SANTA SUSANA

FIELD LABORATORY–GROUNDWATER INVESTIGATION

As a result of past rocket-engine testing and energy research, chemicals seeped into the soil and groundwater of the Santa Susana Field Laboratory site. The primary groundwater contaminant is trichloroethylene (TCE), a common industrial solvent. TCE was used in the early years at the lab to clean out residual fuel after rocket engine testing and degrease parts and equipment.

In 1984, Rocketdyne, the previous owner of the property, began an extensive investigation and cleanup program to identify and prevent the spread of groundwater that was contaminated by past industrial activity. Groundwater investigation efforts at Santa Susana also have been conducted over several decades by the US Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA). This work has been performed under the oversight of the California Department of Toxic Substances Control (DTSC).

Since 1996, Boeing has received input and guidance on its groundwater investigation from the **Santa Susana Groundwater Advisory Panel**, which is made up of renowned groundwater experts (for more information see page 2). Under their direction, several new techniques were developed to examine the fractured bedrock and deep groundwater and study the distribution, transport and fate of chemical contamination.

GROUNDWATER INVESTIGATION

Groundwater Investigation Findings

The wealth of groundwater data collected at and around the Santa Susana site provides a clear understanding of the location and extent of groundwater contamination from historic site operations:

- Site-related contaminants are limited to groundwater within the Santa Susana site boundary, with one minor exception in an area to the northeast of the site.
- The groundwater plumes are stable and not migrating or moving offsite.
- The areas of impacted groundwater beneath the site are steadily decreasing or shrinking in size.
- Testing of property surrounding the Santa Susana site revealed no traces of site-related chemicals in groundwater emerging above-ground through seeps and springs.
- Contamination from Santa Susana is not impacting any community or private drinking water supply wells.

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OVERVIEW OF GROUNDWATER INVESTIGATION WORK COMPLETED TO DATE

- Installed more than 500 monitoring wells on- and off-site.
- Collected approximately 28,000 groundwater samples with close to 1 million individual analyses.
- Mapped Simi Hills geology.
- Identified and sampled 65 locations where groundwater comes up to the surface in seeps and springs.

  "Springs" are where groundwater emerges and flows continuously, feeding a stream. "Seeps" are groundwater that flows intermittently, when the water table rises sufficiently; such as after a rainy season.
- Analyzed 8,400 rock samples for contaminants in rock pore water.
- Constructed a groundwater extraction treatment system (GETS) that can pump groundwater (up to 100 gallons of water per minute) from wells throughout the site to remove chemicals.

Explanation of the Findings

Contamination is contained. The limited movement of groundwater contamination at Santa Susana is due to characteristics of the aquifer at the site. Groundwater at the former Santa Susana Field Laboratory is primarily in the Chatsworth formation, a common geologic formation of the Simi Hills and western Santa Susana Mountains. The Chatsworth formation is primarily sandstone, with some embedded siltstones. There is significant faulting and folding of the rocks below the site, and there are several medium to large faults having been mapped at the site. The faults (or fractures) are small cracks that allow the water to move through the rock in addition to the pore spaces in the sandstone. Most of the groundwater flow is in the fractures, but the vast majority of the water is stored in the pore spaces of the sandstone between the fractures. The significant porosity of the Chatsworth formation sandstone allows contaminants to diffuse and be absorbed into the bedrock as groundwater flows through the fractures. This process strongly slows down the migration of contaminants. In fact, most contaminants in groundwater at Santa Susana remain within about a half mile of where they entered the groundwater about 60 years ago.

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MEET THE EXPERTS

The Santa Susana Groundwater Advisory Panel is and has been made up of renowned groundwater experts who have been providing guidance to Boeing since 1996. Under their direction, several new techniques have been developed and used at Santa Susana to provide a detailed examination of the fractured bedrock and deep groundwater to study the distribution of the chemical contamination.

John A. Cherry, Ph.D, Professor Emeritus, University of Waterloo

Dr. Cherry conducts field research on the migration and fate of contaminants in groundwater and their remediation. He has participated in the development of technologies for groundwater monitoring and remediation, co-holds several patents, is a Fellow of the Royal Society of Canada, and has received awards from scientific and engineering societies in Canada, the United Kingdom and the United States. He is currently the Director of the University Consortium for Field-Focused Groundwater Contamination Research at the University of Guelph in Ontario.

David B. McWhorter, Ph.D, Professor Emeritus, Colorado State University

Dr. McWhorter has extensive experience in teaching and researching multi-phase flow in porous media, specializing in the combined use of mathematical models and laboratory experiments to develop practical methods for more effective site analysis and remediation. He has won university and national awards, most recently the M.K. Hubbert award of the National Groundwater Association. For more than 30 years, he has been a frequent consultant to government and industry on problems involving dense non-aqueous phase liquids (DNAPL) and light non-aqueous phase liquid (LNAPL) in the subsurface. Dr. McWhorter recently retired and is no longer active on the Groundwater Advisory Panel.

Beth L. Parker, Ph.D, Professor University of Guelph

Dr. Parker has more than 25 years of experience as a groundwater professional investigating subsurface contamination issues at industrial sites. Her current research and consulting activities emphasize field and laboratory studies of DNAPLs in sedimentary rocks, clayey deposits and heterogeneous sandy aquifers. Her studies focus on the effects of diffusion into and out of low permeability zones and on DNAPL fate, plume attenuation and controls on remediation. She has won the John Hem award from the National Groundwater Association.

GROUNDWATER STUDIES

An update on the current status of different aspects of Boeing's decades-long investigation of groundwater under and near the Santa Susana site is provided below:

Treatability studies IN-WORK

Boeing continues to perform studies to better understand groundwater conditions that affect the fate of chemical concentrations under the Santa Susana site. Results from these studies will support the DTSC site-wide cleanup plan.

The unique geology of the Santa Susana area makes it difficult to remove groundwater contamination or treat it in place. Boeing is evaluating different techniques and technologies that have the best prospects of addressing site contaminants in groundwater.

Degradation study IN-WORK

This study evaluates the naturally occurring degradation of chemical concentrations in groundwater. Throughout Boeing's groundwater investigation, data suggests the contaminants have broken down on their own. The study involves field investigations of groundwater conditions using the site's existing network of over 500 wells, as well as newly installed wells to examine and monitor the groundwater.

In situ chemical oxidation experiment ✓COMPLETED

This field experiment tested a state-of-the-art application of a remediation technology designed to destroy targeted chemical contaminants in groundwater. A team of environmental engineers identified an on-site area with high concentrations of TCE in groundwater and installed six monitoring wells. One of the wells was used to inject potassium permanganate seven times over the

course of 10 months to see if the solution would combine with the TCE to oxidize it into harmless byproducts.

Results indicate this treatment technology did not significantly lower the levels of contaminants in groundwater because of the unique characteristics of the fractured underground rock.

Biostimulation lab experiment ✓COMPLETED

Researchers recently completed several laboratory tests to understand whether adding nutrients will speed up the natural degradation process. These tests show that transformation of TCE in the Santa Susana sandstone is aided by the addition of certain nutrients (e.g. lactic acid). However, the addition of these nutrients did not in and of itself aid in completing the degradation process. Several of the tests showed that the transformation of TCE in the studies produced vinyl chloride, and did not completely degrade.

Bedrock vapor extraction field study ✓COMPLETED

NASA completed a preliminary test using a vacuum system to attempt to pull vapors out of the unsaturated sandstone bedrock. This test showed limited ability to extract volatile organic compounds (VOC) (including TCE) from the fractured sandstone. Although some VOCs were produced during the extraction test, there is limited application for wide-spread removal of the TCE in the unsaturated rock, primarily because of the limited connectivity of the fracture network.

Thermally-enhanced lab study ✓COMPLETED

DOE completed an evaluation of published material for the application of thermal destruction of VOCs in sandstone. There has been limited success in removing VOC mass in sandstone using the thermal technique.

Faults study ✓COMPLETED

Faults — the fractures in the Earth's crust associated with blocks of rock moving past each other — can influence groundwater flow paths. The fault zones in the Chatsworth Formation have resulted in numerous fractures throughout the rock under the Santa Susana site. These fractures can either enhance groundwater flow or act like a barrier that slows groundwater flow because they become filled with mineral deposits.

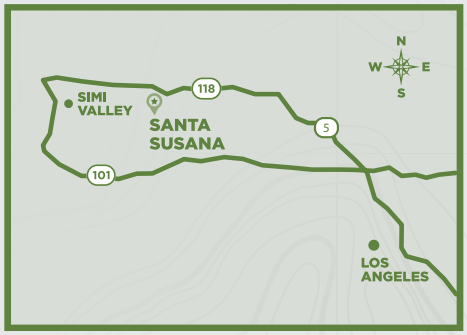
Experts from Stanford University conducted a study to better understand how faults influence the flow of groundwater and contaminant concentrations at Santa Susana. The study results show no clear evidence of cross-fault groundwater flow affecting the distribution of groundwater contamination. These findings complement more than two decades worth of site-wide data on contaminant concentration levels.




Contamination concentration is decreasing. The lessening extent of groundwater contamination and decreasing concentration of contaminants in the groundwater indicate that contaminants are actively breaking down on their own (natural degradation). Even so, Boeing is currently conducting studies to determine the feasibility of other options to potentially accelerate the reduction or elimination of chemical concentrations in groundwater below the Santa Susana property. One of the interim measures will be to pump groundwater from certain areas of Santa Susana and treat the water at the GETS before re-injecting the clean water back into the ground.

Drinking water is not affected. It is important to note that although Boeing, DOE and NASA are working under the oversight of DTSC to reduce contamination in groundwater at Santa Susana, groundwater below the Santa Susana site is not — and never will be — used for public consumption. The use of groundwater for drinking water purposes is expressly prohibited in the 2017 Conservation Easement that Boeing recorded over its approximately 2,400 acres at Santa Susana. In addition, the groundwater at Santa Susana is part of a different aquifer with no direct connection to the aquifer that Simi Valley had proposed to use to supplement drinking water supplies. Any contamination that may exist in the Simi Valley aquifer is from local sources and not related to Santa Susana operations.

For more information. Additional information about the groundwater contamination at Santa Susana can be found in the Document Library of DTSC's website (https://dtsc.ca.gov/sitecleanup/santa_susana_field_lab/ssfl_document_library/) under the "RCRA Facility Investigation – Groundwater" and "Public Involvement" categories. The information available on DTSC's website includes the "Groundwater U" materials, which were created to provide the public with an understanding about groundwater at Santa Susana. Groundwater U (University) comprised six classes that covered geology and hydrogeology, contaminant fate and transport, groundwater remediation approaches, groundwater flow at Santa Susana, contaminant sources at Santa Susana, contaminant fate and transport at Santa Susana as well as a geology field trip.



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For more information, please visit: **https://dtsc.ca.gov/sitecleanup/santa_susana_field_lab/ssfl_document_library/**