



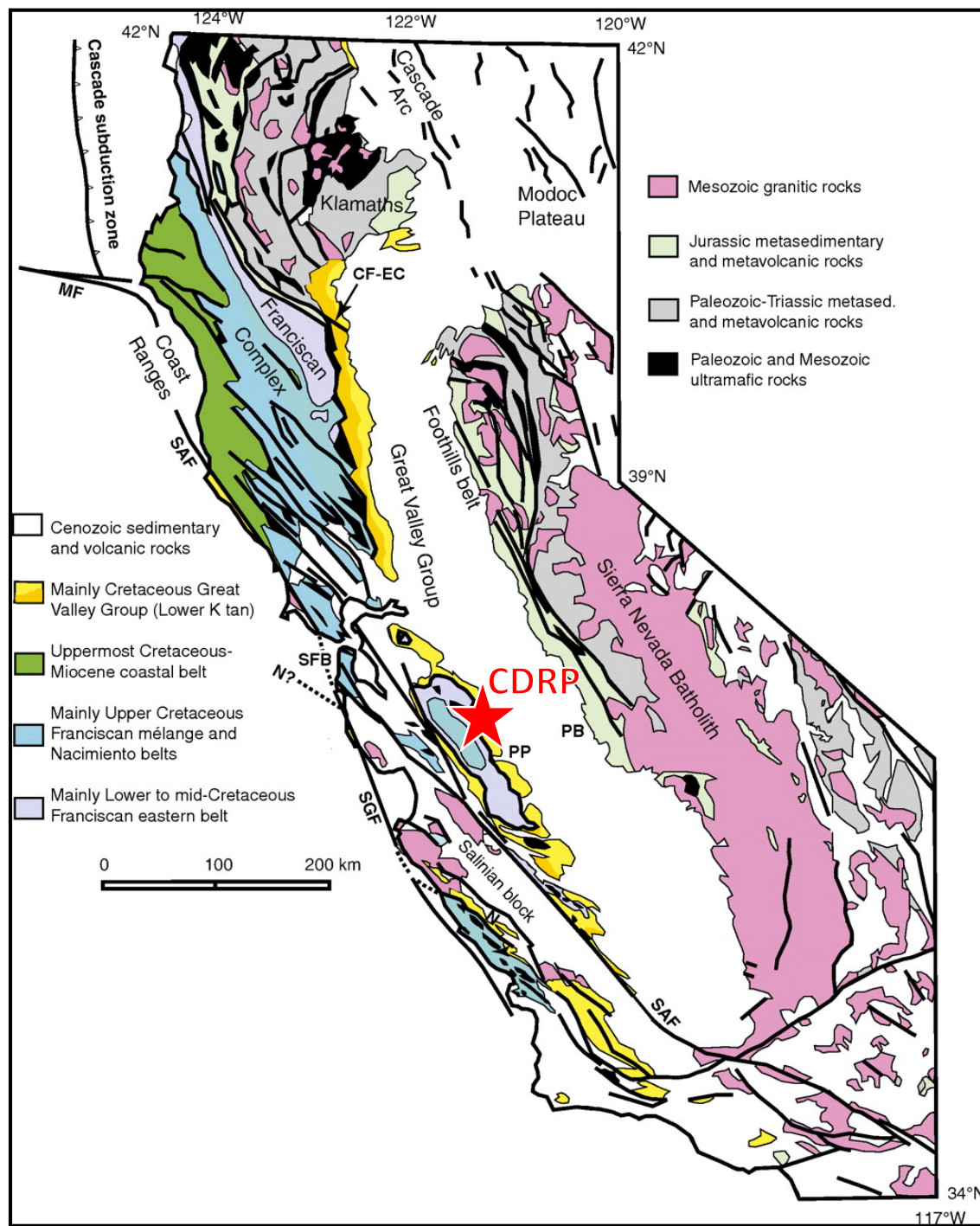
*The New Frontier in Naturally Occurring Asbestos:  
Elongate Mineral Particles*

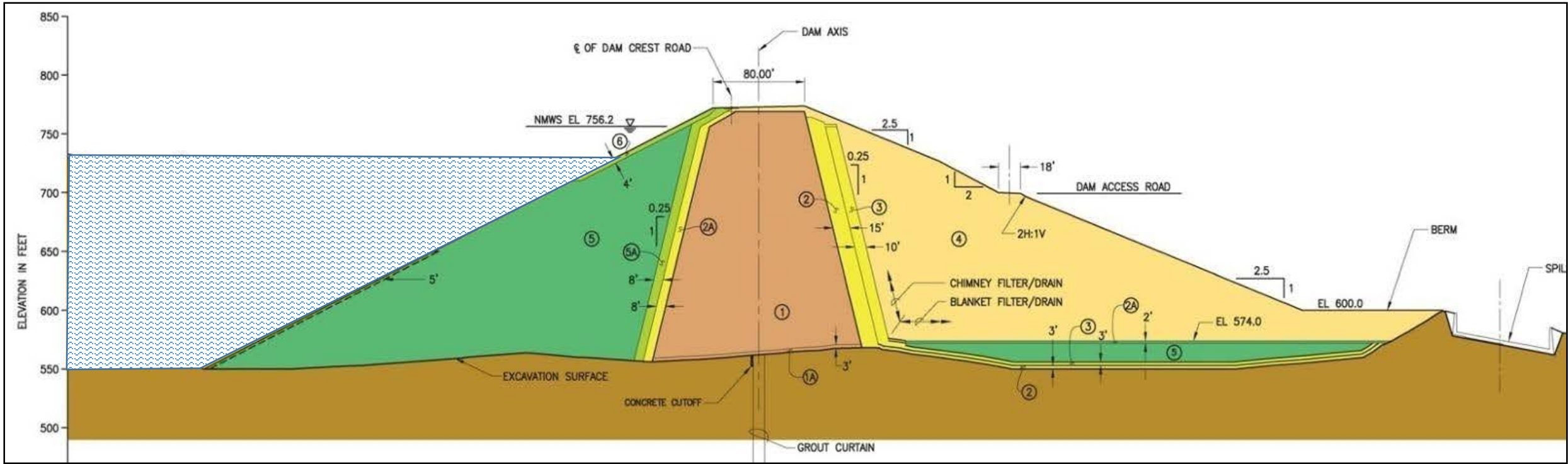
*Applying a Mega Data Set to Solve Major  
Constructability Issues at the Calaveras Dam*

*Daniel W. Hernandez, MPH, CIH*

*Bradley G. Erskine, Ph.D., CEG*



















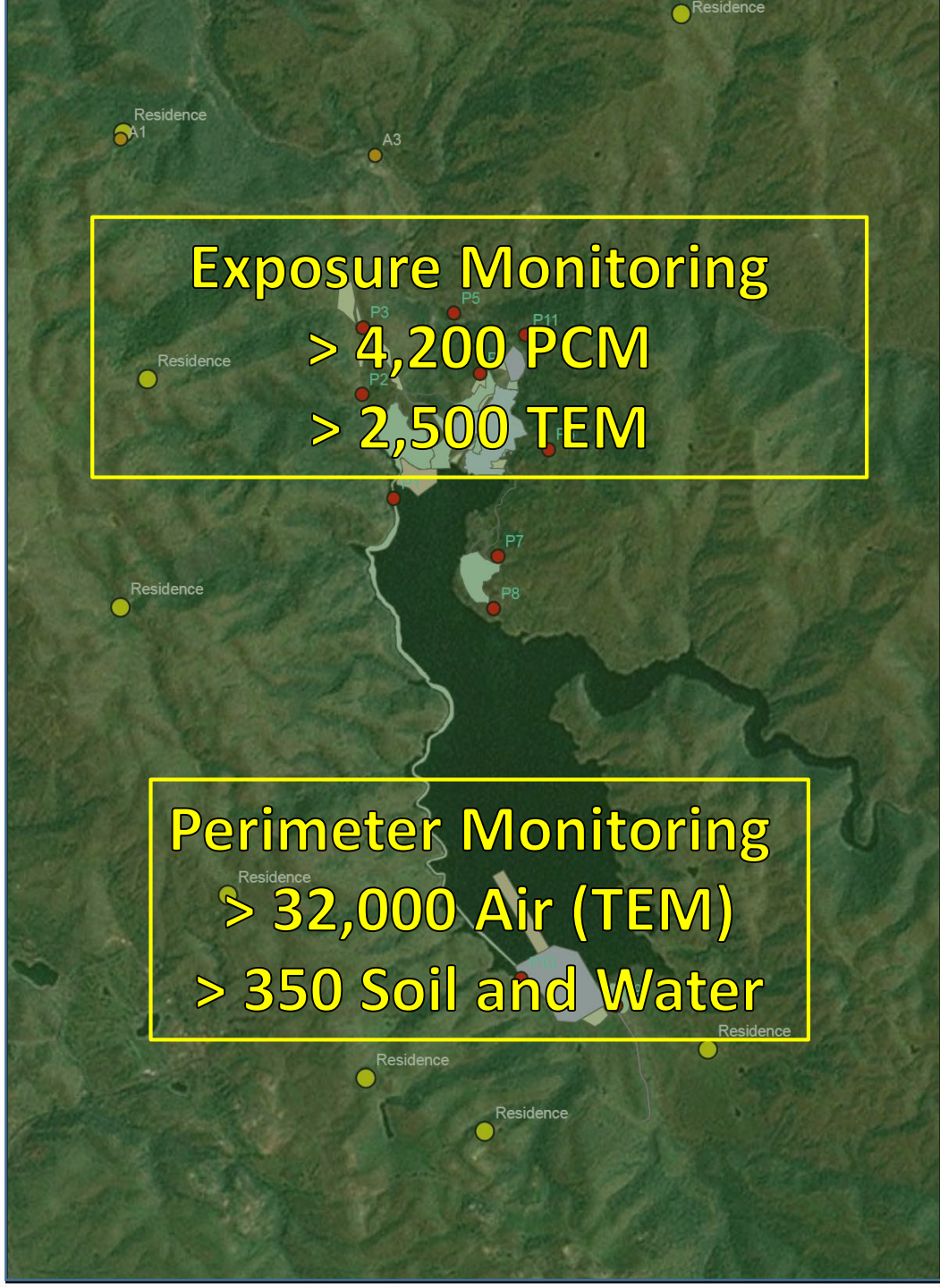
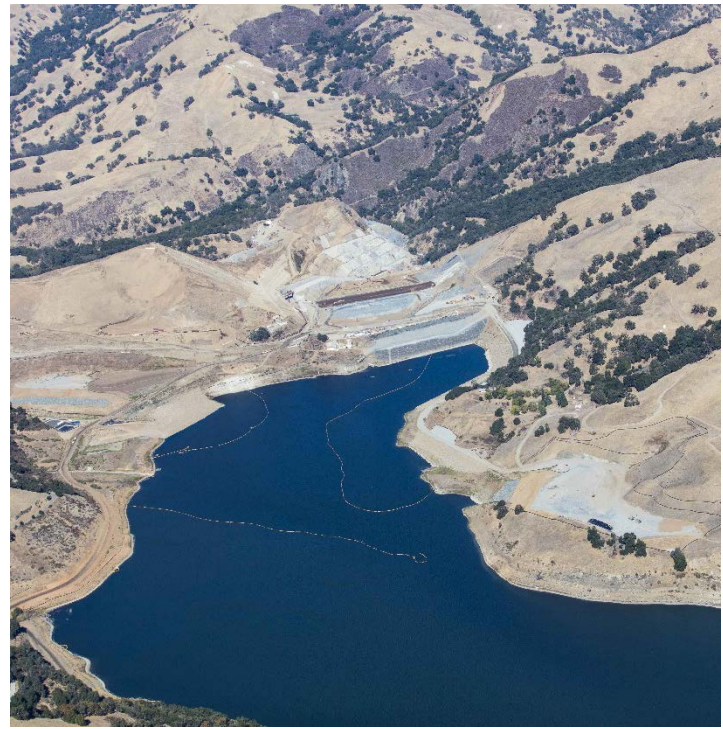




Exposure Monitoring  
> 4,200 PCM  
> 2,500 TEM

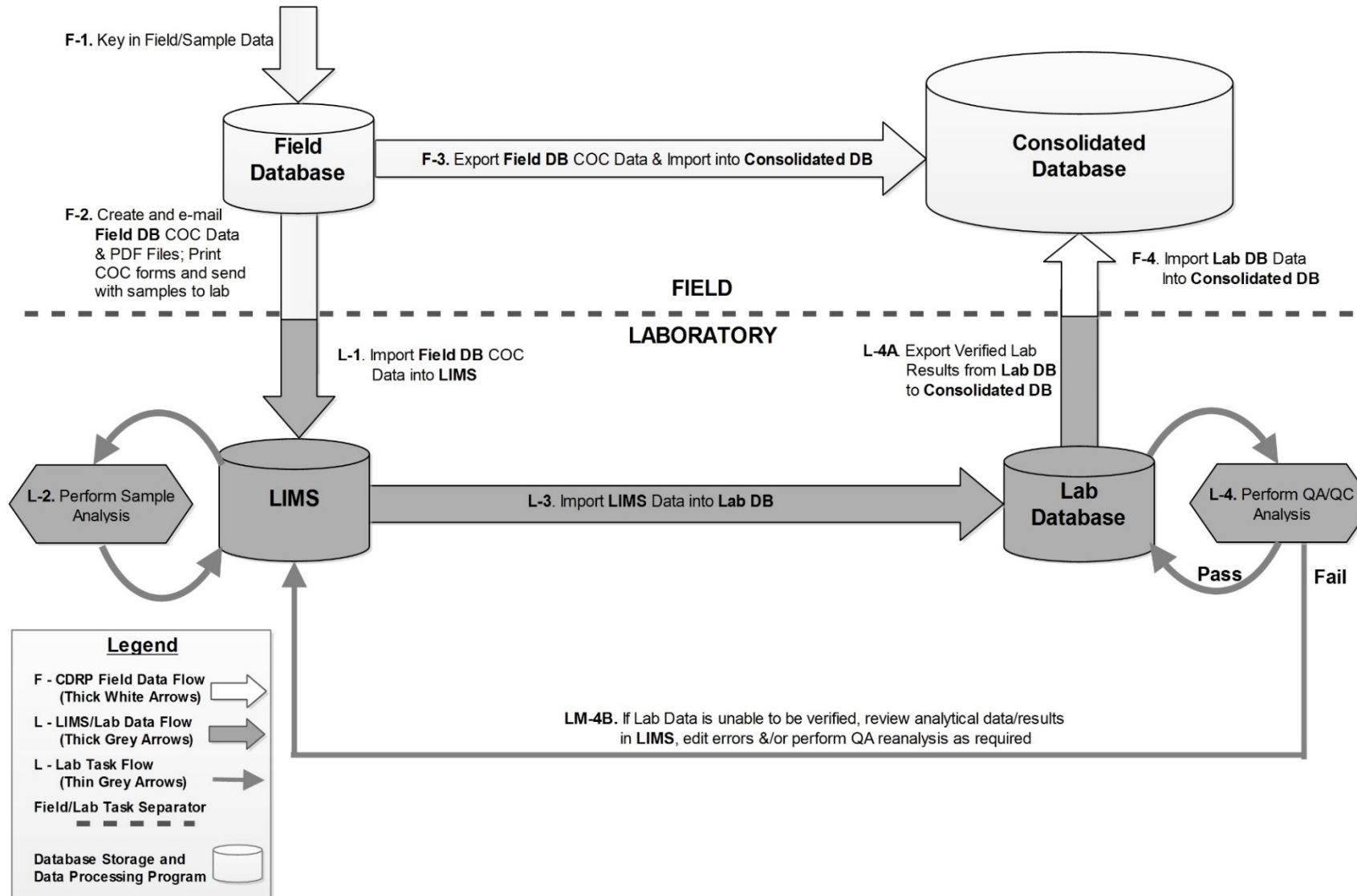


Perimeter Monitoring  
> 32,000 Air (TEM)  
> 350 Soil and Water





## Field/Lab/LIMS/Consolidated Database Air Sample Data & Reporting Flow Chart





Meteorological Raw Data

Criteria Information

Meteorological Raw Data														Date and Met Stationwise Summary											
Sampling Date	Sampling Station	Time	Sampling Day	Temp F	Wind Direction	Wind Direction Degree	Wind Speed MPH	Wind Speed Gust MPH	Wind Gust Direction	Wind Gust Direction Degree	Sigma Theta Degree (°)	Precipitation	Humidity	Clouds Cover	Wind Speed Max	Wind Speed AVG	Wind Speed Gust Max	Wind Speed Gust Avg	Temp F MAX	Temp F MIN	Temp F AVG	Humidity MAX	Humidity MIN	Humidity AVG	Ra
1/1/2013	Top of Dam	0:00:00	Tue	36.79	SSE	155.90	2.353	3.726	SSE	164.70	10.49	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	0:15:00	Tue	36.49	S	180.80	3.206	6.284	S	189.00	21.87	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	0:30:00	Tue	36.16	NNW	341.30	2.550	5.480	N	0.14	64.64	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	0:45:00	Tue	36.26	NNW	333.30	1.164	3.873	N	0.58	83.40	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	1:00:00	Tue	36.17	S	179.70	2.140	7.672	SSW	201.10	30.69	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	1:15:00	Tue	35.82	S	188.60	4.190	8.770	SSW	211.60	24.71	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	1:30:00	Tue	35.88	NNE	13.97	1.664	4.530	N	5.01	72.86	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	1:45:00	Tue	36.14	N	351.70	3.765	6.941	NNE	11.46	22.54	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	2:00:00	Tue	36.07	NNW	322.20	2.731	5.480	NNE	13.10	34.61	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	2:15:00	Tue	35.95	S	171.10	1.652	3.946	S	178.90	24.47	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	2:30:00	Tue	35.57	SW	214.60	1.527	3.946	SSW	207.80	40.70	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	
1/1/2013	Top of Dam	2:45:00	Tue	35.23	NNW	240.20	1.411	3.507	N	3.85	80.20	0.00	0.00		22.88	6.25	35.95	10.90	46.84	33.19	39.47	0.00	0.00	0.00	

Meteorological Data Summary

Sampling Station	Top of Dam	Temperature Max (F)	46.84	Humidity Max	0.00	Rainfall	0.00	Wind Speed Max (MPH)	22.88	Wind Speed Gust Max (MPH)	35.95
Sampling Date	01-Jan-2013	Temperature Min (F)	33.19	Humidity Min	0.00	Rainfall Previous 30 Days (To)	0.00	Wind Speed Avg (MPH)	6.25	Wind Speed Gust Avg (MPH)	10.90
		Temperature Avg (F)	39.47	Humidity Avg	0.00	No Rainfall Previous Days (To)	0.00				

Description	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Wind Speed Max (MPH)	8.38	6.02	1.02	0.00	0.00	1.91	1.83	3.56	4.19	0.98	1.53	0.00	0.00	0.00	0.00	22.88
Wind Speed Avg (MPH)	5.28	3.85	1.02	0.00	0.00	1.91	1.44	2.13	2.13	0.98	0.88	0.00	0.00	0.00	0.00	9.91
Wind Speed Gust Max (MPH)	12.93	9.28	2.34	0.00	0.00	3.21	4.31	6.50	8.77	3.00	3.95	0.00	0.00	0.00	0.00	35.95
Wind Speed Gust Avg (MPH)	8.91	6.97	2.34	0.00	0.00	3.21	3.33	4.24	5.08	3.00	2.59	0.00	0.00	0.00	0.00	16.72
Fraction of Time (HH:MM)	4.00	0.45	0.15	0.00	0.00	0.15	1.45	2.15	2.45	0.15	0.30	0.00	0.00	0.00	0.00	11.15
Fraction of Day (%)	16.67	3.13	1.04	0.00	0.00	1.04	7.29	9.38	11.46	1.04	2.08	0.00	0.00	0.00	0.00	46.88
Fraction of Time with WS ≥ Avg (HH:MM)	2.15	0.30	0.00	0.00	0.00	0.00	1.00	1.15	1.15	0.00	0.15	0.00	0.00	0.00	0.00	5.00

Beginning Date: **February** 2013  
 01-Jan-2013  
 Set Date  
 Ending Date: 28-Feb-2013  
 Set Date

Mo	Tue	Wed	Thu	Fri	Sat	Sun
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

Daily Time: >= From: 9:00:00 To: 17:00:00  
 Subtended Angle: 90 Days: 30  
 Total Rain: 0.01 0.02 0.05 0.10  
 0.20 0.50 1.00 2.00  
 Wipe Date Clear Filter Filter Data

Refresh Return



# Glaucophane in Outcrop

**Eclogite**



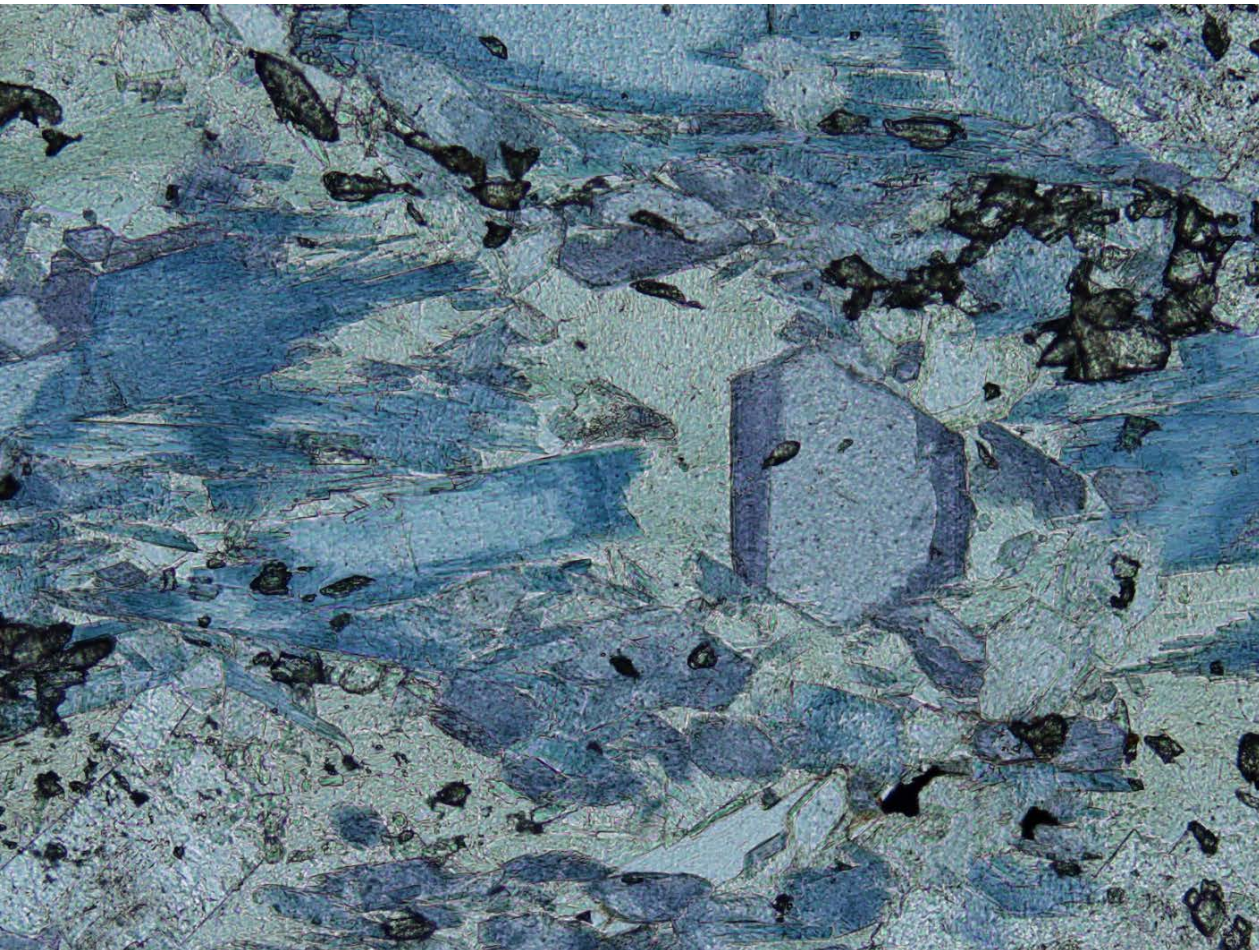
**Blueschist**



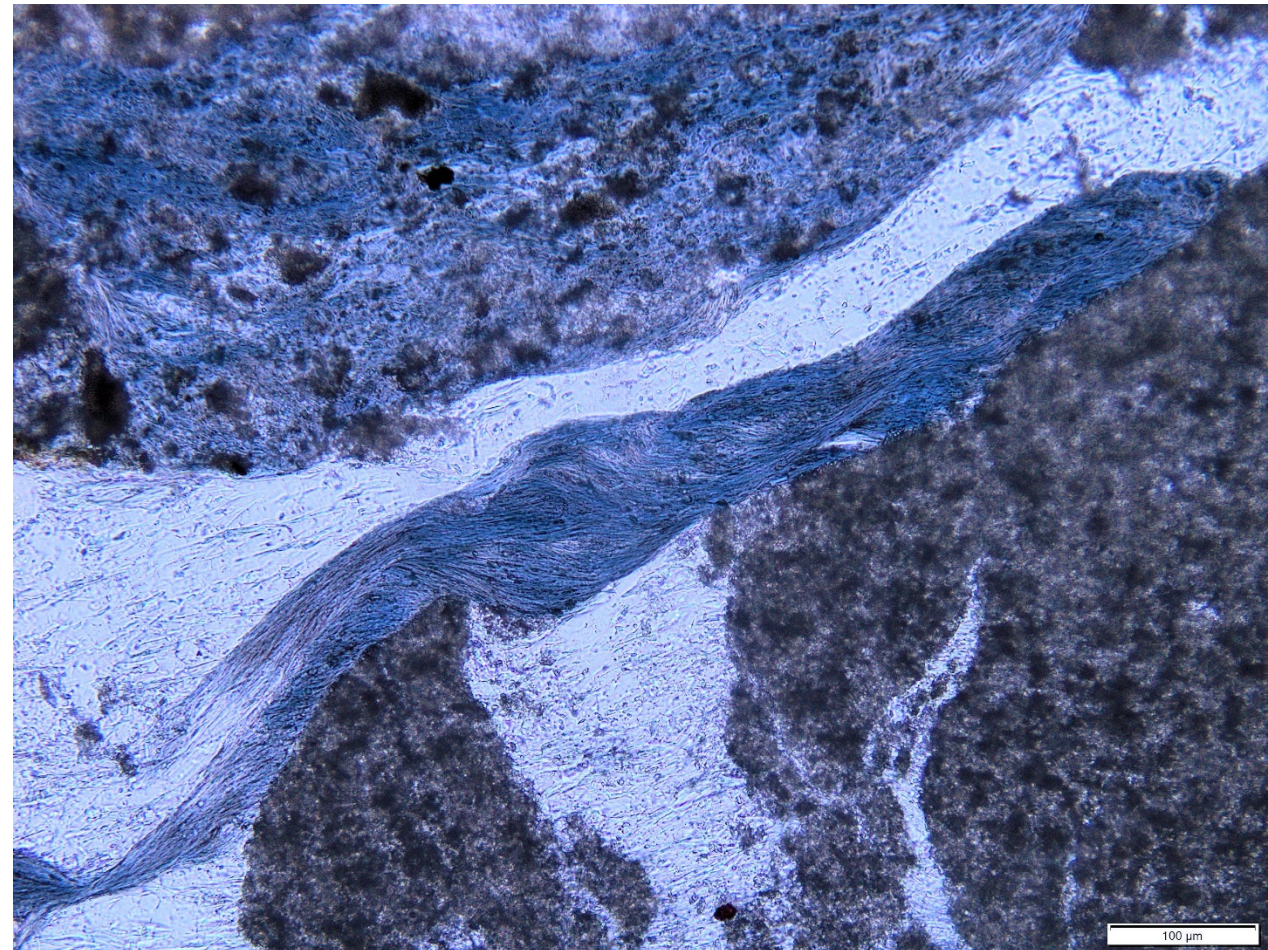


# Glaucophane in Thin Section

**Eclogite**

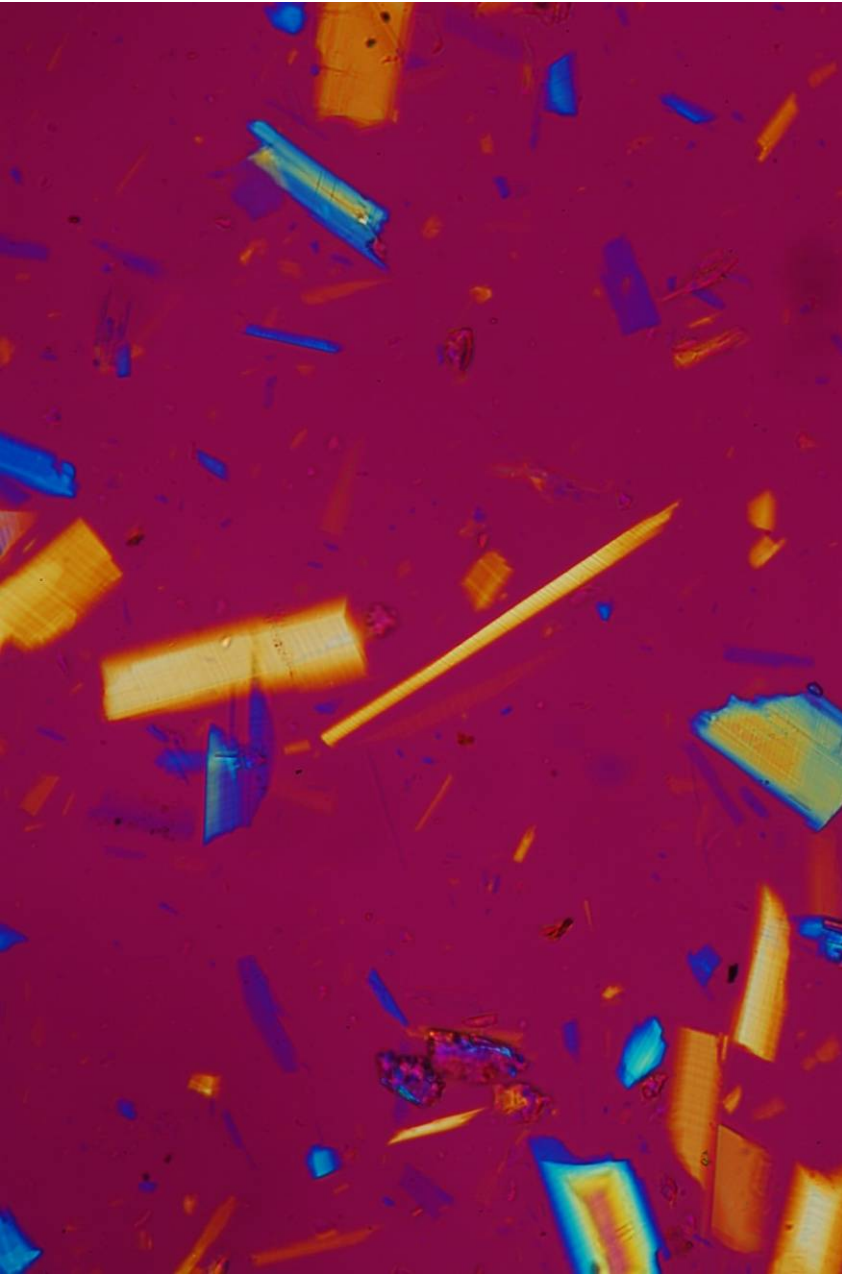


**Blueschist**

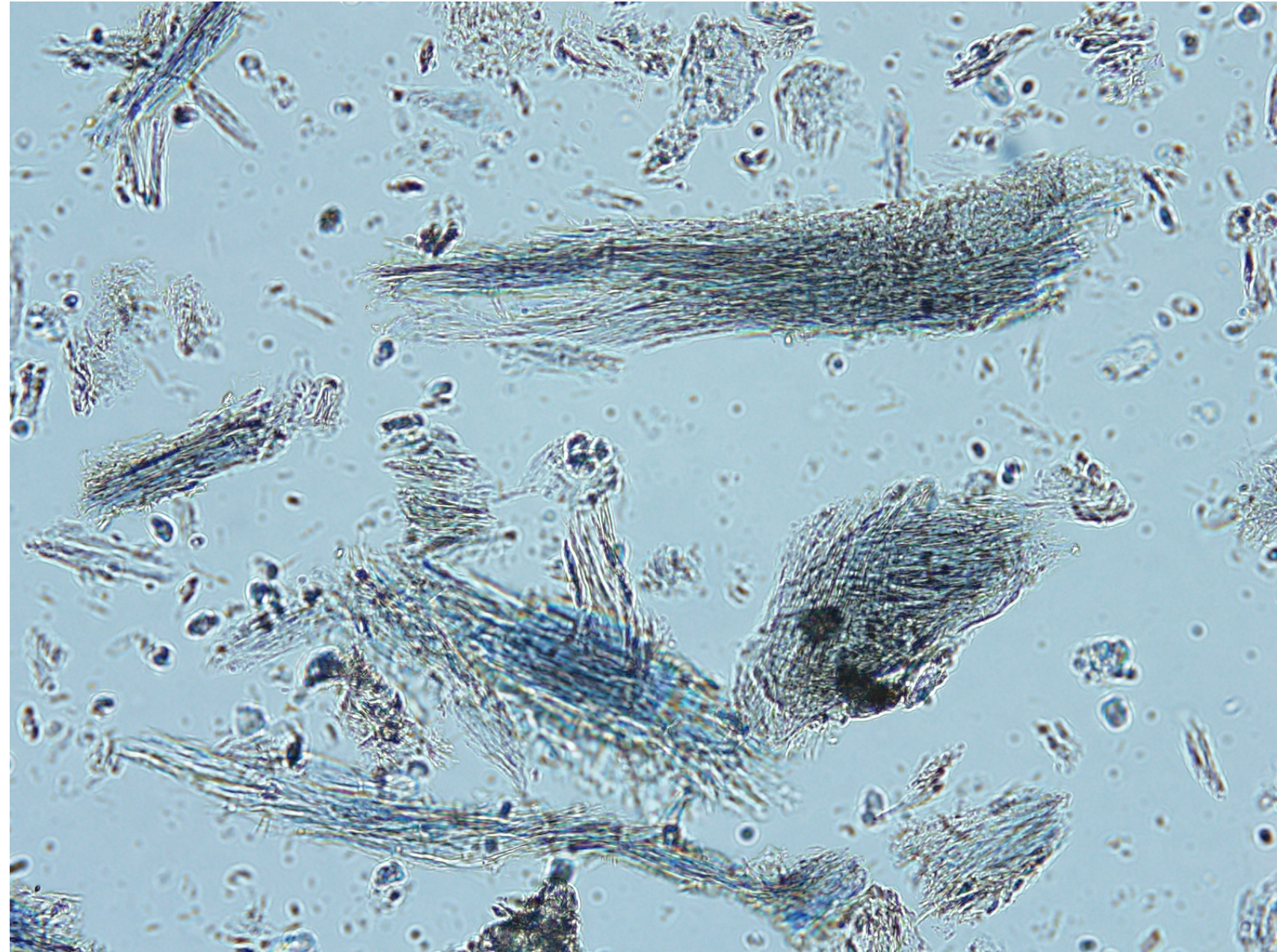




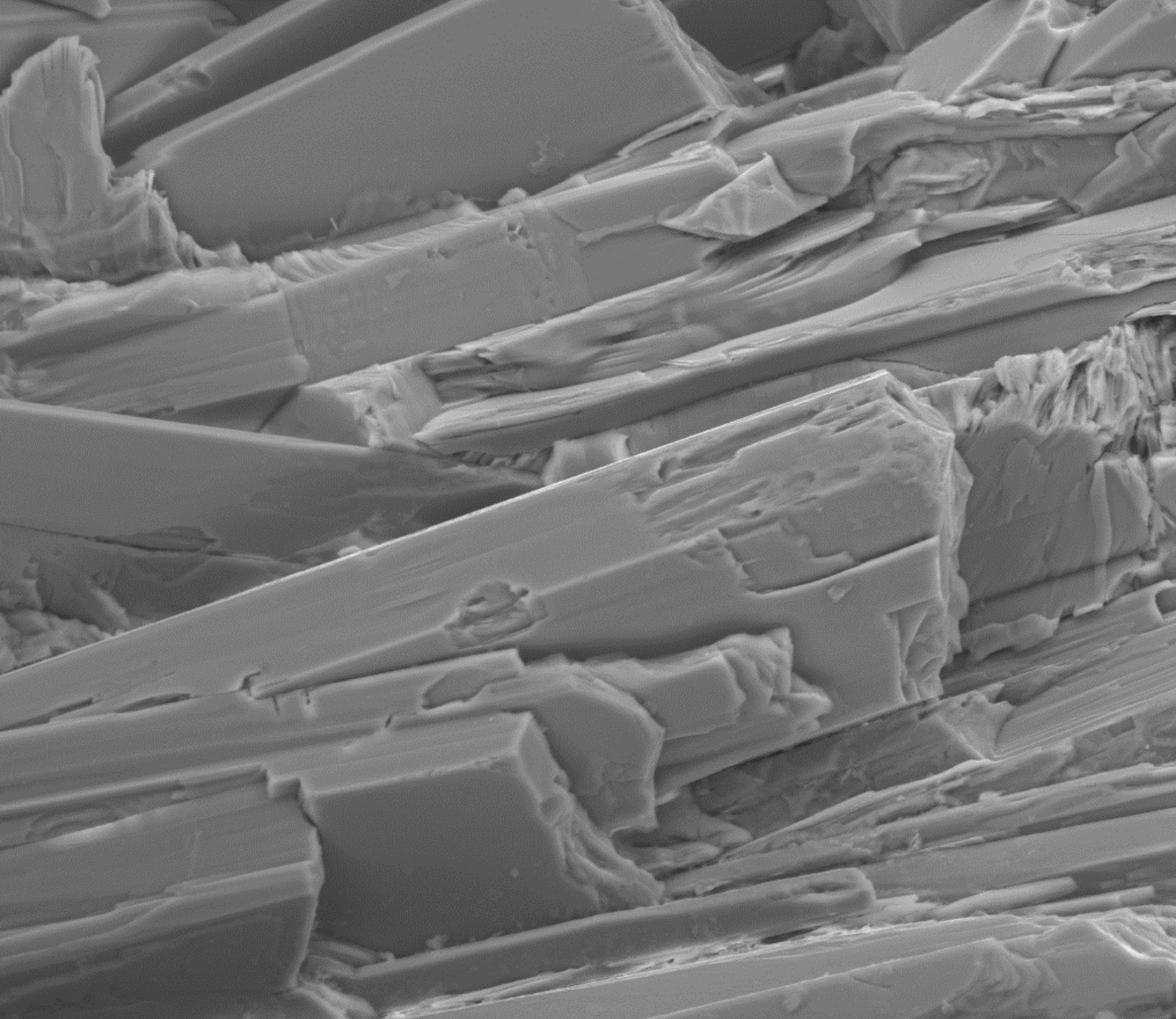
**Non-Asbestiform**



**Asbestiform**







HV	Mag	WD	Sig	HFW	Spot	100.0μm
20.0 kV	734x	10.3 mm	---	0.20 mm	6.0	







Penge amosite asbestos, 50 mm



Finland grunerite, 38 mm

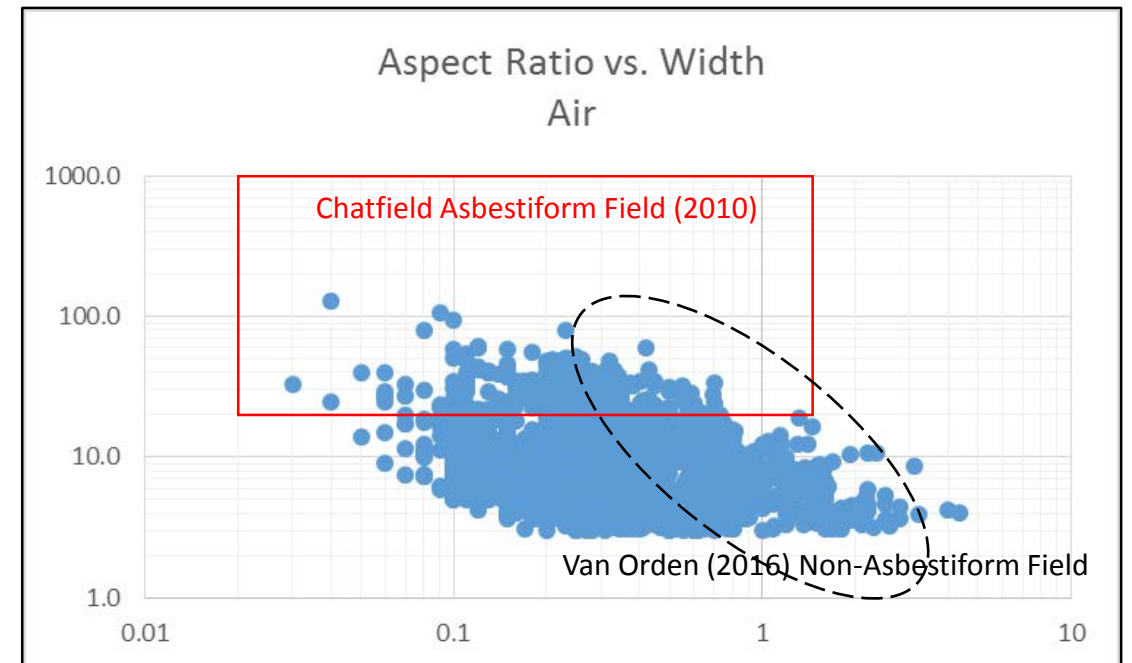
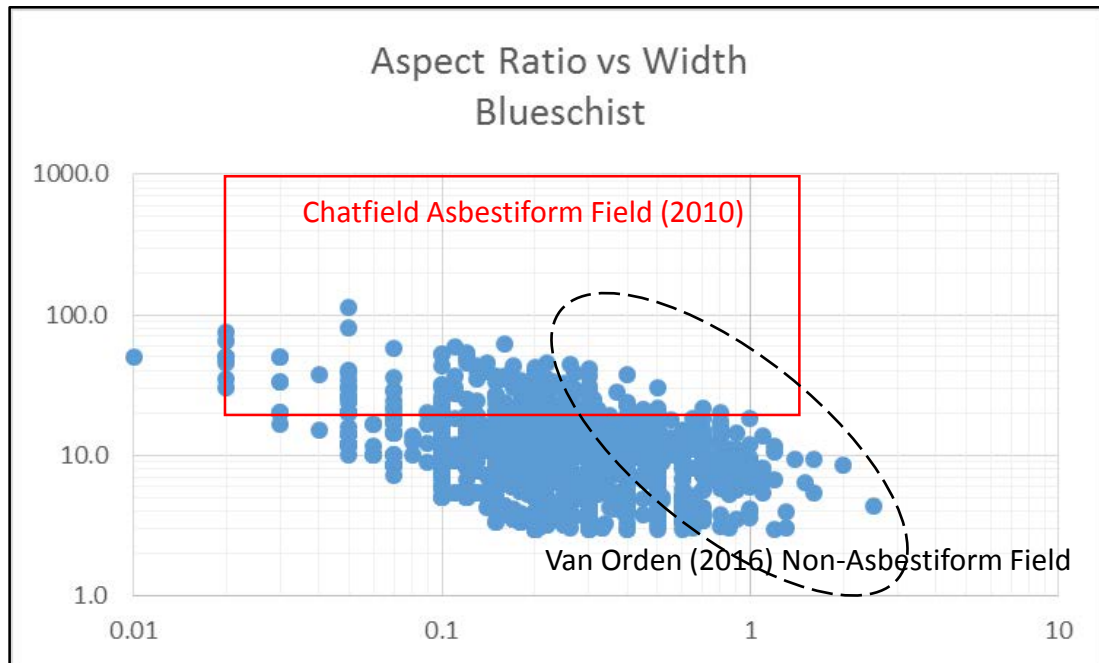
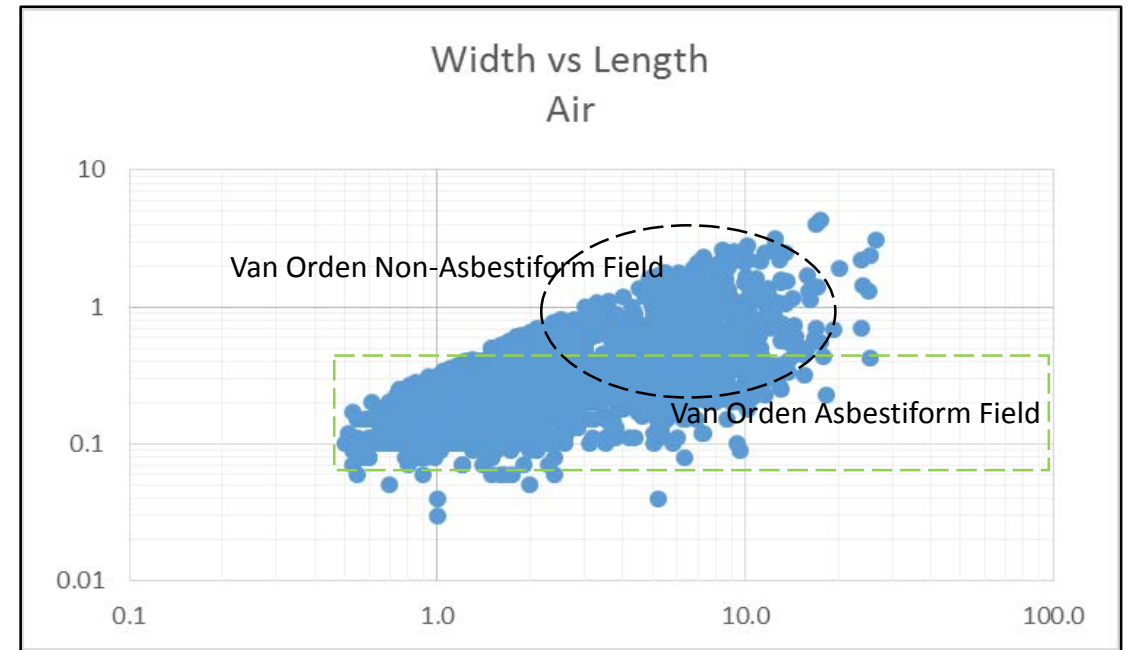
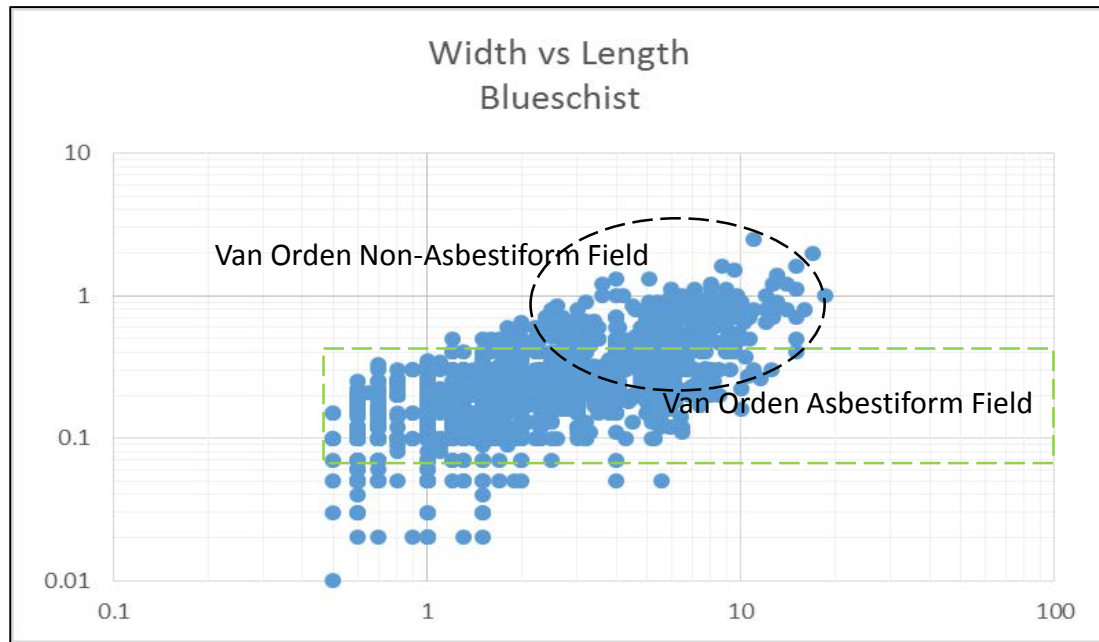


HSE actinolite asbestos, 25 mm



San Bernardino actinolite, 18 mm





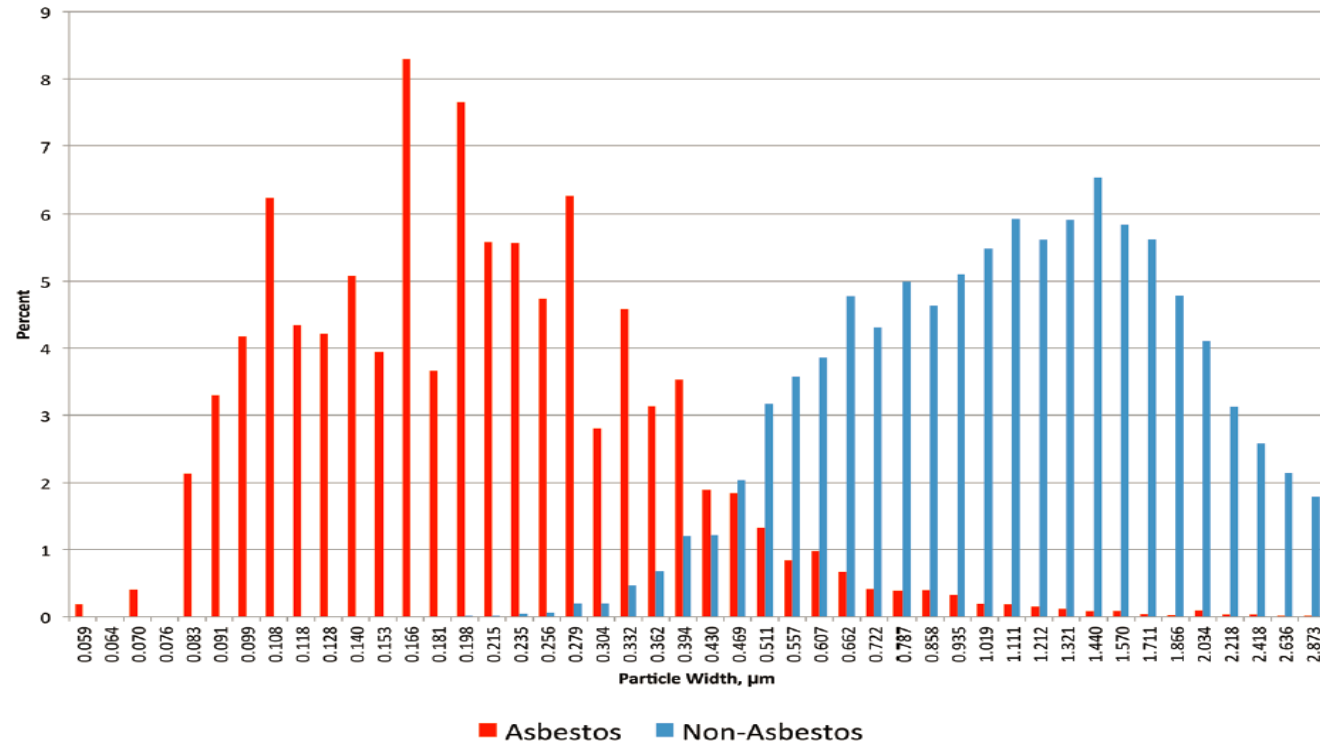




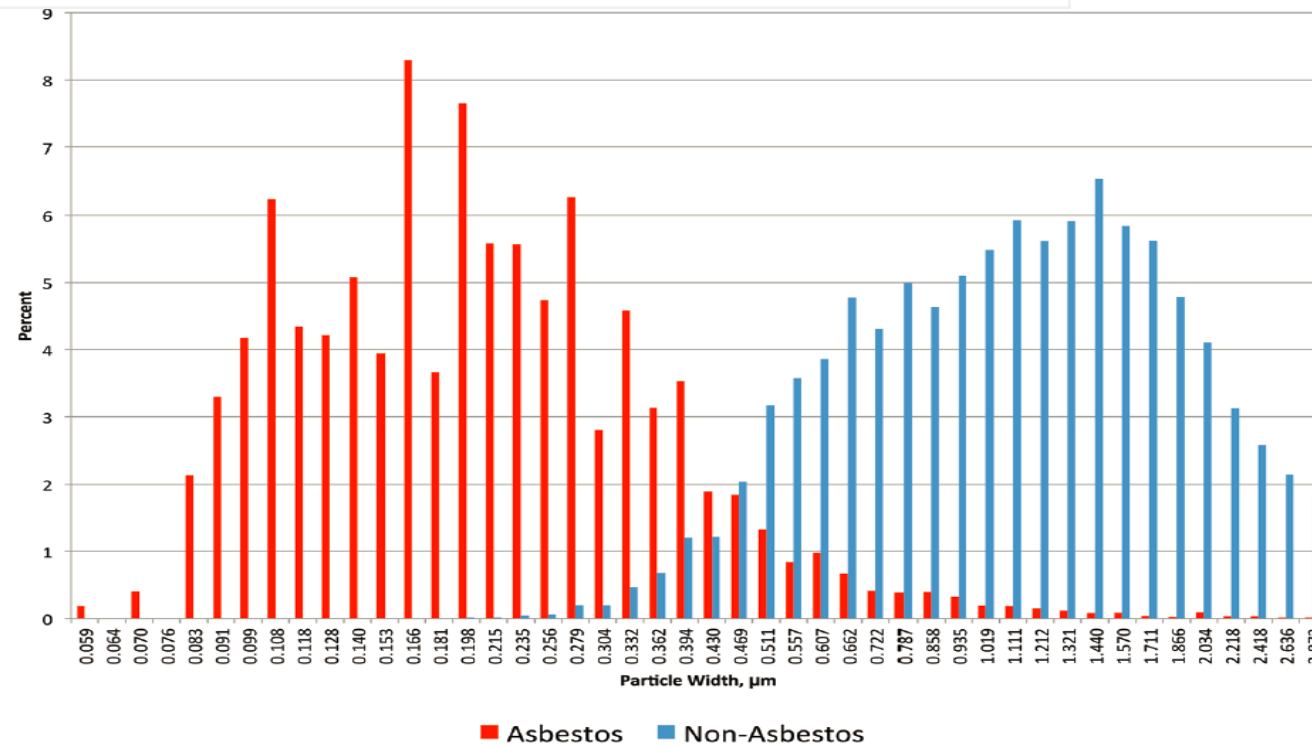
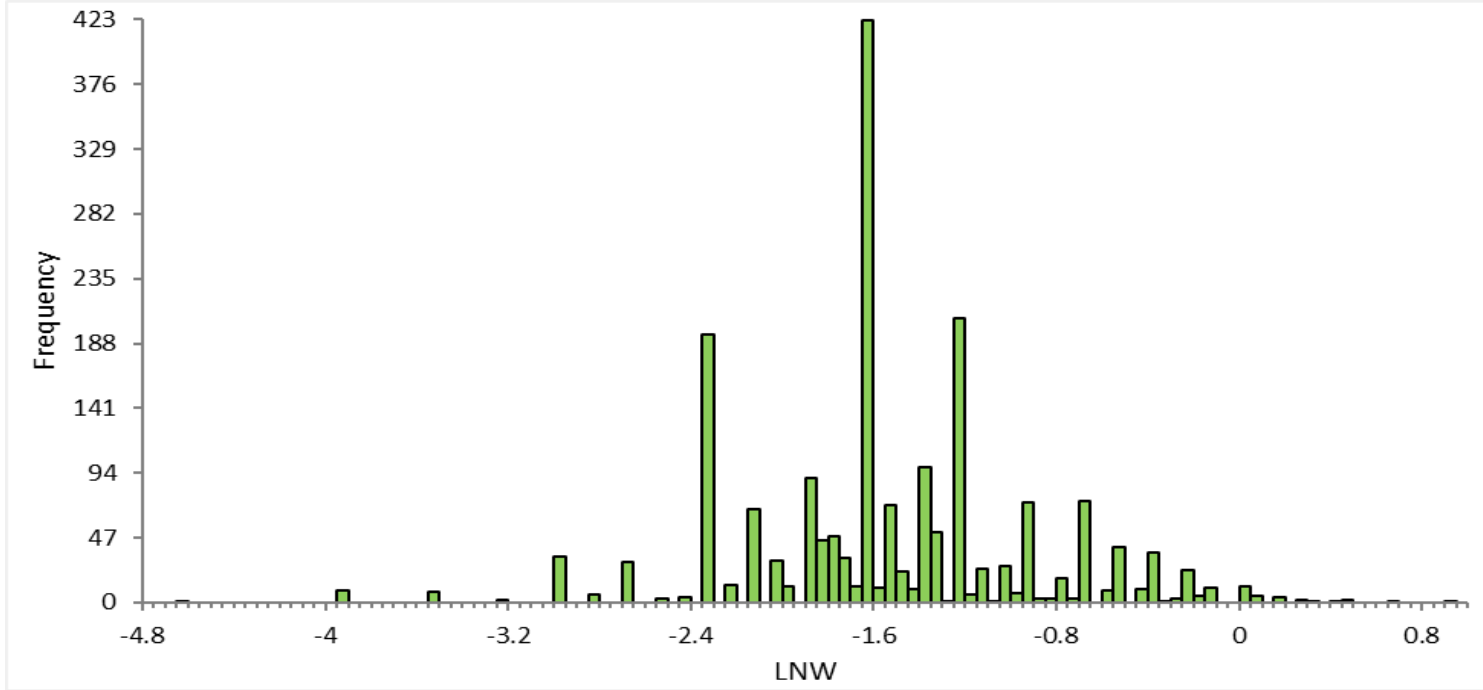
Penge amosite asbestos, 50 mm



Finland grunerite, 38 mm

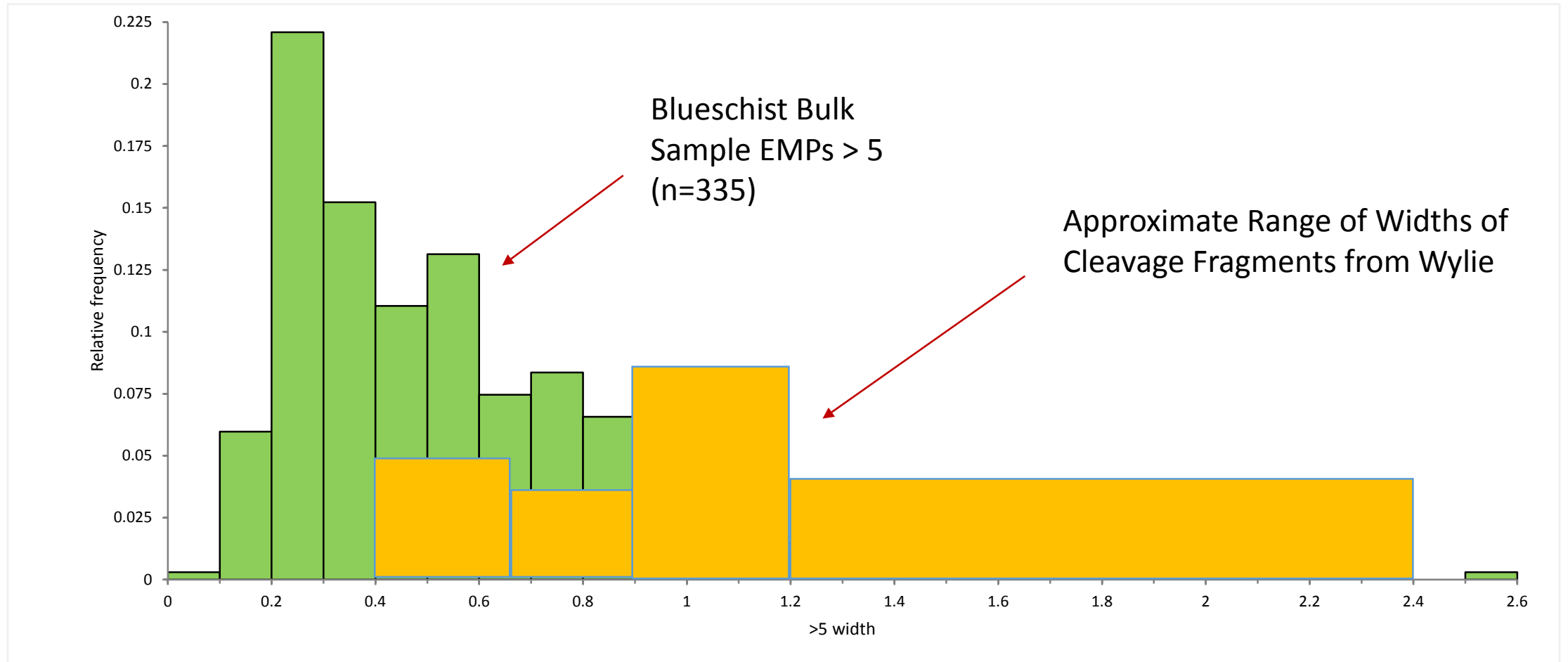








# Width Distributions EMPs > 5 $\mu\text{m}$

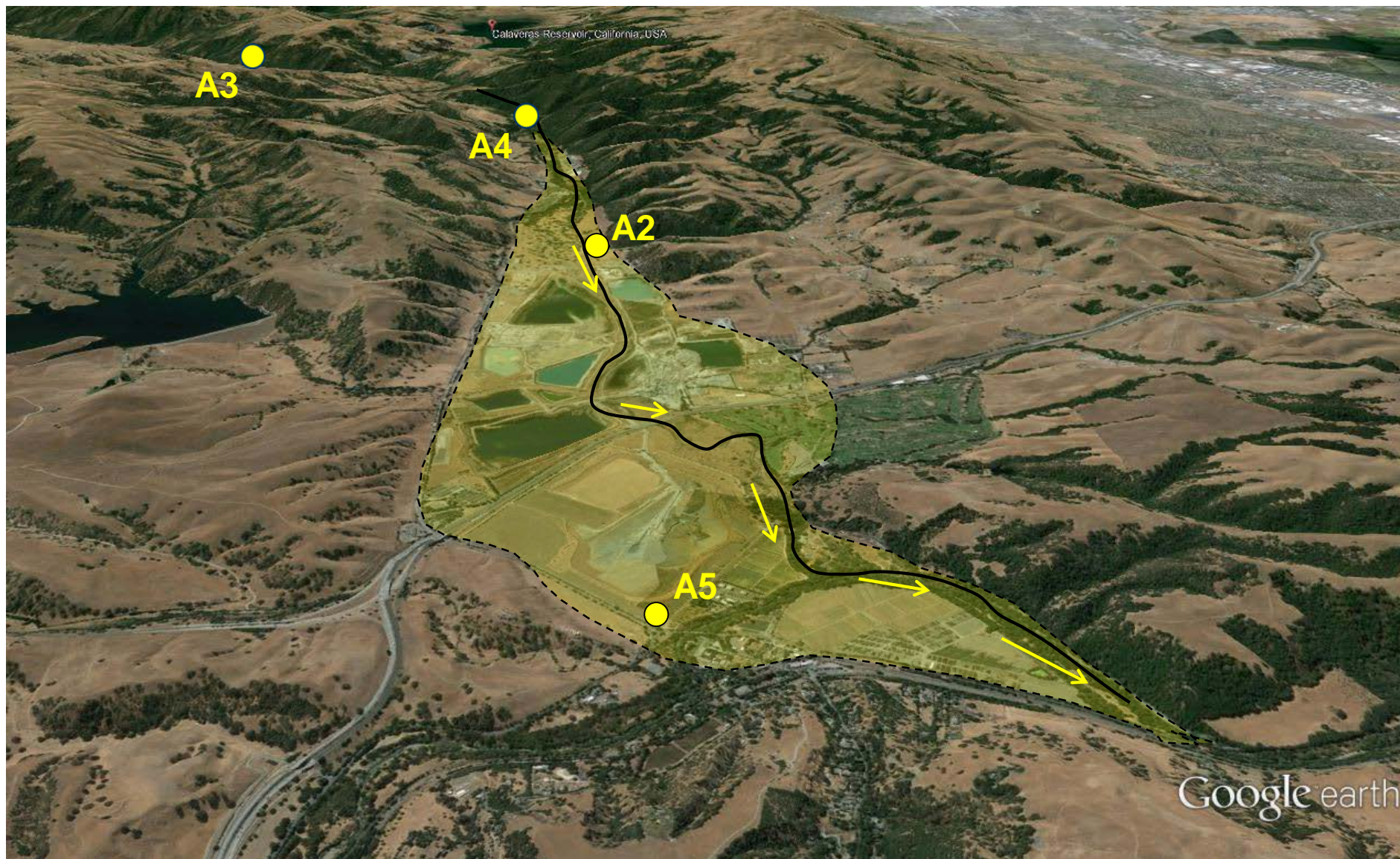






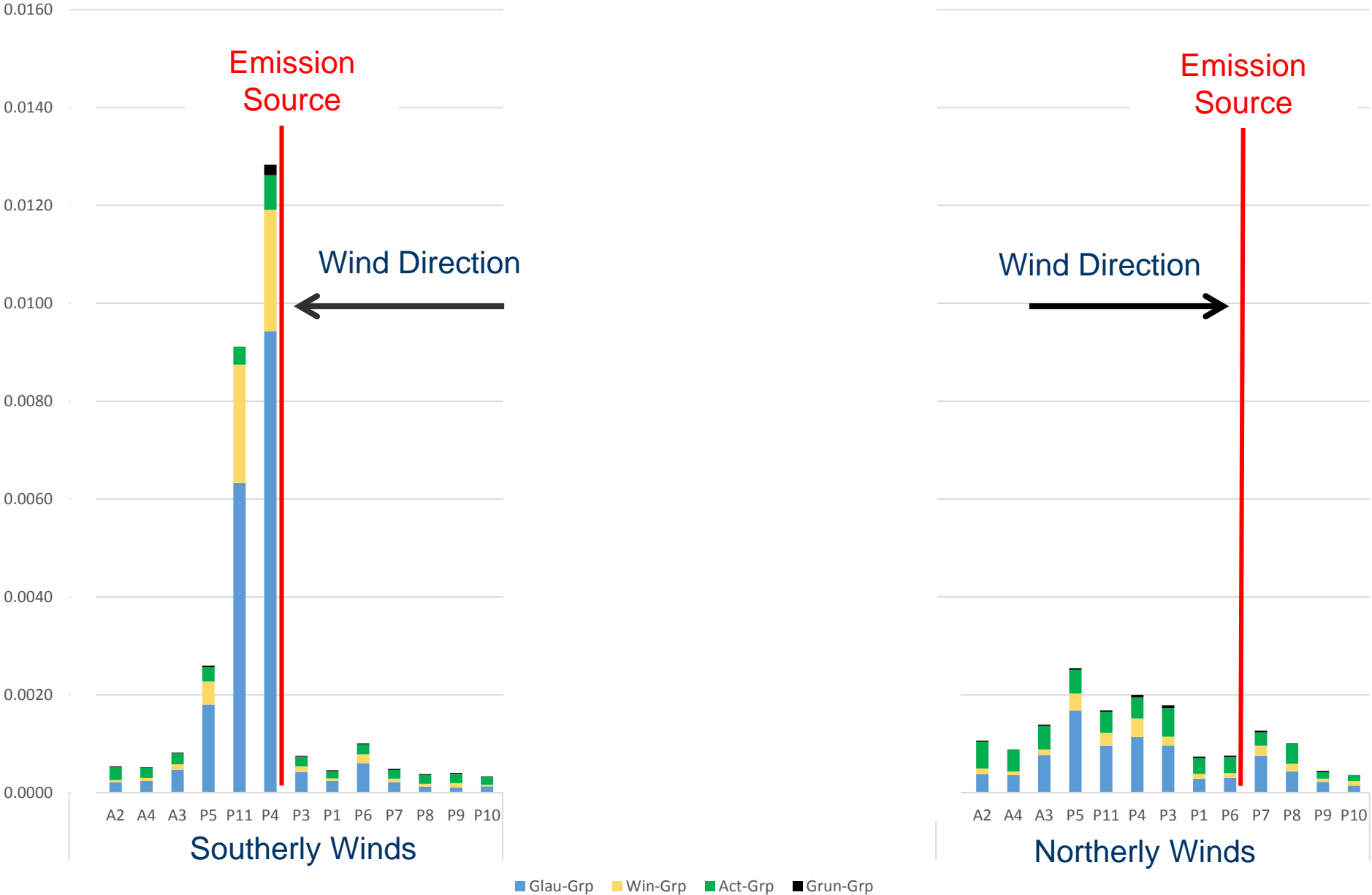


# Extent of Alluvial Terrace





# Concentrations of Mineral Groups Observed at Indicated Monitoring Locations on Work Days Under Wind Conditions Based on DT Data





An aerial photograph of a large, deep blue reservoir situated in a dry, hilly landscape. The surrounding terrain is mostly brown and tan, with scattered green trees and patches of grass. A concrete dam is visible in the lower-left quadrant, with a road and some buildings nearby. The reservoir's water is a vibrant blue, contrasting sharply with the arid surroundings. The text "Chrysotile in California Reservoirs: Is it a Health & Safety Risk?" is overlaid in yellow, bold, italicized font across the center of the image.

***Chrysotile in California Reservoirs:  
Is it a Health & Safety Risk?***



River	Location	MFL
Klamath River	Orleans	200,000
Putah Creek	Lake Berryessa	30,000
Feather River	Lake Oroville	300
American River	Folsom Lake	200
North Yuba River	New Bullards Reservoir	100
Bear River	New Camp West Reservoir	1,000
Mokelumne River	Pardee Reservoir	30

*From Bales et al., 1979*





484 MFL







$2 \times 10^{14}$  Fibers  
Project Lifetime



$2 \times 10^{11}$  Stars  
Milky Way

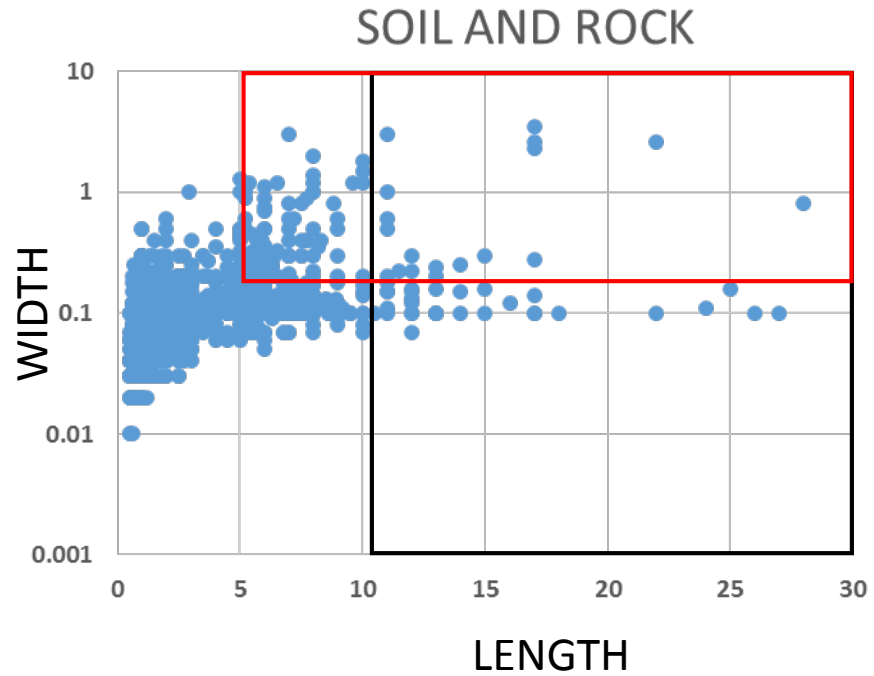




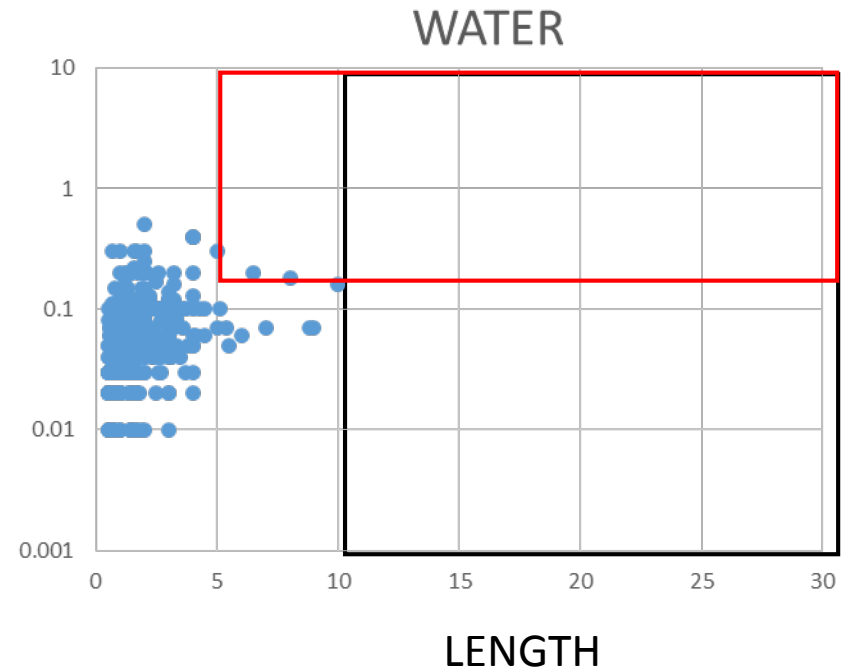


# Chrysotile Dimensions Comparison of Soil and Water Samples

**2% Long Fibers**



**0.2% Long Fibers**



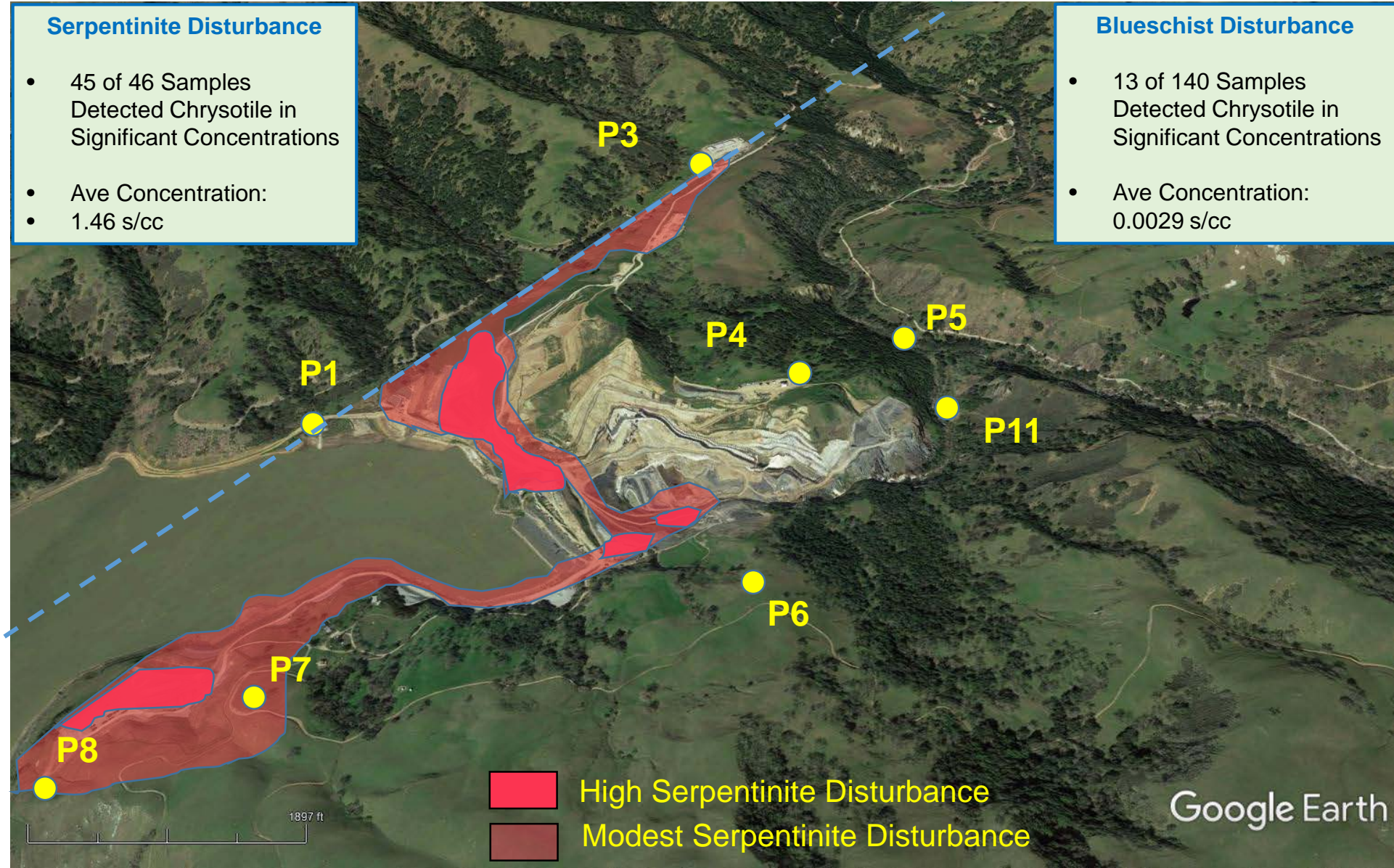


### Serpentinite Disturbance

- 45 of 46 Samples Detected Chrysotile in Significant Concentrations
- Ave Concentration: 1.46 s/cc

### Blueschist Disturbance

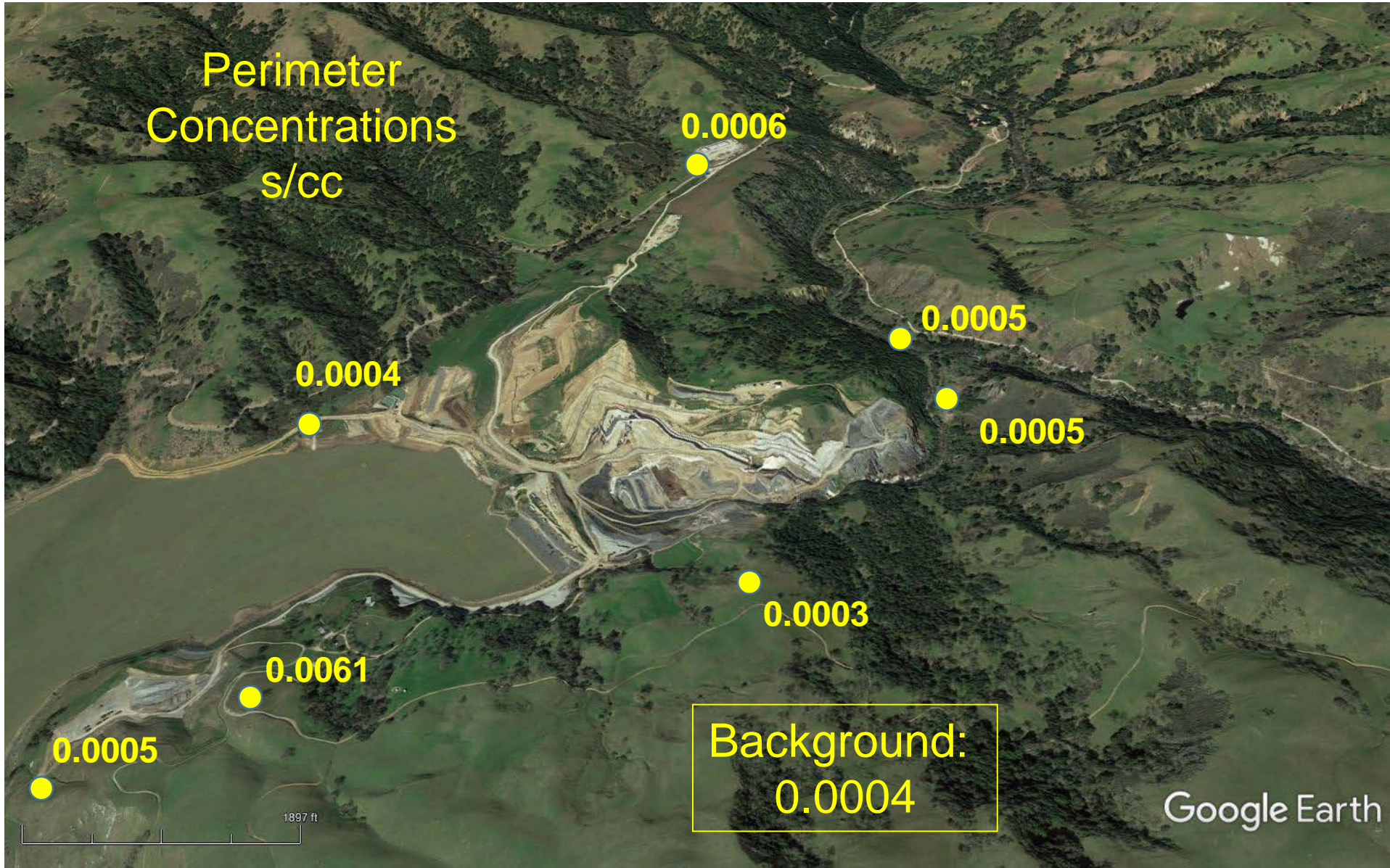
- 13 of 140 Samples Detected Chrysotile in Significant Concentrations
- Ave Concentration: 0.0029 s/cc



High Serpentinite Disturbance  
Modest Serpentinite Disturbance

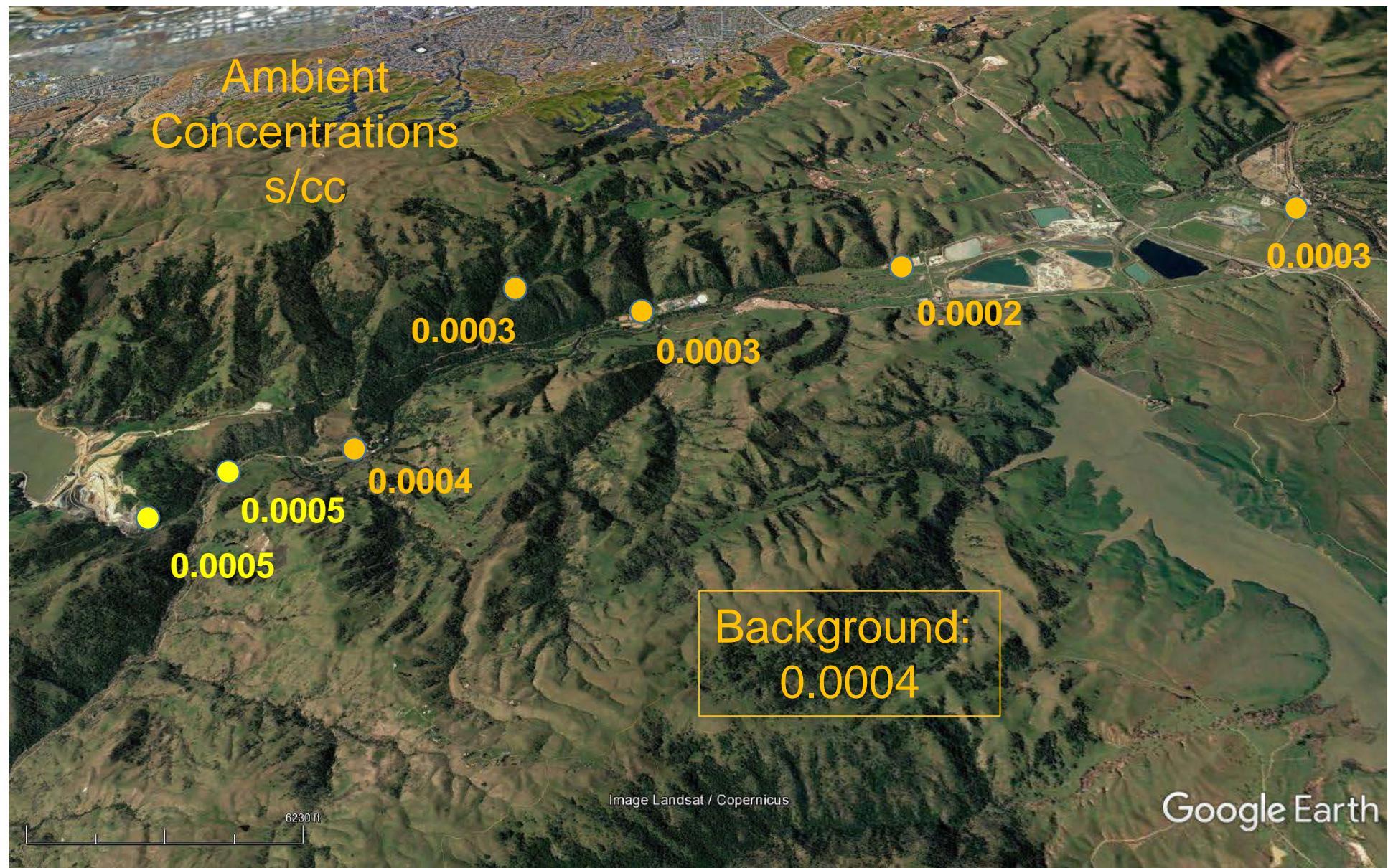
Google Earth





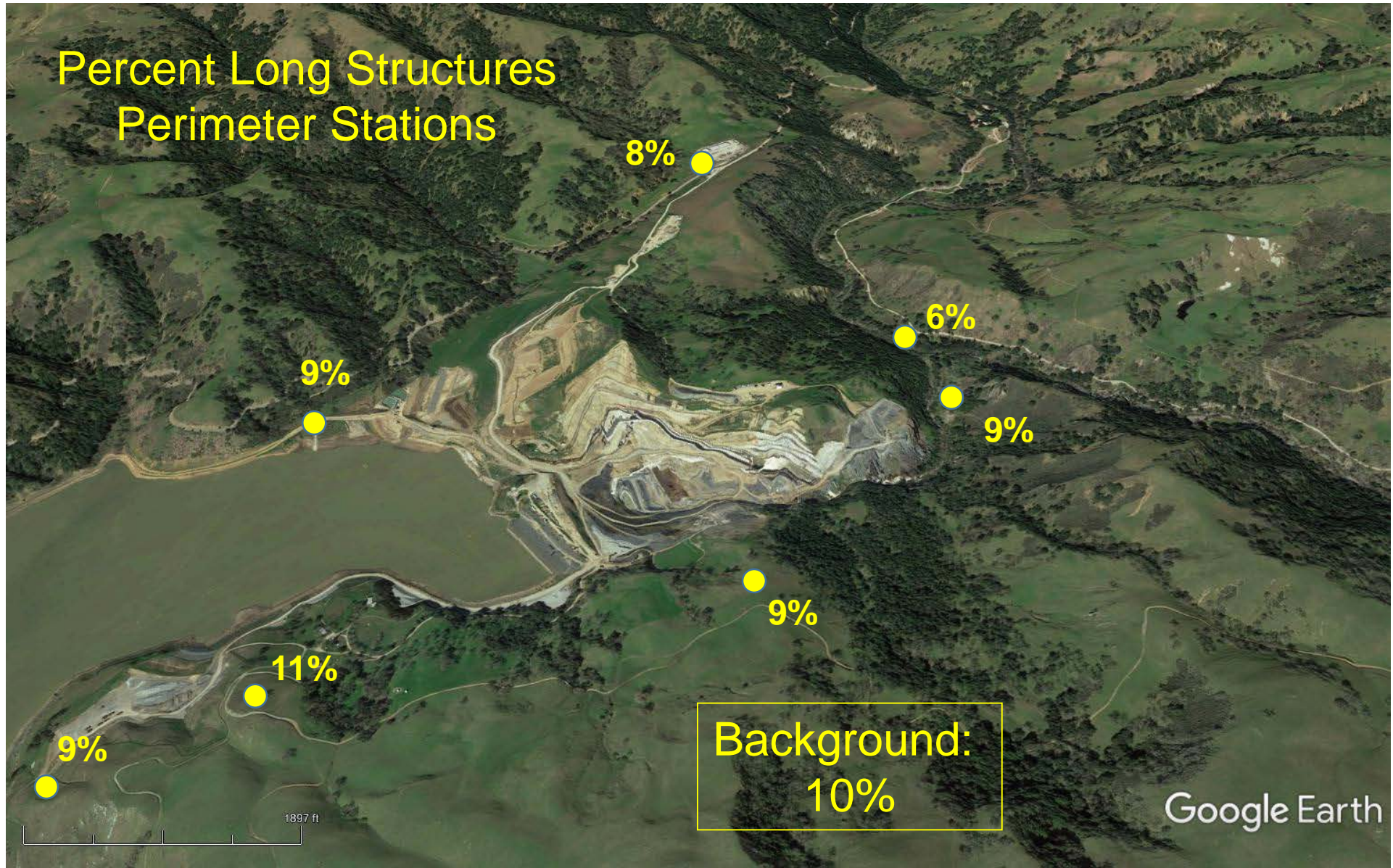


Ambient  
Concentrations  
s/cc



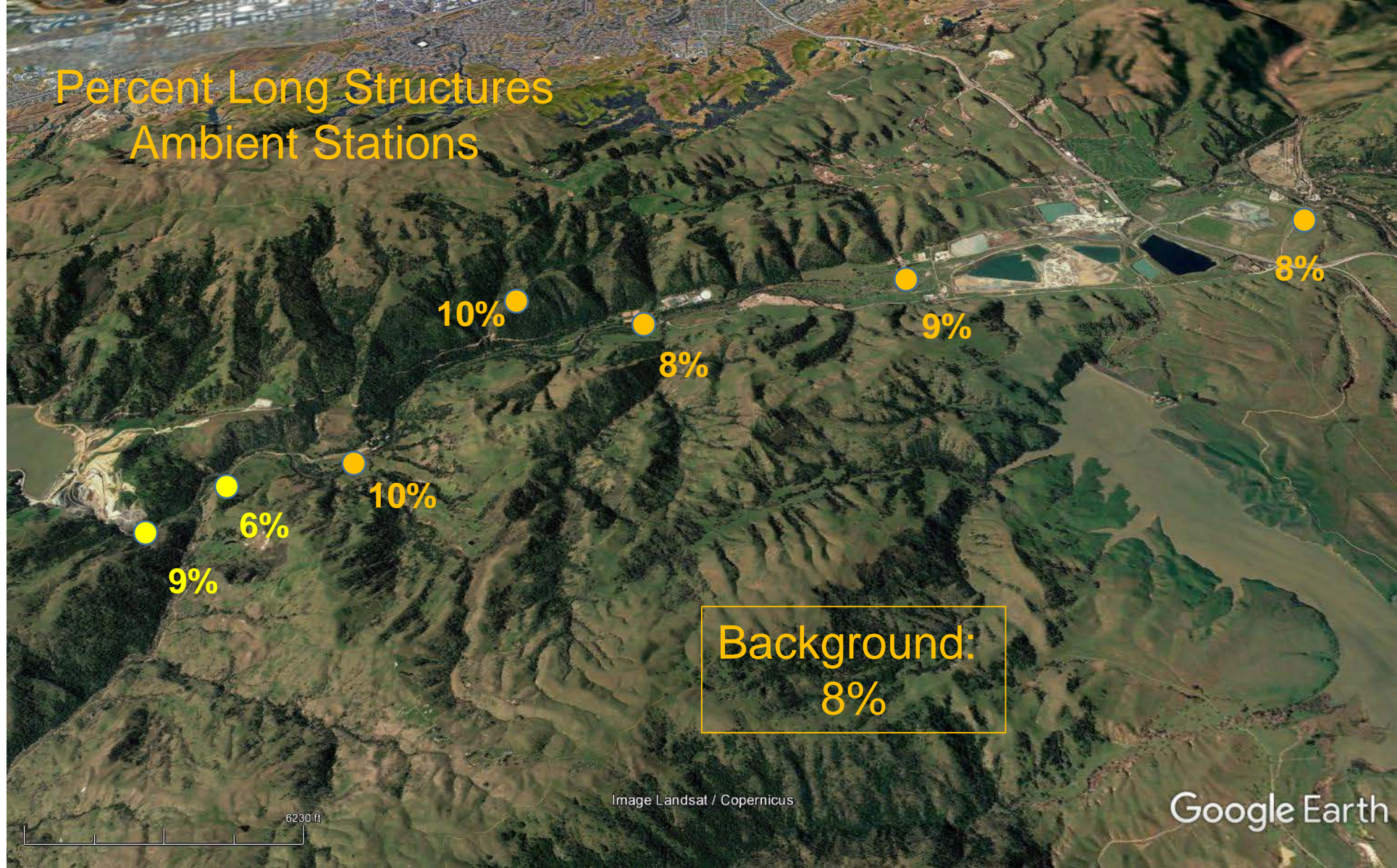


# Percent Long Structures Perimeter Stations





# Percent Long Structures Ambient Stations







*Daniel W. Hernandez, MPH, CIH*



# Challenges

- Large boulders !
- Other operations involving this material, in spite of application of water, were resulting in elevated exposures
- Perimeter/Ambient monitoring thousands of feet from the project showed elevated concentrations of EMPs





# Construction Activities













































# Work Place Monitoring

Over 2,200 samples collected as of February 2015.

- 1422 breathing zone samples (187 were overloaded).
- Sampling by job category, operation, geologic unit

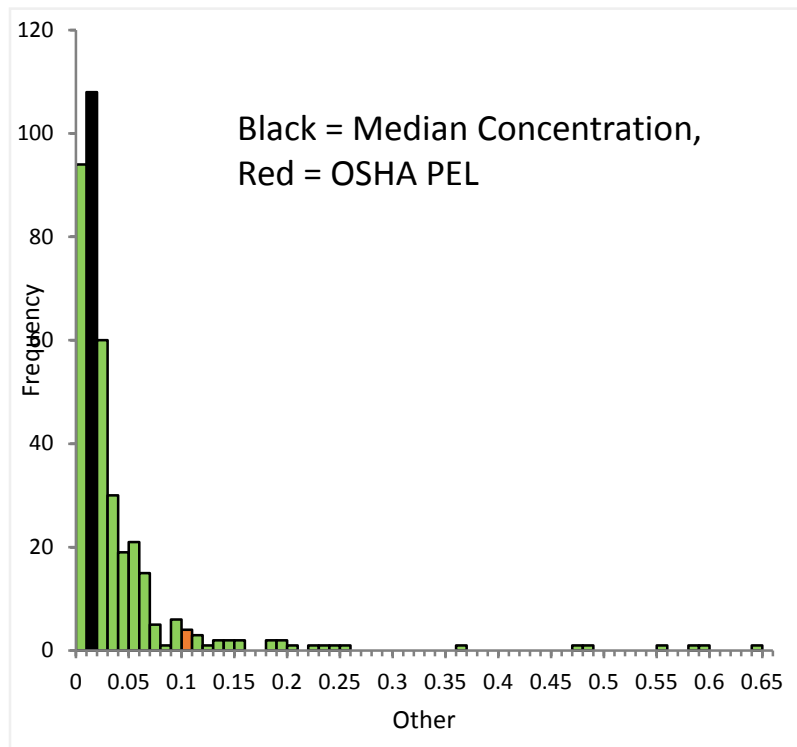
	Serpentine Group (Chrysotile)	Amphibole Group (Blueschist)
Total PCM Samples	761	474
Adj PCM (NIOSH 7402)	390	374
Min (7402)	0.0003 (f/cc)	0.0006 (f/cc)
Max (7402)	0.65 (f/cc)	1.81 (f/cc)
Median (7402)	0.02 (f/cc)	0.05 (f/cc)
Geometric Mean (7402)	0.02 (f/cc)	0.06 (f/cc)



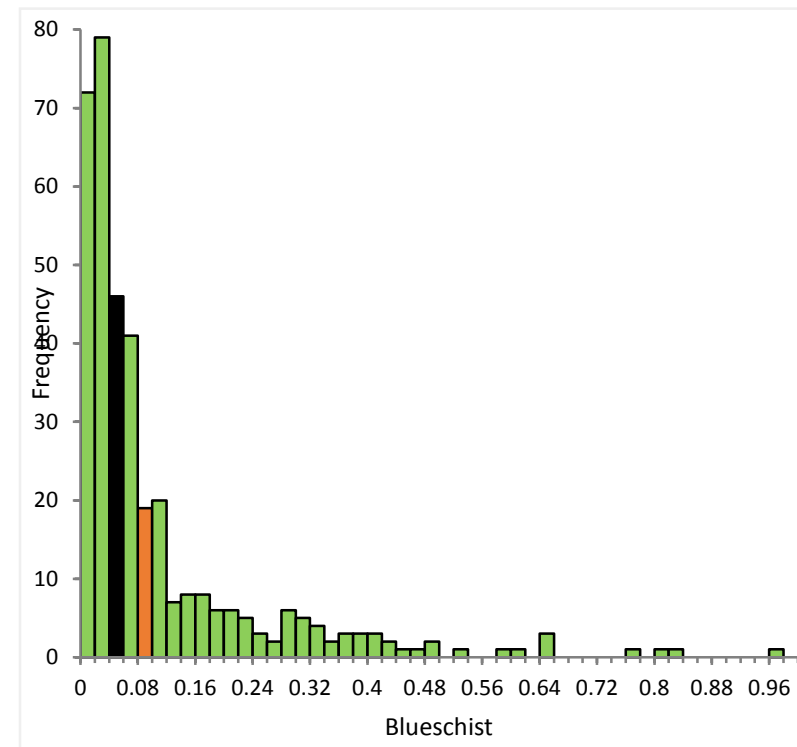
# NIOSH 7402 Adjusted PCM Results

[\* Highest 15 results (>1 f/cc) removed for Visual Purposes]

## Other Franciscan (Chrysotile) n= 390 samples



## Amphibole n = 374 samples\*





Adjusted PCM Personal Breathing Zone Sampling Statistics by Job Category in f/cc for the Amphibole Exposure Group (NIOSH 7402 Adjusted) \*QC, Geologist, Grade Checker, Soil Testing

Job	No.	Min	Max	Median
Driller Operator	81	0.002	1.81	0.05
Driller Laborer	30	0.002	1.25	0.10
Rock Crusher Operator	4	0.18	1.173	0.53
Laborer (Dust Suppression)	117	0.006	1.1	0.10
Excavator Operator	35	0.003	0.65	0.044
Dozer Operator	11	0.001	0.606	0.025
Drum Roller Operator	7	0.011	0.46	0.041
Fill Placement	9	0.006	0.238	0.063
Miscellaneous*	9	0.01	0.215	0.033
Rock Truck Operator	23	0.001	0.156	0.045
Rock Breaker	32	0.011	0.156	0.034
Front Loader	6	0.007	0.129	0.016
Water Truck	10	0.014	0.1	0.033



# Collaboration IH, Geologist, and Laboratory

Is there a relationship between elongate mineral particle content and exposure experience?

**A crude comparison between average exposure concentrations for all activities within the geologic unit :**

**Activity Differences**

**Number of Samples**

**Equipment Differences**

Unit (Geologist)	Millions of Structures Per Gram of Material (Geologist/Laboratory)	Average Exposure Concentration (f/cc) All Activities (Hygienist)
Blueschist	242,796	0.175 (n = 586)
Granodiorite Import	305	0.0344 (n = 25)
Serpentinite	859	0.0216 (n = 104)
BAE Aluvium	71	0.006 (n = 17)





**PPE**





## Stilling Basin Excavation/Embank Summer Months 2013

70 Exceedance Days Experienced

60 K yards processed

Four Consecutive Exceedance Days Requires  
Shutdown (\$100K/day)

Trigger Concentrations Range from  
0.0015 s/cc to 0.0068 s/cc

**Problem: Need to Process 1.0M Yards** for  
Embankment, Operation moving 1500 feet  
closer to perimeters/receptors





**We Didn't Know It at the Time!**



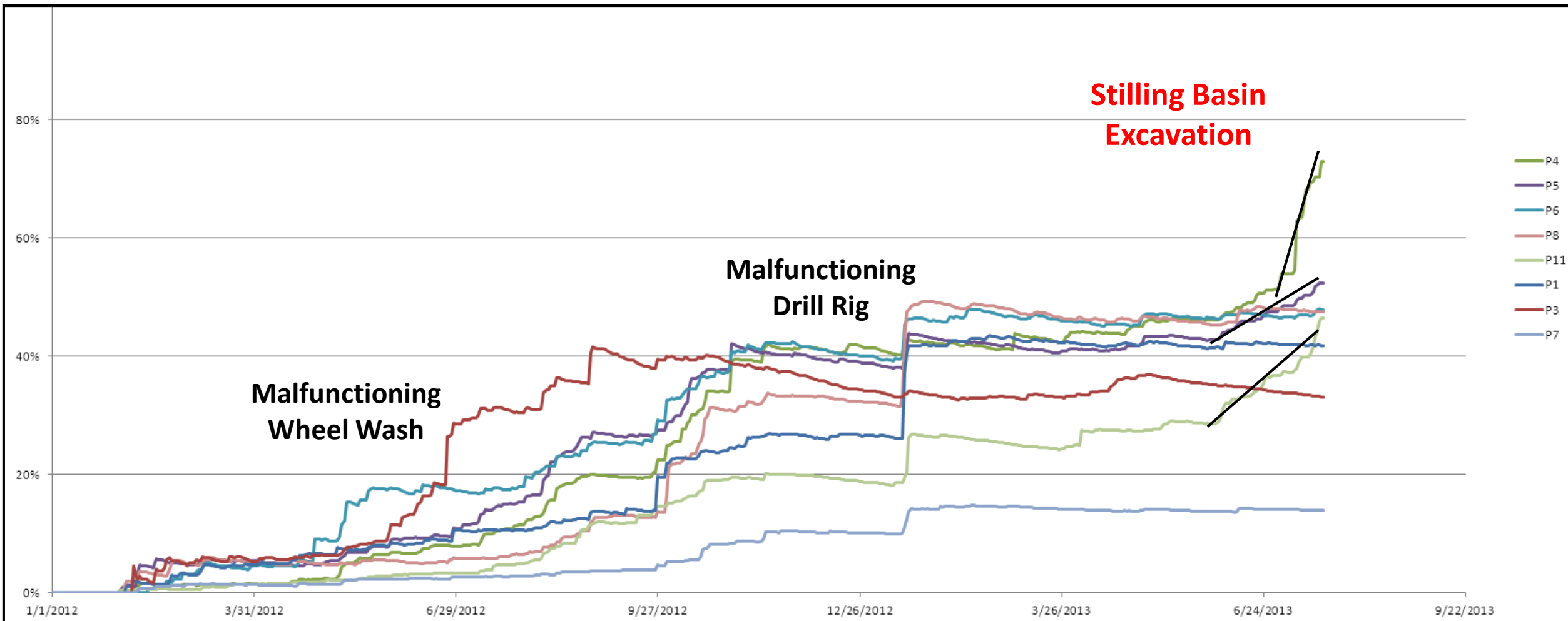


Sample Date	P1	P3	P4	P5	P6	P7	P8	P11
Mon, July 1, 2013	0.00031	0.00160	0.01345	0.00707	0.00000	0.00000	0.00000	
Tue, July 2, 2013	0.00031	0.00031		0.00611	0.00095	0.00128	0.00063	0.00735
Wed, July 3, 2013	0.00095	0.00000	0.00459	0.00635	0.00155	0.00096	0.00031	0.01470
Mon, July 8, 2013	0.00030	0.00031	0.01247	0.00405	0.00032	0.00065	0.00062	0.01015
Tue, July 9, 2013	0.00063	0.00122		0.01164	0.00301	0.00095	0.00065	0.00945
Wed, July 10, 2013	0.00107	0.00095	0.01293	0.00596	0.00126	0.00032	0.00000	0.03143
Thu, July 11, 2013	0.00000	0.00000	0.00701	0.00237	0.00064	0.00000	0.00033	0.02172
Fri, July 12, 2013	0.00031	0.00058		0.00867	0.00061	0.00032	0.00126	0.00630
Sat, July 13, 2013	0.00000	0.00030		0.00155	0.00063	0.00000	0.00000	0.00130
Mon, July 15, 2013	0.00127	0.00031		0.00219	0.00031	0.00062	0.00031	0.01116
Tue, July 16, 2013	0.00064	0.00088	0.01004	0.01014	0.00146	0.00122	0.00062	0.03850
Wed, July 17, 2013	0.00031	0.00312	0.01801	0.01575	0.00361	0.00162	0.00032	0.04686
Thu, July 18, 2013	0.00095	0.00031	0.00432	0.00467	0.00286	0.00058	0.00098	0.02823
Fri, July 19, 2013	0.00063	0.00000	0.00601	0.00539	0.00159	0.00000	0.00064	0.04436
Sat, July 20, 2013	0.00031	0.00031		0.00164	0.00031	0.00063	0.00000	0.01654
Mon, July 22, 2013	0.00091	0.00151		0.00313	0.00097	0.00000	0.00032	0.04398
Tue, July 23, 2013	0.00031	0.00122		0.00719	0.00278	0.00090	0.00000	0.03064
Wed, July 24, 2013	0.00031	0.00155	0.00207	0.01148	0.00503	0.00121	0.00064	0.02305
Thu, July 25, 2013	0.00061	0.00000		0.00188	0.00069	0.00000	0.00000	0.01838
Fri, July 26, 2013	0.00126	0.00126		0.00123	0.00404	0.00094		0.01922
Sat, July 27, 2013	0.00000	0.00000	0.00097	0.00064	0.00094	0.00000	0.00064	0.04410
Mon, July 29, 2013	0.00000	0.00123		0.01085	0.00124	0.00000	0.00031	0.03419
Tue, July 30, 2013	0.00030	0.00060		0.00444	0.00047	0.00000	0.00000	0.02172
Wed, July 31, 2013	0.00032	0.00062		0.00368	0.00063	0.00225	0.00062	0.01673
Thu, August 1, 2013	0.00032	0.00062	0.00988	0.00954	0.00125	0.00197	0.00032	0.00958
Fri, August 2, 2013	0.00031	0.00000	0.00643	0.00397	0.00190	0.00000	0.00065	0.02658
Sat, August 3, 2013	0.00000	0.00032	0.00525	0.00466	0.00031	0.00000	0.00032	0.03106
Mon, August 5, 2013	0.00032	0.00128	0.01841	0.00542	0.00017	0.00031	0.00063	0.03067
Tue, August 6, 2013	0.00061	0.00032	0.01658	0.00687	0.00031	0.00094	0.00062	0.05972
Wed, August 7, 2013	0.00094	0.00062	0.01123	0.00888	0.00415	0.00063	0.00153	0.02778
Thu, August 8, 2013	0.00095	0.00186	0.01611	0.00245	0.00063	0.00016	0.00000	0.01723
Fri, August 9, 2013	0.00032	0.00199	0.02291	0.00868	0.00030	0.00032	0.00063	0.02960
Sat, August 10, 2013	0.00031	0.00157	0.00095	0.00226	0.00032	0.00095	0.00095	0.01654
Mon, August 12, 2013	0.00062	0.00090	0.01654	0.00642	0.00061	0.00031	0.00156	0.03445
Tue, August 13, 2013	0.00585	0.00061	0.00794	0.00252	0.00409	0.01221	0.00197	0.02831
Wed, August 14, 2013	0.00060	0.00424	0.02998	0.01017	0.00061	0.00031	0.00065	0.02389
Thu, August 15, 2013	0.00064	0.00187	0.01195	0.01598	0.00159	0.00000	0.00095	0.00925
Fri, August 16, 2013	0.00061	0.00015	0.00513	0.00881	0.00234	0.00063	0.00156	0.00664
Sat, August 17, 2013	0.00032	0.00031	0.00147	0.00032	0.00094	0.00032	0.00000	0.02297
Mon, August 19, 2013	0.00124	0.00092		0.00785	0.00533	0.00207	0.00000	0.06039
Tue, August 20, 2013	0.00031	0.00063	0.01694	0.01362	0.00093	0.00092	0.00000	0.02756
Wed, August 21, 2013	0.00063	0.00124	0.01190	0.00701	0.00031	0.00000	0.00000	0.02334
Thu, August 22, 2013	0.00061	0.00000	0.01568	0.00226	0.00031	0.00095	0.00066	0.01350
Fri, August 23, 2013	0.00030	0.00091	0.00768	0.00202	0.00030	0.00000	0.00000	0.03533
Sat, August 24, 2013	0.00000	0.00000	0.00000	0.00047	0.00000	0.00094	0.00000	0.02389
Mon, August 26, 2013	0.00061	0.00093	0.02457	0.00571	0.00123	0.00060	0.00032	0.09188
Tue, August 27, 2013	0.00000	0.00190	0.00537	0.00700	0.00167	0.00031	0.00065	0.01566
Wed, August 28, 2013	0.00031	0.00092	0.01011	0.00309	0.00061	0.00063	0.00093	0.00517
Thu, August 29, 2013	0.00061	0.00089	0.00159	0.00223	0.00097	0.00215	0.00031	0.00594
Fri, August 30, 2013	0.00092	0.00092	0.00324	0.00215	0.00157	0.00031	0.00032	0.00301





# Amphibole Concentrations Running Averages





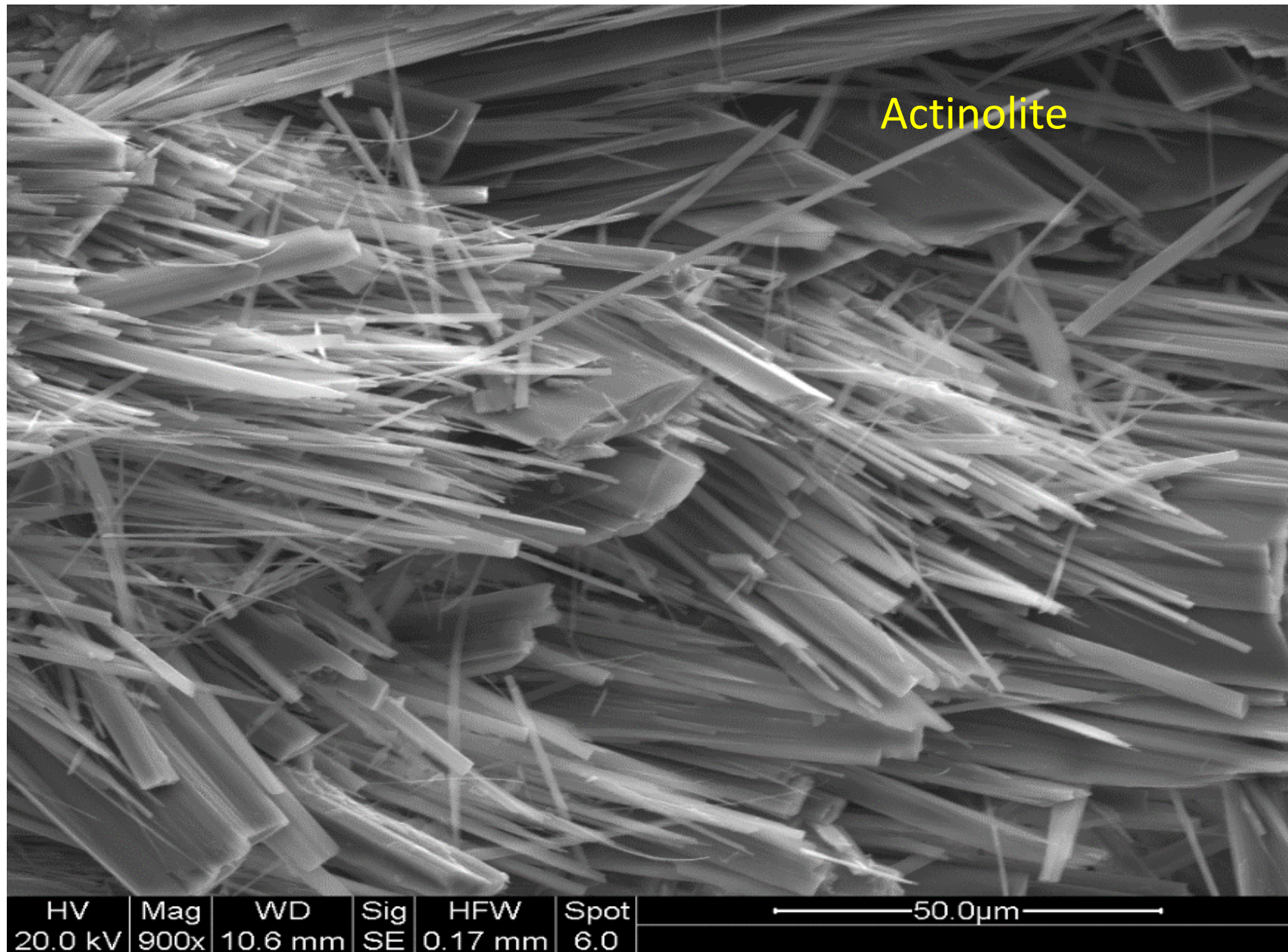
# Constructability

- Required the JV to Evaluate Import Options
  - 58,000 Import Truck Loads versus Onsite mining of blueschist
- Evaluation included
  - Dust Controls
  - Engineering Cost Estimates
  - Assess production emissions
  - Modeling Emissions
  - Calibration of the Model with Empirical Measurements
  - Simulation of Production
  - Mineralogical characterization of exposure, perimeter and ambient samples





Actinolite



HV	Mag	WD	Sig	HFW	Spot
20.0 kV	900x	10.6 mm	SE	0.17 mm	6.0

50.0µm



# Dust Control Technology Condensation Nuclei

## Dust Control Technology Testing

Sampling Array

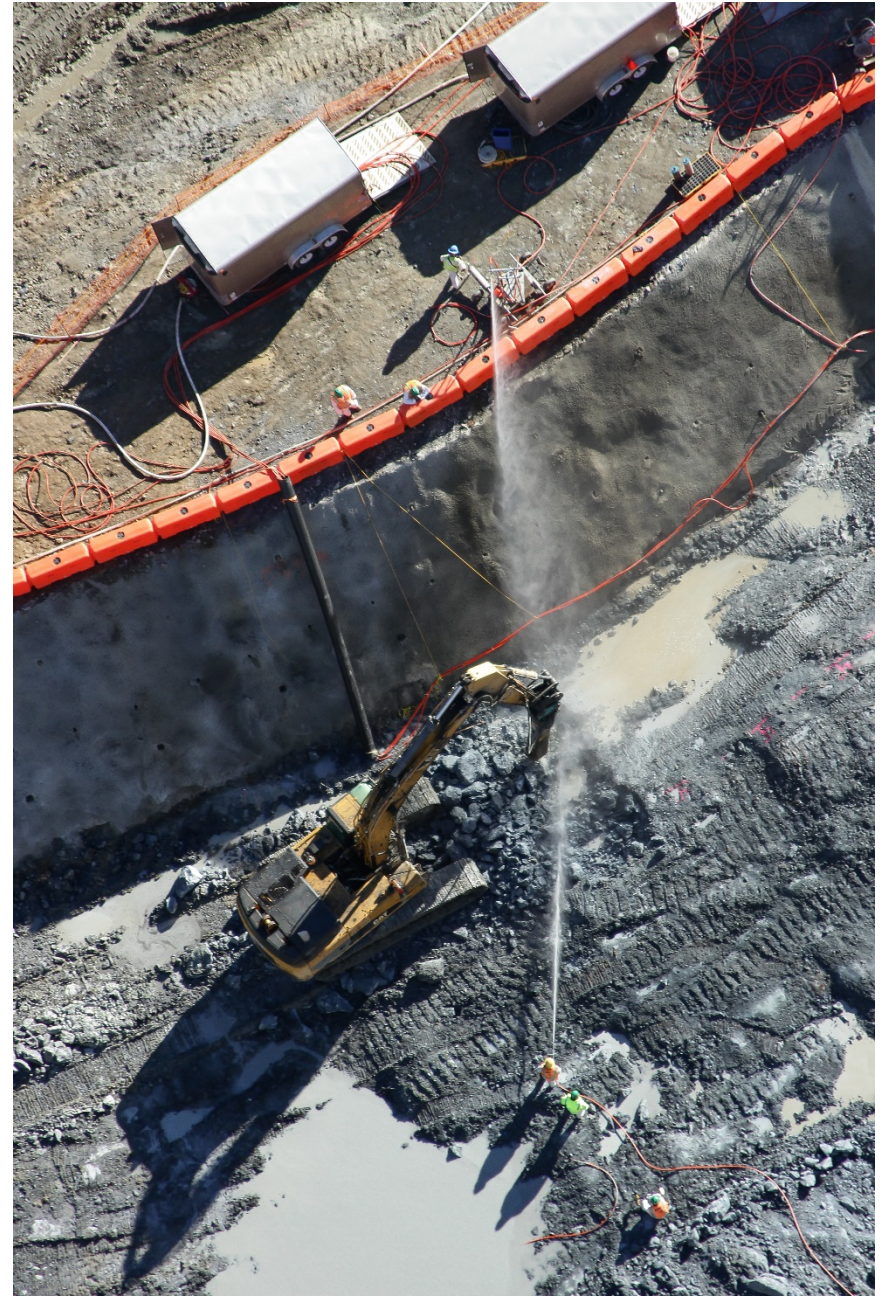
Wind and Weather Measurements

Air Measurements

Reductions in emission rates related  
to the effectiveness of the control  
technology





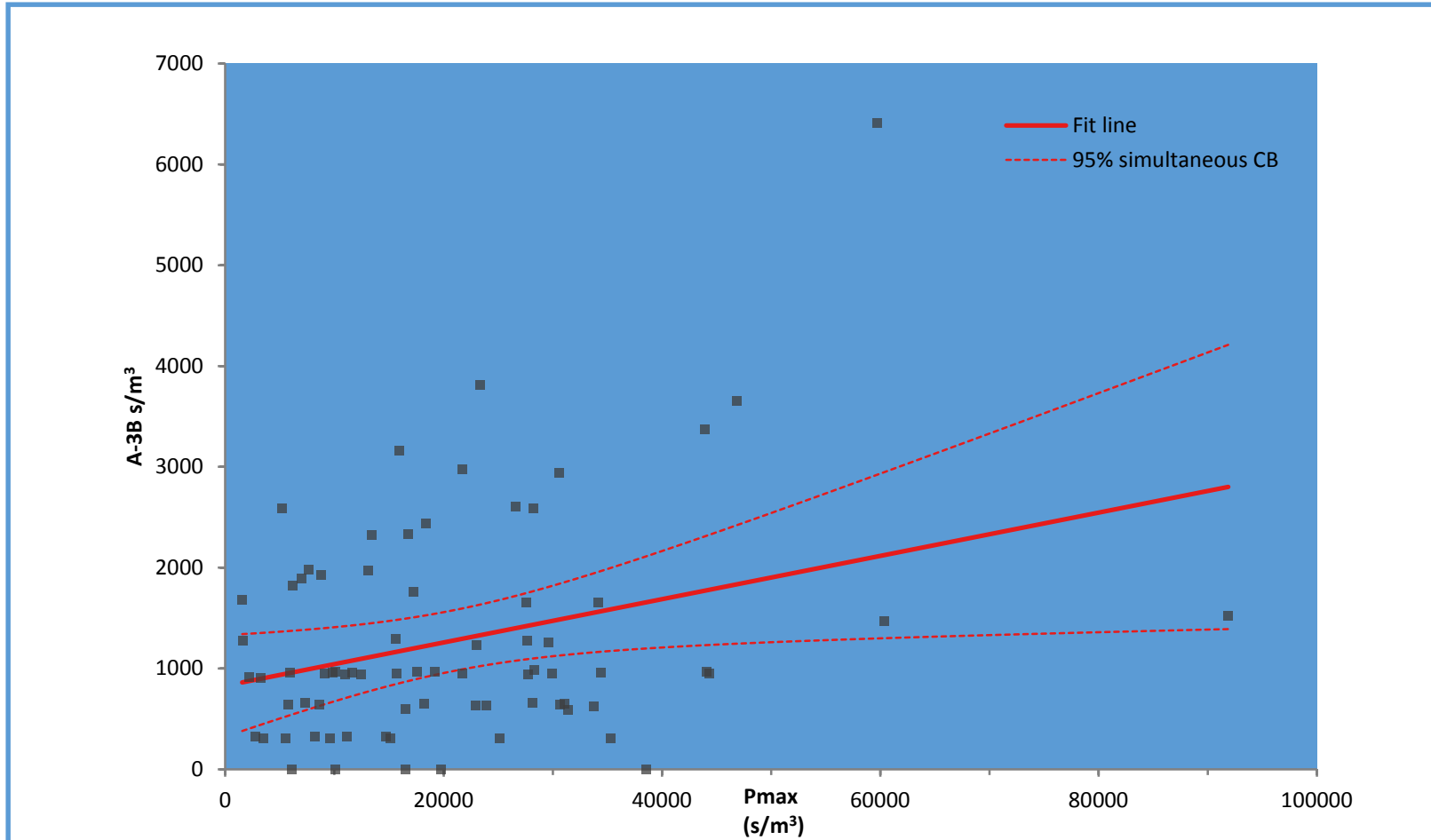








# Summer 2013: Concentration Relationship





# Emissions Testing

The Objective here, where possible, was to isolate individual operations and conduct testing.

- Plume Centerline Downwind
- Mostly Short Term Samples
  - **15 to 60 minutes each**
  - **Best when steady wind**
  - **Record Other Information**
    - # Dumps
    - Timing of Dumps
    - Linear feet drilled
    - Drill time/bore hole
    - Production Rates
    - Areal extent of dozing
    - Etc.

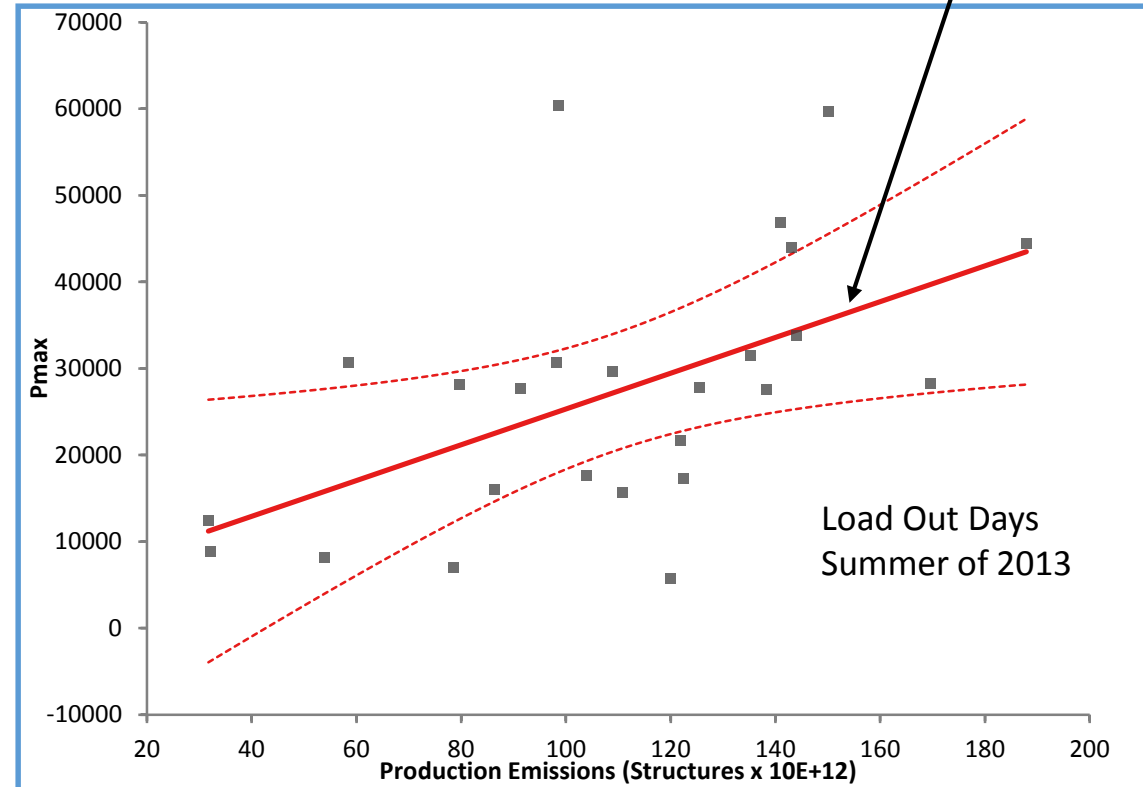
Operation(s)
Blasting
Dozing
Drilling
Loading/Dumping
Rock Breaking/Sizing and Sorting
Slope Shaping
Load Out (multiple tools)
Grinding
Trenching



# Construction Activity versus Perimeter Concentrations

CM Group:

1. Went through Daily Tags
2. Identified Operating Hours for Equipment Used on Site
3. Factored In Emissions Inventory from the JV
4. Totaled Emissions for all equipment over the day





# Model Calibration

## Compare Modeled versus Measured Z5 Operations

### Summer 2013

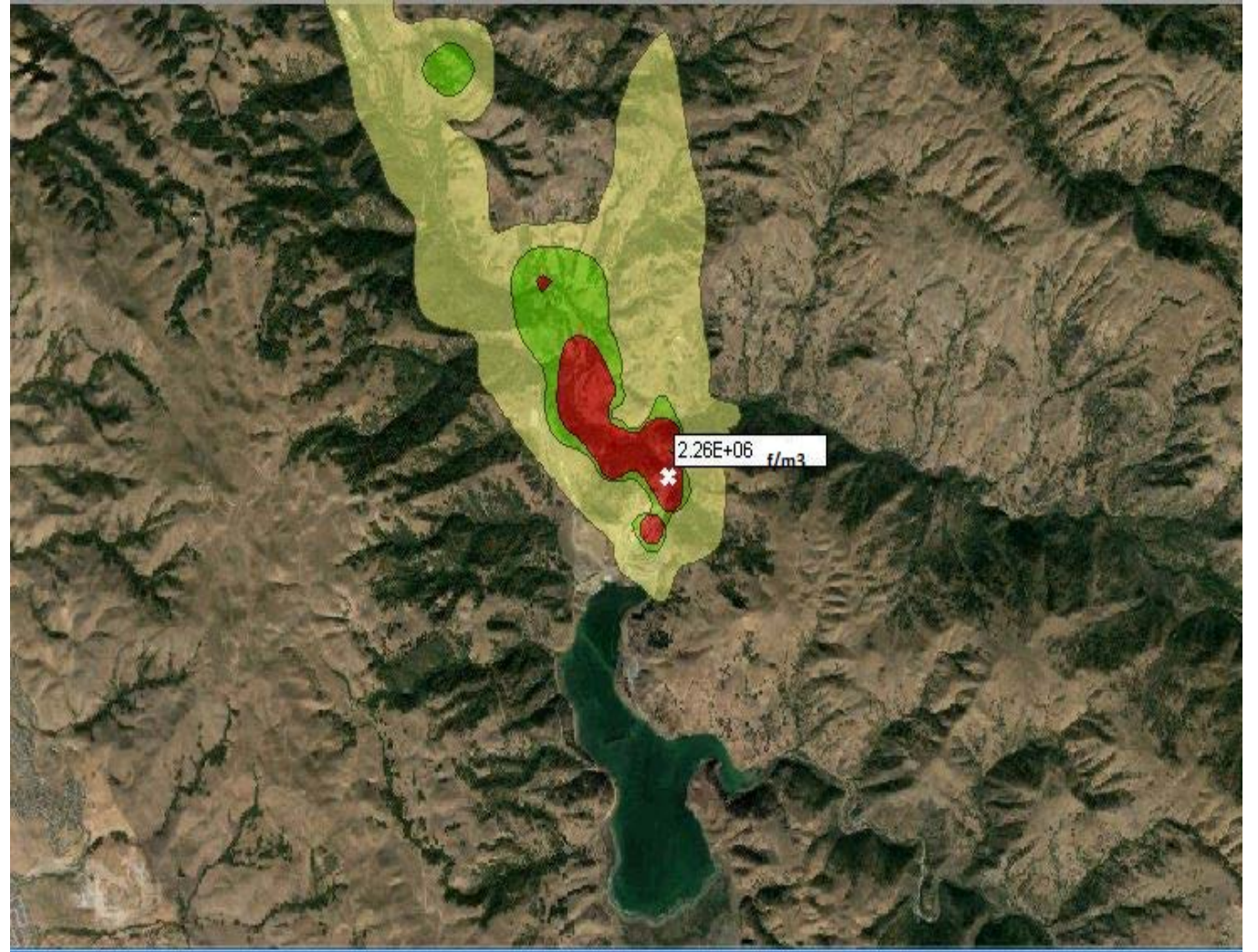
Ratio Modeled to Measured (S/m <sup>3</sup> )	A-2 (4.6 mi.)	A-3 (1.3 mi.)	P-5 (0.33 mi.)	P-4 (0 mi.)	P-11 (0 mi.)	Avg. P4 & P11 (0.0 mi.)
Ratio	0.93	0.89	1.4	1.7	0.65	1.11



# Modeling Emissions

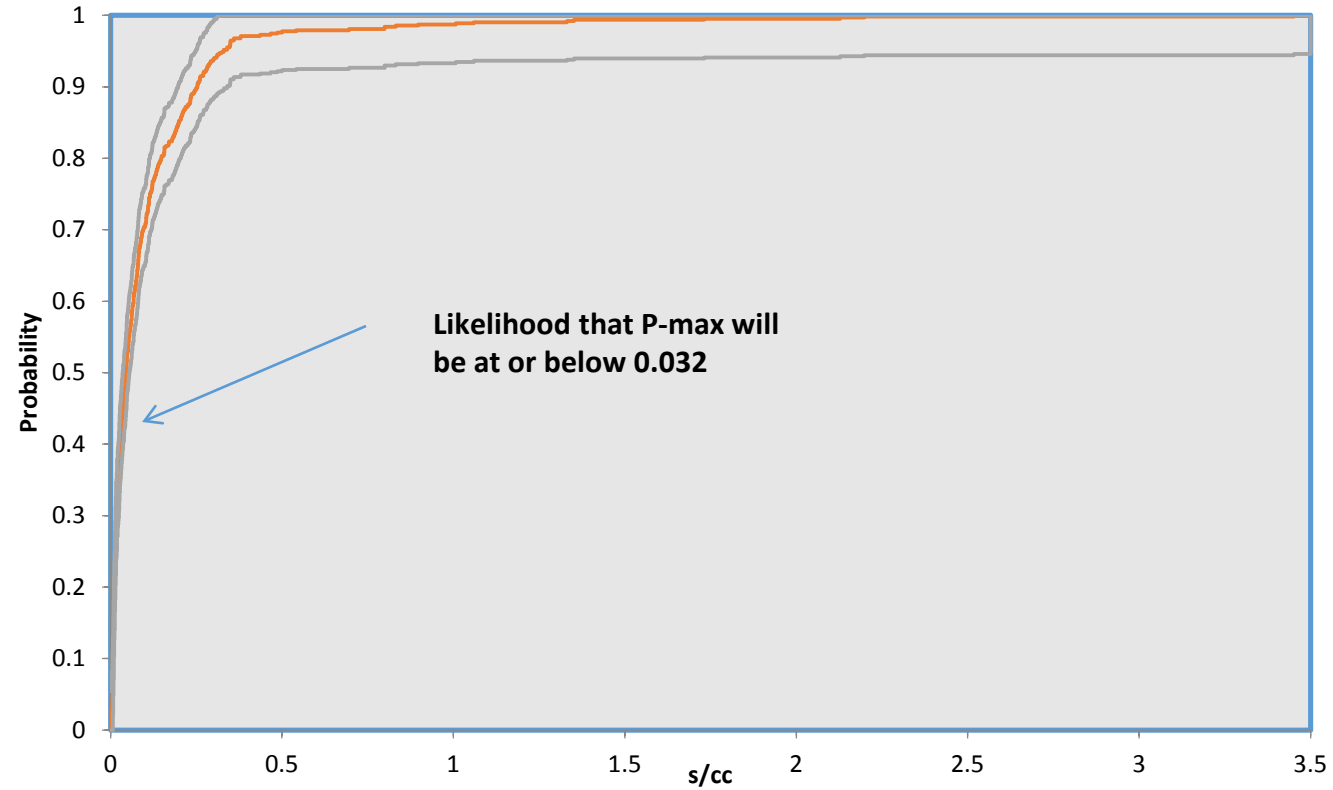
## Modeling Techniques

- Enables the Contractor to Simulate Production
  - Effect of various equipment ensembles
  - Sequencing of the construction operations
  - Generate data to evaluate the likelihood of exceeding trigger criteria





# Assessing Operational Impacts





*Questions?*

