Remember the Titan
TCE Contamination from the Former Missile Site in Lincoln, California

by Lenny Siegel
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In the early 1960s, the U.S. Air Force deployed 54 liquid-fueled Titan I intercontinental ballistic missiles at 18 sites in 6 states. One such site was in Lincoln, California, about 20 miles northeast of Sacramento. At the time Lincoln had little more than 3,000 residents. Today, a groundwater plume of trichloroethylene (TCE), left over from missile system maintenance, threatens Lincoln's growing community of over 50,000 people.

History

The 46-acre Lincoln Titan site, associated with nearby Beale Air Force Base, went operational in 1962 and shut down in 1965. Each month, Air Force personnel in underground bunkers would lift one of three two-stage 98-foot-long missiles from its 160-foot-deep silo above ground and fill its tanks with RP-1 (a kerosene-like fuel) and liquid oxygen before emptying the tanks and returning the missile to its hardened, subterranean hiding place. Each time they flushed its fuel tanks with TCE, the universal solvent known to increase the risk of several forms of cancer, cardiac birth defects, and neurological disease such as Parkinson's, even at low levels of exposure, through both inhalation and ingestion. It appears that they released the TCE directly onto the ground where it penetrated down to the twenty-feet deep water table.

Crocker Hills Development Site, with Sun City Lincoln Hills in the Distance

Today, measured by the five-part-per-billion groundwater isopleth, the TCE plume appears to cover some 25 to 30 acres, mostly to the south and west of the actual missile installation. It underlies two large properties planned for housing development, posing a

risk of *vapor intrusion*, and it is slowly approaching Sun City Lincoln Hills, a Del Webb retirement community of nearly 6,800 homes built at the turn of the 21st Century.

In 1968 the Federal government transferred the surplus property to Placer County, which used portions for a fire station, maintenance yard, a pistol range, and a skeet range.

In 1991, an investigation at an adjacent private property uncovered TCE in groundwater at nearly 500 ppb, triggering an Army Corps of Engineers (USACE) response under the Formerly Used Defense Sites program.

> In June 2001, the USACE began operation of a small-scale pilot groundwater extraction and treatment system. The extraction system was composed of four extraction wells, two 50-foot-long extraction trenches, and one 200-foot-long extraction trench. The groundwater extraction pilot test operated for approximately three years (26 June 2001 to 26 June 2002 and 1 January 2003 to 21 December 2004) over which time approximately 10 pounds of TCE was removed from the extracted groundwater.[1]

The Corps also conducted small-scale tests of soil vapor extraction, *in situ* chemical oxidation, and *in situ* bioremediation.

In 2007, Brown and Caldwell completed a feasibility study (FS) for the Army Corps. It evaluated five remedial alternatives in addition to "No Action," but it did not select a preferred alternative because it concluded that the Corps was not the responsible party and thus would not be selecting the remedy. The report stated, "Very late in the FS, USACE determined that the DoD [Department of Defense] is not the responsible party for TCE and related VOC [volatile organic compound] contamination in groundwater, but finalized the FS report to document the study."[2]

Though today the Defense Department accepts responsibility for cleaning up the TCE at the site, its assertion was not entirely implausible. The greatest concentrations of TCE have always been found near and downgradient from the Placer County maintenance buildings.

In response to Water Board comments, Brown and Caldwell evaluated an additional alternative in 2008, based upon the installation of two permeable reactive barriers (PRBs) beyond the edge of the former Defense site. This alternative included the excavation of two trenches, 400 feet long and 655 feet long. Each trench would have been filled with sand and granular iron. The TCE in the groundwater would react with the iron as it flowed

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[1] "Groundwater Remedial Action Plan," Central Valley Regional Water Quality Control Board, August 5, 2009, p. 2 (https://geotracker.waterboards.ca.gov/view_documents?global_id=T0606189198&document_id=5647920) The Army Corps estimates that somewhere around another 10 pounds of TCE remain in the subsurface, but I find it hard to believe that the quantity of routine releases was not significantly greater.

[2] Brown and Caldwell, "Feasibility Study Report," U.S. Army Corps of Engineers, April 2007, p. 1-1 (https://geotracker.waterboards.ca.gov/view_documents?global_id=T0606189198&document_id=5632596)

through the trenches, degrading into harmless substances. Contamination not caught and treated by the barriers would be assumed to degrade through natural processes.

In December 2008 the Water Board selected the PRB-based remedial action plan as the preferred alternative, but it was never implemented because the potentially responsible parties (PRPs), the Army Corps and Placer County, could not agree upon their respective responsibilities. Meanwhile, the TCE plume continued to spread to the southwest, at the reported rate of 11 feet per year. The preferred alternative included the institutional control that all buildings above the plume be underlain with vapor barriers.

In March 2010 the Water Board sought a meeting with the PRPs, but I have found no follow-up in the public record until July, 2017, when the Water Board sent Notices of Intent to Issue a Draft Cleanup and Abatement Order to both parties. Those orders were never issued. The Water Board told the *Lincoln News-Messenger* that there is a voluntary agreement between the Corps and the Water Board, but no such agreement has been made available to the public. In March 2023 the Water Board issued a fact sheet explaining that the Army Corps had accepted responsibility for addressing the TCE contamination while Placer County had agreed to clean up the shooting-range lead on the former Titan site.[3]

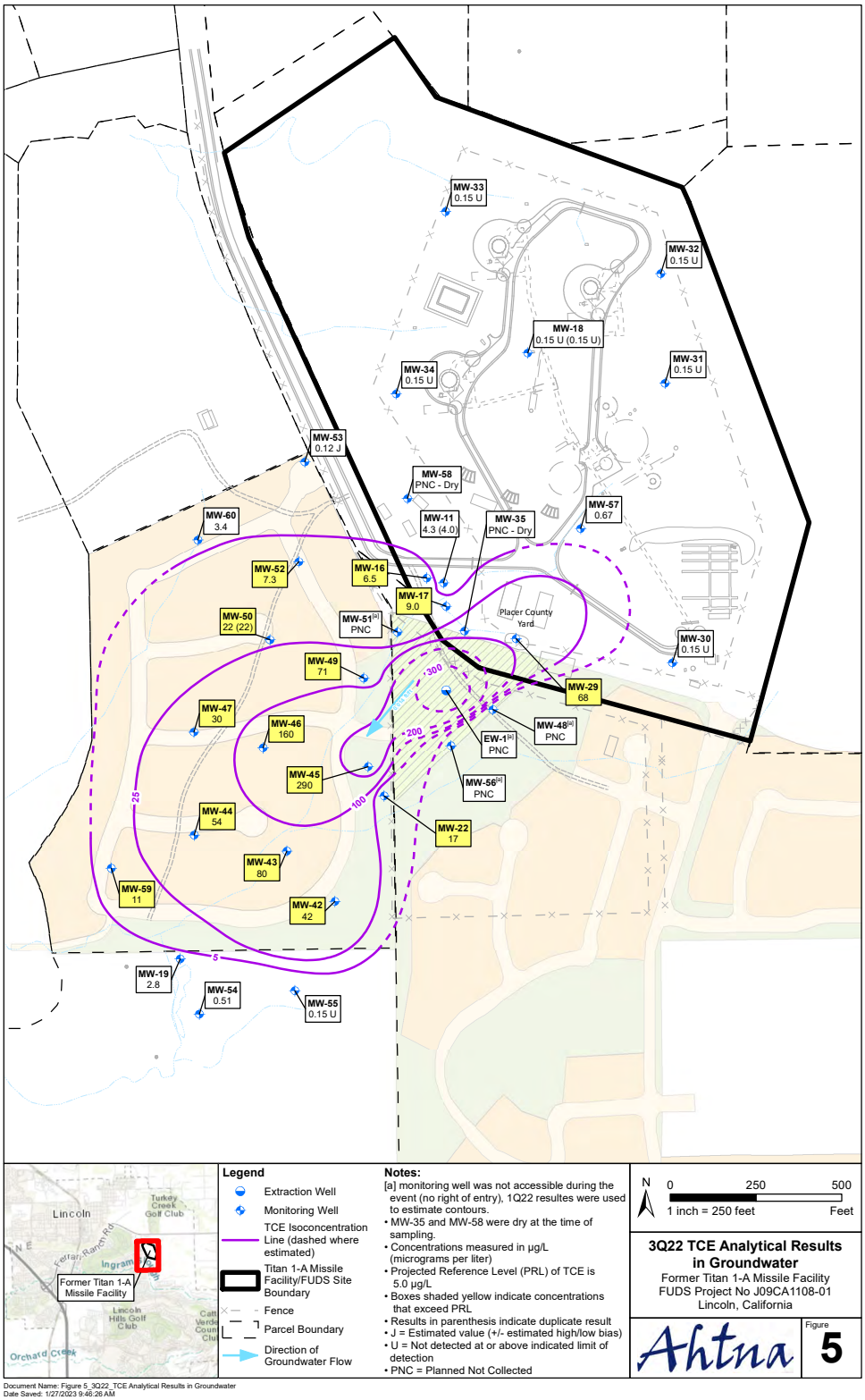
Groundwater

Indeed, the Army Corps is now taking the site seriously. Its consultant, Ahtna, has issued a series of monitoring reports, updating the groundwater and soil gas[4] contamination data on and near the former Defense site. Ahtna states that the plume is moving toward the southwest at a rate of 11 feet per year. The TCE contour maps included in those reports clearly show the groundwater contamination moving slowly toward Sun City Lincoln Hills, but those maps are inexact. There are insufficient monitoring wells on the near the Sun City boundary to reliably draw TCE contour lines between those wells.

The Water Board's assurance that no one is currently being exposed to the TCE is valid, because no one is drinking the groundwater at the site and the soil gas contamination has not been detected under existing buildings. But its insistence that the TCE plume is "relatively stable and not moving" is not borne out by the sampling results. Unless something is done to again address the TCE plume—as the Army Corp did at the beginning of the century, the TCE-contaminated groundwater will make its way under Sun City homes, creating a risk of unacceptable vapor intrusion and threatening the property values—the life's savings, in many cases—of homeowners both near and well beyond the plume. Vapor intrusion occurs when volatile substances such as TCE in the subsurface are pulled into overlying buildings by the lower air pressure inside.

[3] Central Valley Regional Water Quality Control Board, "Public Notice Fact Sheet: Former Titan 1A Missile Facility," March, 2023, (https://geotracker.waterboards.ca.gov/view_documents?global_id=T0606189198&enforcement_id=6533028)

[4] Soil gas refers to gases embedded in soil between the water table and the surface of the land.



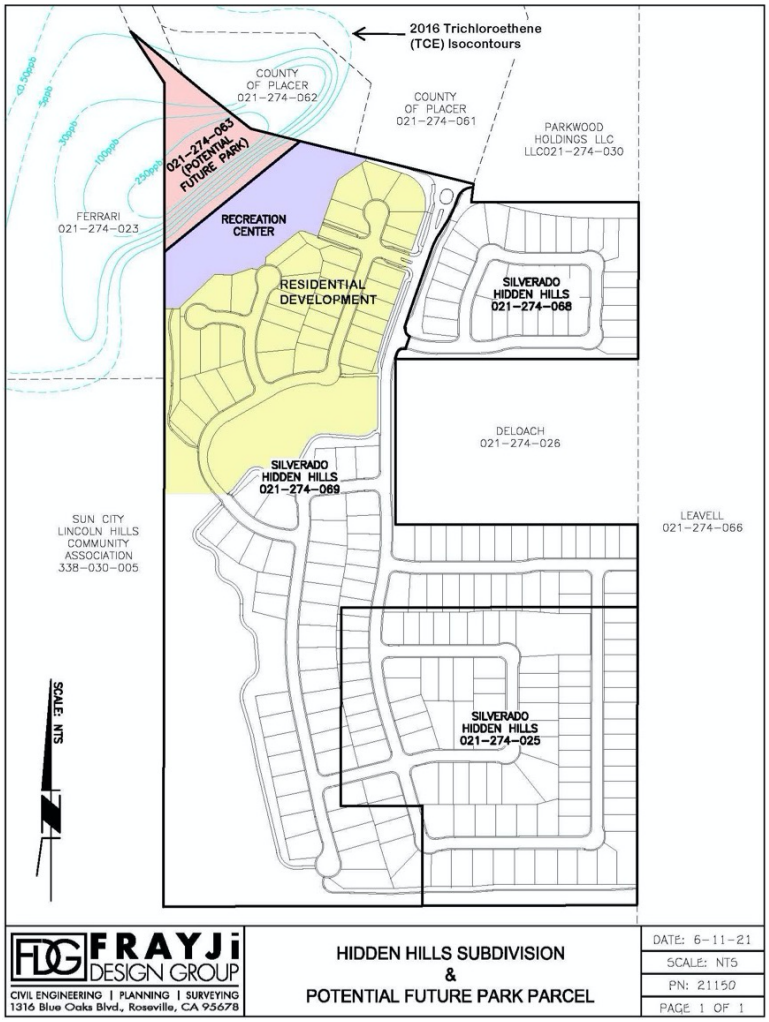
TCE Groundwater Plume on the Edge of Sun City Lincoln Hills (to the West)

Development

Lincoln is one of the fastest growing cities in the U.S. With home prices a fraction of comparable houses in the Bay Area, it's an attractive location for retirees and other "refugees" from California's urban centers. I've been told that Del Webb avoided including properties adjacent to the Titan site in Sun City, but for more than 10 years other developers have been preparing to build homes at Hidden Hills, just to the south of the Defense site, and Crocker Knoll, to the southwest.

Hidden Hills

Reportedly, Hidden Hills is about to break ground to build a gated community with 235 homes. The upper corner of Hidden Hills contains the heart of the TCE groundwater plume, so the owners plan to dedicate those 3.4 acres as a city park, to be linked eventually to a larger park at the Titan missile site. Vapor intrusion is not an issue there because vapor intrusion occurs only where there are buildings (with lower air pressures than the subsurface vapor pressures) to pull up toxic vapor from below.



The Colored Areas Represent Different Vapor Mitigation Responses

Next to the parkland is a band designated as the Recreation Center. The developers have agreed to install vapor barriers and sub-slab venting—that is, passive sub-slab depressurization—to prevent any TCE from entering any buildings in that section.

The owners/developers have also agreed to install vapor barriers in the new homes near the Recreation Center. And therein lies the rub. California guidance on mitigating vapor intrusion—that is, prevent exposure to toxic gases rising from the subsurface—is clear that in new buildings even the best vapor barriers must be supplemented by active or passive depressurization system. Reading between the lines in the available documents, it appears that barriers without systems have been approved by the Water Board because they are essentially voluntary, not required. They are not required, apparently, because there is scant evidence of elevated levels of TCE in groundwater or soil gas on that portion of the Hidden Hills property.

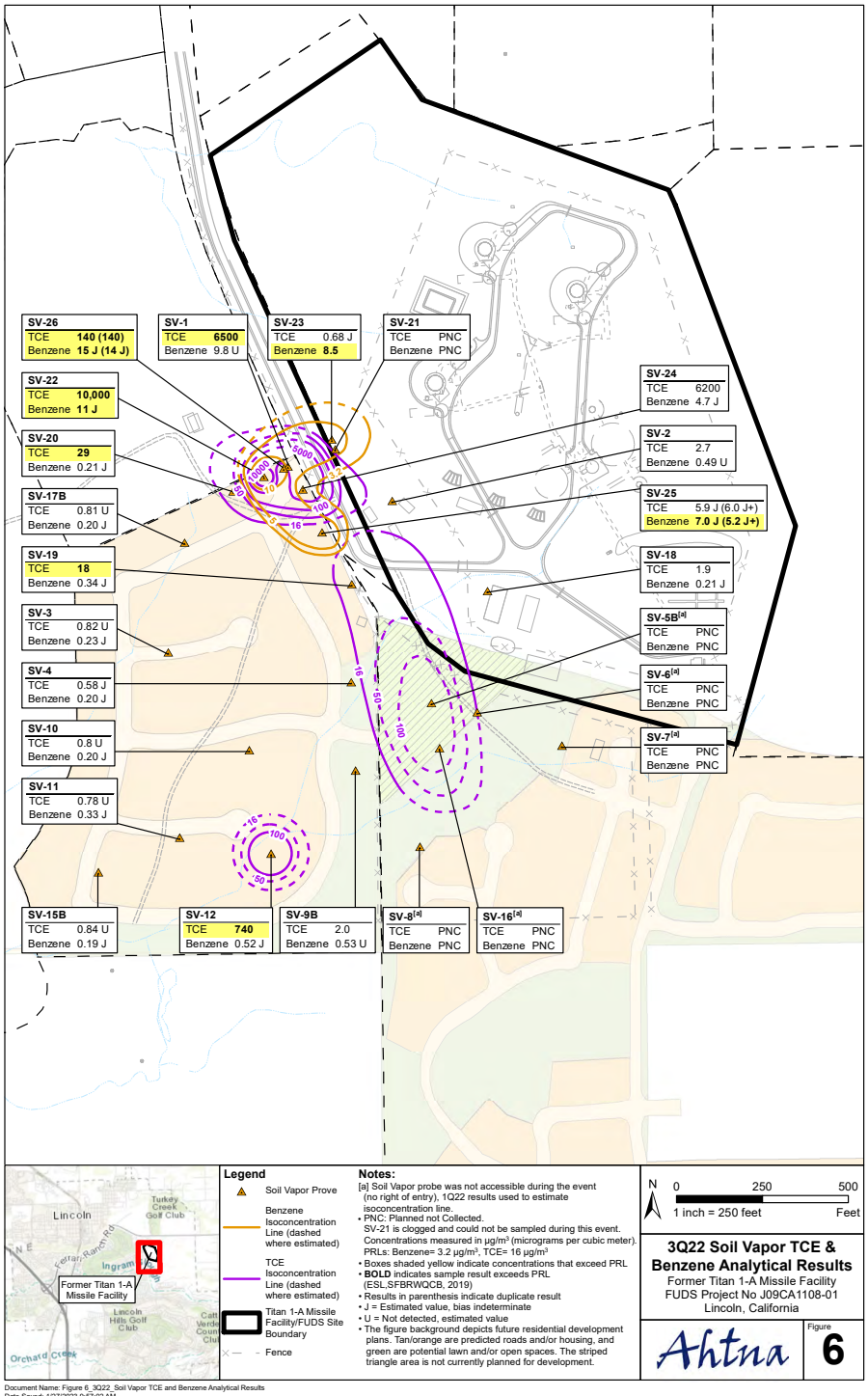
However, reviewing publicly available sampling data, I have concluded that the absence of evidence of TCE at the residential section does not meet the threshold of evidence of absence. TCE may be slowly flowing through the property, but the only groundwater monitoring wells are in the northeast corner. The extent of TCE in soil gas—the principal source of vapor intrusion—has not yet been delineated. In 2022, Ahtna, the Army Corps' contractor, proposed two new soil vapor monitoring points for exactly that purpose, but I have seen no indication that they were ever emplaced.

With the developer about to start building, there is little time to ensure that future residents will safe from TCE vapor intrusion. Either additional groundwater and soil gas sampling must be conducted and analyzed before construction, or the new homes should be built with reliable but inexpensive vapor mitigation systems, backed up with a robust long-term management plan to ensure that residents are protected as long as TCE or its daughter products remain at the site.

Crocker Knoll

Much more sampling has been done on the Crocker Knoll property, which lies downgradient from the TCE plume source area—that is, to the southwest. In 2009, Stromer Realty bought the property and hired AEG to sample TCE soil vapors on the site. AEG found significantly elevated levels at two sampling points, and subsequent sampling continues to confirm those findings, well above today's Water Board screening levels. AEG recommended implementation of the 2009 groundwater remedy, avoidance of the TCE soil gas hotspot at the northern tip of the property, and vapor barriers for all new homes. In 2015 the Water Board agreed with the mitigation recommendation, clarifying that venting systems would be required in addition to vapor barriers, and that a long-term site management plan would be needed.

Investigators believe that the TCE found in soil gas at the Titan site has volatilized (evaporated) from the groundwater, but the TCE soil gas hot spot at the northern tip of the property is not matched by high levels of TCE in groundwater at that location. In 2022 Ahtna speculated that a utility trench was acting as a preferential pathway, and it took additional nearby samples. It's also possible that soil from the Titan site was carted across



Two Soil Gas Hotspots at Crocker Knoll
Have TCE Levels Far Above the 16 µg/m³ Screening Level

Oak Tree Lane, bringing with it TCE contamination. Thus far, the results from the new sampling points are inconclusive.

There is another hotspot at SV-12, a sampling location in the southeastern quadrant of the property. When sampled, it consistently shows high levels of TCE in soil gas, but it does not show up on some of the quarterly soil gas maps because high groundwater levels prevented the taking of samples.[5] The existence of this hotspot, with no explanation, suggests the need for denser sampling throughout the Crocker Knoll. There may be other, thus far undetected, soil gas hot spots.

There has been no progress in the development of the Crocker Knoll, but Ken Long, the developer with an option on the property—and who lives in Sun City—has said that he does not intend to build until he can be assured that the residents will be safe.

Activism

Though the Water Board had placed many site documents on its Geotracker web site, until summer of 2022 most local residents knew nothing about the TCE or even the existence of the Cold War missile site nearby. At that time, a retired law enforcement officer—Anne Constantin Birge—living in Sun City Lincoln Hills started asking questions. She quickly amassed a library of documents, and she shared her information with Carol Feineman, a Sun City neighbor who is editor of the local paper, the *Lincoln News-Messenger*. Feineman had a personal interest: She lives a stone's throw from the Titan TCE plume.

On January 19, 2023, Feineman blew the lid off the story with her exposé, "Lincoln's Defunct Missile Site Contamination Has Spread."[6] That led to a series of public meetings, the largest of which took place mid-day March 8 at a Sun City community center. I was among the panelists addressing a crowd of about 500 local residents, with another hundred connecting via Zoom. People were concerned about the risk to both health and property values associated with the TCE in their neighborhood.

The press coverage and public outcry have earned the attention of elected officials as well as the Water Board and Army Corps. The Army Corps sent a mailing to 450 Sun City households, promising to conduct community outreach. It is considering the formation of a Restoration Advisory Board, which it is obligated to do under Defense Department guidance. Plenty of local residents have volunteered.

But the Corps does not expect to have an approved remediation plan until 2026. After more than a decade of inaction, that's not soon enough. More sampling is needed, but there is enough data to develop an interim remedy to stanch the migration of the plume toward Sun City. When the Corps operated a pilot pump-and-treat system in the early 2000s, that reduced the size of the plume. Something similar, or perhaps an innovative technology, could be employed now while investigators resolve the extent of soil gas

[5] Research shows that fluctuations in the water table level are a key factor in the release of volatile organic compounds such as TCE from groundwater into soil gas.

[6] https://goldcountrymedia.com/news/261443/lincolns-defunct-missile-site-contamination-has-spread/

contamination. California law requires that action be taken to protect groundwater, even if it is not currently serving as a public water supply.

Hundreds of Residents Attended the March 8, 2023 Community Forum

My Recommendations

There is still an opportunity to address the TCE contamination before anyone is exposed to unacceptable levels. I recommend:

- The Army Corps should establish a Restoration Advisory Board (RAB) to regularly inform the public about investigation and cleanup progress and hear public concerns and suggestions. The Water Board and local agencies should participate.
- The RAB should be offered independent technical assistance to promote constructive community engagement.
- More sampling should be conducted at Hidden Hills, Crocker Knoll, and the St. Joseph's Catholic Church property to delineate the contamination, understand the sources of soil gas hotspots, and study the fate and transport of the TCE and other volatile organic compounds.

- All development on or near the TCE plume should have complete mitigation (venting) systems, not just vapor barriers. It's common to install passive sub-slab depressurization systems during construction with an option to go active—that is, install a blower fan—if elevated levels of TCE are found.
- The Army Corps should quickly implement an interim remedy to halt the continuing migration of the TCE plume.
- In consultation with the impacted community and other property owners, the Army Corps should accelerate its timetable for removing or treating the TCE contamination and protecting residents from residual exposure.

It is the obligation of the U.S. government—indeed, any polluter—to clean up after itself. The Lincoln Titan TCE plume is not among the worst contamination sites in the country, but it still poses a long-term threat to public health. Fortunately, no one has yet been exposed to TCE-contaminated water or vapor. That means there is time to be protective, but after the abandonment of an approved cleanup plan in 2009, it's past time to take action.

Neighborhood in the Path of the Titan 1A TCE Plume