Understanding Soil Gas at Former Fort Ord

Frequently Asked Questions about Soil Gas and Soil Vapor Intrusion

1. What is soil gas or soil vapor and are there potential sources of soil gas at the Former Fort Ord?

Soil vapor, also known as soil gas, is the air found in the spaces between soil particles. The specific chemical composition of soil gas varies throughout the soil spaces, depending on a variety of conditions. Close to ground surface, the soil gas composition will be similar to ambient air. The composition will vary with depth from ground surface, as well as animal, plant, bacterial and fungal activity and other influences. The soil gas found near soil or groundwater contaminated with volatile chemicals can become contaminated when these chemicals vaporize or evaporate into the soil gas. Volatile chemicals are another name for Volatile Organic Compounds (VOCs) a class of chemical compounds which include chlorinated solvents such as trichloroethene (TCE) and tetrachloroethene (PCE) commonly used in dry cleaning and industrial processes as well as petroleum products such as gasoline from gas stations. Gases that are already in the gas or vapor phase, such as methane generated from landfills, can also contaminate soil gas.

VOCs that have historically been found at the Former Fort Ord include chlorinated solvents TCE and PCE found in the groundwater plumes of Operable Unit 1 (OU-1), Operable Unit 2 (OU-2), and Sites 2/12. The chlorinated solvent carbon tetrachloride (also called "carbon tet" or CT) is found in the groundwater plume at Operable Unit Carbon Tetrachloride Plume (OUCTP). Other VOCs have been found associated with buried wastes at the OU-2 Landfills. Methane is also generated at the OU-2 Landfill and has been found in soil gas within the boundaries of the landfill. With the exception of the OU-2 Landfill, VOCs have been removed from the soil through excavations at Sites 2/12 and OU-1 or through the soil vapor extraction at OUCTP. The Army continues to remove VOCs from the OU-2 Landfills through the current soil vapor extraction system. Therefore, the only potential sources of contaminated soil gas remaining at the Former Fort Ord would be the four groundwater plumes and the OU-2 Landfills. Each of these sites is discussed in more detail in Item 4.

The toxicity of the chemicals, or how harmful they are to people, determines the risk associated with contaminated soil gas and groundwater. The primary VOCs in groundwater at Former Fort Ord, TCE and CT, are toxic and therefore present a potential risk to humans. The degree of risk depends on the concentration, length of time of exposure and other factors. This potential risk is assessed in great detail in remedial investigation/feasibility studies and is what drives the cleanup of these chemicals at the Former Fort Ord.

2. What is soil vapor intrusion?

Soil vapor intrusion refers to the process of contaminated soil gas entering buildings through cracks in slabs, basement floors and walls, or where pipes and electrical wires go through the foundation. Heating, ventilation or air-conditioning systems may reduce the air pressure inside, drawing soil vapor into buildings. If soil gas is contaminated and enters a building, the air quality inside the building may be affected. The risk to human health from soil vapor intrusion depends on the concentration and type of compounds the soil vapor contains. If contaminated soil gas reaches the ground surface where there are no buildings, the soil gas disperses into the atmosphere, mingling with ambient air and having little or no effect.

3. What factors determine the probability of soil vapor intrusion occurring?

Several factors affect how contaminated soil gas travels through ground surface and possibly into buildings. These factors include the following:

- The volatility of the chemicals, or how easily the chemicals can evaporate, greatly influences how much contaminated soil gas is generated from the source. VOCs such as chlorinated solvents are volatile and may create contaminated soil gas at large distances from the sources of contamination (for example, contaminated soil or a contaminated groundwater plume). The distance or depth between the source of contamination and occupied buildings determines if the there is a possibility for contaminated soil gas to enter. Shallow contamination such as releases from surface spills of chemicals or underground storage tanks pose the greatest possibility for soil vapor intrusion since the contamination can be very close to buildings. The shallow soil contamination has been cleaned up at the Former Fort Ord remedial sites; only contamination in groundwater remains. Fort Ord's remaining groundwater contamination is much deeper (usually more than 100 feet below ground surface) and therefore poses less of a potential of soil vapor intrusion occurring since the source of contamination is far removed from the buildings. According to guidance documents from the Environmental Protection Agency (EPA) and the California Department of Toxic Substances Control (DTSC), soil vapor intrusion is possible when buildings are located within 100 feet of a source of chlorinated solvents. This guidance is explained in the DTSC *Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (Vapor Intrusion Guidance),* http://www.dtsc.ca.gov/AssessingRisk/upload/Final_VIG_Oct_2011.pdf. Therefore, the possibility of soil vapor intrusion should be considered in locations at the Former Ford Ord where contaminated groundwater or soil is present both at depths less than 100 feet and under occupied buildings.
- The concentration of chemicals, or the amount of the chemicals, left in soil or groundwater will determine how much soil gas can be generated from the contamination source. Higher contamination concentrations produce larger amounts of contaminated soil gas as compared to lower contamination concentrations. At Former Fort Ord, while the groundwater plumes may be somewhat large in area, they are low in concentration as illustrated by the annual and quarterly groundwater monitoring reports.
- The depth of contamination within the aquifer itself can also determine if contaminated soil gas will be generated. The chemicals that have contaminated the groundwater at the Former Fort Ord have slightly different densities than water, and therefore do not distribute evenly with depth in the aquifers. As the contaminated groundwater flows further from the source of contamination, the chemicals tend to migrate deeper into the aquifer due to groundwater flow leaving the top of the aquifer relatively clean. Other factors, such as local variation in groundwater flow, may also affect where contaminant molecules are located within the aquifer itself. The top of the aquifer, where the soil spaces filled with water contact the soil spaces filled with air, is where soil gas is generated. Places where the top of the aquifer contains clean water would not generate contaminated soil gas as the clean groundwater on top of the contaminated water acts like a barrier keeping the VOCs from evaporating upward into the soil gas above the groundwater. At the Former Fort Ord, groundwater samples are collected from monitoring wells using passive diffusion bags (or PDBs) which allow for samples to be collected from various depths within the same well. Data collected from the placement of multiple PDBs in the same well have confirmed that contaminant concentrations vary with depth into the aquifer, and, specifically, that the maximum

concentrations are found several feet down into the aquifer but the upper most portion of the aquifer (where soil gas would be generated) typically contained no detectable concentrations of contaminants.

4. How is the potential for soil vapor intrusion assessed?

To assess the possibility of soil vapor intrusion at each of the remedial sites, we will ask the following questions in order:

a. **Are VOCs or gases present in soil or groundwater at the site?** If the answer is yes then we will continue to evaluate for the potential for soil vapor intrusion. If the VOCs have been removed from soil, as is the case with the Former Fort Ord remedial sites except the landfill, we will then look at the possibility of soil vapor intrusion occurring from the contaminated groundwater.

b. **Are occupied buildings located over or near the VOC contamination?** If no buildings are present over the VOC contamination such as areas in undeveloped areas or nature preserves, soil vapor intrusion could not currently occur. However, we must also include the planned reuse of the area and assess whether soil vapor intrusion could occur in areas where development is planned.

c. **For sites where groundwater is contaminated, is the groundwater less than 100 feet in depth?** According to the EPA and DTSC guidance, soil vapor intrusion is not a concern where contaminated groundwater containing chlorinated solvents is deeper than 100 feet below ground surface since the soil gas cannot travel to the ground surface from that depth. If VOCs are present in groundwater shallower than 100 feet, we will continue to evaluate for the potential of soil vapor intrusion.

d. **Has data been collected to show that the top of the aquifer where soil gas could be generated is not contaminated with VOCs?** Using the data from groundwater monitoring with PDBs, the depth of contamination can be determined and the top of the aquifer can be evaluated. If no contamination is found in groundwater at the top of aquifer, contaminated soil gas cannot be generated and soil vapor intrusion could not occur.

e. **Has soil gas either been sampled or modeled to estimate that the amount of soil gas that could be present in occupied structures?** By using either groundwater data or data from soil gas samples, calculations can be made to determine how much contaminated soil gas could enter a structure. The most common calculation which is accepted by both the EPA and DTSC is called the Johnson-Ettinger (or JE) model. The depth to contamination, concentration of contamination, soil type, and other site-specific parameters are entered into the model to estimate the potential concentration of VOCs inside a building from the contaminated groundwater. This calculated concentration is then compared to screening values established by EPA and DTSC to determine if the concentration of soil gas in the building is a potential concern.

5. Is soil vapor intrusion a concern at the Former Fort Ord remedial sites?

The possibility of soil vapor intrusion has been carefully evaluated at each of Former Fort Ord remedial sites that have been contaminated with VOCs. Each of these sites is discussed in detail below:

- **Operable Unit 1 (OU-1):** VOCs in soil at OU-1 have been removed through excavation of the Former Fire Drill Area and currently only remain in the groundwater plume which is contaminated with TCE. The current extent of the groundwater plume is shown in the *2010 Annual and Third Quarter Groundwater Monitoring Report, Operable Unit 1, Fritzsche*

Army Airfield Fire Drill Area (AR No. OU1-588). The property above the groundwater plumes resides completely within the Ford Ord Nature Reserve (FONR) where no buildings are present. This land will remain part of the FONR in perpetuity and no buildings will be constructed. The groundwater plume is expected to be cleaned up in the next few years. Since no buildings are present over the groundwater plume or within 100 feet of the boundary of the plume, the possibility of soil vapor intrusion does not exist at OU-1.

- **Operable Unit 2 (OU-2) Groundwater Plume:** The groundwater plume contains TCE and other chlorinated solvents and originates at the OU-2 Landfills extending north and west across Imjin Parkway under a planned residential area with small pockets of contaminated groundwater further west. The depth to contaminated groundwater and the concentrations at the top of the aquifer are used to determine if soil vapor intrusion is a concern from the OU-2 groundwater plume.
    - The depth to groundwater in the area where the groundwater plume leaves the OU-2 Landfills extends from 110 to 130 feet, much deeper than the EPA's identified depth of 100 feet.
    - A small pocket of the groundwater plume near California Avenue is shallower in depth at around 65 to 70 feet deep. However, results from the groundwater monitoring with the PDBs have shown the upper most part of the aquifer is not contaminated and the detected amounts of TCE are only found in deeper parts of the aquifer separated from contact with air-filled soil spaces by uncontaminated groundwater. This is demonstrated from the groundwater data collected from monitoring well MW-OU2-04-A. The top of the aquifer was found to be clean when samples were collected at varying depths from this well during the groundwater sampling events in 2001, 2002, and 2003 as documented in the annual reports of groundwater monitoring from the corresponding years (AR Nos. BW-2165B, BW-2218H, and BW-2277).
    - The other pocket of the OU-2 groundwater plume near the Western Network of extraction wells near 3rd Avenue is located at depths of approximately 105 to 110 feet in depth.
    - As the groundwater plume has migrated from the original contamination source, the OU-2 Landfills, the VOCs have mixed in the aquifer through dilution and dispersion resulting in a large but relatively low concentration plume. Concentrations of TCE in groundwater do not typically exceed 25 micrograms per liter (parts per billion) in the groundwater plume. This low concentration of VOCs limits the amount of contaminated soil gas generated combined with the depth to groundwater which would limit the possibility of soil vapor intrusion occuring.

  Since the OU-2 groundwater plume is found at depths exceeding 100 feet in depth for the majority of the plume and with clean groundwater on the top of the aquifer where the aquifer is shallower, the possibility of soil vapor intrusion is not a concern for areas overlying the OU-2 groundwater plume.

- **Operable Unit 2 (OU-2) Landfills:** Both VOCs and methane have been found in soil gas within the boundaries of the OU-2 Landfills. As with all landfills, the decay of organic waste produces gases, primarily methane. Over time, as the wastes continue to decay, less methane will be produced and eventually production will decline to near zero. While methane

gas has little toxic effect, at levels of 5% to 15% in air, methane can be ignited and could endanger landfill workers and nearby residents.

State regulations require that landfill gases be monitored at the property boundary. In compliance with regulations, the Army installed underground probes to monitor the landfill gas. Measurements indicated that the methane in the soil at the edges of the landfill was higher than state standards (5%) on one side of one landfill cell known as Area F. In response, the Army installed a landfill gas collection system adjacent to the landfill near the closest residences, California State University Monterey Bay housing. The system has since been expanded and draws methane and other gases from various landfill locations then transports the gas to a thermal treatment facility where the gases are destroyed through thermal treatment. This process also reduces the concentration of the VOCs found in soil gas at the OU-2 Landfill which prevents the additional VOCs from migrating into the groundwater. Without the continuing addition of VOCs to groundwater, the time required to clean up the groundwater is likely to be reduced although specific estimates are difficult.

Monitoring of permanent gas wells located around the perimeter of the landfill confirms that methane and VOCs are not migrating outside the boundary of the OU-2 Landfill. The most recent monitoring data from these wells is found in the *Annual Report, 2010, Operations and Maintenance, Operable Unit 2 Landfills (*AR No. OU2-682).

Contaminated soil gas is contained within the boundaries of the OU-2 Landfill and does not extend offsite where buildings are present, demonstrating that soil vapor intrusion from the landfill is not occurring. Continuing to operate the landfill gas collection system will prevent soil vapors from migrating offsite.

- **Operable Unit Carbon Tetrachloride (OUCTP):** OUCTP includes a groundwater plume contaminated with CT that was suspected to originate from surface disposal/spills near the current Lexington Court area in Marina. The contaminated soil in the source area represented a potential source of soil vapor intrusion by upward migration into the buildings and a continuing source of groundwater contamination through downward migration into the aquifer. The Army conducted a soil gas sampling program which included collection of soil gas and indoor air samples as well as air samples from below foundation slabs in one house in the source area. Results from the sampling showed no increase of VOC concentrations in sub-slab or indoor air samples as compared to ambient air. The Army then installed a soil vapor extraction and treatment system in the suspected source area. The Army's cleanup actions successfully removed the carbon tetrachloride from the soil and soil gas in the area; although some low concentrations remained in the soil gas close to the top of the aquifer. Furthermore, the low concentrations in the soil gas and groundwater indicate the groundwater is not a source for soil vapor intrusion. For the remaining groundwater plume, the depth to groundwater, concentration at the top of the aquifer, and soil gas modeling were all used to evaluate the potential for soil vapor intrusion.
    - The current groundwater plume extends from the former source area near Lexington County north under the FONR and then west along Reservation Road to the boundary of the City of Marina. Depth to groundwater near the former source area and south of Reservation Road is approximately 65 to 80 feet. The concentration of CT at various depths was evaluated to determine if groundwater mixing has occurred downgradient of the source which would leave the top of aquifer uncontaminated. Clean groundwater was been found on the top of the aquifer in monitoring wells MW-BW-24-A, MW-BW-52-A, MW-BW-53-A, and MW-BW-71A in this area.

This is documented in the annual groundwater monitoring reports from 2001, 2002, 2003, 2004, 2006, and 2007 when shallow data was collected (See AR No. BW-2165B, BW-2218H, BW-2277, BW-2333C, BW-2324F, and BW-2460D).

- In the areas where the plume extends under the FONR, no buildings are present and therefore soil vapor intrusion could not occur.
- In the area where the OUCTP plumes extends offsite under a portion of the City of Marina, concentrations of CT in groundwater are very low, less than 1 part per billion in groundwater which is not a significant source of contaminated soil gas. However the depth to groundwater is relatively shallow from 25 to 50 feet deep. The OUCTP plume is present below occupied residences and commercial buildings.
    - Groundwater data collected from the top of the aquifer in this area has shown that the top of the aquifer in this area does contain low concentrations of CT. Therefore additional evaluations were necessary to determine the potential for soil vapor intrusion.
    - In order to assess the potential for soil vapor intrusion in this area, soil vapor intrusion modeling was completed using the Johnson-Ettinger model using site-specific data to evaluate groundwater in the offsite area. This is documented in Appendix V of the Remedial Investigation/Feasibility Study (AR No. OUCTP-0011P). The results of the modeling showed that soil vapor intrusion potentially could occur in this area but at very low concentrations. It is likely that the J & E model's estimate is high, since the actual average concentration of CT in the OUCTP area is half that used in the model. The OUCTP is under remediation which will reduce concentrations of CT within the next ten years.

- **Sites 2/12:** The Sites 2/12 groundwater plume is currently contaminated with TCE and PCE that originated from runoff into nearby soils from a Former Fort Ord motor pool. Soil gas sampling conducted in 1993 as part of the original site investigation identified very low concentrations. The contaminated soil was excavated in 1998. Soil testing showed that the area was clean and the excavation was backfilled. A groundwater treatment plant was constructed in 1999 and continues to operate. Significant grading of the top 15 feet of soil was conducted for the current shopping center development, and no residences are planned for the area of concern.
    - The depth to groundwater in the Sites 2/12 groundwater plume is approximately 65-75 feet deep. Since the depth is less than 100 feet, the depth of contamination within the aquifer and concentration of VOCs at the top of the aquifer is evaluated.
    - The depth of contamination in the Sites 2/12 area has been found to be located 40 to 50 feet deeper than the top of the aquifer in this area. Data over the past 15 years from groundwater monitoring and extraction wells in the area have also shown very low or non-detect concentrations at the top of the aquifer. Based on these results we would not anticipate soil vapor intrusion would occur.
    - Recent groundwater monitoring results in June and September, 2011, identified increased concentration levels of TCE and PCE in groundwater. As part of the Army's continuing responsibility to monitor site conditions, additional assessment of the situation is warranted to assess potential for elevated soil gas concentrations to

occur in the area. The Army will provide additional information during the January 2012 Community Involvement Workshop.

The remaining remedial or cleanup sites at the Former Fort Ord are related to the investigation and removal of Munitions and Explosives of Concern (MEC) or removal of Munitions Constituents (MC), neither of with contain VOCs or would be considered a potential source of soil vapor intrusion.

6. How is soil gas typically monitored and what is the data used for?

Soil gas is typically monitored by the collection of soil gas samples that are collected from either permanent soil gas wells or temporary soil borings. The use of permanent soil gas wells allows for soil gas monitoring on a periodic basis from the same location and depth to evaluate soil gas over extended periods of time. The use of temporary soil borings to collect soil gas samples allows for a one-time "snapshot" of the current soil gas concentrations. To collect soil gas samples, tubing is connected to the soil gas wells or connected to piping that has been driven into the ground in a soil boring. Soil gas is then drawn into containers (typically stainless steel vacuum sampling devices called Summa canisters, Tedlar bags, or glass syringes) with pumps or a vacuum. These containers are then shipped or delivered to laboratories specially equipped to analyze for VOCs in the soil gas. The laboratory used must be certified by the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) or National Environmental Laboratory Accreditation Program (NELAP). Both of these accreditations are based upon International Organization for Standardization (ISO) / International Electrotechnical Commission (IEC) international standard 17025. The ISO and IEC are international organizations that develop standards for many processes. This standard focuses on the general requirements for laboratory accreditation and guidance for the laboratory's approval to do work. For more information you can visit the ISO web site at http://www.iso.org/iso/home.htm and the NELAP website at:http://www.nelac-institute.org/newnelap.php.

The results from collection and analysis of soil gas samples can be used for assessing the potential for soil vapor intrusion, for helping to identify the location of potential sources of contamination, and for long-term monitoring of soil gas sources such as landfills. Typically assessing for the potential of soil vapor intrusion and the location of potential sources of contamination is done by collecting soil gas samples from temporary borings. Long-term monitoring typically uses permanent soil gas wells.

7. How is soil gas monitored at the Former Fort Ord?

Soil gas samples have previously been collected during the Remedial Investigations at OU-1, OUCTP, OU-2 and Sites 2/12 to assist in determining the location and extent of contamination in both soil and groundwater at each of these cleanup sites. The soil gas samples were collected from temporary soil borings. As discussed earlier, soil gas samples were also collected from OUCTP in the source area to evaluate if soil vapor intrusion would be a concern from the contaminated soil and groundwater.

Since soil vapor intrusion was found not to be a concern at the cleanup sites except possibly at Sites 2/12, soil gas is not routinely monitored at the former Fort Ord, with the exception of the OU-2 Landfills. The collection of soil gas samples at the OU-2 Landfill is conducted to meet a regulatory requirement as well as to monitor operation of the landfill thermal treatment plant. The Army is currently evaluating if additional groundwater or soil gas data is necessary at Sites 2/12 to further assess the potential for soil vapor intrusion.