Naturally Occurring Asbestos & Elongate Mineral Particles in the United States (and Worldwide)

Overview of Occurrences, Regulations & Emerging Issues

Sarah Kalika
California Professional Geologist (PG)
California Certified Asbestos Consultant (CAC)

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Who is Sarah?

- California-based Geologist
- California Asbestos Consultant
- Lead Inspector / Assessor Supervisor (for lead in paints)

- For AEG:
  - Northern CA Regional Director
  - Meetings Advisory Committee Co-chair
  - NOA Technical Working Group / IAEG Commission on NOA
  - Chaired the 2018 AEG / IAEG meeting in San Francisco
  - Various other AEG committee involvement

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What is Asbestos?

- Common Myths:
  - Created by a chemic
  - Only danger
  - I do
  - J
  - J
  - Cl
  - I ca
  - Only in California

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products

lem

not harmful”

ly in this rock, so we’re good

FALSE!

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What is Naturally Occurring Asbestos (NOA)?

- Mineral found in mafic & ultramafic rocks across the US & around the world
  - Mafic (igneous & metamorphic: high in Mg & Fe)
  - Ultramafic (igneous & metamorphic: high in Mg & Fe, low in silica)
- Mined in US from 1894 – 1993 for use in building materials as “manufactured asbestos”
- Serpentine named state rock of California in 1965
- At least 34 states have outcrops of mafic & ultramafic rocks
- Many countries have mapped outcrops of mafic & ultramafic rocks

Serpentinite: San Luis Obispo, CA

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“Asbestos” Minerals Form in:

- Serpentinites
- Altered ultramafic rocks
- Some mafic rocks
- Others: metamorphosed dolostones, iron formations, carbonatites, alkalic intrusions
- Often found as an accessory to other non- “asbestos” minerals

- Recipe needed: faulting and fracturing of these rocks with increased temperatures, pressures, and the **presence of water**
- Replicated around the world with similar environmental conditions
- Much more common than you would think

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Quiz Time!

- How many types of Asbestos are there?
  - Only one type of Asbestos mineral
  - Six Asbestos minerals
  - Hundreds of Asbestos minerals
  - I don't know, tell me!

Geology as Art, courtesy of Asbestos TEM Labs
Chrysotile veins in serpentine – Diablo Range
Fremont, CA
Thin section – PLM w/ crossed polarizers

ASBESTOS TEM LABORATORIES, INC.

20 mil

Six “Regulated” Asbestos minerals

- Chrysotile: found in serpentinites
- 5 Amphiboles:
  - Amosite (fibrous grunerite)
  - Actinolite
  - Tremolite
  - Crocidolite (fibrous riebeckite)
  - Anthophyllite: less common, accessory to talc

- These were “most common types” mined for use in building materials
- Asbestos in rock not necessarily considered a health hazard, unless made friable
  - Threshold for regulation is generally 1% (same as building materials)
  - Except in California (0.25%)
  - Europe (0.1% in some countries)

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Hundreds of Non-Regulated "Asbestiform" Minerals

- Presumed to have similar health hazards
  - 3:1 aspect ratios (meet the counting rules)
  - Sometimes reported (depending on lab)
  - In California, Department of Toxic Substances Control & other regulators increasingly interested in non-regulated minerals
    - If it's on the lab report, we're being asked to mitigate it
  - Projects in California often identify dozens of non-regulated asbestiform minerals, recorded & reported depending on lab

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USGS NC
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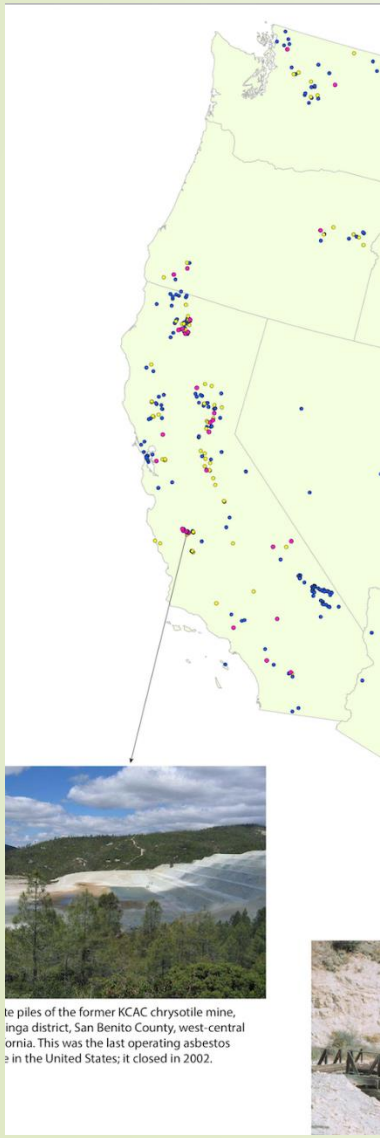
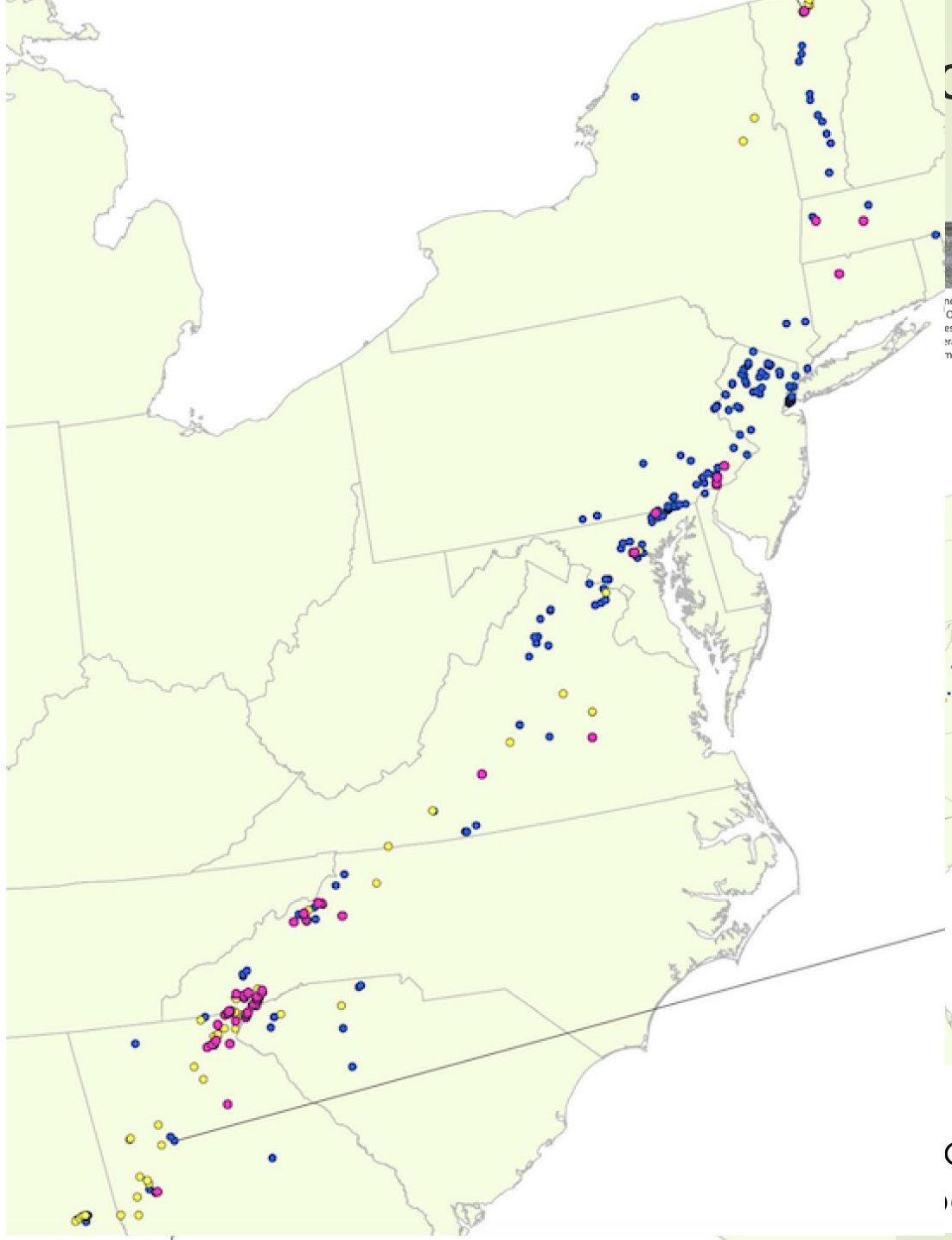
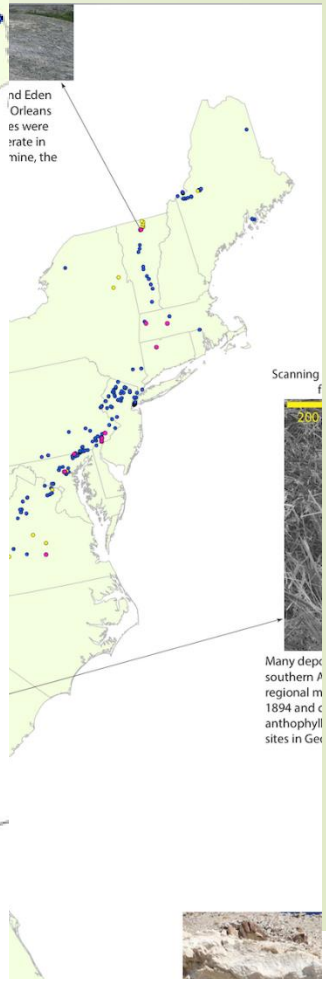


te piles of the former KCAC chrysotile mine,
inga district, San Benito County, west-central
ornia. This was the last operating asbestos
e in the United States; it closed in 2002.





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International NOA

- Use of asbestos in products banned in 50 countries
  - Currently mined in Russia & China
    - Exported to developing countries (Thailand: top importer)
  - Previously mined in many countries (stop year)
    - USA (1993)
    - Canada (2010)
    - Brazil (2017)
    - South Africa (2008)
    - others

Asbestos , Quebec: home of the Jeffrey mine

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East Coast: Pioneer in asbestos mining!

- In 1858, the Johns Company (Johns Manville?) began to mine for fibrous anthophyllite for use as asbestos insulation at the Ward's Hill quarry in Staten Island, New York.
- Production of asbestos in the United States became more widespread in 1899, when large deposits of the mineral were discovered at Belvidere Mountain in Vermont.
- Peak production of asbestos occurred in the mid-1970s. In 1973, the United States alone was consuming over 800,000 tons.
- First studies on asbestos in surfacing occurred in Maryland!

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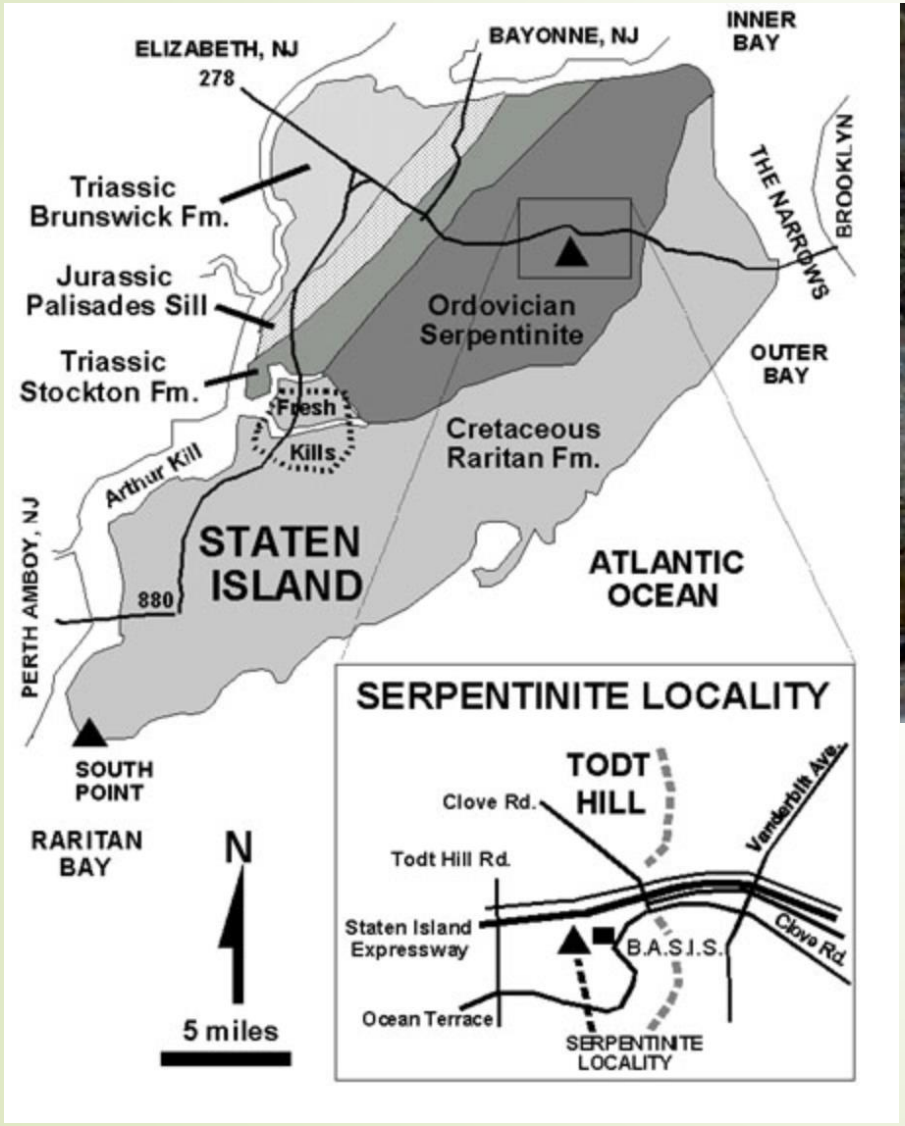
Asbestos in Staten Island, New York



- Staten Island Serpentinite: antigorite, chrysotile, magnetite, talc
- Up to 50% by weight

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Asbestos was so common!

(Credit: Gregg Swayze, USGS. Public domain.)

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Where is NOA still found outdoors?

Lots of places!

- Rock outcrops / veins
- Fault zones
- Within soil / alluvium
- Fluvial deposits
- Imported fill or roadbase
- Decorative rock used in landscaping

Hillside in Oakland, CA

- Typically in areas where oceanic crust was subducted

- Note: Cannot always see fibers. Individual fibers or veins in rock & soil *generally* invisible to eye…

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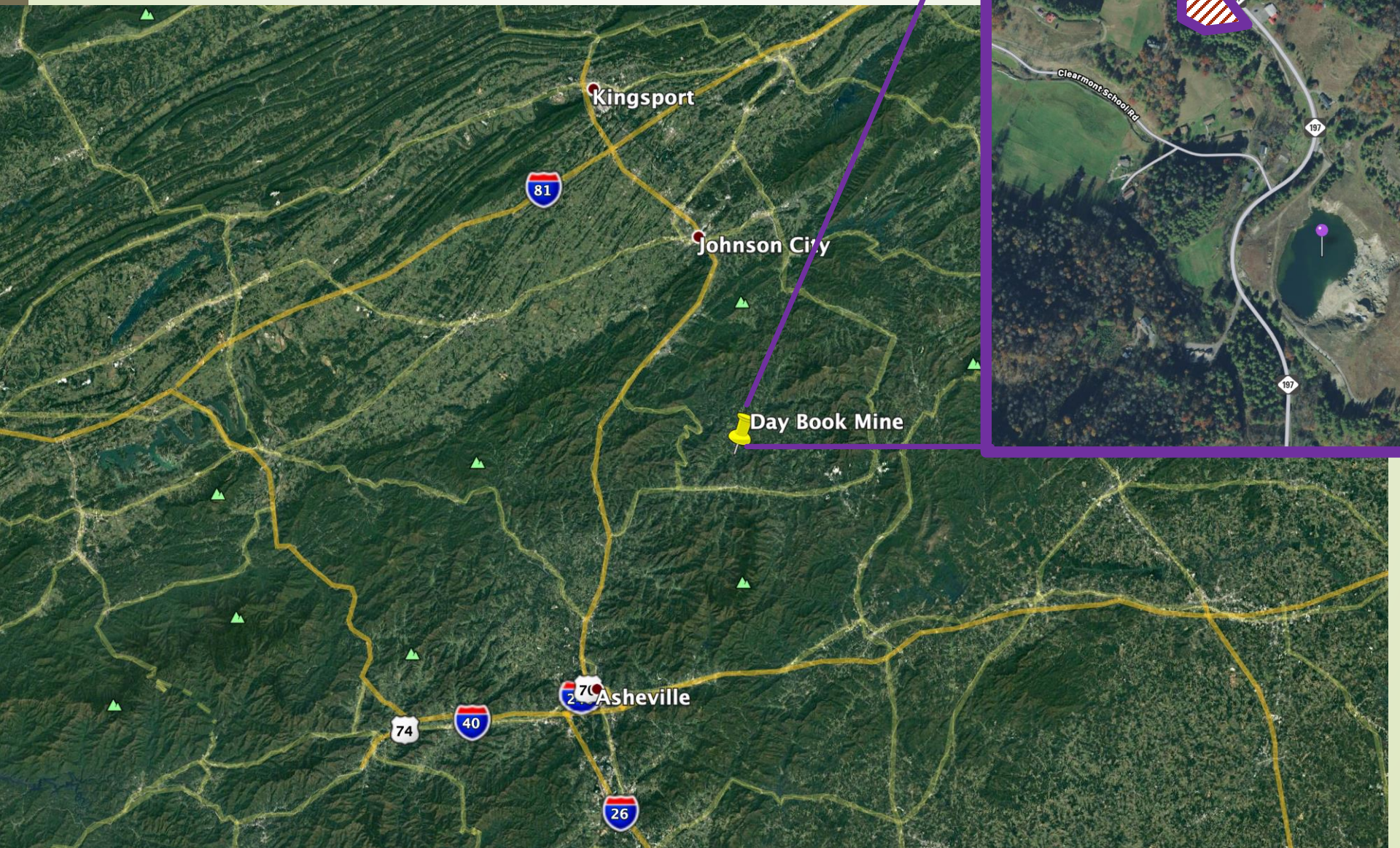
Chrysotile “in the wild”: Middle Point Road, San Francisco

Observed during 2018 IAEG field trip

AEG NOA Field Trip
Asheville AM 2019



Amphiboles “in the wild”: North Carolina

Parking lot / former truck staging area <1 mile from Day Book Dunite Mine (AEG 2019 field trip)

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Frank Mine, Avery County, North Carolina

- Former anthophyllite mine – only mine in North Carolina mined for asbestos (on purpose), anthophyllite occurs as part of the phased metamorphism of the area
- Closed in the 1930's, now private property

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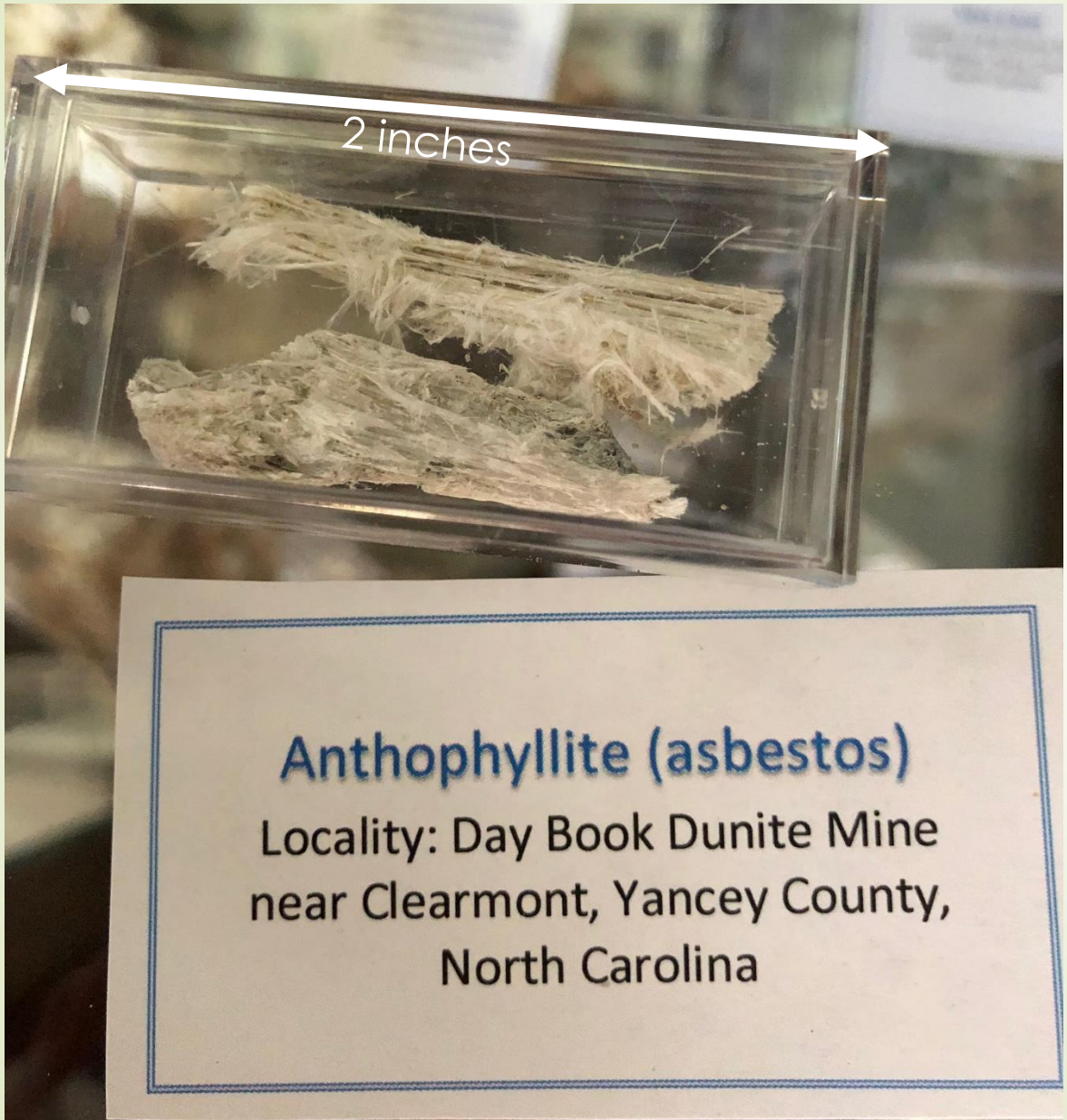
Amphiboles in their protective enclosures



On display in my collection of "cancer minerals"

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Quiz Time!

- True or False:

Asbestos has been banned in the US since 1978, so there are all kinds of laws preventing asbestos in rock and soil from being released during construction.

ASBESTOS TEM LABORATORIES, INC.

200 µm

Geology as Art courtesy of Asbestos TEM Labs
Chrysotile veins in serpentine – Diablo Range
Fremont, CA Thin section – PLM w/ crossed polarizers & compensator plate

There is no comprehensive

We have a Problem!

- Regulation
- Guidance Document
- Training Requirement
- Standard of Practice

for NOA in the USA, or anywhere outside the USA (yet!)

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Resources to Review & Understand

Knowledge based on **individual level of effort** made to track down the various regulatory agency Fact Sheets, papers, regulatory language.

- 1973: EPA National Emission Standards for Hazardous Air Pollutants
- 1991, with periodic revisions: Cal-OSHA CCR Title 8, Subchapter 4, Article 2, Section 1529, Asbestos
- 2001, reviewed 2008: CARB Asbestos Airborne Toxic Control Measure for Surfacing Applications
- 2001: California Geological Survey: SP-124 Field Methods
- 2002, reviewed 2008: CARB Air Toxics Control Measures for Construction, Grading, Quarrying, and Surface Mining Operations
- 2002: Federal OSHA 29 CFR 1926.1101 (applies to workplaces / rules for employers)
- 2004: DTSC Schools Unit: Interim Guidance for Naturally Occurring Asbestos at School Sites
- 2006: CGS SR-190 study on relative likelihood of asbestos in Placer County, CA

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International NOA Regulations

- Surprisingly few global NOA Regulations!
- Australia (published guidance docs through their EPA)
- Italy, Turkey, Germany, France, South Africa
  - Varying levels of regulation for NOA
  - France and Italy have mapping programs tied to universities
  - Generally follow World Health Organization restriction recommendations
  - Stated: no “safe threshold” for asbestos
- WHO estimates 107,000 annual deaths from asbestos
  - Includes all occupational asbestos-related deaths (factories, mining, mesothelioma & lung cancers)
  - Several thousand from “environmental exposure”
  - Harder to track

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World Health Organization

Estimates about 125 million people in the world are exposed to asbestos at the workplace

"All forms of asbestos including chrysotile, are carcinogenic to humans"

- Many countries regulate asbestos to 0.1 f/cc in air
  - Venezuela, European Union countries, India, Indonesia, Malaysia, Norway, South Korea, Singapore, parts of Canada
- Some have higher limits:
  - 0.01 Netherlands; 0.15 Japan; 0.2 South Africa; 0.8 China
- Recommends worker protection, mitigation measures to prevent inhalation
- More than 50 countries have banned use of asbestos (primarily Europe, USA)
- Asia – Pacific region has reported increased usage, particularly in production of asbestos-cement products

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Problem: You can't ban the presence of asbestos in soil and rock

Solution: We need to sample, analyze, mitigate, educate others

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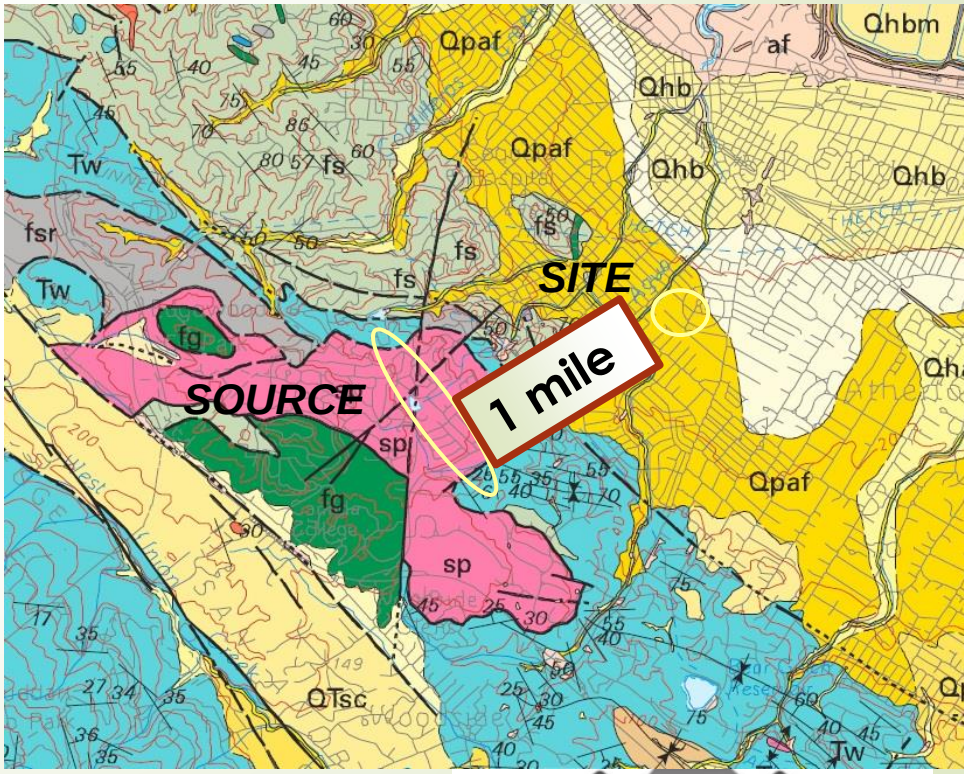
Look for “Downstream” NOA in Soil

- Review the Geologic Map
  - Consider upstream soil sources
  - Fault nearby?
  - Alluvial fan origination?
  - DTSC recommends radius of 10 miles
- Site history
  - Soil and rock import?
  - Source of import?



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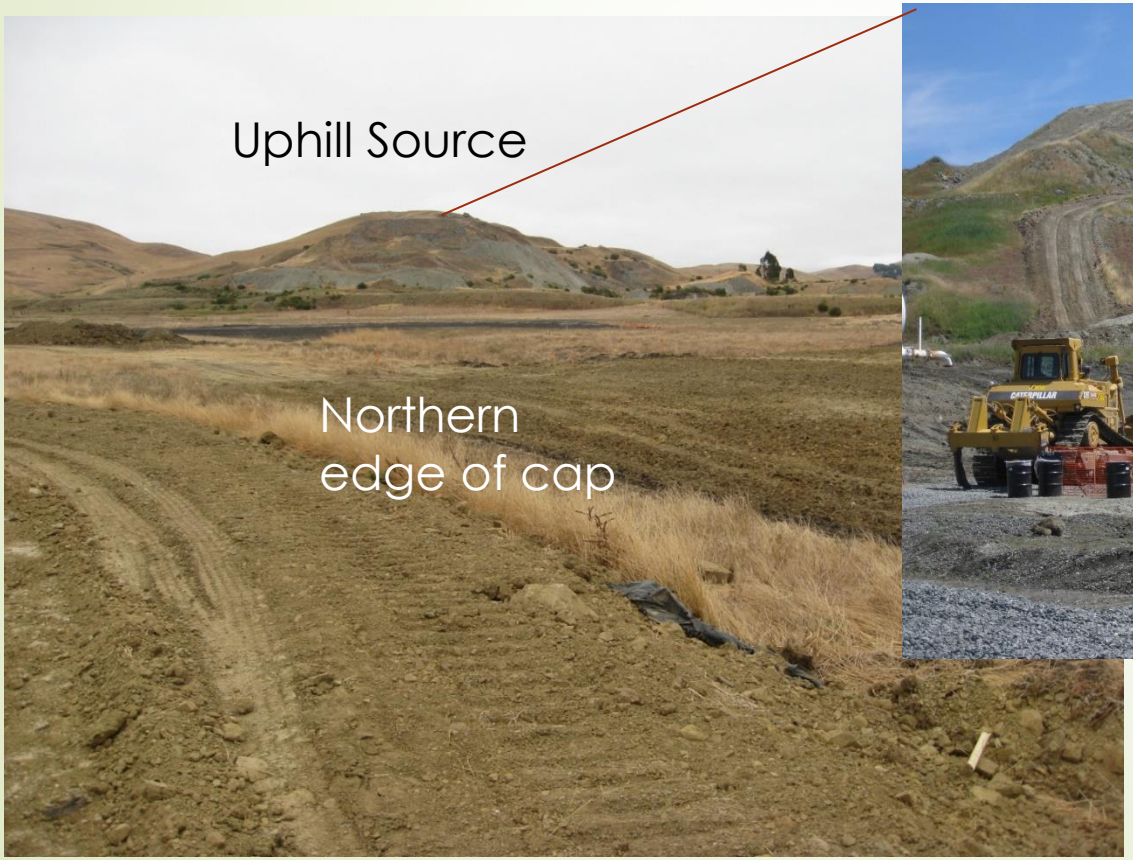
Case Study: American Canyon High School

- Located downstream of serpentinite outcrop (up to ~5% chrysotile) & former aggregate quarry
- Low-lying areas of school property required to be covered with non-NOA soil



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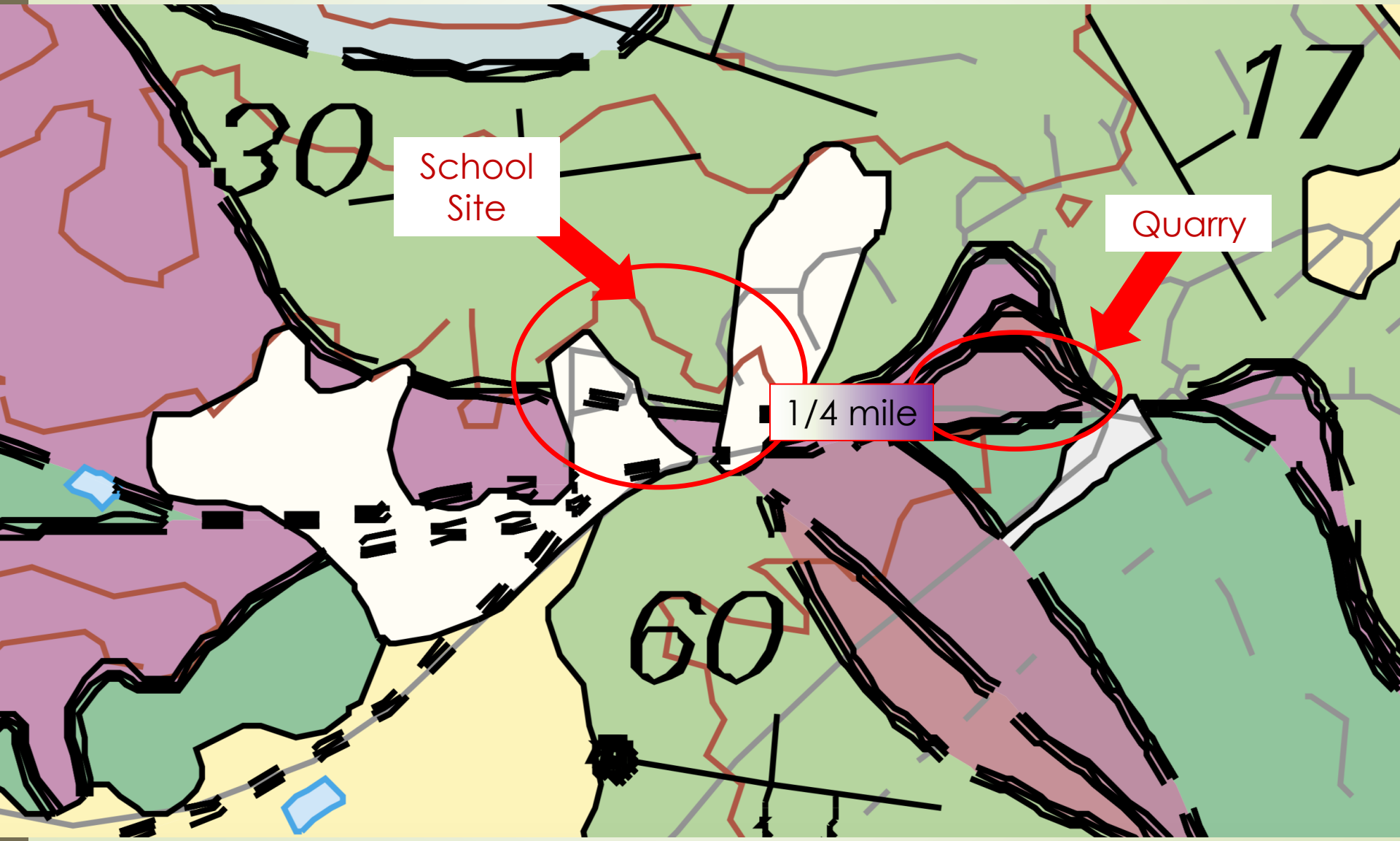
Geologic Map (zoomed in)



Quarry Views Pre-Reclamation

Kleinfelder, 2009

Google Maps Aerial Images, 2007

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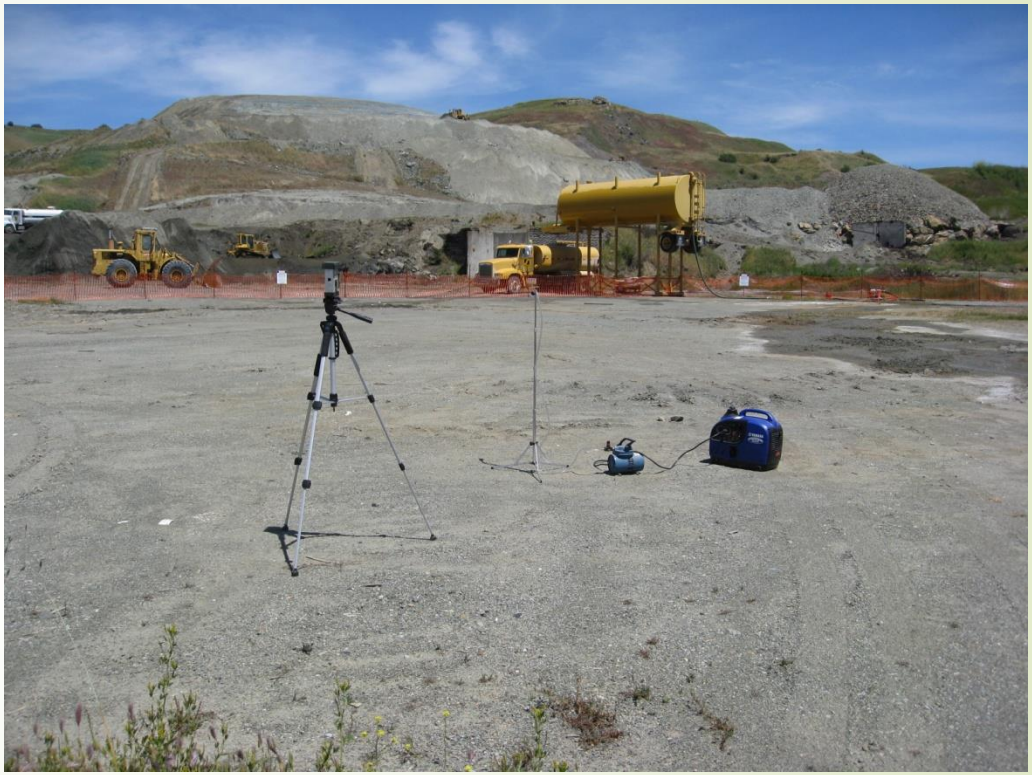
We conducted monitoring during grading for High School AND Quarry (separately)

Water truck on hillside for dust control



Asbestos samples by high-volume pump powered by portable generator

Required by BAAQMD:

- 1 upwind and 3 downwind perimeter monitoring stations
- Records of wind speed & direction

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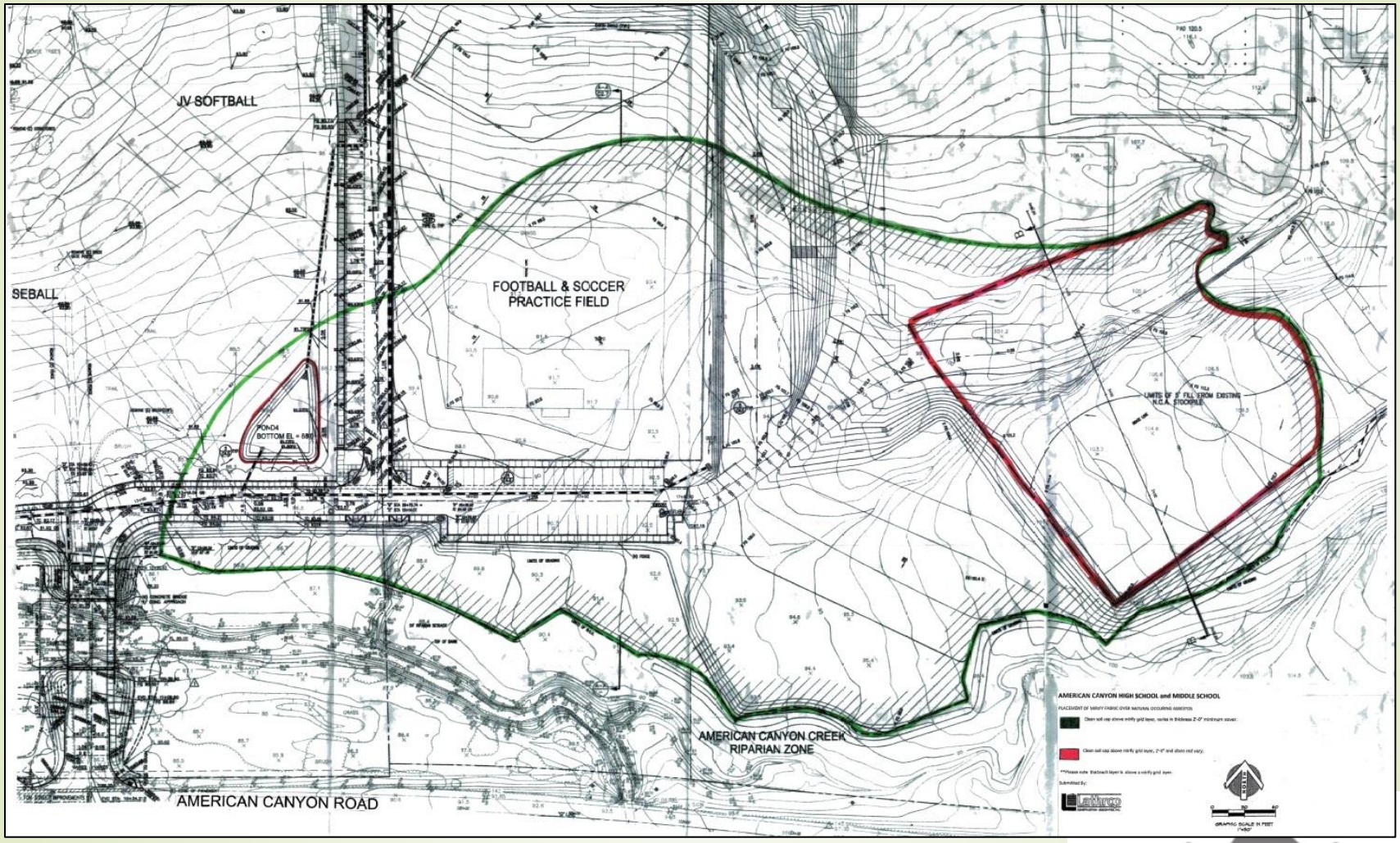
Water application during High School earthwork

High School Capped Area



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NOA Soil capped, annual inspections, reporting to DTSC, deed restriction filed…

- Dark Brown native soil (bottom)
- Mirafi geotextile layer "visual barrier"
- Clean soil cap (top)

Oops! Breached anyway

Eight locations in cap, 4 outside cap drilled through by subcontractor who didn't read map correctly

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Case Study: Asbestos in Washington

- Most notable case in Washington: **Swift Creek**
- 150,000 cubic yards moves annually into the creek from a approx. 225-acre landslide on Sumas Mountain (landslide reactivated in the 1940's)
- Toe of landslide deposits into lower fork of Swift Creek
- Swift Creek transports sediment downstream, depositing along banks of creek
- Sedimentation rate requires frequent dredging
- Additional asbestos reportedly in Skagit County
- **I'm not an expert on this project** – info obtained from discussion w/ Julie Wroble (EPA) and review of "latest" from Dept of Ecology website

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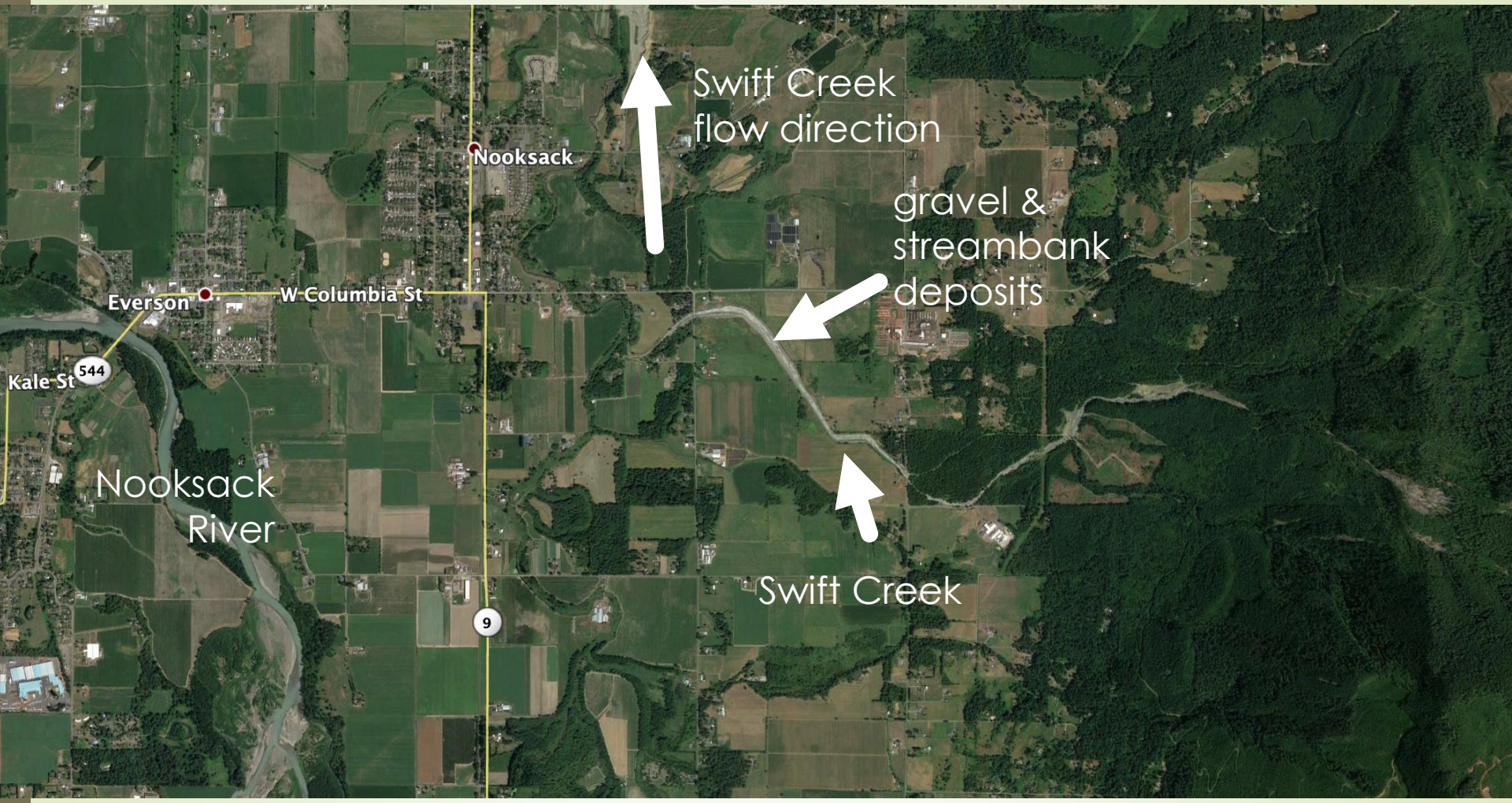

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(photo & diagram from Department of Ecology)

Swift Creek facing east towards Sumas Mountain, April 2019

So, what's the problem?

- **Serpentinite** is major component of rock within the landslide
  - Reportedly contains **asbestos**, **nickel**, manganese, cobalt, **chromium**, magnesium
  - **Often chromium & nickel are indicators that you'll likely find chrysotile**
  - Soluble nickel often fails the waste extraction test (WET) for CA landfills
- Extreme sedimentation requires periodic dredging
  - Minimize flood sediment from collecting on adjacent properties
  - Stockpiles previously available for public off-haul
  - Asbestos content from dredged materials ~1.6% but up to 6% (EPA, 2006)
  - 2019 flooding causes more creekbed deposits, test results up to 27%
- response.epa.gov/swiftcreek
- Julie Wroble (EPA) good contact person for history

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Current & Future of Swift Creek project

- Action Plan, Public Participation Plan developed (2019)
- Consent Decree (legal agreement) that requires design documents for flood control, management of deposited sediment, maintenance and monitoring, easements

Swift Creek and dredged sediment pile

- Currently in the project design process
- Summer 2020: Public comment process for Supplemental Environmental Impact Statement for sediment storage repositories
- 2021-2023: obtain funding from Washington State Legislature for project completion

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So how do I know? What do I do?

- If asbestos is suspected at a project site (based on geologic map, import history, field observation, or general interest)
- Design a sampling plan (grid, targeted)
- Map locations for future delineation
- Analyze samples using proper method – find a reputable lab!
- Mitigate for asbestos dust during construction
- Plan to ensure workers are protected from airborne asbestos
- Ensure public (outside project boundaries) are protected from airborne asbestos leaving the site
- Document findings

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Sampling / Lab analysis Methods

- Rock / soil: collect approx. 1 quart – 1 gallon size bag
  - Targeted vs. “random” representative soil sampling
  - Analyze by CARB 435 method (not asbestos bulk), both methods use PLM
  - CARB 435 requires crushing, sieving, homogenizing
  - Not all labs do the same prep or mineral identification & counting!
- Breathing zone / air: collect on cartridge with pump
  - Perimeter / Area: 0.45 micron / CARB Mod-AHERA TEM
  - Personal exposure: 0.8 micron / PCM

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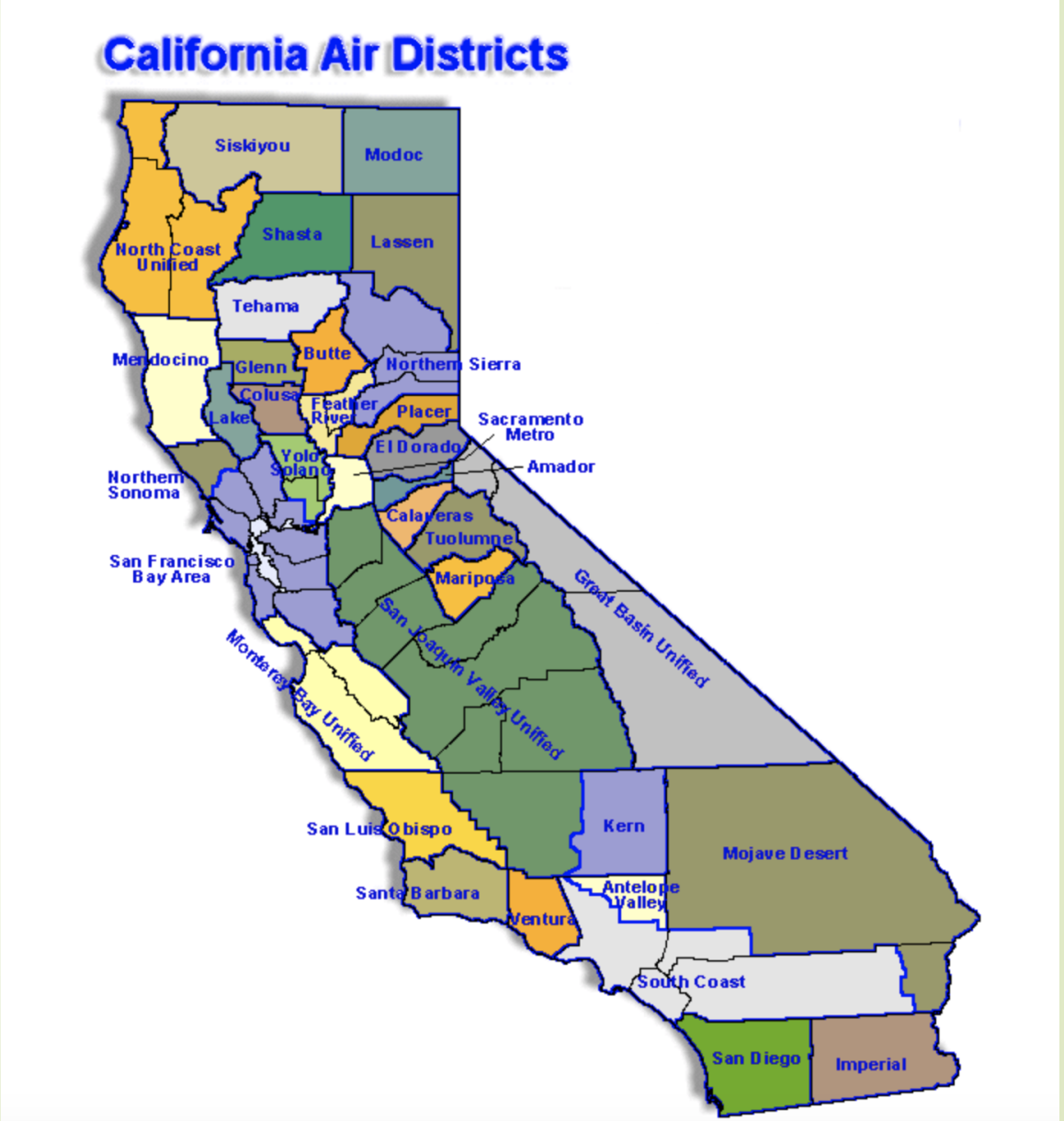
CARB / Local Air Districts

- Cal-EPA developed Air Toxics Control Measures (ATCM) for asbestos (and other airborne pollutants)
- Local air districts = enforcement authority to ensure air pollution is controlled within their jurisdiction
- Each District has their own policies / requirements for Naturally Occurring Asbestos
- Few guidance documents that apply to all areas other than ”Discovery Notification Form”



Air Toxics Control Measures

- CARB prepared two ATCMs for asbestos that apply to most projects:
  - Surfacing (roads, etc)
  - Construction, Grading, Quarrying, Surface Mining
- Each ATCM limits use of materials that contain asbestos at >0.25% as indicated by CARB 435
  - Cannot remain on the surface for vehicle travel
  - Must be capped with <0.25% asbestos cover

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Asbestos Dust Mitigation Plan & Air Monitoring

- Several State Air Quality Districts require ADMPs
  - ADMP required to be reviewed if Site is >1 acre
  - If Site is within ¼ mile of a developed area:
    - Air Monitoring possibly required (depending on Air District)
    - Minimum 3 sample locations (up, cross, down)
    - Data review / inspection fees assessed
  - Voluntary monitoring may be recommended by consultant in a Site Management Plan

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Potential Gaps in Site Permitting

- Permitting Process asks about:
  - Asbestos in buildings to be demolished
    - Can't have greater than 1% (friable) remain in structure
  - Survey required by a CAC in California
    - Requires exam, initial & annual courses, 1 year experience
- Does NOA exist in on-Site soil? Not asked!
- Suggestion:
  - Require owners / permit applicants to provide asbestos soil sampling results during excavation & grading permitting process
  - Require a sampling method & analysis that we can all agree upon

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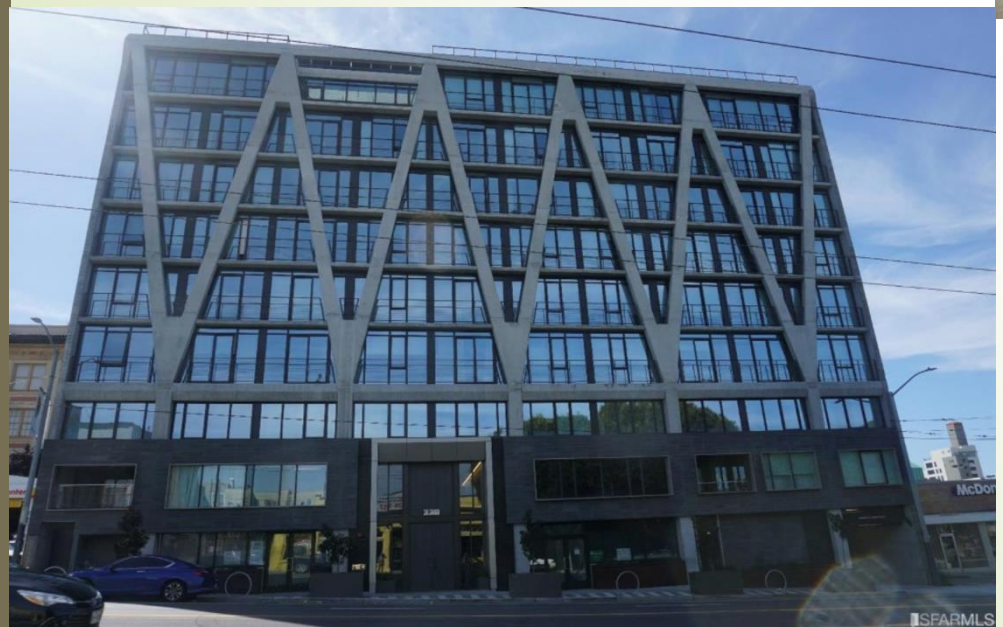
Case Study: Was air monitoring required?

- San Francisco, CA
- 70-unit condo building
- 7 stories + subgrade garage (14 foot depth excavated)
- Urban neighborhood (homes, commercial businesses, park in vicinity)
- **5-8% chrysotile asbestos** in rock (excavated for offhaul)
- 810-870 mg/kg Cr; 1,600-2,300 mg/kg Ni



Quiz Time!
Yes or No?

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Quiz Time!

Did this building construction project require air monitoring?

- Yes
- No

Geology as art courtesy of Asbestos TEM Labs
Glaucophane in Blueschist & Greenstone– Diablo Range
Fremont, CA
Thin section – PLM in plane polarized light

200 µm

Well, did this project require area air monitoring?

- Asbestos sampled, due to consultant's incidental knowledge of chrysotile presence in the area
- ADMP written!
  - But not required to be submitted for review due to parcel size of 0.25 acres
- Air District requires air monitoring!
  - But only for projects they review = no monitoring required!
- Public protected!
  - Maybe?
  - Without data collection, we don't know!
  - 1 acre threshold for projects doesn't make sense in urban areas

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ADMP Components

- Speed limits (15 mph)
- Dust control measures (reduce emissions / control visible dust with water)
- Roadway wet sweeping
- Methods to prevent asbestos dust generation during excavation, grading, loading, and off-haul
- Covering inactive stockpiles
- Air monitoring required (if ¼ mile or less to commercial / residential development) AND greater than 1 acre project size

Tymco regenerative air sweeper truck

Water truck saturating soil

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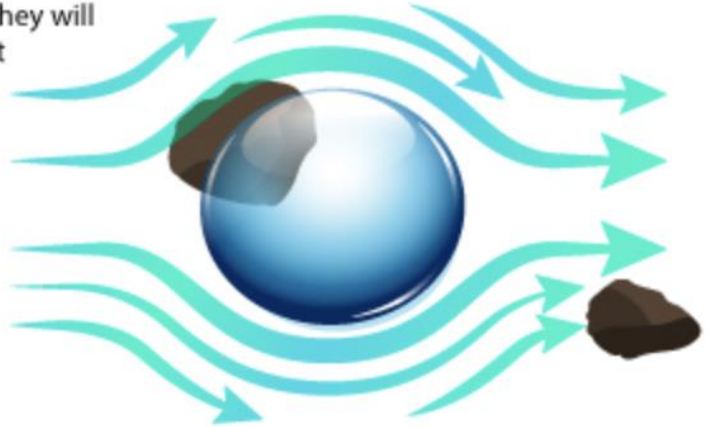
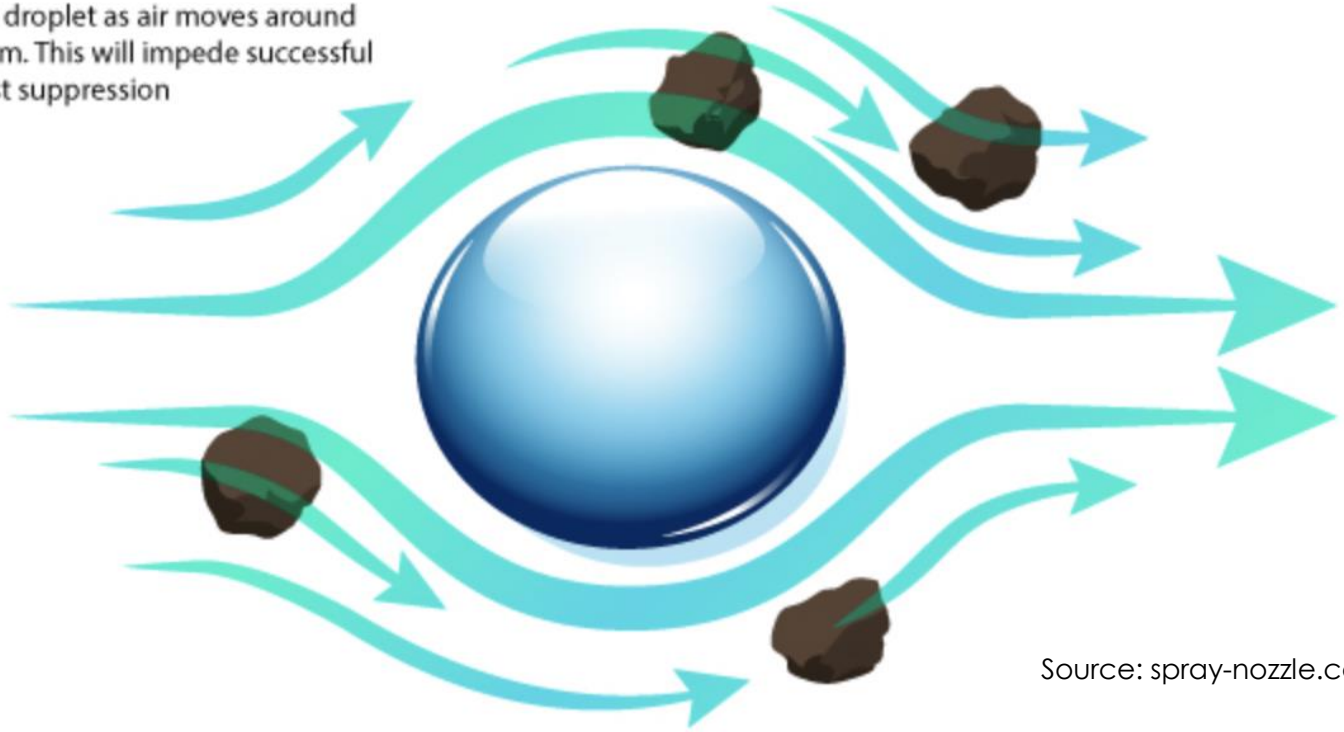
If droplets are similarly in size to the suppressing droplets they will collide with them and dust suppression will be more successful



If droplets are too big then dust particles will tend to move around the droplet as air moves around them. This will impede successful dust suppression



Source: spray-nozzle.co.uk

How do we know if Dust Control is working?

- Air sample minimum:
  - Upwind (background?), crosswind, downwind
- Wind direction monitoring is helpful!
- Collect at least 8 hours / workday, if not 24 hours
  - TEM 0.45 micron cartridge
  - Analysis by CARB-modified AHERA (counts all fibers 3:1 ratio, >5um length, detection limit ~0.001 f/cc based on ~3,000 liters of air, can get lower with more air)
  - Personal air samples by PCM are <u>not directly comparable</u>

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Worker Protection under OSHA / Cal-OSHA

- "Federal" OSHA enacts worker protection regulations for asbestos (the asbestos "classes of work" are Federal)
- All states must comply with these – many states don't require sampling for asbestos in rock & soil
- Cal-OSHA is California's enforcement branch of OSHA
  - Friable & >1% asbestos = Cal-OSHA interprets this (in Northern California) as Class II Work

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Class II OSHA Worker Requirements

- Respirators required
- Protective clothing required, if >PEL or no NEA
- Training (equivalent to ~2hr awareness)
  - Including hands-on training (on the job)
- Regulated areas with signage
- Decon area with wash water

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Respirators & Fit Testing (per OSHA)

- Anyone wearing a respirator needs:
  - Written employer respiratory protection plan
  - Medical exam & “fitness to wear respirator” letter from doctor
  - Prevent “Beard Creep”
    - See handy CDC chart!
  - Obtain a respirator - minimum ½ face APR
    - P100 filter cartridge (purple) or combo OVM (black)
    - Use same brand cartridge as respirator

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Facial Hairstyles and Filtering Facepiece Respirators

*If your respirator has an exhalation valve, some of these styles may interfere with the valve working properly if the facial hair comes in contact with it.
†This graphic may not include all types of facial hairstyles. For any style, hair should not cross under the respirator sealing surface.

Source: OSHA Respiratory Protection Standard
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=12716

Further Reading: NIOSH Respirator Trusted-Source Webpage
https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/respsource3fittest.html

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Experience Requirements

- At this time in California:
  - Only requirements for specialized asbestos training & certification apply to building materials assessment / abatements.
  - California DTSC requires outdoor site assessments & map interpretation by PG
  - Geologic recommendations by PG
- Outside CA: recommendations for PG to be consulted, no formal training anywhere (yet)
  - Industrial Hygienists often contacted for worker protection design / advice
- Outside USA: research performed by Geologists, Chemists, Industrial Health / Occupational Health specialists

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What is the AEG / IAEG NOA Commission?

- International group of NOA & EMP researchers - expanded from 2018 San Francisco IAEG / AEG meeting
  - Website to centralize information: noa-emp.info
  - Led by Mark Bailey, Francesco Turci, Sarah Kalika
  - International team of geologists, industrial hygienists, chemists, and occupational asbestos experts
- Accomplishments so far:
  - As AEG TWG: Held 4 NOA Symposiums in Oakland, Calif.
  - Formed IAEG Commission 39: NOA in 2019
  - Published 20 papers in special edition of the AEG/GSA Environmental & Engineering Geoscience Journal, February 2020
  - Issued letter in support of FDA Interagency Working Group Recommendations on Asbestos in Talc
  - 5 sub-teams: Field Methods, Project Design, Lab Methods, Mitigation Methods, Erionite
    - Working on guidance documents & methods
    - Subset working on Cal-OSHA NOA Regulations

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FDA Hearing on Asbestos in Talc

- US FDA hearing on Talc in Consumer Products (Feb 2020)
  - Interagency Federal Working Group – met for the past year
  - Developed recommendations for lab counting & analysis
  - If adopted, likely that these definitions may become nationwide standard for talc
  - Possible to become a standard for all NOA analysis
    - **Published methods were not intended to determine presence of asbestos in products at less than 1% concentration**
    - TEM should be used for talc, even if PLM results are negative
    - All mineral particles should be counted
    - Covered minerals should include chrysotile and all members of the amphibole group
    - Aspect ratio >= 3:1 and length of >0.5 um
    - Adopt term “Elongate Mineral Particle” for any particle 3:1 or greater
  - https://www.fda.gov/media/134005/download

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Contact me with Questions!

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