212 Environmental Consulting, LLC

INNOVATION IN ENVIRONMENTAL SOLUTIONS

Section 1

Human Health Risk Assessment

Establishing Background Concentrations Using Historical Data

Project at a Glance

- Client wanted to establish site-specific background concentrations for naturally occurring metals.
- Team used historical remedial data to establish background concentrations
- Stepwise approach leads to significant cost savings and expedited redevelopment of 300-acre site.

Risk Assessment Calls for Site-Specific Background Concentrations for Metals

Our client wanted to establish site-specific background concentrations as part of the human health and ecological risk assessment for surface and subsurface soils at a remote project site underlain by fractured bedrock.

At the time that this work was completed, the state regulatory agency had only established background concentrations for arsenic, based on a limited data set and relied on nationwide studies such as the frequently cited Shackeltte and Boerngen (1984) for evaluating background concentrations for other naturally occurring metals. Conducting an independent background study can be expensive and complicated, often including negotiations with third-party property owners.

Historical Remedial Investigation Data Provides Answers

Our team identified that a substantial data set for metals collected from both surface and subsurface soil was collected as part of historical remedial investigation activities. We were able to negotiate the use of the existing data to establish site-specific background concentrations with the regulatory agency.

A grid pattern had been established across the 300-acre site with higher density sampling conducted within former process areas and lower density sampling occurring in undisturbed areas. The background data was selected by segregating sampling locations in impacted or potentially impacted areas based on four criteria.

1. We eliminated all the samples that were collected in redeveloped areas as there was a potential for non-native backfill to have been used during construction.
2. Samples with lead concentrations that exceeded the site-specific screening criteria (including direct exposure as well as migration to groundwater) were eliminated. The site has been used to process leaded gasoline and as such lead was one considered one of the primary risk drivers.
3. We eliminated any samples collected in former tank berms, due to the potential for historical releases from bulk storage tanks.
4. Any remaining outliers were eliminated using Rosner's algorithm implemented in ProUCL version 4.0.

Stepwise Approach Reduces Costs and Expedites Redevelopment

The resulting data set was comprised of 25 samples that were used to calculate background concentrations of naturally occurring metals using ProUCL version 4.0. This stepwise approach for establish background concentrations using existing historical data resulted in a significant cost savings and expedited redevelopment of portions of the site that had not previously been used for historical refining and bulk storage activities

Preserving the Beauty of California Coastline

Project at a Glance

- Highly desirable property along California coastline had high levels of arsenic in soil sample analysis.
- Remediation would have required extensive excavation across entire site and changed the landscape and ecosystem
- Team developed a risk-based approach that segregated the site based on impact and use.
- Worked with redevelopment team to prepare preliminary layouts and required excavation for each lot.
- Addressed vapor intrusion pathway by requiring mitigation systems for future residences
- Approach saved millions of dollars in redevelopment and preserved coastline.

Soil Contamination Pauses Residential Development

Our client approached our team with a desire to redevelop contaminated property situated on the central California coastline. This property was highly desirable for residential development given the sweeping views of the ocean and rolling landscape.

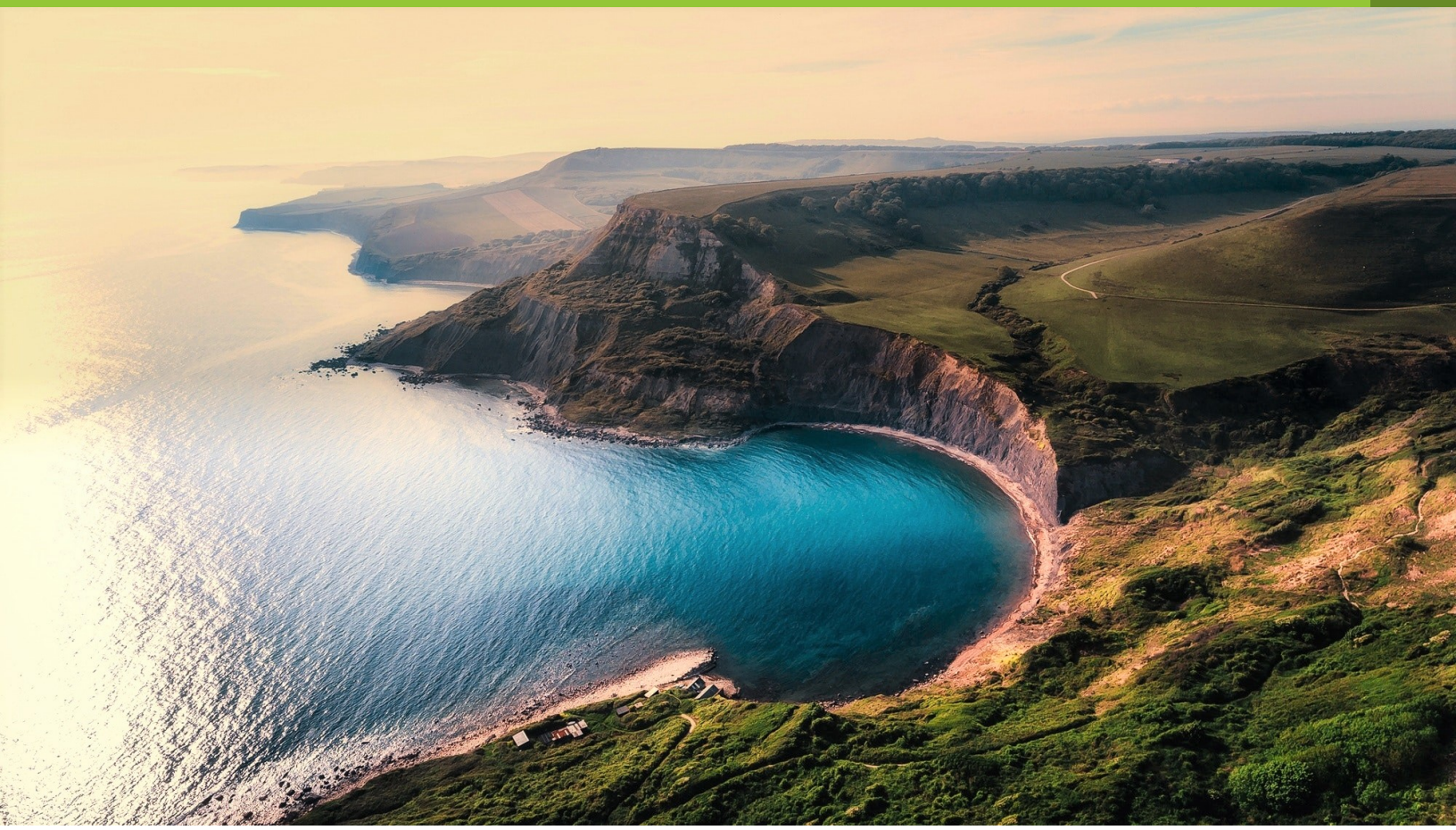
Sampling results indicated that there were potential risks to human health due to concentrations of arsenic and to a lesser extent, polycyclic aromatic hydrocarbons, measured in surface and subsurface soils. Arsenic was ubiquitously elevated across the site partially due to the historical use of arsenic as an herbicide.

Remediation of these contaminants would have required extensive excavation across the site to achieve the generic residential risk-based screening levels in surface and subsurface soils. This would have been challenging considering the topography and expansive spatial extent of arsenic within soil. In addition, this would have significantly damaged the natural landscape and ecosystem along the coastline.

Deploying Tailored Risk-based Approach to Redevelopment

Our team developed a risk-based approach that segregated the site based on the level of impacts within soil. Areas with the highest concentrations of arsenic and polycyclic aromatic hydrocarbons were designated for use as natural, recreational areas, such as walking trails. Areas with lower concentrations of these constituents of concern were targeted for residential use and subdivided into estate lots, ranging from one to three acres.

Our team tailored the human health risk assessment for these anticipated uses. For example, within those areas designated for recreational use, risk was only considered for surface soils, assuming a short exposure duration. Whereas in areas being considered for residential development, risks for exposure to both surface and subsurface soils were considered, as is typical for residential exposure inputs.



Multipronged, Safe Approach Saves Millions and Preserves Landscape

To address potential risk to future residences, our team worked with the redevelopment team to prepare a preliminary layout for each estate lot, including location of future structures, to minimize the footprint for excavations in areas where subsurface soils exceeded risk-based limits. We also recommended that clean fill be brought in to cap other areas where constituent concentrations in surface soil posed a potential risk, which also limited excavations activities.

The extent of excavation and amount of fill necessary were specified for each of the estate lots based on the risk assessment findings. Deed restrictions were recorded for each of the estate lots limiting future excavation by the property owners. Lastly, the vapor intrusion pathway was addressed by requiring mitigation systems be installed preemptively within any future residential structures built within the estate lots.

Overall, this risk-based approach resulted in millions of dollars in savings during redevelopment and preserved the beauty of this fading landscape along the California coastline.

Assessing Potential Vapor Intrusion Pathways with Radon Tracing

Project at a Glance

- Client required to evaluate human health risks associated with petroleum vapor intrusion across 48 residences
- Lack of understanding of attenuation rates creates more questions about vapor rates and movement
- Former refinery site underlain with bedrock results in considerable lateral and vertical variation in the volatile petroleum-related constituents
- Team uses radon to better understand attenuation rates and determine volatile vapor migration
- Solution saves time, reduces project costs and dramatically reduces client liability

Lack of understanding of attenuation impact on vapor migration

The client was required to evaluate human health risks associated with the vapor intrusion pathway per the requirements of a state regulatory agency with limited understanding or guidance regarding evaluation of this exposure pathway. Of particular concern, was the lack of understanding that attenuation has on the migration of vapors across a building foundation.

As vapors migrate from beneath the ground into a structure, the concentration of volatile constituents decreases due to dilution with indoor air, as well as restriction of vapor movement across the foundation. Risk assessors use attenuation factors to account for this reduction in volatile constituent concentrations and separate structures with the potential for a completed vapor intrusion pathway from those with background sources inside the structure.

These background sources are ubiquitous in indoor air from many sources, including, but not limited to, building products, cleaners, paints, and automotive products. If these background sources cannot be accounted for during an investigation, it may mistakenly appear that a completed vapor intrusion pathway and inhalation risks are present, when in reality, the source of vapors are related to chemicals inside a building and not releases underneath the building.

Site foundation results in significant variation of volatile petroleum-related constituents

This client's site, a former refinery, is underlain by fractured bedrock with irregularly distributed light non-aqueous phase liquids and dissolved phase impacts, resulting in considerable lateral and vertical variation in the composition and concentration of volatile petroleum-related constituents.

The residential structures to be evaluated included a combination of full or partial basements, full or partial crawlspaces, and slab-on grade structures. The age of the structures spanned several decades, and conditions of the building slabs and foundations varied from dirt floors to brand new concrete slabs.

Tracking radon movement from subsurface to indoor analogous to migration of volatile vapors

To better understand attenuation rates at the site, our team developed an innovative solution to quantify a specific rate of attenuation into each residence. Radon, derived from the natural breakdown of radioactive uranium in soil, rock, and water, was used as a conservative, naturally occurring tracer. The movement of radon from the subsurface into indoor air is analogous to the migration of vapors from a source of volatile constituents through the vadose zone and into a structure.

Commercially available radon passive samplers, as well as a real-time, continuous radon gas monitors were tested to determine the best means of quantifying concentration inside and beneath the building slab. Our team selected the real-time radon gas monitor, as this technique provided reliable results and allowed for continuous samples to be collected over specified time frames. Paired samples (indoor air, subslab, and crawlspace) were collected and used to develop attenuation factors for each residence.

Ultimately, the radon-based attenuation factor was an important line of evidence in evaluating the vapor intrusion pathway and supported findings that the pathway was incomplete within 47 of the 48 residences.

Innovative solution reduces costs, project timeline and client liability

Consequently, our client was only required to implement mitigation measures to address potential inhalation risks within a single structure, significantly reducing the costs, project timeline, and the potential liability if this innovative approach had not been implemented by our team.

Protecting Construction Workers in a Trench Scenario

Project at a Glance

- Concerns of construction worker safety pauses installation of sub-grade utility in trenches at SW Ohio project
- Trench-scenario evaluated to identify inhalation risks of volatile compound
- Team designed field study to measure trench air exchange rates to better constrain modeling and provide realistic estimates of risks to workers
- Carbon dioxide used as tracer
- Study reduces risks to workers, reduces costs and expedites redevelopment

Construction Workers Face Inhalation Risk in Sub-grade Utility Install

Our client approached our team with the desire to expedite redevelopment of approximately 80 acres of a former marketing terminal located in southwest Ohio. While many of the potential exposure pathways were addressed via a combination of engineering controls (e.g. capping, vapor mitigation systems) and administrative controls (e.g. environmental covenants, deed restrictions), there was significant concern regarding the safety of construction workers during horizontal redevelopment activities, particularly those workers installing sub-grade utilities in trenches.

The so called “trench scenario” is typically evaluated by estimating exposure concentrations to determine potential inhalation risk for construction workers. The exposure concentration is calculated by combining a vadose zone model to estimate transport of vapors from the source into the trench, with a box model to estimate the exposure point concentration following mixing of the volatile constituents with atmospheric air in the trench.

There are two primary assumptions:

(1) the trench dimensions and

(2) the air exchange rate within the trench.

Industry best practices and professional judgement can be employed to constrain the modeled trench dimensions; however, default air exchange rates have not been developed for trenches. Regulatory agencies typically recommend using air exchange rates based on historical studies of air flow between tall buildings in an urban setting.

Field Study Leads to Better Modeling and Risk Estimations

We designed a field study which allowed us to directly measure trench air exchange rates to better constrain modeling to provide more realistic estimates of inhalation risk to construction workers during horizontal redevelopment.

Trenches were installed over a light non-aqueous phase liquid source with no impediments to air movement (e.g. above grade structures in proximity to the trenches). Meteorological data, with an emphasis on wind direction and speed, were continuously monitored throughout the study to understand the relationship of air exchange with meteorological factors.

Two field events were conducted to evaluate trench air exchange rates, which allowed for estimation under various ambient conditions within trenches of different dimensions and orientations. During the first field event, four trenches of dimensions 3-feet wide by 8-feet long by 8-feet deep were installed and oriented in four directions. During the second field event, a longer trench (20 feet in length) was installed to determine if trench length would affect the air exchange rate.

Carbon dioxide was used as the tracer gas for estimating the trench air exchange rate. Each trench was covered and filled with carbon dioxide until a concentration of approximately 50% was measured. The sheeting was then removed, and the fixed gas concentrations were recorded until carbon dioxide was measured below 1%.

The air exchange rate was estimated by assuming that the decrease in the carbon dioxide concentration, as a result of mixing with ambient air, followed first order exponential decay, typical of air exchange rate studies.

Study identifies risk to workers while reducing costs and redevelopment timeline

The measured trench air exchange rates were more than an order of magnitude greater that the regulatory-recommended rate estimated using historical air flow between tall buildings. The trench length and orientation did not affect air exchange.

Use of the measured trench air exchange rate significantly reduced the inhalation risk calculated for construction workers, and in most cases, the risk was below the acceptable threshold. For the limited areas where inhalation risks were above the acceptable threshold, naturally ventilating the trench for a period of 4-hours was sufficient to reduce risks below acceptable thresholds. If entrance into the trench was necessary prior to 4-hours of natural ventilation, then the trench could be mechanically vented.

Ultimately, our trench study reduced the cost and expedited horizontal redevelopment of the former marketing terminal.

Mitigating Petroleum Vapor Intrusion in Rocky Mountain Community

Project at a Glance

- Petroleum vapors threaten Rocky Mountain residential community
- Failed floor of storage tank blamed
- Team exampled soil vapor analytics to narrow list of volatile constituents
- Found that background sources complicated evaluation of the vapor intrusion pathway in nearby residences.
- Found that source of constituents within 11 residences were attributed to background sources and not from client refinery site.
- Innovative approach eliminated costly mitigation and investigation

Petroleum Vapors Threaten Residential Community Near Refinery

Gasoline was measured at increasing thickness in several monitoring locations within a residential community adjacent to a refinery in the Rocky Mountains. It was determined that the source of the gasoline was associated with the failed floor of a massive storage tank. In response, the state regulatory agency and its technical expert requested that our client expedite the investigation of the vapor intrusion pathway and proceed with mitigation measures as needed to ensure protection of the nearby residential community.

Narrowing Constituents of Concern to Reduce False Determination

To expediate evaluation of the vapor intrusion pathway, our team examined the soil vapor analytical results collected from the light non-aqueous phase source to develop a list of constituents that might be present at concentrations that could pose an inhalation risk within residences. We were able to narrow the list of potential volatile petroleum hydrocarbons to three constituents of concern for sub-slab soil vapor and indoor air.

Background sources, particularly petroleum related, are ubiquitous in indoor air from many sources, including but not limited to, building products, cleaners, paints, automotive products, and tobacco uses. These background sources complicate evaluation of the vapor intrusion pathway. Narrowing the constituents of concern within indoor air reduced the potential for a false determination of a completed vapor intrusion pathway within the nearby residences.

Furthermore, our team worked with the regulatory agency and its technical expert to identify residences that were at the greatest risk due to:

(1) the proximity to the significant gasoline release or
(2) the building construction type.

This limited the collection of indoor air, crawlspace, and sub-slab soil vapor samples to eleven structures within the residential community.

Solution Helps Client Avoid Costly Mitigation and Investigation

Following collection of the samples within the eleven structures, a decision matrix was developed to segregate the structures into six potential behavior types. This decision matrix simplified evaluation of the vapor intrusion pathway for each structure.

Within each of the residences, the concentration of the constituents of concern were above the USEPA vapor intrusion screening levels. However, the source of these constituents was attributed to background sources in indoor and outdoor air and the vapor intrusion pathway was determined to be incomplete within each structure. This determination was supported by the multiple lines of evidence and decision matrix.

The regulatory agency and its technical expert quickly approved the findings of the expedited investigation. Our innovative approach helped our client avoid costly mitigation and prolonged investigation within the residential community. Our client was able to instead focus their efforts on reducing their long-term liability and recovering the significant gasoline release beneath the residential community.

Analytical Investigation of Soil Samples Identifies True Source of Mercury Contamination

Project at a Glance

- Elemental mercury levels exceed screening criteria across 700-acre facility
- Team linked presence of mercury to background source not related to historical operations
- Small soil sample collected to speciate mercury using six-step selective sequential extraction procedure
- Analysis linked mercury source to decommissioned power plant upwind
- Solution expedited redevelopment and avoided unnecessary corrective actions and costs.

Elemental Mercury Levels Exceeds Inhalation-Based Screening Criteria

Our client was in the final phases of corrective action at a 700-acre facility located outside Chicago. Final confirmation sampling conducted in accordance with the regulatory requirements identified that the concentration of elemental mercury exceeded the inhalation-based screening criteria across large portions of the facility. Gauges and meters containing elemental mercury were used at the facility; however, elemental mercury was not observed during demolition or restoration activities.

Innovative Extraction Procedure Solves Mystery of Mercury Levels

Our team determined that the presence of mercury across large swaths of the facility suggested a potential background source unrelated to historical operations. Mercury generally exists in one of three phases including elemental, inorganic, or organic. The presence of mercury can be from natural sources such as volcanic eruptions and forest fires or from anthropogenic sources such as burning of coal and fossil fuels.

We determined that the analytical laboratory that the client had selected was reporting total (elemental, inorganic, and organic) mercury concentrations within the final confirmation samples.

Through discussions with the regulatory agency, it was decided that a small, but representation number of soil samples would be collected across the facility to speciate mercury using a six-step selective sequential extraction procedure. This six-step process separated elemental mercury from other forms.

Analysis Connects Mercury to Upwind Power Plant, Avoiding Costs and Expediting Redevelopment

The analytical results indicated that elemental mercury was not present within any of the representative soil samples and therefore there was not an inhalation risk for future receptors on the facility. It was determined that the source of mercury was related to emissions from a decommissioned power plant located approximately 1-mile upwind of the facility, which explained the ubiquitous presence of total mercury across the facility.

Our findings resulted in expedited redevelopment and avoided unnecessary costs associated with additional corrective actions.