Geogenic Concentrations of Metals in the San Diego Embayment – Preliminary Findings

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Geogenic – Naturally occurring and derived from natural geologic processes Anthropogenic – Derived from human activities "Background" – Anthropogenic and geogenic signatures In total, over \$20,000 in analytical laboratory cost have been donated by the following:



H.M. Pitt Labs, Inc.

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EnviroMatrix Analytical, Inc.









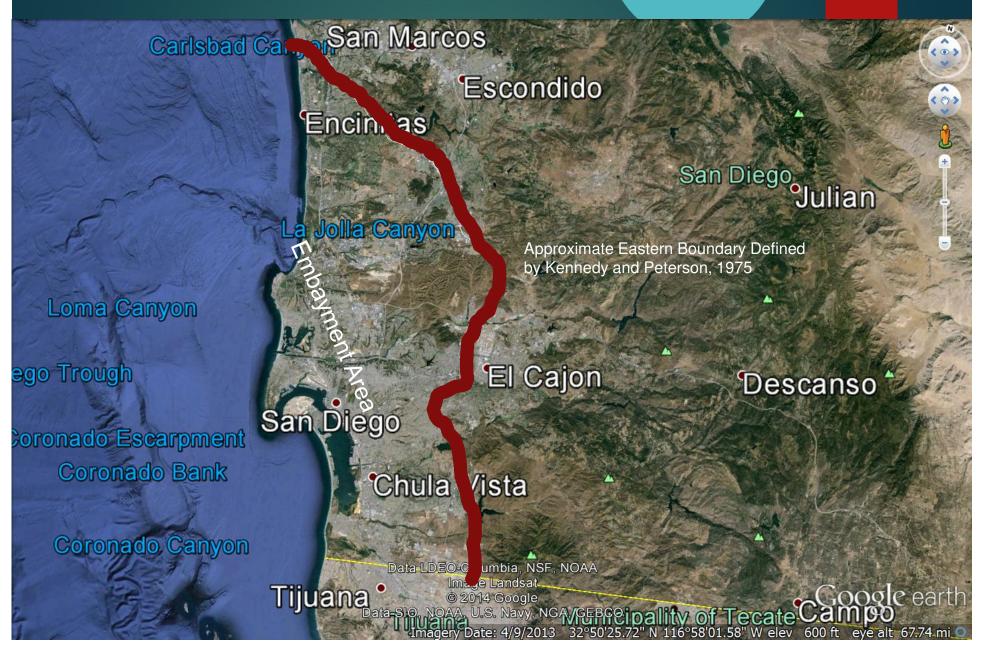
Purpose and Motivation for this Study

- Report the 95% Upper Confidence Limit (UCL) of the mean and the range of concentrations of 17 (Title 22) metals within the Embayment Region Formations
 - CCR Title 22 section 66261.24 specifies the 17 metals that can qualify waste as hazardous
- Create a public database and reference document reporting geogenic metals concentrations in San Diego County
 - Educators, researchers, regulators, and consultants will benefit from and use this data
- Ultimately, this study will make it easier to differentiate between geogenic and anthropogenic metal signatures in sediments

Title 22 Metals

Antimony Arsenic Barium Beryllium Cadmium Chromium Cobalt Copper Lead Mercury Molybdenum Nickel Selenium Silver **Thallium** Vanadium Zinc

San Diego Embayment

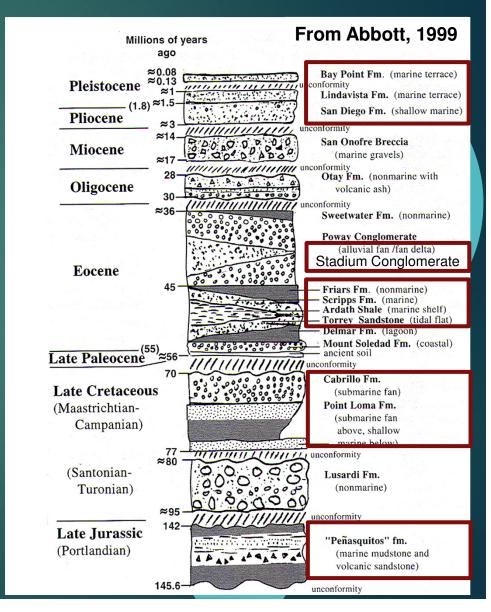


San Diego Embayment

- Area of former marine inundation
- Late Jurassic to

Pleistocene sedimentary sequences

- ~SeventeenSedimentary FormationsIdentified
 - Currently eleven sampled as part of this study



Previous Studies

- ► A lot of work has been done all over the US and California researching the concentrations of "Background" metals in soils.
 - Our study has specifically excluded soils and only includes undisturbed native formation material.
- Recently, graduate theses have focused on background Arsenic in San Francisco (Duverge, 2011) and geogenic Arsenic in Oregon (Hurtado, 2016)
- Journal articles regarding the geogenic concentrations of metals are becoming more and more common in the literature.

(Very Abridged) Literature Review – Southern California Studies

Bradford, G. R., et al. 1996. "Background Concentrations of Trace and Major Elements in California Soil – Special Report." *Kearney Foundation of Soil Science Division of Agriculture and Natural Resources at University of California*.

► Three samples collected from San Diego County collected from the surface to 50 cm below the ground surface.

Chernoff, G., Bosan, W., and Oudiz, D. 2008. "Determination of a Southern California Regional Background Arsenic Concentration in Soil." *California Department of Toxic Substances Control.*

- Focused on School Sites in Southern California
- Only 3 school sites sampled in San Diego County
- Arsenic Specific Screening Level of 12 mg/kg established for background
- Not Formation Specific

Literature Review (cont.)

Flegal, R. A., and Sanudo-Wilhelmv, S. A. 1993. "Comparable levels of trace metal contamination in two semienclosed embayments: San Diego Bay and south San Francisco Bay." *Environmental Science and Technology. 27* (9), pp 1934–1936.

Background Concentrations in Shallow Sediments

Kleinfelder, Inc. 2005. "Background Characterization Study for Twenty-Five inorganic Constituents of Potential Concern to the Point Loma Naval Complex, San Diego, California."

- ► Limited to Point Loma Naval Complex
- ▶ Data set used in this study

Field Methods

- Samples were collected from re-development sites during the construction of subterranean parking structures
 - Sampled at depths ranging from 3.0 46.0 feet below the ground surface
 - No samples collected within 6 feet of static groundwater
- Samples were collected from undeveloped parks and canyons throughout the region
 - Sampled from cliff faces by hand tools
- Collected samples with sterilized 4 ounce jars using industry standard sampling protocols
- All sediment samples taken from in situ formation material









Artificial Fill



Analytical Methods

- Analyzed at California Certified Laboratories
- ► EPA method 6010/7000
 - Not all samples analyzed for the entire suite of metals
- EPA methods 8260 (VOCs), 8270 (SVOCs), 8015 ext (TPH)
- SPLP Analyses (Artificial Fill)



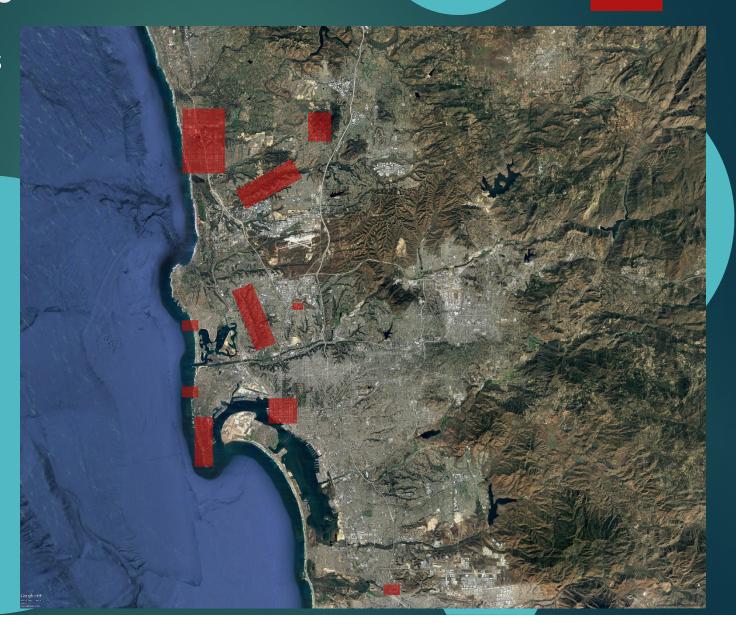
Statistical Methods

- All Statistical Analyses were performed using ProUCL software
 - Outliers
 - ▶ Rosner's Test n>25
 - ▶ Dixon Test n<25
 - Outliers were calculated for each formation
 - For cumulative data (statistics for all formations combined), raw data was used and the outliers were recalculated
 - ▶ 95% Upper Confidence Limit (UCL)
 - Box Plots



Results

 878 Samples collected from the Embayment Region



Antimony

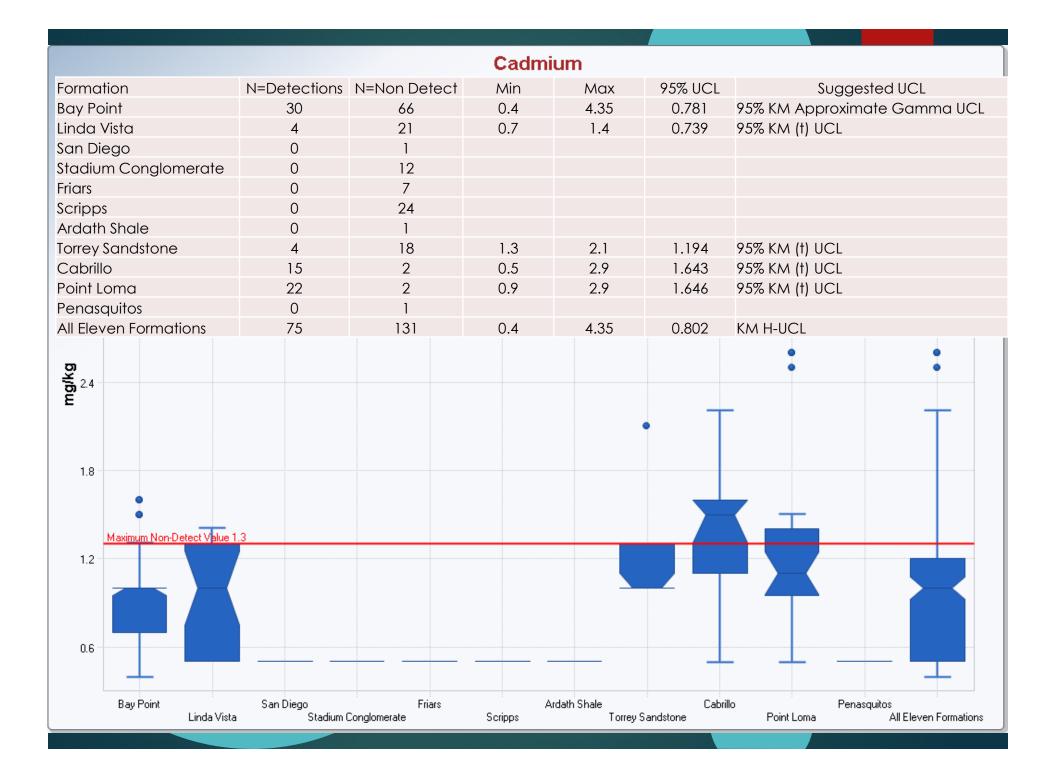
Formation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
Bay Point	0	107				
Linda Vista	0	25				
San Diego	0	1				
Stadium Conglomerate	1	11				
Friars	0	7				
Scripps	13	11	1.01	1.87	1.348	95% KM (t) UCL
Ardath Shale	0	1				
Torrey Sandstone	0	22				
Cabrillo	1	16				
Point Loma	1	21				
Penasquitos	0	1				
All Eleven Formations	16	217	0.6	1.87	0.636	95% KM (t) UCL

			Arsen	ic		
ormation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
Bay Point	136	41	1	7.9	2.673	95% KM Approximate Gamma UCL
inda Vista	69	19	0.5	3.94	1.765	95% KM (t) UCL
an Diego	1	0	14.1	14.1		
tadium Conglomerate	12	0	4.01	21.8	13.38	95% Student's-t UCL
riars	6	0	0.76	12.7	9.418	95% Student's-t UCL
cripps	24	0	5.07	13.6	10.12	95% Student's-t UCL
rdath Shale	1	0	20.1	20.1		
orrey Sandstone	53	3	1.17	8.9	3.823	95% KM Approximate Gamma UCL
abrillo	16	0	1	3.8	2.677	95% Student's-t UCL
oint Loma	24	0	2.8	10.6	6.483	95% Student's-t UCL
enasquitos	1	0	1.19	1.19		
II Eleven Formations	348	63	0.5	21.8	4.15	95% KM (Chebyshev) UCL
9 Maximum Non-Detect Value 1						
3						
0 Bay Point Linda Vista	San Diego Stadium Con	Friars glomerate	Ard Scripps	dath Shale Torrey	C. Sandstone	abrillo Penasquitos Point Loma All Eleven Formatio

Barium Formation N=Detections N=Non Detect Min Max 95% UCL Suggested UCL **Bay Point** 144 0 5.79 281 62.95 95% H-UCL Linda Vista 35 6 61.2 26.52 95% Adjusted Gamma UCL 120 San Diego 120 Stadium Conglomerate 21 157 100.9 95% Student's-t UCL 9.07 83.28 95% Student's-t UCL Friars 103 Scripps 23 24.6 61.5 45.53 95% Student's-t UCL Ardath Shale 55.1 55.1 21 Torrey Sandstone 0 28.5 15.44 95% H-UCL 1.4 Cabrillo 17 6.9 161 84.42 95% Student's-t UCL Point Loma 24 38 211 127.2 95% Student's-t UCL Penasquitos 43 43 All Eleven Formations 256 440 68.64 95% Chebyshev (Mean, Sd) UCL 1.4 മ ²⁴⁰ ച്ലൂമ 180 120 60 0 Bay Point San Diego Friars Ardath Shale Cabrillo Penasquitos: Stadium Conglomerate All Eleven Formations Linda Vista Scripps Torrey Sandstone Point Loma

Beryllium

Formation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
Bay Point	24	74	0.16	0.9	0.341	95% KM Approximate Gamma UCL
Linda Vista	0	22				
San Diego	0	1				
Stadium Conglomerate	4	8	0.46	0.59	0.479	95% KM (†) UCL
Friars	2	5	0.58	0.69	0.609	95% KM (†) UCL
Scripps	0	24				
Ardath Shale	0	1				
Torrey Sandstone	4	18	1.2	1.4	1.119	95% KM (†) UCL
Cabrillo	4	13	0.2	0.4	0.371	95% KM (†) UCL
Point Loma	24	0	0.3	0.5	0.423	95% Student's-t UCL
Penasquitos	0	1				
All Eleven Formations	62	167	0.16	1.4	0.378	95% KM (†) UCL



			01	•		
				mium		
ormation		N=Non Detect	Min	Max	95% UCL	Suggested UCL
Bay Point	115	0	20.9	31.1	15.63	95% Student's-t UCL
Linda Vista	27	0	4.8	23.8	15.3	95% Student's-t UCL
San Diego	1	0	25.3	25.3		
Stadium Conglomerate	11	1	2.02	10.6	6.252	95% KM (†) UCL
riars	7	0	5.51	15.4	12.15	95% Student's-t UCL
cripps	24	0	7.09	20.7	14.63	95% Student's-t UCL
Ardath Shale	1	0	7.63	7.63		
orrey Sandstone	18	3	2.6	10.1	5.041	95% KM Adjusted Gamma UCL
Cabrillo	16	0	8.6	93.1	48.59	95% Student's-t UCL
Point Loma	24	0	13.2	40.7	30.53	95% Student's-t UCL
enasquitos enasquitos	1	0	62.8	62.8		
All Eleven Formations	246	4	20.2	93.1	19.17	95% (Chebyshev) UCL
20						
Maximum Non-Detect Value Bay Point Linda Vis	San Diego	Friars Conglomerate	Scripps	Ardath Shale Torrey	Cabri Sandstone	llo Penasquitos Point Loma All Eleven Formations

			Cobalt			
ormation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
ay Point	114	0	1.18	15.4	5.38	95% Student's-t UCL
inda Vista	20	2	1	5.48	3.122	95% KM Adjusted Gamma UCL
an Diego	1	0	16.7	16.7		
tadium Conglomerate	12	0	1.5	5.2	3.689	95% Student's-t UCL
iars	7	0	2.05	3.29	2.953	95% Student's-t UCL
cripps	23	1	2.98	9.51	6.331	95% KM (†) UCL
rdath Shale	1	0	2.44	2.44		
orrey Sandstone	11	11	1.1	3.87	2.264	95% KM (t) UCL
abrillo	16	0	1.5	11.3	7.087	95% Student's-t UCL
oint Loma	24	0	2	23.9	11.89	95% KM Adjusted Gamma UCL
enasquitos	1	0	21.5	21.5		
ll Eleven Formations	230	14	1	23.9	5.56	KM H-UCL
12 gg 12 9						
6	_					
3 Maximum Non-Detect Value 2.	5					
0 Bay Point Linda Vista	San Diego Stadium Co	Friars onglomerate	Arda Scripps	th Shale Torrey Sand	Cabrillo dstone	Penasquitos Point Loma All Eleven Formations

			Coppe			
ormation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
ay Point	113	2	1.02	28	8.594	KM H-UCL
inda Vista	19	6	1	4	2.783	95% KM (t) UCL
an Diego	1	0	15.6	15.6		
tadium Conglomerate	10	2	1.51	11	7.485	95% KM (†) UCL
riars	7	0	3.14	9.1	7.819	95% H-UCL
cripps	23	0	6.22	25.3	13.4	95% KM Adjusted Gamma UCL
krdath Shale	1	0	1.67	1.67		
orrey Sandstone	15	7	1.1	6.35	2.595	95% KM (t) UCL
Cabrillo	17	0	2	25	13.51	95% KM Adjusted Gamma UCL
oint Loma	24	0	4	31	25.22	95% Student's-t UCL
enasquitos	1	0	57.7	57.7		
II Eleven Formations	231	17	1	31	10.4	95% (Chebyshev) UCL
32 24						

Ardath Shale

Scripps

Cabrillo

Torrey Sandstone

Point Loma

Penasquitos

All Eleven Formations

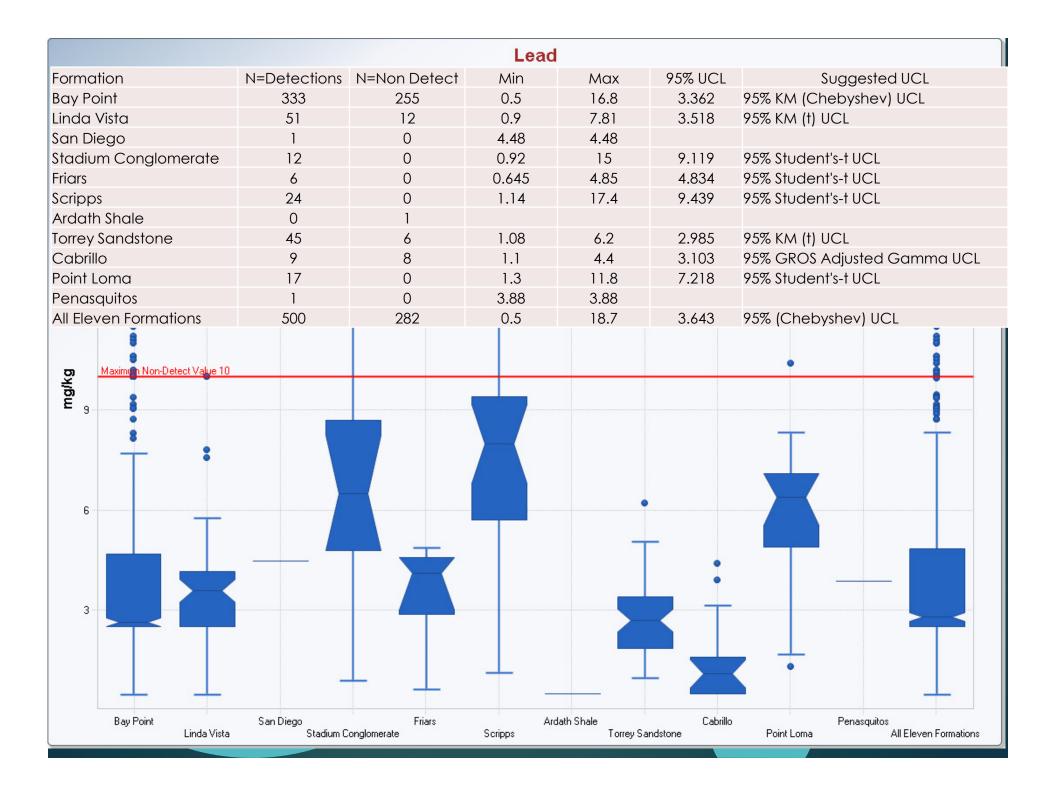
San Diego

Friars

Stadium Conglomerate

Bay Point

Linda Vista



Mercury

Formation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
						95% KM Approximate Gamma
Bay Point	28	86	0.007	0.41	0.0359	UCL
Linda Vista	1	24				
San Diego	0	1				
Stadium Conglomerate	0	12				
Friars	0	7				
Scripps	0	24				
Ardath Shale	0	1				
Torrey Sandstone	0	22				
Cabrillo	0	17				
Point Loma	5	24	0.01	0.03	0.0229	95% KM (†) UCL
Penasquitos	0	1				
All Eleven Formations	34	214	0.007	0.41	0.0343	95% KM (Chebyshev) UCL

Molybdenum

Formation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
Bay Point	15	100	0.5	1.2	0.633	95% KM Approximate Gamma UCL
Linda Vista	6	16	0.5	2.94	1.162	95% KM (Chebyshev) UCL
San Diego	0	1				
Stadium Conglomerate	0	12				
Friars	1	6				
Scripps	1	23				
Ardath Shale	0	1				
Torrey Sandstone	0	22				
Cabrillo	12	4	0.6	4.4	2.522	95% KM (†) UCL
Point Loma	14	10	0.5	2	0.871	95% KM (†) UCL
Penasquitos	0	1				
All Eleven Formations	49	195	0.5	4.4	0.972	95% KM (Chebyshev) UCL

			Nick	tel		
ormation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
ay Point	110	4	1.13	18.5	7.572	95% KM (Chebyshev) UCL
inda Vista	22	3	1.7	5.5	3.85	95% KM (†) UCL
an Diego	1	0	8.31	8.31		
tadium Conglomerate	11	1	1.36	4.33	3.457	95% KM (†) UCL
iars	6	0	2.29	3.5	3.061	95% Student's-t UCL
cripps	24	0	3.26	13.6	8.755	95% Student's-t UCL
rdath Shale	1	0	3.16	3.16		
orrey Sandstone	14	8	1.03	4.62	2.547	95% KM (t) UCL
abrillo	17	0	2.4	17.4	10.28	95% Student's-t UCL
oint Loma	24	0	5	21.1	17.25	95% Student's-t UCL
enasquitos	1	0	27	27		
Il Eleven Formations	232	16	1.03	21.1	7.361	KM H-UCL
8 Maximum Non-Detect Value 2						
Bay Point Linda Vist	San Diego Stadium	Friars Conglomerate	Scripps	Ardath Shale	Cabr Sandstone	illo Penasquitos Point Loma All Eleven Formations

Selenium

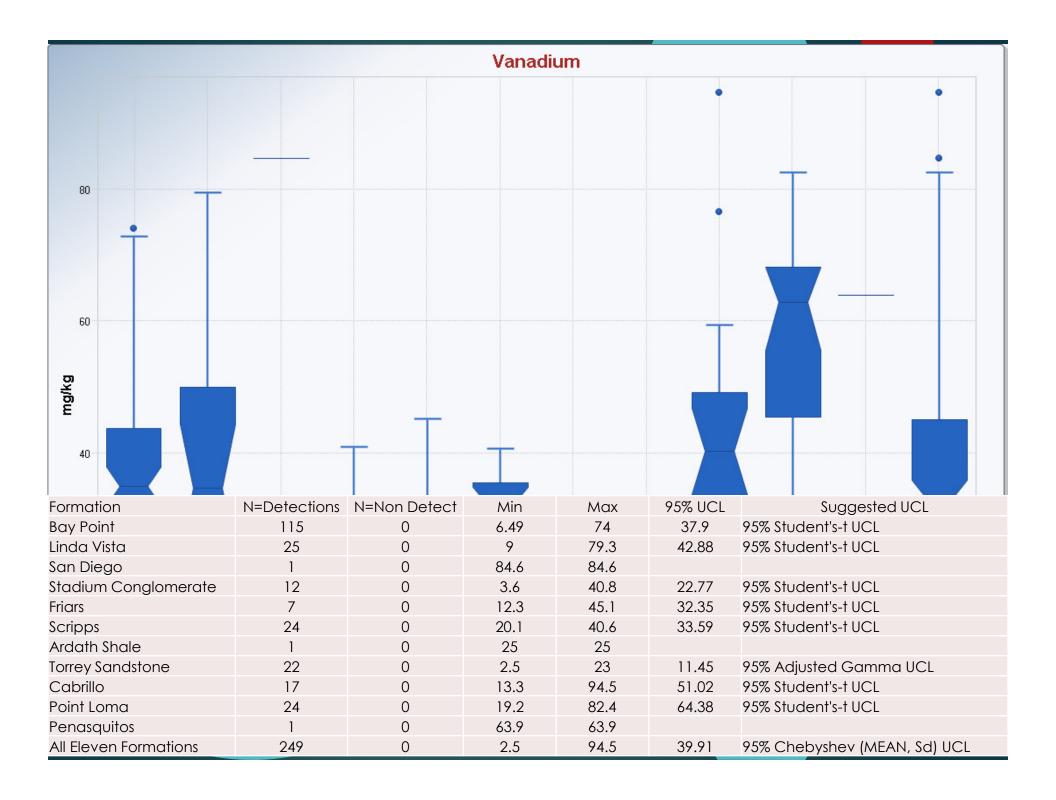
Formation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
Bay Point	20	78	0.5	1.2	0.592	95% KM (†) UCL
Linda Vista	0	22				
San Diego	0	1				
Stadium Conglomerate	1	11				
Friars	1	6				
Scripps	0	23				
Ardath Shale	0	1				
Torrey Sandstone	0	22				
Cabrillo	0	17				
Point Loma	5	19	0.5	1	0.586	95% Adjusted Gamma UCL
Penasquitos	0	1				
All Eleven Formations	27	201	0.5	3.98	0.663	95% KM (Chebyshev) UCL

Silver

Formation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
Bay Point	4	110	0.03	0.6	0.156	95% KM (†) UCL
Linda Vista	0	22				
San Diego	0	1				
Stadium Conglomerate	0	12				
Friars	0	7				
Scripps	0	24				
Ardath Shale	0	1				
Torrey Sandstone	0	22				
Cabrillo	0	17				
Point Loma	2	22	0.08	0.11	0.121	95% KM (†) UCL
Penasquitos	0	1				
All Eleven Formations	6	239	0.03	0.6	0.162	95% KM (†) UCL

Thallium

Formation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
Bay Point	2	96	0.15	0.34	0.659	95% KM (Chebyshev) UCL
Linda Vista	0	22				
San Diego	0	1				
Stadium Conglomerate	0	11				
Friars	0	7				
Scripps	0	23				
Ardath Shale	0	1				
Torrey Sandstone	0	22				
Cabrillo	0	17				
Point Loma	2	22	0.41	0.45	0.464	95% KM (t) UCL
Penasquitos	0	1				
All Eleven Formations	4	222	0.15	0.45	0.447	95% KM (†) UCL



			Zind	:		
formation	N=Detections	N=Non Detect	Min	Max	95% UCL	Suggested UCL
ay Point	102	12	3.88	77.3	31.39	95% Approximate Gamma UCL
inda Vista	25	0	4	16	11.73	95% Student's-t UCL
an Diego	1	0	45.8	45.8		
tadium Conglomerate	12	0	6.3	47	35.11	95% Student's-t UCL
iars	7	0	8.88	27.2	20.69	95% Student's-t UCL
cripps	23	1	15.5	61.1	41.88	95% KM (t) UCL
rdath Shale	1	0	14.7	14.7		
orrey Sandstone	22	0	1.69	24.2	15.79	95% Student's-t UCL
abrillo	17	0	6	91	48.75	95% Student's-t UCL
oint Loma	24	0	17	108	80.89	95% Student's-t UCL
enasquitos	1	0	95.6	95.6		
l Eleven Formations	235	13	1.69	108	37.49	95% KM (Chebyshev) UCL
40						
20					_	
20						

Discussion

- Antimony (n=16), Silver (n=6), Thallium (n=4) detected in limited samples.
 - ProUCL will handle data sets with ND results (below method detection limits); but, needs some detectable concentrations for valid statistics
 - Need more data for these metals
- Need more samples of the San Diego, Penasquitos, Ardath Shale, and Friars Formations
- Some of the other metals (e.g. Mercury and Selenium) only detected in a few formations, likely due to a lower detection limit.
- The Cretaceous Formations generally have higher concentrations of most metals. Could be tied to Arc Volcanism and related to the geologic history of the area.

Discussion

- Potential to use Geotracker and NOI's for the Inert Soil Waiver
- Many soil samples were collected from an area with known anthropogenic impacts
 - ▶ Good consistency with ranges of concentrations between sites
 - ▶ If the metals are not completely geogenic, the results are still representative of downtown conditions
- Beginning to see lateral and vertical variability within formations
 - Natural Variability in Concentrations of Metals
 - More samples needed
 - North County
 - Clairemont
 - ▶ La Jolla
 - Southbay
- Working on funding (\$\$)

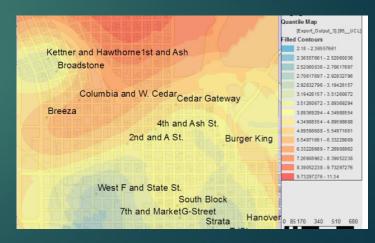


Figure: Map depicting spatial variability constructed with ArcMap

Conclusions

- ► To date All 95% UCL concentrations for metals are below EPA Region 9 Regional Screening Levels for residential soils, except Arsenic.
- ► Further research is currently underway to identify the distribution and range of concentrations of metals in additional formations throughout the San Diego Embayment.
- Additional data will be collected from specific locations so that a comprehensive study of the concentration of naturally occurring metals in San Diego County sediments can be published.

Future Work

- Continued data collection
 - ► Would be ideal to obtain at least 50 geogenic samples from each of the ~17 formations
- Speciation and bioavailability
- Metals in groundwater
- Metals in natural alluvium and soils
- Metals in the plutonic rock sequences
- Dr. Bethany O'Shea is interested in using this data regarding the cycling of metals, nutrients, and contaminants in the environment; specifically controls on the movement and distribution of trace elements in groundwater, lakes, and sediments
- Potential for multiple Masters Theses and research projects!

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 - Taylor Moniz
 - ▶ Emily Pacholski
 - Kevin Pelaez
 - Cornelius Harris
 - Javier Gomez\
 - Dillon Itri

Questions and Comments?

Naturally Occurring Concentrations of Seventeen Metals in the Bay Point Formation*, San Diego, California



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Abstract

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The natural variability of masks in the native formations of fain Diagn County is poorly understood, Specific formation studies are circlain. In identifying the spatial variability of metals and concentrations that are anthronogenic and what may be naturally occurring. Few studies of the concentrations of metals within the native sediments of San Diego County spicit. The existing studies are regional in native and formation specific studies in the San Diego Entidyment criteria regarding remediation and potential disposal options for roles removed from contamination of potentially contaminated properties in San Diego County.

We present the results of distinct geogenic soil samples representing the in-situ-Bay Point Formation (upper and lower facies) of San Diego, Caldornia. The approximately 1.5 agues miles (3.3 dist) between bitterial lines 30.0 43 307 4, and 50.0 47 307 N, and longitude lines 117.0 09 00 W and 117.0 107 307 W. All of the soil samples collected were analyzed by a Caldornial Certified Analystic Laboratory for various metals following Environmental Protection Agency 6000 /7000 Series Methods on a ICP Mass Spectrometer.

The naturally occurring Arsenic concentrations detected during this study exceed commonly used health risk soil screening levels and other risked-based corrective action guidelines utilised by many regulatory agenties on exceed any such published criteria. Additional research is needed to assess the bio-availability of the Arsenic, the potential impact to human health and the environment, and the impact these results may have on current regulatory thresholds for assessing soils or residential and commercial properties.

Utilinately, this project will include the uploading of all raw analytical data to a central database for public use. Firther research is currently underway to identify the range of concentrations of metals in additional formations throughout the san biege fernbayment (e.g. San Diege Formation, Torrey Sandstone, Mission Valley Formation). Additional data will be collected from specific locations to that a comprehensive study of the concentration of naturalized coursing metals in San Diego County sediments can be published.

Introduction and Methods

Although research regarding the background concentrations of metals in urban areas is being conducted in other parts of California (e.g. Duverge (2011), studies of geogenic metals concentrations within the sediments of San Diego County are poorly represented in the literature (e.g. Chernoff et al. (2008), Kearn (1936), Klainkiefer (2005), Specifically, no published studies were found regarding the geogenic concentrations of metals in the Bay Point Formation, San Diego, California.

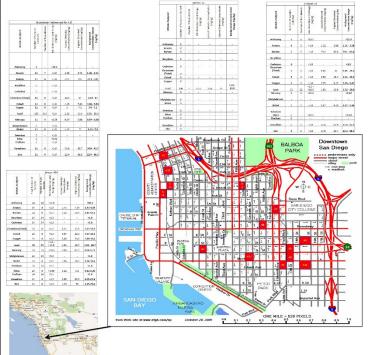
A total of 883 soil samples from the native Bay Point Formation were collected for this study, All of the soil samples were analyzed for various metals using EPA Method 6010/7000 protocols by a California Certified Analytical Laboratory. Random anapies were also analyzed for total patroleum hydrocarbons (EPA Method 8015), volatile organic compounds (EPA Method 80760), permi-volatile organic compounds

All of the sites used in this study were associated with the construction of underground parking structure. Samples were collected from a minimum of 3 feet to a maximum of 46 feet below the ground surface. Due to prior commercial and industrial use at many of the sites, soil samples with detectable concentrations of inorganic chemicals or hydrocrabon signatures were eliminated from the datasets. Due to the presence of artificial fill material at the sites, complete Site Characterization Reports and / or final Grading Reports were generated for each site in accordance with State and Local environmental regulations. The artificial fill material was defined prior to the collection of soil samples used in this study. Synthetic Precipitation Leaching Procedure (SPP) analyses were performed at multiples liste to determine the leachability of metals from the artificial fill into the in-situ formation material. All SPP results were below the method detection limits.

All samples were collected from in-situ formation material above the static groundwater table. Confirmation of in-situ formation material was obtained by lithology studies including the absence of construction debris and ash, geophysical surveys, and / or the presence of fossils or contiguous cobble layers.

ProUCL (version 4.1.00) is a statistical software package recommended by the Environmental Protection Agency (EPA) to calculate the upper confidence limits (UCL) in data sets with and without non-detect observations. ProUCL was utilized to calculate the recommended 95% UCLs for this study.

Representative Site Specific Results



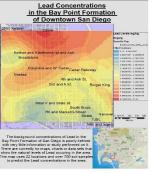


This poster may be downloaded from http://home.sandiego.edu/~cathcart/metals.pdf May 21, 2013

Future Research

We are currently incorporating GIS and Kriging Analyses to study the spatial distribution of metals in the subsurface.





Analytical Summary

Med	Wanter of Samples With Concentrations Over the Method Defoction Chair	Number of Sample With Concentration Below the Abeliad Delevior Link	Perserrage of Serrythe Bellevichte Method December Literi	Method ferrodon into (reging)		Merimen Telected Concentration (rughd)	Mainten Delected Coccerbadon (mg/kg)	MCN Lapper Confidence Links	Tipes Certifiers that holded tool
				Minimum	Madeure				
Antimony	2	53	96.36%	1	10	1.74	1.78	<10.0	
Arsenic	101	34	25.19%	1	10	1	11	2.505	KM (Percentile Bootstrap UCL
Barium	69	0	0.00%	1	1	1.43	176	54.52	Chebyshev (Mean, Sd) UC
Beryllium	0	13	100.00%	1	1		-	<1.0	
Cadmium	2	56	96.55%	1	1	1.02	4.35	<4.35	
Chromium (Total)	60	6	9.09%	1	1	3.23	29.8	16.69	95% KM (Chebyshev) UCI
Cobalt	60	6	9.09%	1	1	1.43	15.40	6.191	95% KM (Chebyshev) UCI
Copper	59	7	10.61%	1	1	1.08	19.9	7.106	95% KM (Chebyshev) UC
Lead	585	298	33.75%	1	10	1	19.5	3.609	95% KM (BCA) UCL
Mercury	18	47	72.31%	0.001	0.08	0.02	0.17	0.0367	95% KM (t) UCL
Molybdenum	0	18	100.00%	5	5		-	<5.0	
Nickel	60	6	9.09%	1	1	1.96	18.5	5.866	95% KM (BCA) UCL
Selentum	0	11	100.00%	1	1		-	<1.0	
Silver	3	52	94.55%	0.1	1	0.12	0.2	<0.2	
Thallium	0	13	100.00%	1	1	-	-	<1.0	
Vanadium	45	21	31.82%	0.1	0.5	0.12	72.6	34.81	95% KM (Chebyshev) UCI
Zinc	61	5	7.58%	1	1	1.25	155	39.3	95% KM (Chebyshev) UCI

Conclusions

Baryllium, Molybdenum, Selenium, and Thallium were not detected in concentrations above the mathod detection limits in any of the samples collected and Antimony, Cadmium, and Silver were only detected in limited samples Therefore, the 39% Upper Confidence Limit (LUCL) was not calculated for these metals as the population work adequate for statistical analyses. We reported the 55% UCL as either less than the highest method detection limit, less than the highest detected concentration (which ever was greatest) in order to yield the most conservative mesults.

The 95% UCL for the remaining metals was calculated using the default values on ProUCL (Version 4.1.00) and incorporated the non-detect values along with the detected consentration. The recommended UCL to use for the dataset was provided by the ProUCL program. The 95% UCL for Arsenic (2.5 mg/kg) exceeds commonly used risk assessment thresholds (0.39 mg/kg residential RSL = EPA Region 9) utilized by many regulatory agencies on contemporated time (a California).

The raw data and results presented here will be uploaded to a central database for public use. Further research is currently underway to identify the distribution and range of concentrations of metals in additional formations throughout the San Diego Embayment. Additional data will be collected from specific locations so that a comprehensive study of the concentration of naturally occurring metals in San Diego County sediments can be published.

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