


Statistical Evaluation of Elevated Concentrations of Background Metals in Soils

Geosyntec Consultants and
North Carolina Department of Transportation

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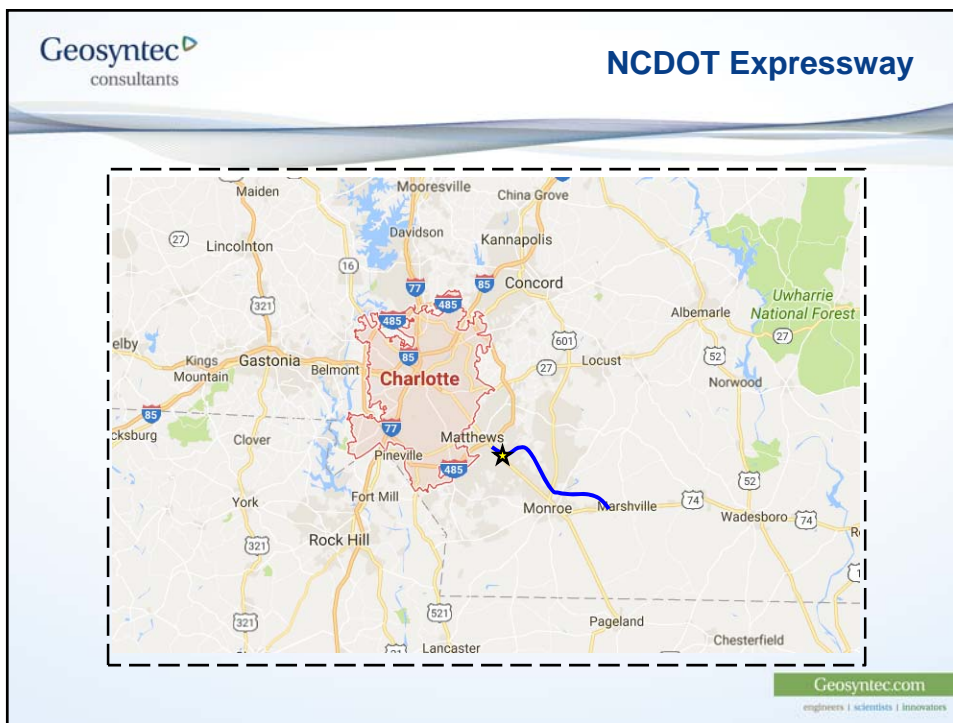
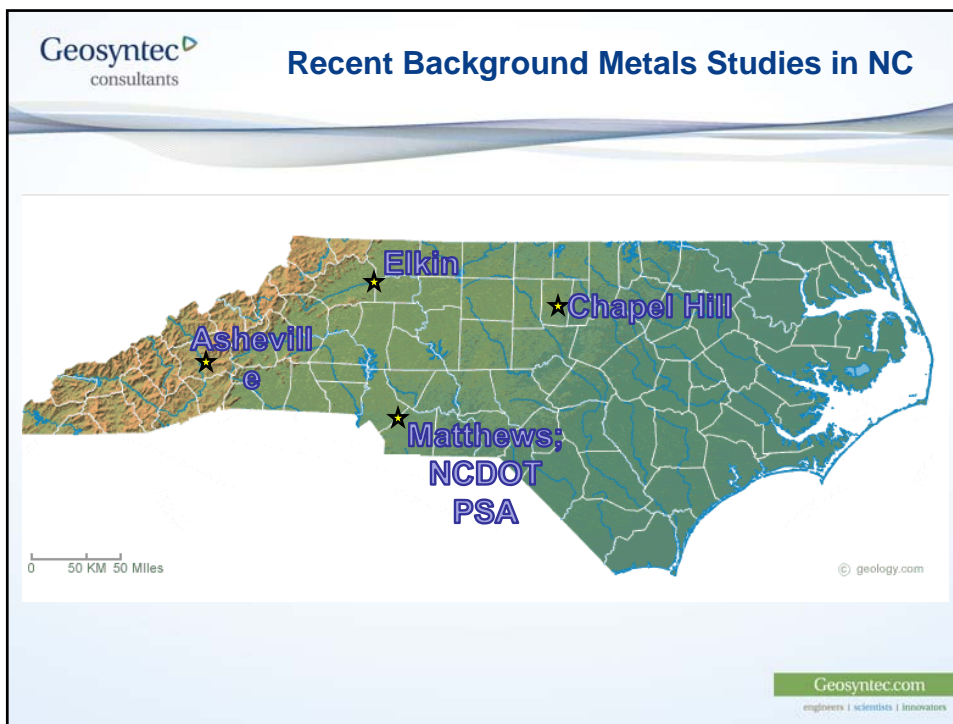
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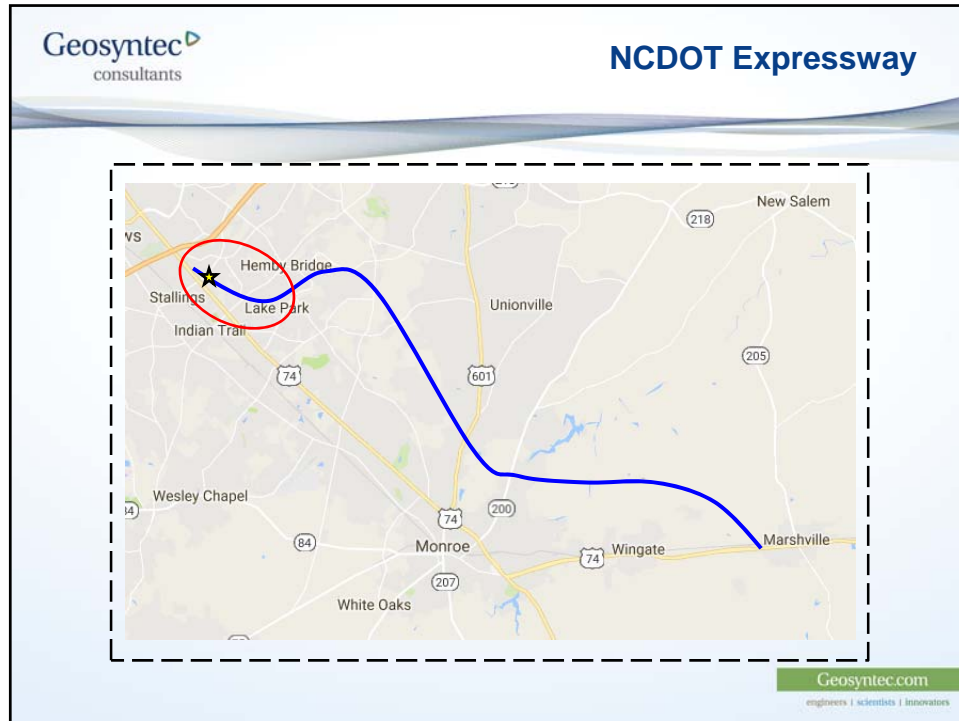


Overview

- Statistical evaluation to estimate naturally-occurring background concentrations of metals in soil
 - Environmental Preliminary Site Assessment (PSA), Monroe, NC
 - NCDOT Expressway from U.S. 74 east of I-485 to U.S. 74 between Wingate and Marshville, R-3329 & R-2559 (Monroe Connector & Bypass); \$840 million, 19.5 mile Strategic Highway Corridor
 - Coal Combustion Byproduct (CCB) sites
 - Brownfields Redevelopment; near Winston-Salem, NC
 - Registered Environmental Consultant (REC) Program Site; Chapel Hill, NC
 - Scrapyard site near Asheville, NC
- Regulatory establishment of soil screening criteria

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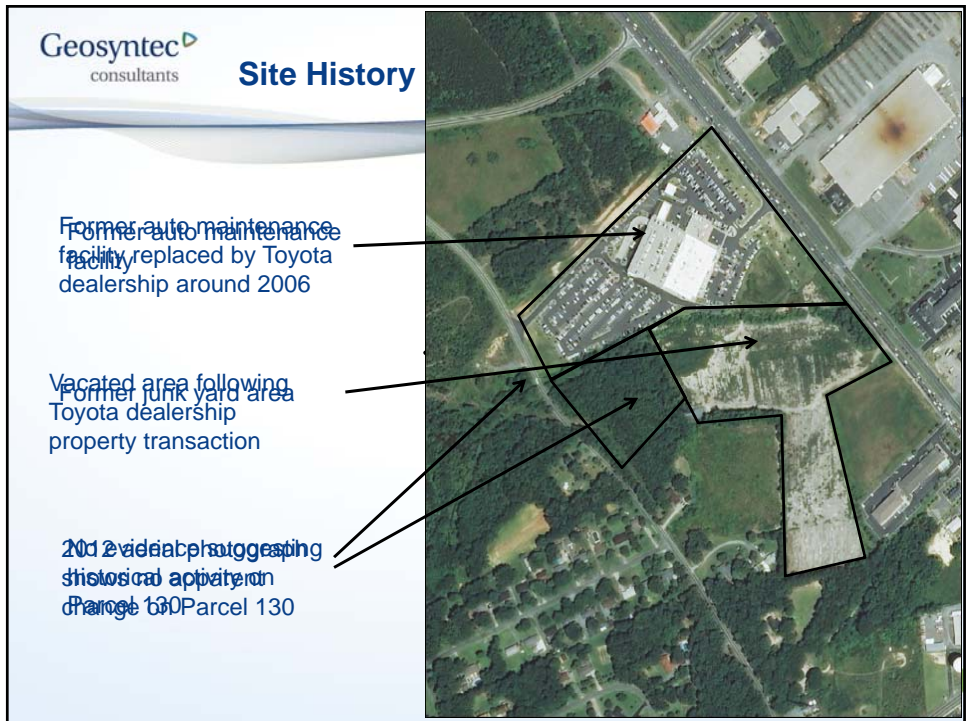
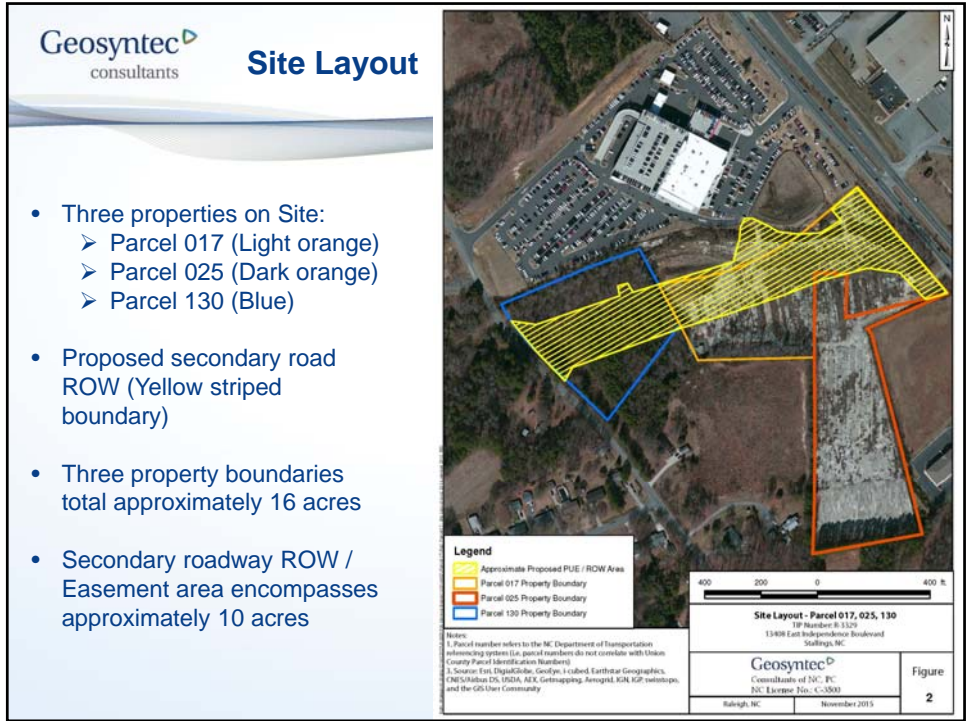


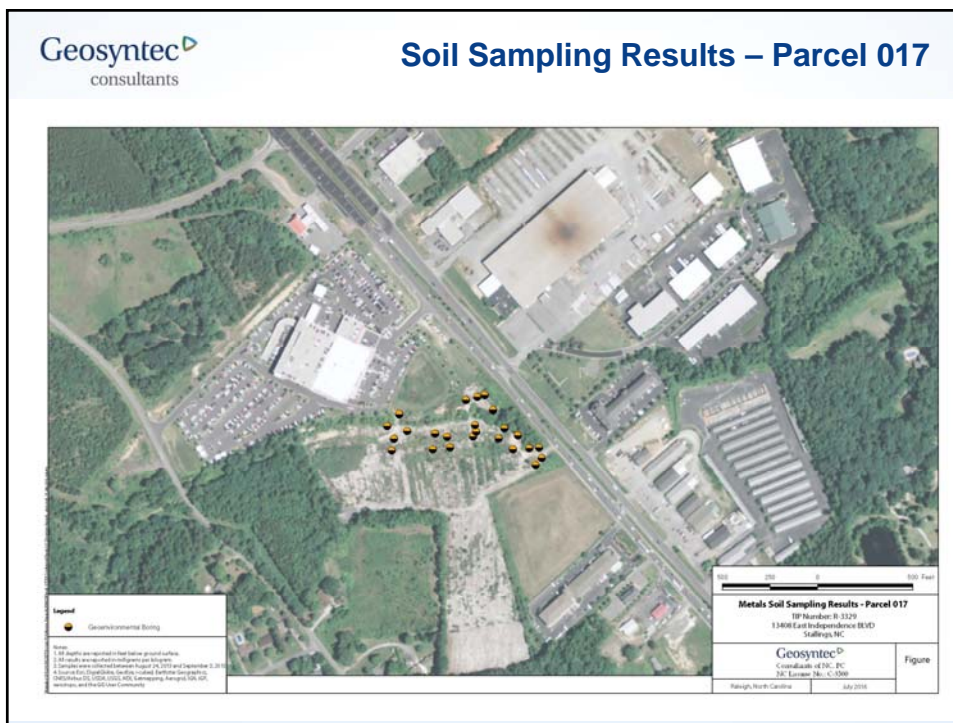
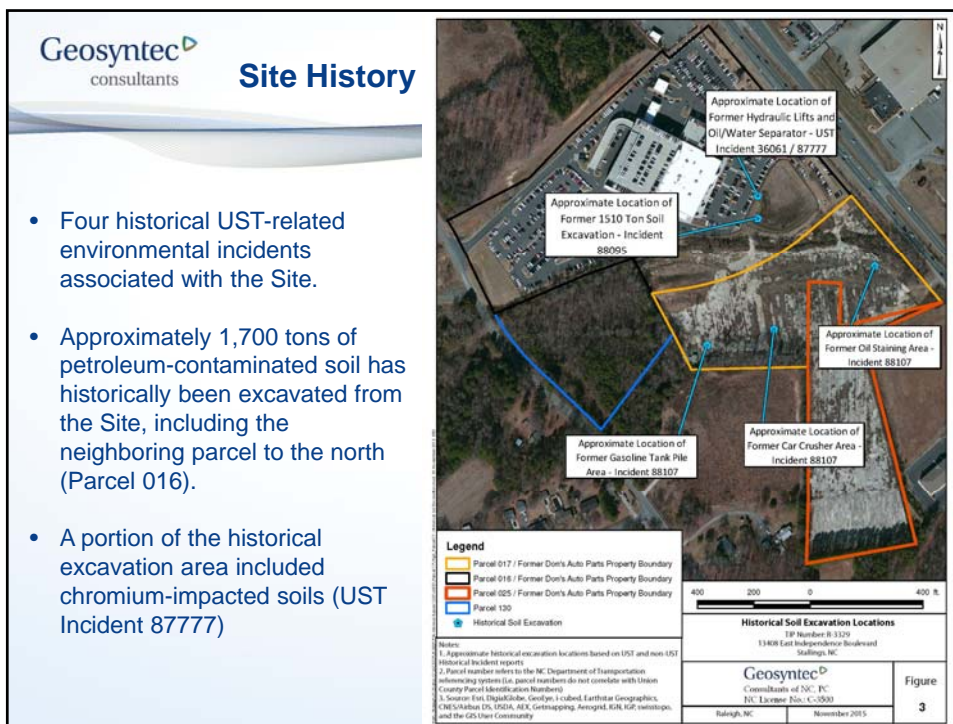
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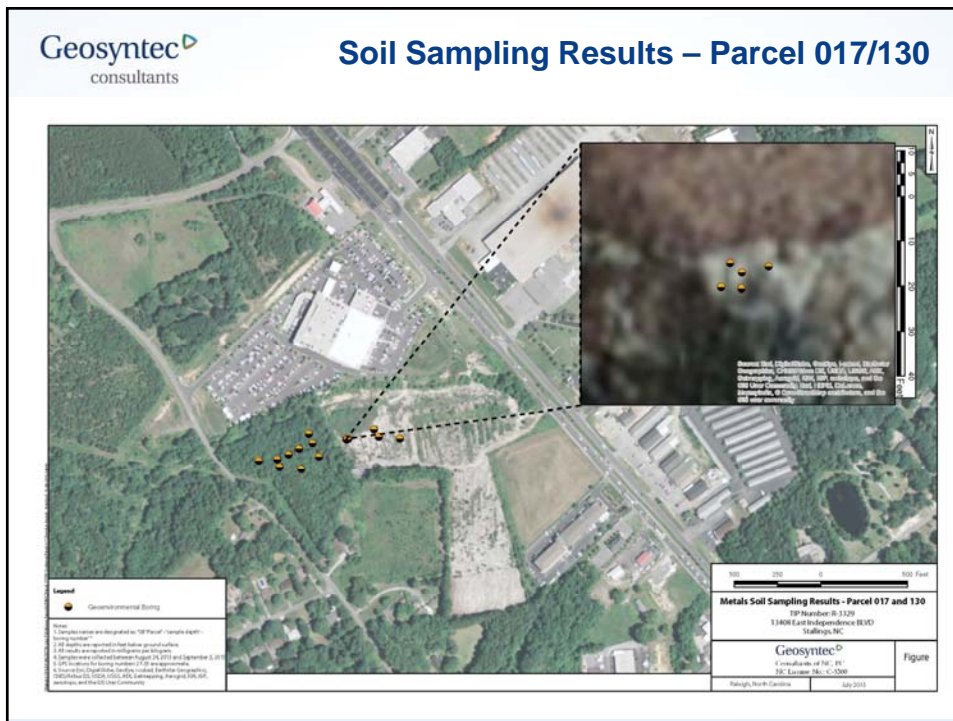
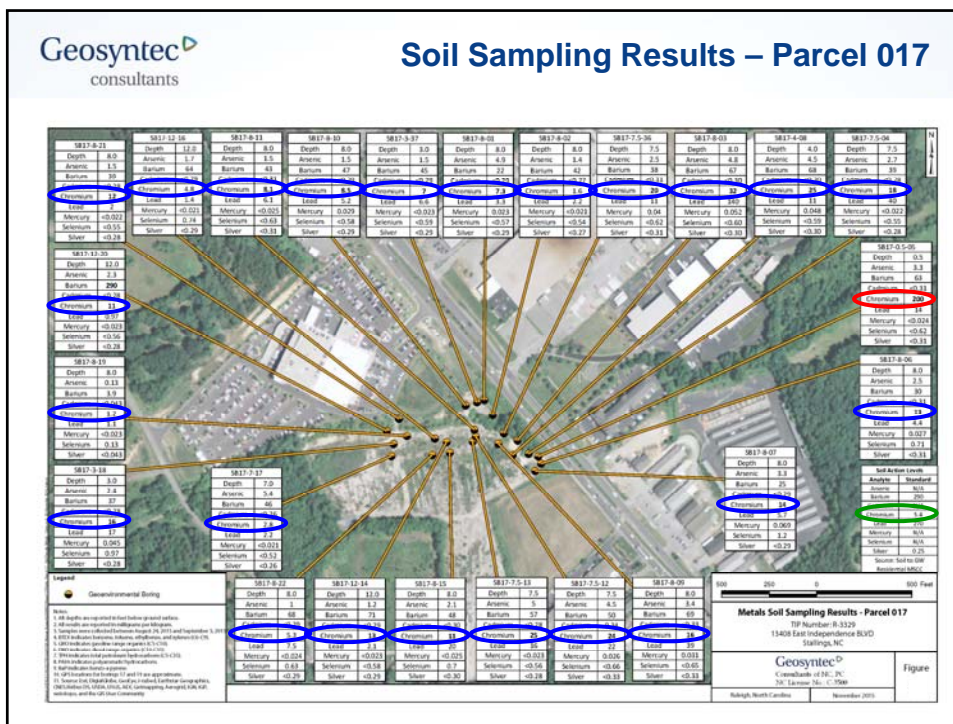
NCDOT Project Objectives

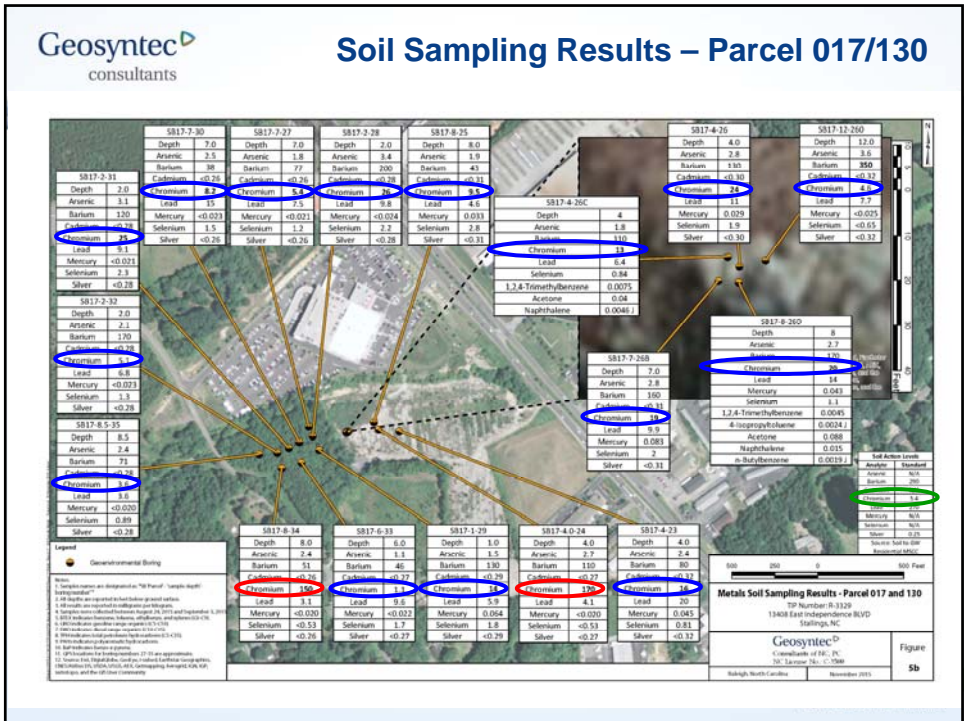
- 1) Determine if environmental impacts are likely within the proposed study area
- 2) If environmental impacts are identified within the roadway construction area, provide consultation on proper material handling
 - Minimize waste generation; maintain efficient operations; avoid construction delays
- 3) Based on (1) and (2), provide a recommendation for the property acquisition process:
 - Fee simple (i.e. NCDOT purchases the property outright)
 - Permanent easement [i.e. NCDOT purchases an easement on the applicable property(s) to facilitate roadway completion]

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Data Interpretation

- NCDEQ DWQ (Mooresville Region) collected soil samples to determine naturally-occurring background metals concentrations (1998);
- Geosyntec analyzed total chromium concentrations from the DEQ study to establish Site-specific action levels;
 - Used data from five (5) adjoining counties
 - Total of 19 data points
- Data analyzed to establish an Upper Tolerance Limit (UTL);
 - UTL represents the upper confidence limit of a percentile of the population.
 - UTL to serve as a Site-specific action level
- ProUCL, a statistical software developed by the USEPA, was used to perform the analysis

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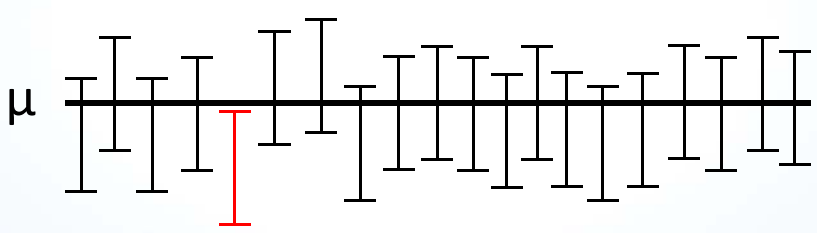
Data Interpretation – Confidence Limits

- The Upper Confidence Limit (UCL) is the upper boundary of a sample of data which is likely to contain an unknown population parameter;
 - Our analysis was performed with a 95% confidence interval.
 - i.e. if a set of soil samples were collected 20 different times, the sample mean confidence intervals are expected to encompass the true population mean in 19 of the 20 samples sets.

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Data Interpretation – Confidence Limits



μ

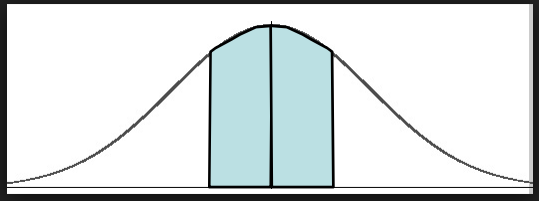
μ : represents the mean population value (unknown)

\bar{I} : represents a sample set confidence interval

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Data Interpretation – Confidence Limits

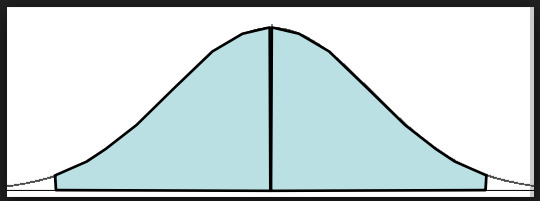


“I’m pretty sure the mean lies in here..”

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Data Interpretation – Tolerance Limits



- The UTL is of a population percentage
- The 95% UTL for naturally occurring materials
- Site specific
• Total cost of warranty

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“I’m pretty sure a large percentage of values fall in here..”

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Post Environmental Assessment



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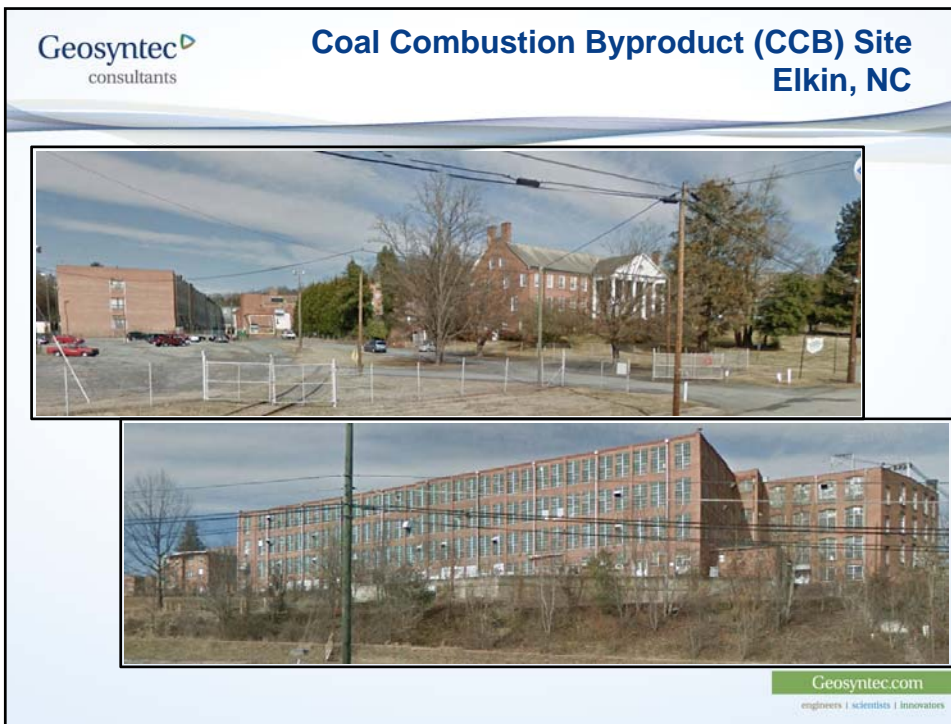
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Recent Background Metals Studies in NC



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Coal Combustion Byproduct Site Elkin, NC

Metals	Residential PSRG (mg/kg)	Commercial /Industrial PSRG (mg/kg)	Protection of Groundwater PSRG (mg/kg)	Units	Site Background Soils										
					SB-01	SB-02	SB-03	SB-04 ⁽²⁰⁾	SB-05	SB-06	SB-07	SB-08	SB-09	SB-11	
Aluminum	15,400	100,000	---	mg/kg	18,800	12,700	14,300	16,200	20,500	18,300	28,000	33,000	18,900	24,600	
Antimony	6.2	94	0.9	mg/kg	<1.21	<1.16	<1.19	<1.22	<1.10	<1.27	<1.23	<1.24	<1.26	<1.27	
Arsenic	0.68	3	5.8	mg/kg	2.78 J	2.17 J	6.42	3.19	5.50 J	2.12 J	2.62 J	4.25	3.38	2.59 J	
Barium	3,000	44,000	580	mg/kg	174	169	79.1	102	247	404	124	155	157	109	
Beryllium	32	460	63	mg/kg	1.43 J	1.19 J	<1.19	<1.22	2.48 J	2.04 J	1.32 J	1.37 J	1.37 J	1.45 J	
Boron	3,200	46,000	45	mg/kg	<30.2	<29.1	<29.7	<30.4	<55.1	<31.6	<30.7	<30.9	<31.4	<31.7	
Cadmium	14.2	196	3	mg/kg	<1.21	<1.16	<1.19	<1.22	<1.10	<1.27	<1.23	<1.24	<1.26	<1.27	
Chromium	24,000	100,000	360,000	mg/kg	193	7.16	19.0	38.6	41.8	47.4	72.4	40.7	59.5	38.5	
Cobalt	4.6	70	0.9	mg/kg	23.6	5.77	6.35	12.8	25.1	22.5	13.4	12.4	26.5	9.83	
Copper	620	9,400	700	mg/kg	44.1	7.63	17.4	33.5	50.1	26.6	24.1	20.4	27.2	20.4	
Iron	11,000	100,000	150	mg/kg	41,900	13,100	37,000	37,800	55,600	50,600	44,800	50,500	57,400	59,100	
Lead	400	800	270	mg/kg	20.8	15.1	88.4	36.8	28.4	27.1	19.9	34.4	16.6	25.3	
Magnesium	---	---	---	mg/kg	9,560	2,030	1,530	2,290	7,810	8,270	2,610	2,320	3,740	3,470	
Manganese	360	5,200	65	mg/kg	698	480	486	394	884	1,310	580	799	1,140	396	
Mercury	2.2	3.13	1	mg/kg	<0.0349	<0.0363	0.0549 J	0.0611 J	<0.0327	<0.0378	0.0566 J	0.0745 J	<0.0369	0.121 J	
Molybdenum	78	1,160	---	mg/kg	<1.21	<1.16	<1.19	<1.22	<1.10	<1.27	<1.23	<1.24	<1.26	1.28 J	
Nickel	300	4,400	130	mg/kg	89.4	10.2	8.12	15.2	20.4	40.5	16.0	12.0	17.9	12.4	
Selenium	78	1,160	2.1	mg/kg	2.10 J	<1.16	1.81 J	1.32 J	4.42 J	2.20 J	1.50 J	1.85 J	1.96 J	<1.27	
Silver	78	1,160	3.4	mg/kg	<0.604	<0.581	<0.594	<0.608	<0.551	<0.633	<0.614	<0.618	<0.628	<0.634	
Strontium	9,400	100,000	---	mg/kg	<30.2	<29.1	<29.7	<30.4	<27.5	<31.6	<30.7	<30.9	<31.4	<31.7	
Thallium	0.156	2.4	0.28	mg/kg	<0.242	<0.233	0.345 J	<0.243	0.507 J	<0.253	0.276 J	0.445 J	<0.251	0.420 J	
Vanadium	78	1,160	6	mg/kg	85.2	14.1	39.1	66.8	122	64.7	102	87.4	124	98.0	
Zinc	4,600	70,000	1,200	mg/kg	105	49.4	62.3	84.4	129	126	65.1	81.8	67.5	97.4	

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Additional Sites in North Carolina

- **Chapel Hill, NC**
 - Coal combustion byproduct site
 - Statistical analysis on metals in background soil
 - Generated Site-specific background threshold values
- **Asheville, NC**
 - Scrapyard site
 - Statistical analysis on metals in background soil
 - Risk assessment alternatives analysis

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Screening Criteria and Risk Assessments

- **Screening criteria (e.g. PSRGs) are established based on an estimated risk to human health and the environment**
 - Native geologic conditions are not considered
- **Risk assessment considers:**
 - Chemical Toxicity
 - Chemical Exposure

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Toxicity Assessment

- **Non-Carcinogenic Chemicals**
 - Exposure below a “Reference Dose” (i.e. a threshold dose) is assumed to **not** result in an adverse health effect
- **Carcinogenic Chemicals**
 - Generally assumes any exposure results in an increased incidence

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Exposure Assessment

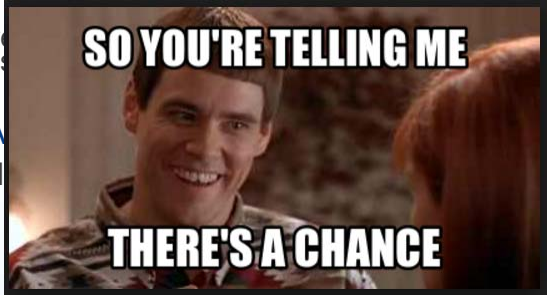
- **Exposure estimates account for:**
 - Pathways (e.g. inhalation, ingestion, dermal, etc.)
 - Chemical concentration
 - Ingestion Intake (mg/kg – day) = $\frac{CS \times IR_o \times CF \times EF \times ED}{BW \times AT}$
 - Exposure duration
 - Body weight
 - Skin contact area
 - Skin absorption
 - Inhalation rate, etc.

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Risk Assessment

- Combine the results of the toxicity and exposure assessments
 - Use risk values to identify identifiable risk
- USEPA
 - 1 in 10,000



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Establishing Screening Criteria

- “Risk Assessment in Reverse”
- Based on an assumed risk criteria (e.g. 1×10^{-6} for carcinogenic endpoints)
- Use the estimated exposure and toxicity criteria (e.g. inhalation rate, ingestion rate, exposure frequency, duration, body weight, threshold dose, etc.)
-to establish screening criteria for the targeted risk level

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Conclusion

Native geologic conditions
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Risk-based screening criteria

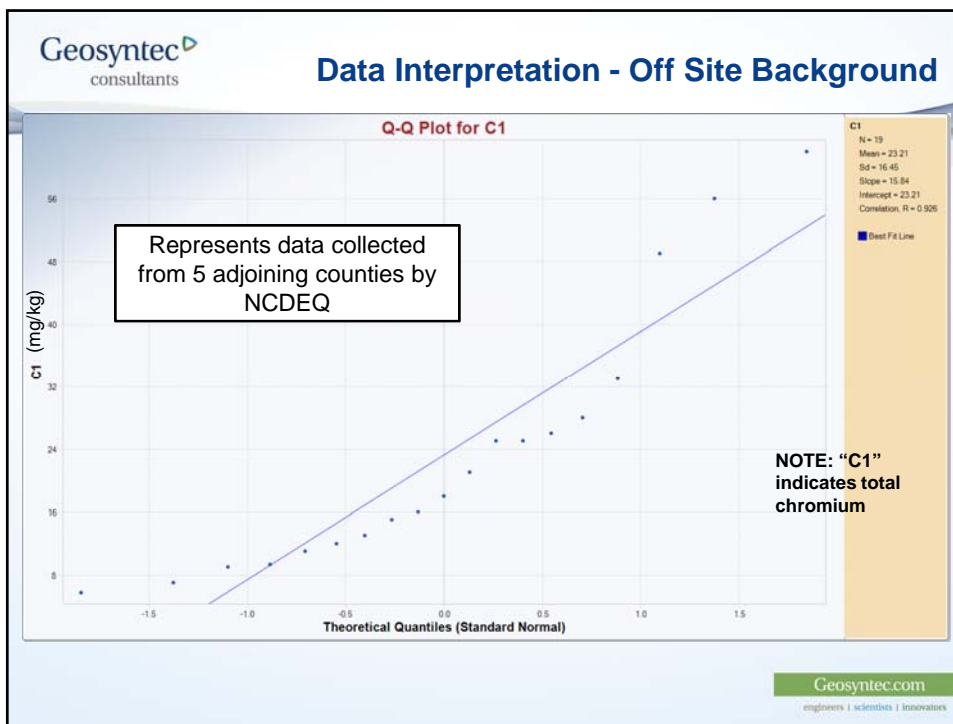
- PSRG's are screening levels; not standards
- Elevated metals concentrations may not indicate environmental contamination
- REC guidance allows the establishment of site-specific concentrations of metals in background soil

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THANK YOU!!

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Coal Combustion Byproduct Site Elkin, NC

Metals by EPA Method 6010C, 6010D, or 6020A		Site Coal Combustion Byproduct Samples								
		CCB-1 (M1)	CCB-2 (M6)	CCB-3 (M4M5)	CCB-4 (M7)	CCB-5 (M1M3)	DB-01	DB-02	SED-01	SED-02
Aluminum	mg/kg	13,600	11,400	13,800	10,300	15,600	25,200	7,440	7,280	23,600
Antimony	mg/kg	1.1 U	1.0 U	1.0 U	1.0 U	0.99 U	0.99 U	1.0 U	1.0 U	1.0 U
Arsenic	mg/kg	43.0	61.7	41.1	13.7	35.4	31.0	19.2	18.3	16.0
Barium	mg/kg	229	626	1,080	242	226	294	282	229	119
Beryllium	mg/kg	1.1	2.1	2.1	1.2	1.4	1.5	1.7	1.6	1.1
Boron	mg/kg	14 U	10 U	10 U	10 U	9.9 U	9.9 U	10 U	10 U	10 U
Cadmium	mg/kg	0.34 U	0.25 U	0.30	0.25 U	0.25 U	0.25 U	0.26 U	0.25 U	0.25 U
Chromium*	mg/kg	18.1	19.3	21.9	17.5	29.6	30.0	14.5	15.0	23.2
Cobalt	mg/kg	5.9	7.7	7.2	5.5	8.2	8.7	11.2	7.5	9.6
Copper	mg/kg	23.5	30.0	29.2	16.5	20.7	22.6	34.5	33.7	17.7
Iron	mg/kg	12,900	14,500	23,100	9,210	16,900	22,400	6,740	7,590	24,400
Lead	mg/kg	14.3	13.4	15.6	10.8	15.2	14.4	12.3	9.3	11.4
Magnesium	mg/kg	1,800	1,230	1350	1,100	2,020	2,760	770	465	3,910
Manganese	mg/kg	85.6	133	117	82.7	200	177	29.6	32.1	168
Mercury	mg/kg	0.23	0.35	0.27	0.18	0.14	0.25	0.14	0.21	0.056
Molybdenum	mg/kg	4.0	3.9	3.5	2.6	4.7	5.1	2.8	1.4	6.3
Nickel	mg/kg	12.5	16.9	16.9	9.4	17.8	17.6	16.8	12.3	16.7
Selenium	mg/kg	5.1	5.4	10.7	7.7	5.0	4.1	1.9	3.9	1.6
Silver	mg/kg	0.34 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.26 U	0.25 U	0.25 U
Strontium	mg/kg	56.9	114	182	109	46.9	64.8	266	161	41.8
Thallium	mg/kg	0.58	1.0	1.1	0.42	0.62	0.50	0.40	0.45	0.39
Vanadium	mg/kg	39.0	42.4	44.2	33.8	44.5	53.5	34.6	29.2	45.9
Zinc	mg/kg	37.4	25.2	35.4	18.3	34.0	46.2	15.6	15.1	47.8

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