 shows this result as well as a breakdown by

[1] The laboratory occasionally reports a value for soil total porosity under ASTM D2937. However, this is a calculated value based upon other measured parameters.

month. Additionally, the majority of the soil samples were taken in the dry months between July and October, likely yielding a conservative value for water-filled porosity.

Soil Vapor Permeability

A site-specific value for soil vapor permeability (k_v) was determined using the method outlined in Section 2.8 of the J&E Model User's Guide (EPA 2004). This model uses an average value of saturated hydraulic conductivity based on soil type. Because grain size data discussed above suggests that soil at the site is between sand and loamy sand, we used the mean of the values for sand and loamy sand saturated hydraulic conductivity provided in Table 2-5 of the User's Guide. The saturated hydraulic conductivity was then used with water density and viscosity to calculate a soil intrinsic permeability. In a similar fashion, the residual soil water content was calculated as the mean of the sand and loamy sand residual soil water content values provided in Table 3 of the User's Guide. From the residual soil water content, site-specific soil water-filled porosity and site-specific soil total porosity, we calculated an effective total fluid saturation. This value is then used to calculate the relative air permeability. The soil vapor permeability is calculated as the product of relative air permeability and soil intrinsic permeability. The resulting site-specific average value for k_v was found to be 3.65E-08 cm^2.

Average Soil Temperature

The J&E Model User's Guide (EPA 2004) provides a figure of Average Shallow Groundwater Temperature in the United States that can be used to approximate average soil temperature. This figure gives an average groundwater temperature of 17°C in the Henderson, Nevada area, which was used as the average soil temperature in the model.

Air Exchange Rate

EPA provides a recommended value for the air exchange rate for a residential building, but not a commercial building, in their J&E Model User's Guide (EPA 2004). The California Environmental Protection Agency (Cal-EPA) recommends a value of 1 per hour (1/hr) for commercial buildings based on the California Energy Commission's *Manual for Compliance with the 2001 Energy Efficiency Standards (for Nonresidential Buildings, High-Rise Residential Buildings and Hotels/Motels* (Cal-EPA 2005). The Michigan Department of Environmental Quality (MDEQ) recommends a value of 2/hr. The basis for this value is two-fold. First, the American Society of Heating, Refrigerating and Air-Conditioning

Engineers (ASHRAE) *Draft BSR/ASHRAE Standard 62-1989R, Ventilation for Acceptable Indoor Air Quality* that suggests that system rates for total supply air in a general office will be approximately 1/hr. Second, natural ventilation, infiltration, and entrance and egress into and out of the building will increase air exchange rates above the approximate 1/hr provided by mechanical systems (Michigan Environmental Science Board 2001). To address the uncertainty in this input parameter, we propose to present a range of estimated indoor air concentrations and corresponding risk estimates based on an air exchange rate of 1/hr or 2/hr.

Enclosed Space Floor Length and Width

For purposes of evaluating vapor intrusion into existing buildings, site-specific data will be used for the enclosed space floor length and width. For purposes of evaluating future buildings, neither EPA nor Cal-EPA provides recommended values for these parameters. The MDEQ does provide a recommended default value for the size of a hypothetical commercial building of 4,000 square feet (ft^2) or 372 square meters (m^2) (Michigan Environmental Science Board 2001). This value is based on data provided in a 1994 U.S. Department of Energy (DOE) report entitled *Commercial Building Characteristics 1992*, which documents the results of a Commercial Buildings Energy Consumption Survey. The most recent survey was completed in 2003 and the results were presented in a 2006 report issued by the U.S. Energy Information Administration (U.S. EIA 2006). The data presented in this report are similar to that presented in the 1994 DOE report in that the majority of commercial buildings (other than malls) are between 1,000 $feet^2$ and 5,000 $feet^2$ in size and a single story, regardless of region of the country. In addition, the reported median square footage (the metric used by MDEQ) for different categories of commercial buildings nationwide ranges from 3,000 ft^2 to 7,000 ft^2. For purposes of this assessment we propose to use a value of 2000 square centimeters (cm^2) for both the floor length and width, which is approximately equal to the default value of 4000 ft^2 (372 m^2) recommended by MDEQ.

Vapor Flow Rate Into Building (Soil Gas Advection Rate)

The vapor flow rate into a building (Q_{soil}) is a controversial input parameter in the J&E Model. As originally conceived, this value was calculated using a “perimeter crack model” by Nazaroff based on various site-specific or default values related to soil vapor permeability, pressure differentials, and size of cracks; however, a wide range of values can be predicted because of the model’s sensitivity to estimates of soil vapor permeability (EPA 2004). Consequently, EPA provides a recommended “default” value for vapor flow rate into residential buildings, but not commercial buildings, in their J&E Model User’s Guide (EPA 1994). The recommended default value is 5 L/m, which is based on empirical data collected in residences; however, such data for commercial buildings are lacking. Cal-EPA has adopted EPA’s recommended default value for Q_{soil} for residential buildings. For commercial buildings, Cal-EPA recommends scaling the default residential value based on the size of the commercial building (e.g., if the commercial building is twice the size as the default residential building, then the Q_{soil} value is doubled (Cal-EPA 2005). To address the uncertainty in this parameter, we propose to present a range of estimated indoor air concentrations and corresponding risk estimates based on a scaled Q_{soil} value (4 × 5 L/m or 20 L/m because the default commercial building size described above is 4-times the default residential building size) as recommended by Cal-EPA and a calculated Q_{soil} based on a site-specific soil vapor permeability. As discussed previously, this value will be based on substantial site-specific data, especially with regard to soil water-filled porosity.

Model Output

Soil gas screening values have been calculated for all chemicals detected in soil gas using the J&E model with both the most conservative and least conservative proposed values for indoor air exchange rate (ER) and average vapor flow rate into building (Q_{soil}). We have called these screening limits the lower screening limit and upper screening limit respectively. Table A-4 shows these screening limits for all chemicals as well as any exceedances. For discussion purposes, the effect on the screening limit of differing values for Q_{soil} and ER are shown below for chloroform, carbon tetrachloride, TCE, and PCE.

J&E Model Output Screening Values

Chloroform (ug/m^3)

		Q_{soil}	
		20 L/m	Calculated
ER	1/hr	377	898
	2/hr	753	1,800

Carbon Tetrachloride (ug/m^3)

		Q_{soil}	
		20 L/m	Calculated
ER	1/hr	696	1,500
	2/hr	1,390	2,990

TCE (ug/m^3)

		Q_{soil}	
		20 L/m	Calculated
ER	1/hr	94	203
	2/hr	188	406

PCE (ug/m^3)

		Q_{soil}	
		20 L/m	Calculated
ER	1/hr	1,870	3,900
	2/hr	3,740	7,800

References

Cal-EPA. 2005. Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air. California Environmental Protection Agency, Department of Toxic Substances Control, Sacramento, CA.

Michigan Environmental Science Board. 2001. Evaluation of the Michigan Department of Environmental Quality's Generic Groundwater and Soil Volatilization to Indoor Air Inhalation Criteria. (A Science Report to Governor John Engler). Michigan Environmental Science Board, Lansing, MI.

U.S. EIA. 2006. 2003 Commercial Buildings Energy Consumption Survey. Detailed Tables. U.S. Energy Information Administration, Washington, DC. http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html (accessed January 13, 2010).

U.S. EPA. 2004. User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

TABLE A-1
USDA Soil Classification Summary

Sample ID	Absolute Weight Percent (%)				Normalized Weight Percent (%)			Soil Type (from tri-plot)	Area
	Gravel	Sand	Silt	Clay	Sand	Silt	Clay		
SA56-10BSPLP	24.6	63.1	10.2	2.08	83.7	13.6	2.76	Loamy Sand	I
RSAM3-10BSPLP	38.5	52.0	8.69	0.794	84.6	14.1	1.29	Loamy Sand	I
RSAJ3-10BSPLP	20.9	63.8	13.2	2.12	80.7	16.7	2.68	Loamy Sand	I
SA166-10BSPLP	35.2	52.1	10.2	2.56	80.3	15.7	3.95	Loamy Sand	I
SA182-10BSPLP	50.0	35.5	11.6	2.93	71.0	23.1	5.85	Sandy Loam	I
SA34-10BSPLP	28.9	58.9	11.3	0.794	82.9	15.9	1.12	Loamy Sand	III
SA52-15BSPLP	29.3	61.3	8.47	0.967	86.7	12.0	1.37	Sand	III
RSAQ8-10BSPLP	34.9	57.0	7.64	0.459	87.6	11.7	0.704	Sand	III
RSAN8-10BSPLP	64.3	29.5	5.85	0.342	82.7	16.4	0.958	Loamy Sand	III
RSAQ4-10BSPLP	41.3	53.1	5.29	0.379	90.3	9.01	0.645	Sand	IV
SA148-10BSPLP	26.3	63.8	8.78	1.05	86.7	11.9	1.42	Sand	IV
SA30-9BSPLP	12.8	77.7	8.54	0.973	89.1	9.79	1.12	Sand	II
SA128-10BSPLP	35.4	54.2	9.29	1.14	83.9	14.4	1.77	Loamy Sand	II
SA102-10BSPLP	26.1	63.6	9.36	0.888	86.1	12.7	1.20	Sand	II
SA64-10BSPLP	26.7	63.9	8.39	0.982	87.2	11.4	1.34	Sand	II
Average	**33.0**	**56.6**	**9.12**	**1.23**	**84.2**	**13.9**	**1.88**	**Loamy Sand**	
Average without Sandy Loam	31.8	58.2	8.95	1.11	85.1	13.3	1.61	Boarderline	

TABLE A-2
Site-Wide Soil Properties Summary

Sample ID	Depth (ft)	Soil water-filled porosity[1]	Dry Bulk Density[2] (g/cc)	Soil total porosity[3]	Wet Bulk Density[4] (g/cc)
SA56-10BSPLP	10	0.107	1.689	0.380	1.823
RSAM3-10BSPLP	10	0.139	1.593	0.389	1.738
SA166-10BSPLP	10	0.092	1.721	0.370	1.820
SA182-10BSPLP	10	0.183	1.740	0.441	1.922
RSAJ3-10BSPLP	10	0.141	1.770	0.533	1.924
RSAI7-10B[5]	10	0.138	1.661	NA	1.799
SA34-10BSPLP	10	0.178	1.738	0.420	1.907
SA52-15BSPLP	15	0.199	1.405	0.351	1.644
RSAQ8-10BSPLP	10	0.207	1.697	0.413	1.844
RSAN8-10BSPLP	10	0.185	1.679	0.392	1.868
RSAQ4-10BSPLP	10	0.129	1.841	0.469	1.982
SA148-10BSPLP	10	0.108	1.762	0.420	1.880
SA30-9BSPLP	9	0.139	1.805	0.375	1.965
SA128-10BSPLP	10	0.151	1.654	0.392	1.810
SA102-10BSPLP	10	0.140	1.769	0.380	1.904
SA64-10BSPLP	10	0.164	1.717	0.383	1.865
Mean		**0.150**	**1.703**	**0.407**	**1.856**

Notes:

1: Average of values measured according to API RP 40 and ASTM D2937

2: As measuredy according to ASTM D2937

3: As measured according to API RP 40

4: Calculated from dry bulk density and water-filled porosity according to ASTM D2937

5: API RP 40 not performed for this sample

TABLE A-3
Site-Wide Estimated Soil Water-Filled Porosity at 10 Feet bgs
(Calculated from Percent Moisture)

	Month						
	June	July	August	September	October	November	All Months
Sample Count	12	75	58	75	39	27	286
Mean	**0.166**	**0.154**	**0.147**	**0.143**	**0.140**	**0.185**	**0.151**
Median	0.151	0.152	0.143	0.141	0.139	0.167	0.145
Standard Deviation	0.078	0.025	0.029	0.037	0.019	0.075	0.040
Maximum	0.411	0.219	0.242	0.411	0.195	0.353	0.411
Minimum	0.113	0.093	0.097	0.097	0.104	0.080	0.080

TABLE A-4
Soil Gas - Johnson and Ettinger Model Lower and Upper Screening Limit Exceedances

Chemical	Result Unit	Sample Count	Detection Count	% Detects	Min Detect (ug/m3)	Max Detect (ug/m3)	Location of Max Detect	Min Non-Detect	Max Non-Detect	JEM Lower screening limit[1] (ug/m3)	Count of Detects > lower limit exceedances	Count of Non-Detects > lower limit exceedances	JEM Upper Screening Limit[2] (ug/m3)	Count of upper limit exceedances	Count of non-detects > upper limit exceedances
1,1,1-Trichloroethane	ug/m3	102	22	22%	0.08	14	SG35B-05	0.074	33	8,200,000	0	0	35,200,000	0	0
1,1,2,2-Tetrachloroethane	ug/m3	102	2	2%	0.17	0.18	SG46B-05	0.094	42	192	0	0	797	0	0
1,1,2-Trichloroethane	ug/m3	102	12	12%	0.12	5.4	SG53B-05	0.074	33	652	0	0	2,800	0	0
1,1,2-Trichlorotrifluoroethane	ug/m3	102	68	67%	0.40	1.9	SG56B-05	0.62	37	112,000,000	0	0	482,000,000	0	0
1,1-Dichloroethane	ug/m3	102	51	50%	0.08	290	SG66B-05	0.074	33	1,930,000	0	0	8,140,000	0	0
1,1-Dichloroethene	ug/m3	102	48	47%	0.08	510	SG46B-05	0.075	33	678,000	0	0	3,070,000	0	0
1,2,4-Trichlorobenzene	ug/m3	102	27	26%	0.12	240	SG95B-05	0.11	50	31,100	0	0	96,500	0	0
1,2,4-Trimethylbenzene	ug/m3	102	73	72%	0.12	42	SG77B-05	1	45	26,500	0	0	104,000	0	0
1,2-Dibromo-3-chloropropane	ug/m3	102	0	0%	-	-	-	0.11	50	NA	-	-	NA	-	-
1,2-Dichlorobenzene	ug/m3	102	24	24%	0.11	52	SG95B-05	0.097	43	812,000	0	0	3,340,000	0	0
1,2-Dichloroethane	ug/m3	102	22	22%	0.09	31	SG57B-05	0.074	33	333	0	0	1,590	0	0
1,2-Dichloropropane	ug/m3	102	27	26%	0.08	2.6	SG51B-05	0.074	33	537	0	0	2,310	0	0
1,2-Dichlorotetrafluoroethane	ug/m3	102	33	32%	0.08	0.14	SG46B-05	0.077	33	NA	-	-	NA	-	-
1,3,5-Trimethylbenzene	ug/m3	102	57	56%	0.09	22	SG77B-05	0.092	39	26,600	0	0	104,000	0	0
1,3-Dichlorobenzene	ug/m3	102	30	29%	0.10	82	SG95B-05	0.091	40	425,000	0	0	1,750,000	0	0
1,4-Dichlorobenzene	ug/m3	102	87	85%	0.26	130	SG21B-05	1.2	37	3,250,000	0	0	13,300,000	0	0
1,4-Dioxane	ug/m3	102	30	29%	0.14	4.2	SG67B-05	0.09	40	NA	-	-	NA	-	-
2-Butanone	ug/m3	102	80	78%	2.00	62	SG84B-05	0.079	33	18,000,000	0	0	78,900,000	0	0
2-Hexanone	ug/m3	102	68	67%	0.17	3.9	SG15B-05	0.13	50	NA	-	-	NA	-	-
2-Methoxy-2-methyl-butane	ug/m3	102	1	1%	0.10	0.1	SG64B-05	0.074	33	NA	-	-	NA	-	-
4-Ethyltoluene	ug/m3	102	60	59%	0.11	21	SG77B-05	0.087	37	NA	-	-	NA	-	-
4-Isopropyltoluene	ug/m3	102	56	55%	0.13	12	SG83B-05	0.1	42	NA	-	-	NA	-	-
4-Methyl-2-pentanone	ug/m3	102	64	63%	0.14	20	SG13B-05	0.088	37	11,500,000	0	0	48,600,000	0	0
Acetone	ug/m3	102	57	56%	4.00	160	SG32B-05	0.11	24	NA	-	-	NA	-	-
Acrylonitrile	ug/m3	102	14	14%	0.11	0.34	SG79B-05	0.1	46	115	0	0	583	0	0
Allyl chloride	ug/m3	102	5	5%	0.17	5.5	SG40B-05	0.074	33	NA	-	-	NA	-	-
alpha-Methylstyrene	ug/m3	102	23	23%	0.11	7.7	SG12B-05	0.11	48	NA	-	-	NA	-	-
Benzene	ug/m3	102	89	87%	1.10	160	SG51B-05	1.7	33	1,230	0	0	5,540	0	0
Benzyl Chloride	ug/m3	102	5	5%	0.14	0.29	SG27B-05	0.13	56	220	0	0	934	0	0
Bromodichloromethane	ug/m3	102	66	65%	0.10	200	SG89B-05	0.077	33	1,240	0	0	3,830	0	0
Bromoform	ug/m3	102	13	13%	0.14	140	SG89B-05	0.11	50	36,600	0	0	95,000	0	0
Bromomethane	ug/m3	102	16	16%	0.08	1.8	SG79B-05	0.074	33	19,500	0	0	81,900	0	0
Carbon disulfide	ug/m3	102	73	72%	0.65	270	SG60BR-05	0.18	78	2,170,000	0	0	10,300,000	0	0
Carbon tetrachloride	**ug/m3**	**102**	**96**	**94%**	**0.11**	**18000**	**SG29B-05**	**3.6**	**16**	**696**	**8**	0	**2,990**	**6**	**0**
Chlorobenzene	ug/m3	102	42	41%	0.09	340	SG83B-05	0.075	33	232,000	0	0	974,000	0	0
Chloroethane	ug/m3	102	48	47%	0.09	100	SG53B-05	0.075	33	6,480	0	0	41,900	0	0
Chloroform	**ug/m3**	**102**	**102**	**100%**	**0.74**	**160000**	**SG32B-05**	**-**	**-**	**377**	**60**	**0**	**1,800**	**41**	**0**
Chloromethane	ug/m3	102	25	25%	0.08	6.5	SG51B-05	0.075	33	7,730	0	0	39,400	0	0
cis-1,2-Dichloroethene	ug/m3	102	12	12%	0.08	13	SG04B-05	0.074	33	333	0	0	1,590	0	0

TABLE A-4
Soil Gas - Johnson and Ettinger Model Lower and Upper Screening Limit Exceedances

Chemical	Result Unit	Sample Count	Detection Count	% Detects	Min Detect (ug/m3)	Max Detect (ug/m3)	Location of Max Detect	Min Non-Detect	Max Non-Detect	JEM Lower screening limit[1] (ug/m3)	Count of Detects > lower limit exceedances	Count of Non-Detects > lower limit exceedances	JEM Upper Screening Limit[2] (ug/m3)	Count of upper limit exceedances	Count of non-detects > upper limit exceedances
cis-1,3-Dichloropropene	ug/m3	102	0	0%	-	-	-	0.076	34	3,050	0	0	12,100	0	0
Dibromochloromethane	ug/m3	102	21	21%	0.12	160	SG89B-05	0.1	44	1,310	0	0	3,630	0	0
Dichlorodifluoromethane	ug/m3	102	80	78%	1.80	51	SG60BR-05	1.7	33	834,000	0	0	3,380,000	0	0
Ethanol	ug/m3	102	77	75%	1.40	180	SG60BR-05	0.079	33	NA	-	-	NA	-	-
Ethyl t-butyl ether	ug/m3	102	0	0%	-	-	-	0.075	33	NA	-	-	NA	-	-
Ethylbenzene	ug/m3	102	71	70%	0.10	90	SG41B-20	0.095	40	3,830,000	0	0	16,200,000	0	0
Ethylene dibromide	ug/m3	102	0	0%	-	-	-	0.079	35	131	0	0	371	0	0
Hexachlorobutadiene	ug/m3	102	50	49%	0.15	460	SG35B-05	0.13	59	601	0	0	2,290	0	0
isopropyl ether	ug/m3	102	0	0%	-	-	-	0.087	38	NA	-	-	NA	-	-
Isopropylbenzene	ug/m3	102	32	31%	0.09	3.8	SG41B-20	0.082	37	1,690,000	0	0	6,810,000	0	0
m,p-Xylene	ug/m3	102	82	80%	0.22	420	SG41B-20	0.2	85	376,000	0	0	1,660,000	0	0
Methyl methacrylate	ug/m3	102	3	3%	0.14	0.42	SG05B-05	0.11	49	2,630,000	0	0	11,300,000	0	0
Methyl tert butyl ether	ug/m3	102	18	18%	0.10	13	SG07B-05	0.074	33	9,360,000	0	0	44,400,000	0	0
Methylene chloride	ug/m3	102	77	75%	0.09	360	SG60BR-05	0.077	33	18,800	0	0	88,500	0	0
Naphthalene	ug/m3	102	76	75%	0.21	73	SG60BR-05	0.12	48	13,600	0	0	52,900	0	0
N-Butylbenzene	ug/m3	102	63	62%	0.12	2.7	SG41B-20	0.081	33	653,000	0	0	2,500,000	0	0
n-Heptane	ug/m3	102	49	48%	0.11	39	SG77B-05	0.098	42	NA	-	-	NA	-	-
n-Octane	ug/m3	102	51	50%	0.11	1000	SG77B-05	0.077	33	NA	-	-	NA	-	-
N-Propylbenzene	ug/m3	102	51	50%	0.08	14	SG77B-05	0.08	34	628,000	0	0	2,450,000	0	0
o-Xylene	ug/m3	102	83	81%	0.12	110	SG41B-20	0.096	41	347,000	0	0	1,550,000	0	0
sec-Butylbenzene	ug/m3	102	18	18%	0.10	0.91	SG41B-20	0.085	38	650,000	0	0	2,500,000	0	0
Styrene	ug/m3	102	39	38%	0.13	4.7	SG30B-05	0.12	50	3,980,000	0	0	16,500,000	0	0
t-Butyl alcohol	ug/m3	102	69	68%	0.20	17	SG66B-05	1.1	48	NA	-	-	NA	-	-
tert-Butylbenzene	ug/m3	102	5	5%	0.14	1	SG67B-05	0.074	33	657,000	0	0	2,510,000	0	0
Tetrachloroethene	**ug/m3**	**102**	**102**	**100%**	**0.47**	**2300**	**SG35B-05**	**-**	**-**	**1,870**	**1**	**0**	**7,800**	**0**	**0**
Toluene	ug/m3	102	94	92%	0.42	430	SG77B-05	3.9	33	1,390,000	0	0	6,200,000	0	0
trans-1,2-Dichloroethylene	ug/m3	102	4	4%	0.09	0.43	SG92B-05	0.074	33	136,000	0	0	571,000	0	0
trans-1,3-Dichloropropene	ug/m3	102	0	0%	-	-	-	0.093	41	3,050	0	0	12,100	0	0
Trichloroethene	**ug/m3**	**102**	**91**	**89%**	**0.11**	**1700**	**SG47B-05**	**0.081**	**33**	**94.1**	**9**	**0**	**406**	**3**	**0**
Trichlorofluoromethane	ug/m3	102	89	87%	0.95	1700	SG61B-05	1.3	16	2,430,000	0	0	10,800,000	0	0
Vinylacetate	ug/m3	102	62	61%	0.73	29	SG72B-05	0.24	100	703,000	0	0	3,120,000	0	0
Vinyl chloride	ug/m3	102	11	11%	0.09	1.9	SG51B-05	0.074	33	973	0	0	4,670	0	0

Notes:

1: JEM Lower screening limit: Johnson and Ettinger Model Screening limit based on Indoor air exchange rate (ER) of 1/h and using default Average vapor flow rate into bldg. (Qsoil) of 20 L/min

2: JEM Upper screening limit: J&E Model screening limit based on ER of 2/h and model calculated Qsoil with site specific soil vapor permeability (kv)

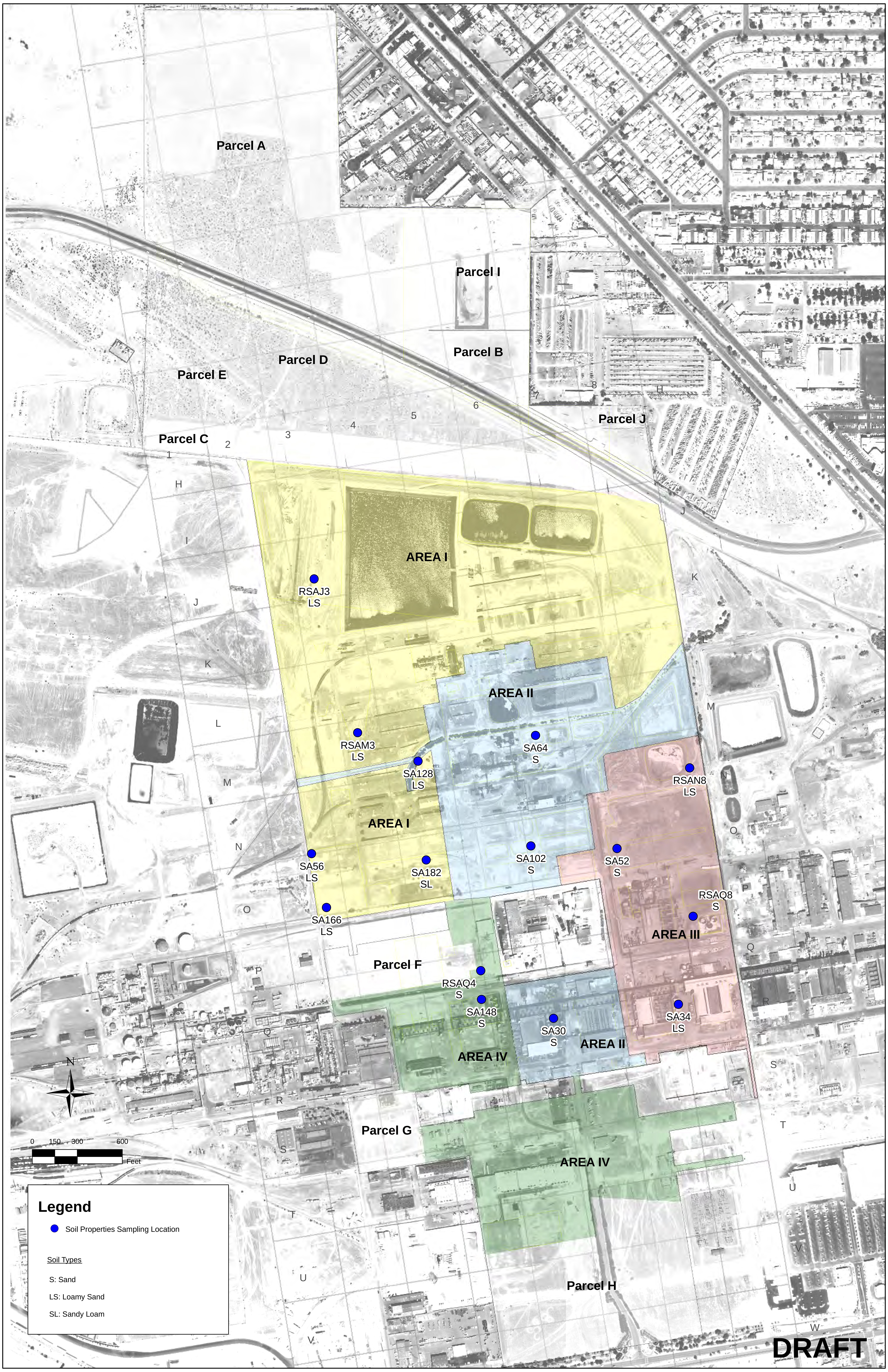

FIGURE NUMBER: A-1

SHEET NUMBER: -

Soil Property Sampling Locations and Soil Classification

Tronox Facility
Henderson, Nevada

SCALE:	DATE:	PROJECT NUMBER:
-	01/29/10	2027.01

DESIGNED BY:	REVISIONS			
	NO.:	DESCRIPTION:	DATE:	BY:
DRAWN BY:				
NGEM				
CHECKED BY:				
NGEM				
APPROVED BY:				
NGEM				

northgate
environmental management, inc.
TRONOX
http://www.ngem.com

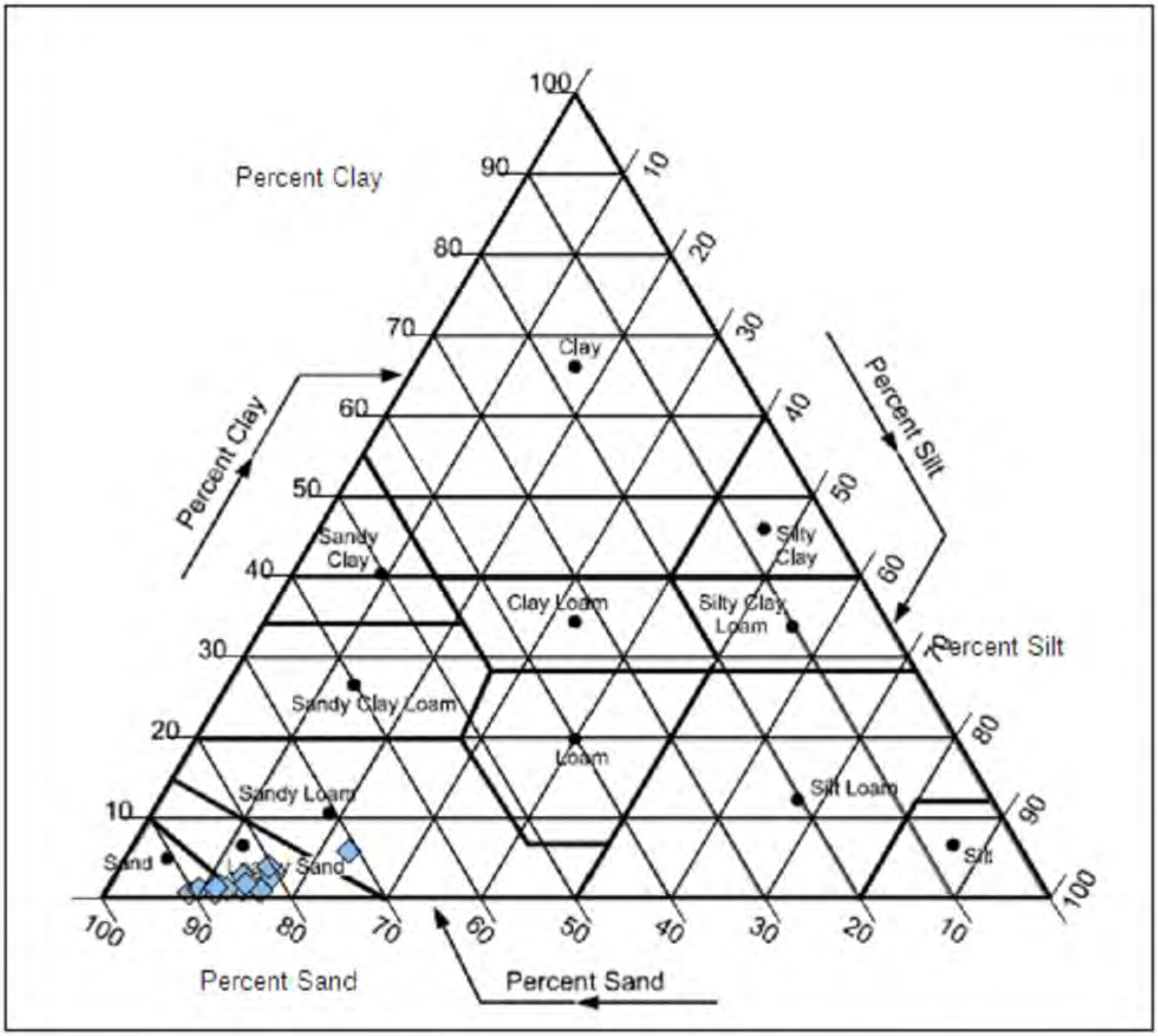

FIGURE A-2
All Samples
Soil Type Classification

Tronox Facility
Henderson, nevada

northgate
environmental management, inc.

1/29/2009
Project No. 2027.01

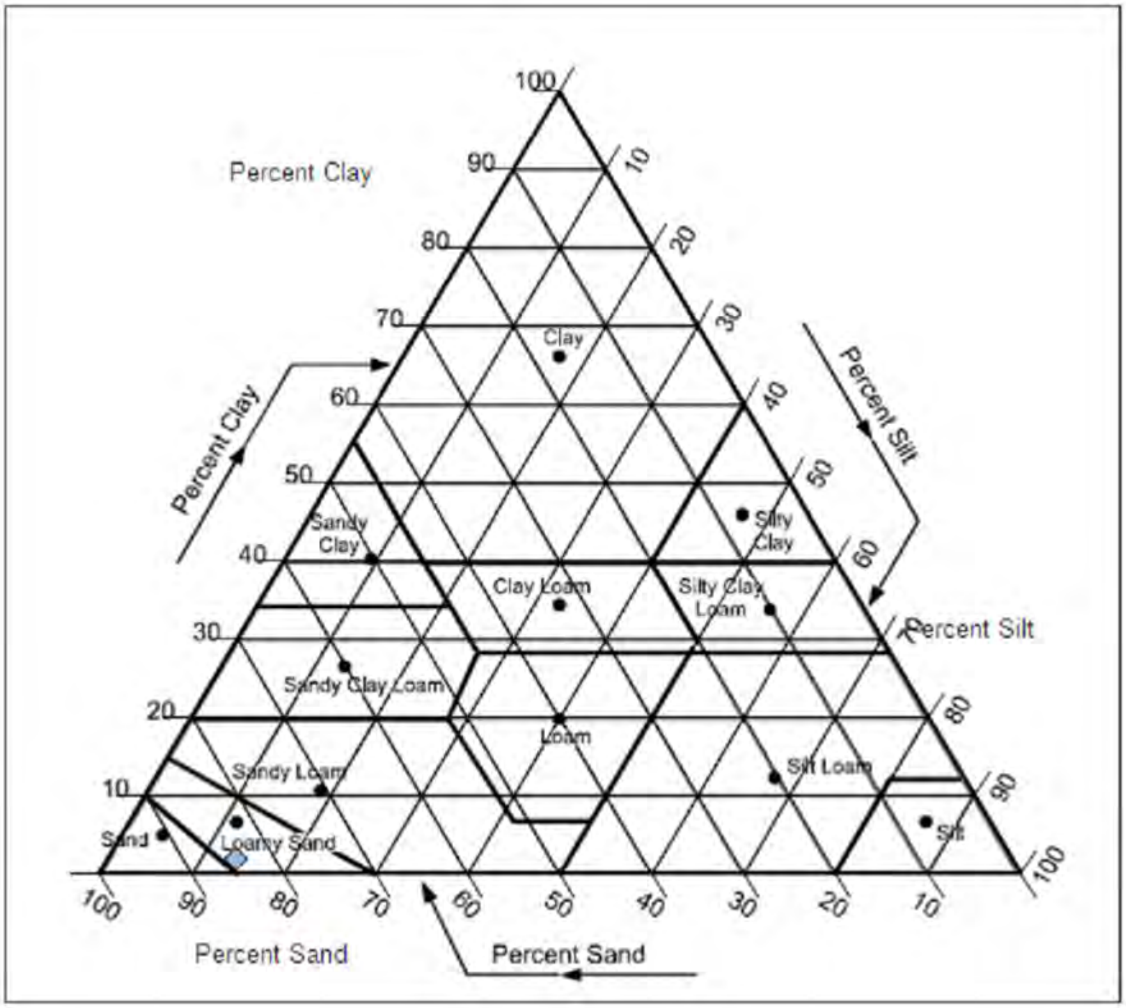

FIGURE A-3
Mean of Samples
Soil Type Classification

Tronox Facility
Henderson, nevada

northgate
environmental management, inc.

1/29/2009
Project No. 2027.01

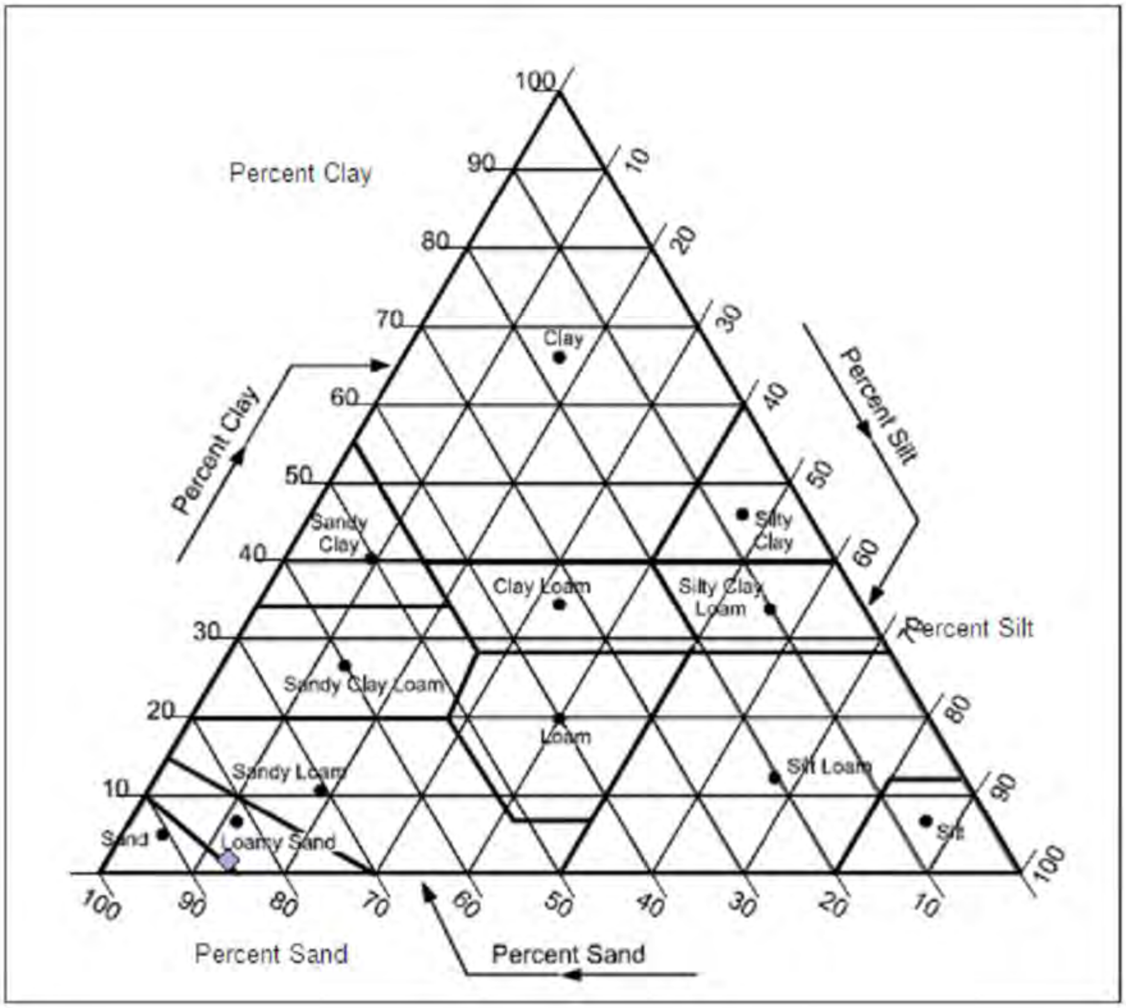

FIGURE A-4
Mean without Sandy Loam
Soil Type Classification

Tronox Facility
Henderson, nevada

northgate
environmental management, inc.

1/29/2009
Project No. 2027.01