Long Baseline Neutrino Facility (LBNF) Update

Community Informational Meeting

20 April 2022

Outline

1. March 30 Incident – Patrick Weber
2. Dust Mitigation Initiatives Going Forward – Mike Gemelli
3. Toxicologist Report & Findings – Gary Krieger, MD

March 30 Incident

- On March 30, Fermilab discharged rock into the Open Cut while the winds were above 15 mph.
- Procedures and controls for rock conveyor operation that were put in place in December were not appropriately followed.
- Fermilab conducted a full investigation of the incident and reviewed the controls that were in place.
- The investigation identified corrective actions to strengthen these procedures and training of personnel to ensure the controls will work as designed.
- Updated controls:
  - No discharging rock while snow or weather obscure visibility of material coming out of the open cut.
  - More specific procedures and training for personnel to ensure multiple checks of the conditions.
  - An automatic system is being installed that will alarm the operator when sustained winds exceed 15 mph.
  - The water spray system will run anytime the conveyor runs.

March 30 Incident (2)

- The March 30 incident resulted in treated material falling from the conveyor being picked up by the wind and getting into the park.
- This is a different problem from the untreated material being picked up by wind.
- The updated controls will minimize the chances that treated material is picked up by the wind.
- When discharged properly, the treated material forms a cap over the untreated material and limits the exposure of the untreated material to wind.
- The treated material will not spread out as much as the untreated material due to the tackifier sticking particles together.

Material in Open Cut

Dust Mitigation Activities Going Forward

Dust Mitigation Activities Going Forward

No.	Engineering Control Name	Purpose	Tentative
1.	Hi-Pressurized Pump Equipment	Mobilize high pressurized pump to shoot water over the Open Cut with a water cannon. The increased pressure cannons will not reach all of the material, but will assist in limiting dust.	May 2022
2.	Agricultural Helicopter	A helicopter descends into the Open Cut and sprays the capping agent on the untreated stockpile.	May / June 2022
3.	Remote Control Agricultural Land Rover	A remote-control battery-operated piece of equipment which descends into the Open Cut on a winch and applies a capping agent on the untreated stockpile.	May 2022

Toxicologist Report & Findings

Gary Krieger, MD MPH, DABT, DTM&H

Who am I

- **Gary R. Krieger MD, MPH, DABT, DTM&H**
  - **Training**: University North Carolina/Mayo Clinic/Johns Hopkins/London School
  - **Certified**: Internal Medicine/Preventive Medicine (Section Occupational Medicine)/ Toxicology/ Tropical Medicine & Hygiene
  - **Experience**: Human health, toxicology and risk assessment work since 1982 with work in over 40 countries and multiple states across the USA, including many significant and complex environmental sites/events
  - **Expertise**: quantitative risk assessment health impact assessment, metals, hydrocarbons, particulates, infectious disease mathematical modeling
  - **Publications**: Co-authored/Edited Multiple toxicology and environmental science textbooks and numerous peer-reviewed papers

Assess and answer questions regarding LBNF excavation activities

- **WHAT**- considering what materials a person could be exposed to- soil metals, silica, fine/coarse particulates
- **WHERE –** determining potential key exposure locations, including the park
- **WHO-** considering who might be exposed to excavation materials- adults and children
- **WHEN**- look at different exposure periods, short and long-term- multiple years of exposure
- **HOW**- considering the way individuals can be exposed- inhalation, ingestion, dermal (skin)
- **HOW MUCH** – calculating exposure-dose for each potential pathway of exposure- how much does a person take into their body over time
- **So, We Can…**
- **CALCULATE RISK**- determine is there a potential problem by using standard and well-established health protective methods to screen for and assess risk
- **COMPARE**- comparing calculated risks against well-established, health protective standards/guidelines/background

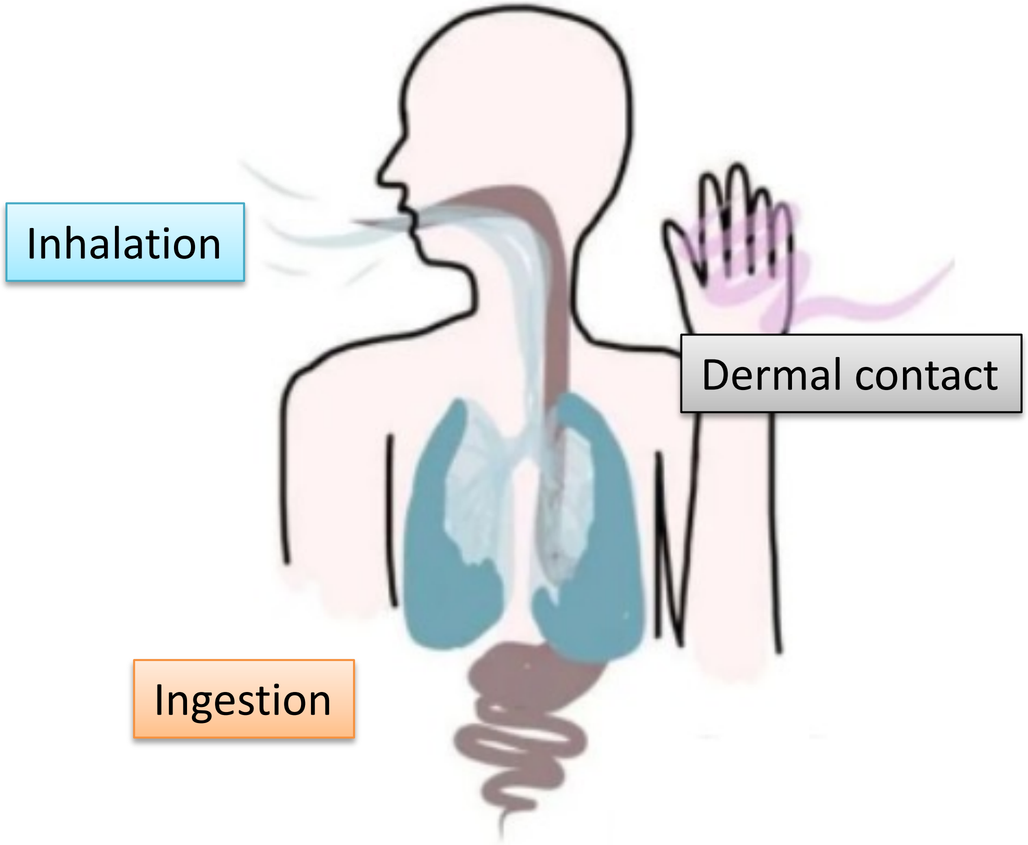
How do we estimate risks?

Risk Assessment has been developed and practiced in the US for almost 40 years so there is a lot of experience!

Risk Assessment

Regional Screening Levels (RSLs)

- Calculated by EPA for risk screening – VERY conservative (likely to overestimate risk)
- Residential scenario exposure assumptions:
  - Daily exposure from age 0 to 26
  - Soil intake by 3 exposure routes:
    - Breathing (inhalation)
    - Eating (ingestion)
    - Skin (dermal) contact
  - ALL of metal in soil is assumed to enter human body



Risk Assessment

- Toxicity assessment
  - Non-cancer
    - Impacts the development, size, or function of the whole body, organs, or organ systems
    - EPA toxicity values are estimates of the daily intake over a lifetime that is not likely to result in any significant adverse health effects (including to sensitive subpopulations)
    - Non-cancer hazard is measured by calculating a Hazard Quotient (HQ):

$$HQ = \frac{\text{Measured concentration in soil}}{\text{Safe concentration in soil (RSL)}}$$

$$= \frac{\text{LBNF sampling result}}{\text{EPA non-cancer Residential Screening Level}}$$

    - An HQ of 1 or less means soil concentration is safe and no concern for adverse health effects = the screen has been passed
    - An HQ >1 does **NOT** mean that adverse health effects are expected! It means look more closely.

Risk Assessment

- Toxicity assessment
  - Cancer
    - General assumption is that any chemical that causes any cancer in any species at any dose is a human carcinogen
    - Default assumption is no threshold for cancer effects: any exposure results in some cancer risk
    - Because there can (theoretically) be no zero risk, EPA established an "acceptable" target cancer risk range of 0.000001 (1 in 1 million) to 0.0001 (1 in ten thousand) additional cancer cases in a population over a lifetime (thousands of times lower than background cancer risk in the US).

$$\text{Cancer risk} = \frac{\text{Measured concentration in soil}}{\text{Safe concentration in soil (RSL)}} \times 0.000001 \text{ (target risk level)}$$

$$= \frac{\text{LBNF sampling result}}{\text{EPA cancer Residential Screening Level}} \times 0.000001$$

- Cancer risk less than 1 in ten thousand is "acceptable" = the screen has been passed
- A cancer risk >0.0001 does **NOT** mean that cancer cases are expected! It means look more closely.

Risk Assessment

Special considerations in **metals** risk assessment

- Natural constituents of the earth's crust, present in all soils
- Bioavailability from soils usually very low, so actual internal absorption from soil contact tends to be very much smaller than assumed in calculating RSLs.
- For metals (like arsenic) with very low RSLs, natural background concentrations are often greater than the RSL. In that case, risk is considered to be negligible.

Special considerations for **silica** in risk assessment

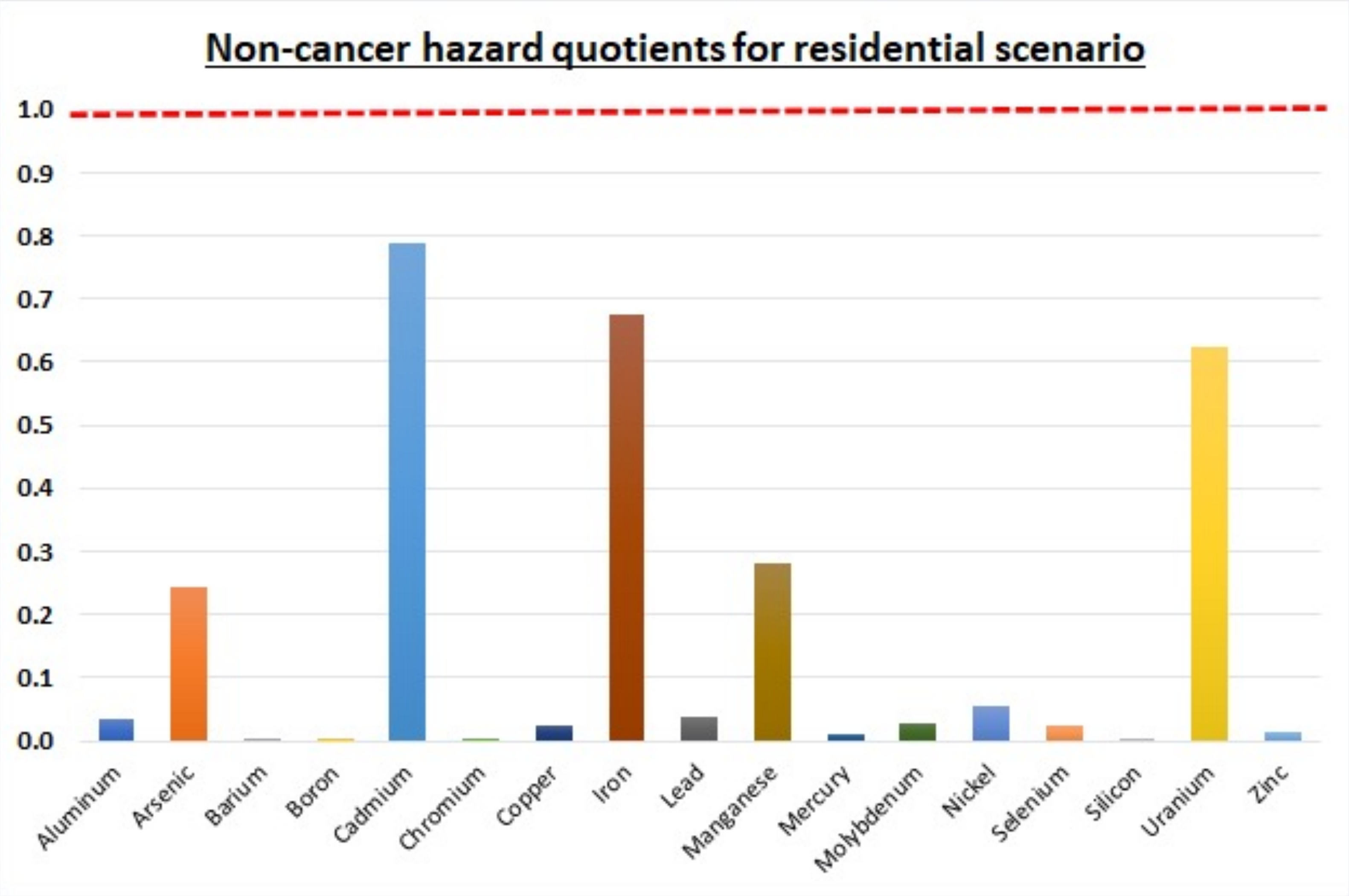
- Form of the silica matters- crystalline (potential toxicity) versus amorphous (not toxic)
- Size, shape, composition and concentration in the air
  - Small particle size is more significant than large (<4 um)
  - Duration of exposure matters
  - Industrial (foundry, sandblasting) versus environmental exposure
  - Occupational exposures require long duration OR extremely high acute exposure (sandblasting)
  - Environmental exposures severe dust storms (60-70% free silica content), indoor/non-ventilated cooking with extremely high dust levels 50x higher than US air quality standards (Himalayas)

Non-cancer screening evaluation

Hazard Quotient (HQ)

$$HQ = \frac{\text{Measured concentration in soil}}{\text{Safe concentration in soil (RSL)}}$$

- HQs for all metals measured in excavated soils <1
- Screen is passed
- Based on sample from the park

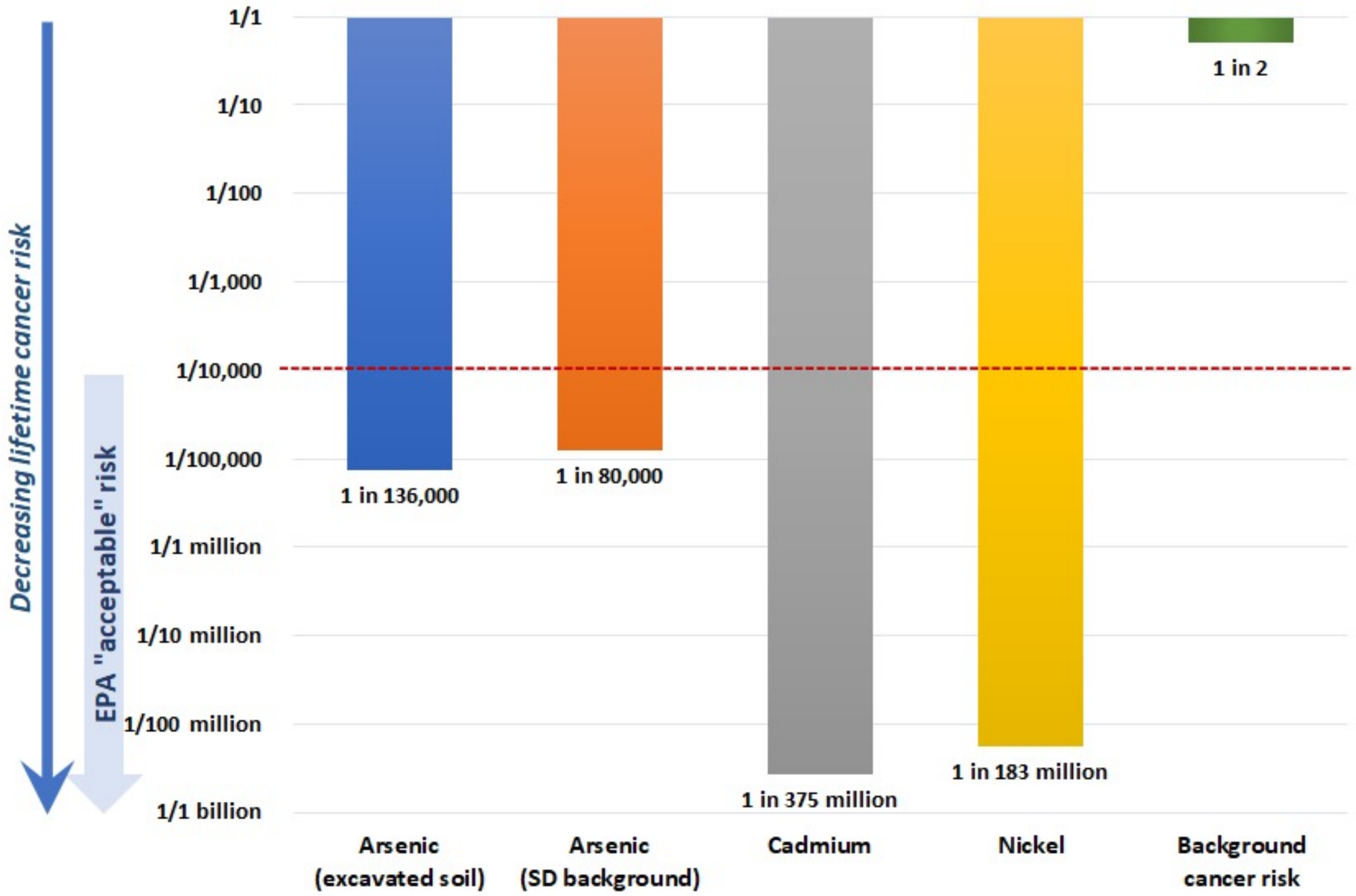


Cancer screening evaluation

Theoretical lifetime cancer risk

$$\text{Cancer risk} = \frac{\text{LBNF sampling result}}{\text{EPA cancer Residential Screening Level}} \times \text{TR}$$

- **Cadmium**
  - Calculated risk = 0.000000003 – one additional case in a lifetime in a population of 375 million
- **Nickel**
  - Calculated risk = 0.000000005 – one additional case in a lifetime in a in a population of 183 million
- **Arsenic**
  - LBNF concentration (5 mg/kg) < South Dakota mean background (8.5 mg/kg)
  - Calculated risk = 0.000007 – one additional case in a lifetime in a population of 136 thousand
  - LBNF risk 41% lower than background risk



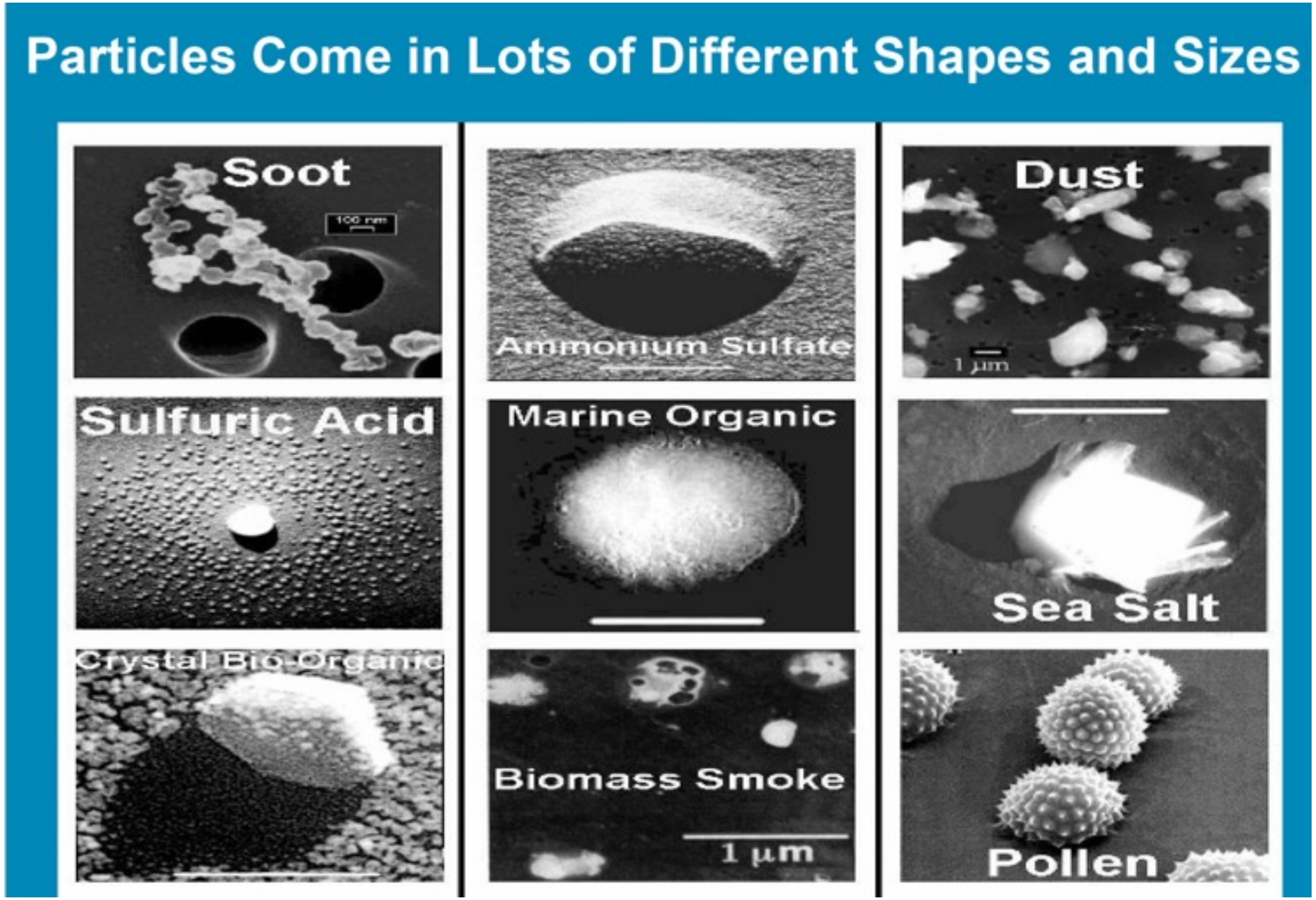
Excavation Soils: Summary

- LBNF excavation soils passed the screen:
  - Do not present increased risk of cancer or non-cancer health effects to children or adults living on the excavated soil.
- Naturally occurring arsenic is often present in concentrations greater than the cancer residential RSL, as it is in South Dakota soil.
  - Cancer risk calculated for arsenic in LBNF excavated soil is "acceptable" per EPA policy.
- Lead was not present (non-detect), so no risk calculation was performed
- Silica assessment is underway, and new data are expected shortly to determine of crystalline silica is present (potential toxicity) versus amorphous silica (minimal/no toxicity)– more on this in the particulate matter discussion!

Particulate Matter (PM)

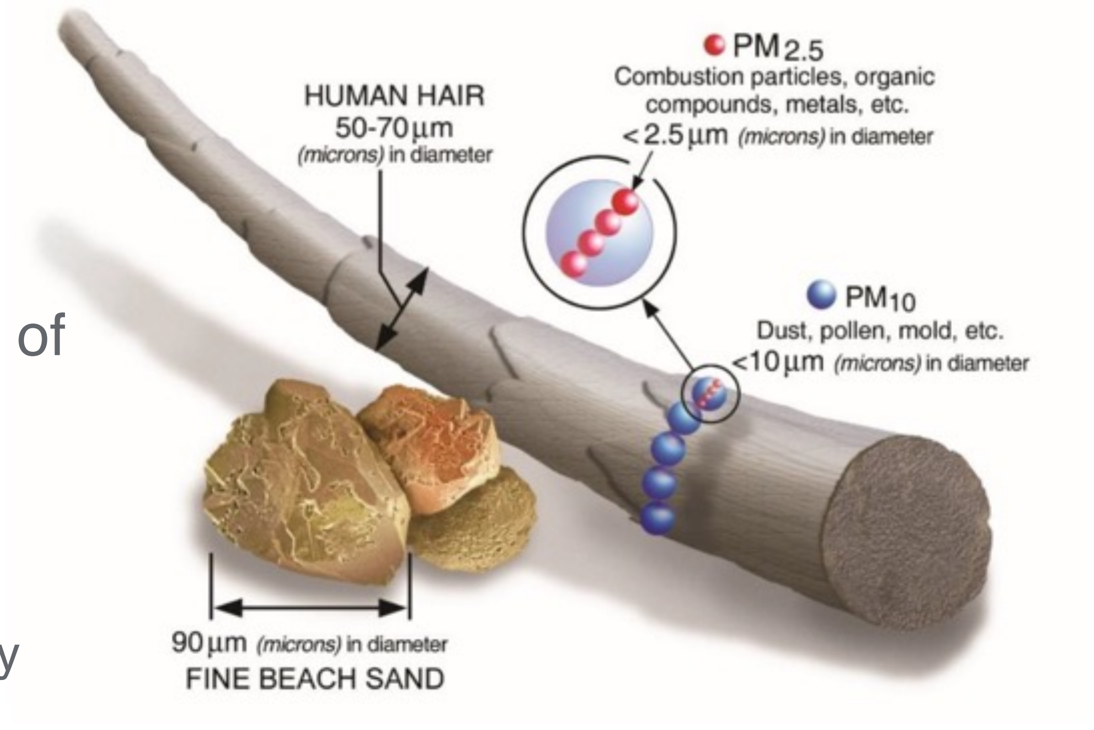
- Naturally occurring
  - Dust
  - Sea salt
  - Biologic material (pollen, spores, plant and animal debris)
  - Forest fires
- Anthropogenic
  - Mobile sources (combustion engines)
  - Power plants
  - Factories
- Secondary particles
  - Chemical reactions in the atmosphere
- Indoor
  - Smoking
  - Cooking
  - Heating

PM Size Distribution



PM Size and Visualization

- We measure PM in units of "microns" (um), a millionth of a meter, or 1/25,000 of an inch
- Monitored PM sizes
  - PM2.5-10 or PM10 (diameter = 10um): inhalable particles, settle in the upper respiratory tract

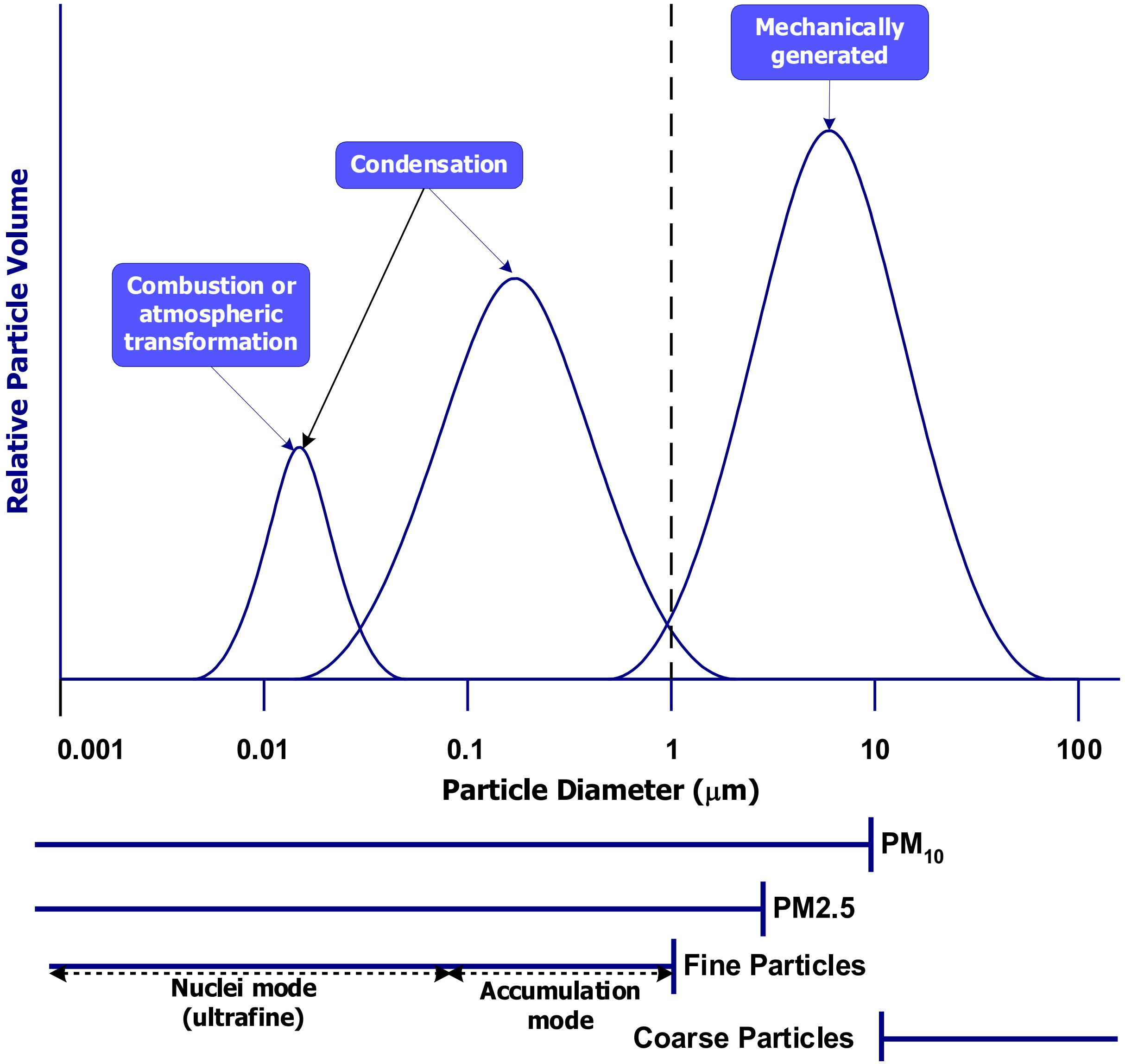


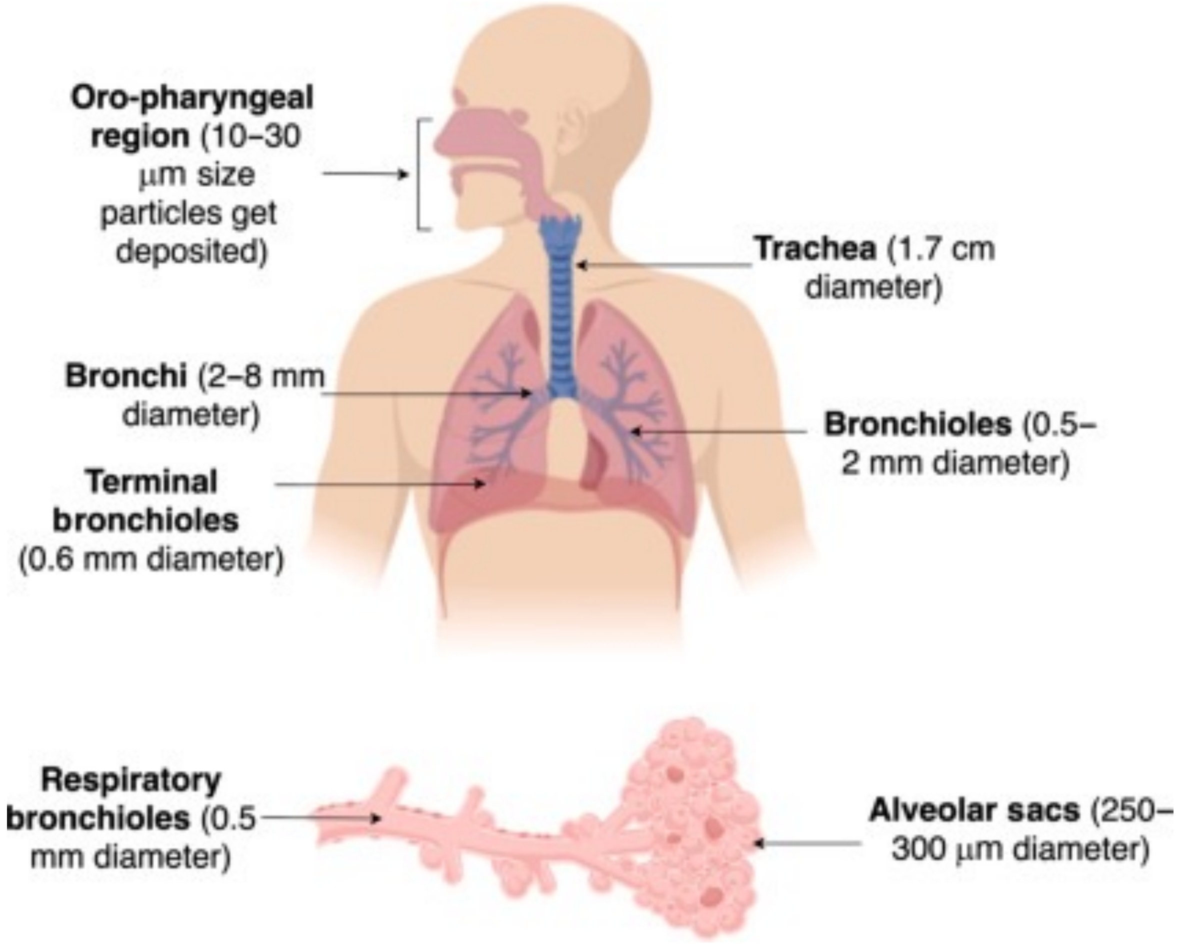
µm = micrometer; PM = particulate matter; $PM_{2.5}$ = particulate matter with a nominal mean aerodynamic diameter less than or equal to 2.5 µm; PM_{10} = particulate matter with a nominal aerodynamic diameter less than or equal to 10 µm.

Source: U.S. EPA (https://www.epa.gov/pm-pollution/particulate-matter-pm-basics).

  - PM2.5 (diameter = 2.5 um): respirable particles, able to penetrate to the deep lung
  - **PM10 and PM2.5 are NOT visible**

Particle Size Distribution





PM Toxicology Key Considerations

- What determines particle toxicity?
  - Small size- PM<2.5 um (fine fraction) more harmful than PM2.5-10 um (coarse fraction)
    - Higher surface area
    - Greater numbers
    - Smaller, combustion-related particles more potent
  - Composition
    - High oxidative stress potential
    - High soot content
    - High concentrations of bioavailable transition metals
- Despite these differences, all particle types toxicity is based on size without regard to their source and chemical composition.

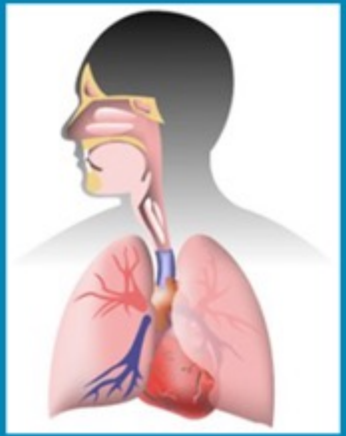
PM Toxicology Key Considerations

- Short-term exposure to high levels of PM10 associated with reversible symptoms of cough, irritation, and possibly triggering pre-existing asthma
- Long-term exposure to fine particulate associated with increased cardiopulmonary morbidity and mortality rates
- Magnitude of effect is much less than tobacco smoking, obesity

PM Toxicology: Health Effects

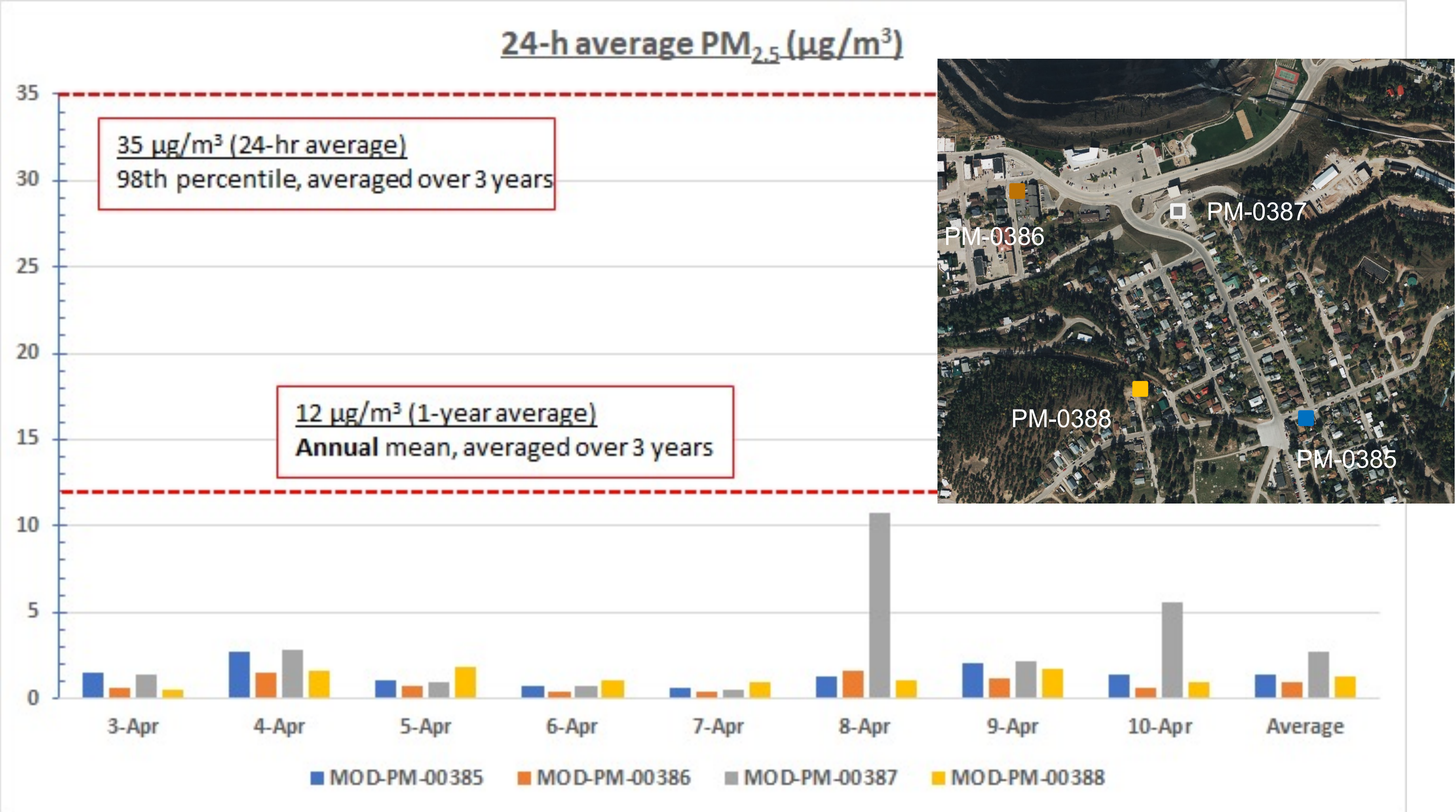
What Happens When You Breathe PM?

- Larger particles (> PM_{10}) deposit in the upper respiratory tract
- Smaller, inhalable particles (≤ PM_{10}) penetrate deep into the lungs and stick (deposit) or are exhaled



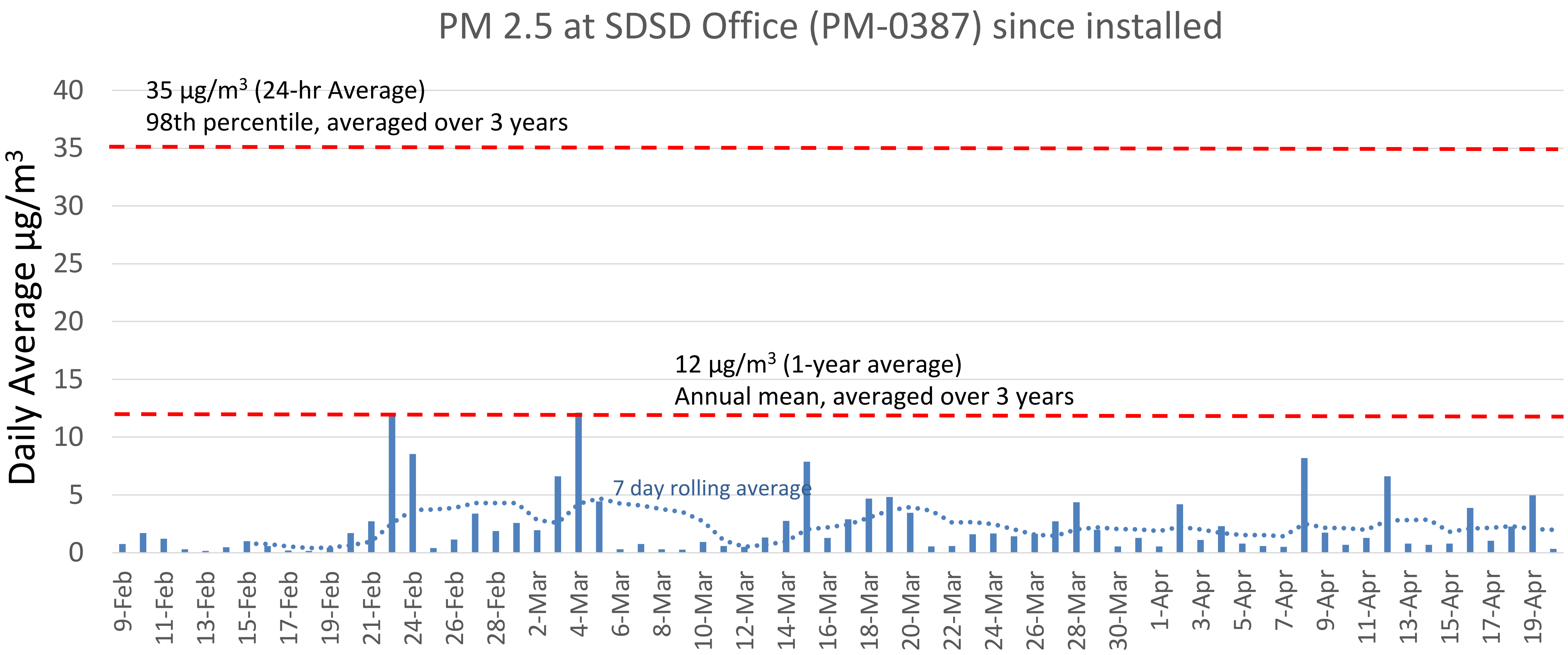
- Both coarse $PM_{10-2.5}$ and fine $PM_{2.5}$ can penetrate to lower lung
- Deposited particles may accumulate, react, be cleared or absorbed

$PM_{2.5}$



24-h average $PM_{2.5}$ ($\mu g/m^3$)
35 µg/m³ (24-hr average)
98th percentile, averaged over 3 years
12 µg/m³ (1-year average)
Annual mean, averaged over 3 years
35
30
25
20
15
10
5
0
3-Apr
4-Apr
5-Apr
6-Apr
7-Apr
8-Apr
9-Apr
10-Apr
Average
MOD-PM-00385
MOD-PM-00386
MOD-PM-00387
MOD-PM-00388
PM-0386
PM-0387
PM-0388
PM-0385

$PM_{2.5}$ at closest sensor to discharge



NewFields

Silica

Special considerations for silica in risk assessment

- Consideration of development of silicosis (lung disease) is the critical effect
- Risk in foundry workers increased after 20 years of exposure at 50 ug/m^3
- Risk in foundry workers increased after 40 years of exposure at 25 ug/m^3
  - Most significant when the PM size is <4 um
- There are minimal/no data regarding silica in infants and children
- Environmental exposure data has been in settings with high dust storms and indoor non-ventilated cooking
  - Dust storm- 60-70% free silica content, indoor/non-ventilated cooking with extremely high dust levels 50x higher than US air quality standards (Himalayas)
- **If ALL of the measured LBNF fine PM were crystalline silica it would still not pose a significant health hazard as the concentration and exposures are extremely small**
  - Nevertheless, in an abundance of caution additional silica data are being collected

LBNF PM Data

- **Fine fraction site-related PM <2.5 um is quite low and well below health-based regulations**
  - LBNF short-term (24-hour average) is 1-3 ug/m^3
  - LBNF fine PM contribution is very unlikely to significantly impact human health, particularly with short-term exposures of < 24 hours
- **If ALL of the measured LBNF fine PM were crystalline silica it would still not pose a significant health hazard as the concentration and exposures are extremely small**
- **Monitoring and dust control/mitigation plans are critical to minimize potential health impacts and address community concerns**

Summary

- Fermilab is strengthening our controls for when we discharge rock after the March 30 incident.
- Multiple options to mitigate the dust are in the process of execution.
- The dust is not a public health hazard.