Studies of Health Effects Possibly Related to the Operation of the Santa Susana Field Laboratory (SSFL)

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Why this review now?

- For over twenty years, some residents in the vicinity of the Santa Susana Field Laboratory (SSFL) and their elected officials have been greatly concerned over the possibility that nuclear and rocket testing operations have increased the incidence of cancer and other illnesses among workers and residents in the vicinity of SSFL.
- To this day, they support their concern by citing various studies conducted over the years.
- This review examines these studies in details to document what they really say and, more importantly, the significance of their findings.
- The review relies primarily on the statements of the authors, and introduces no new analysis.

Organization of Review

- The review is divided into three sections:
- Cancer Incidence in the Vicinity of the Santa Susana Field Laboratory,
- Worker Health Studies, and
- Pathway Studies.
- References and links to the full papers are provided so that the reader can get a comprehensive picture of the issues, and review the source documents, if desired.

Epidemiological Studies

- Since 1990, studies based on Cancer Registry data were conducted by:
- California Department of Health Services (1990 and 1992),
- Tri-County Cancer Registry (1990, 1997 and 2006),
- University of California at Los Angeles (UCLA) School of Public Health (1997, 1999, 2001),
- International Epidemiological Institute (2005),
- Dr. Hal Morgenstern of the University of Michigan School of Public Health (2007), and most recently
- Dr. Thomas Mack of the University of Southern California Keck School of Medicine (2014).

Results of Studies of Cancer Incidence in the Vicinity of SSFL

- Universally, the investigators were unable to establish any statistically significant relationship between chemicals and/or radionuclides used at SSFL and any adverse health effects on either workers or nearby residents.
- Additionally, in 1999, the early studies were reviewed by and Cal/EPA DTSC and the Agency for Toxic Substances and Disease Registry (ATSDR) of the U. S. Center for Disease Control (CDC), and in 2014, by Dr. Thomas Mack. The reviewers confirmed both the results of the studies and their inherent limitations.
- In his study, Dr. Mack concluded that while it is not possible to unequivocally rule out any offsite carcinogenic effects from SSFL, no evidence was found of measureable offsite cancer causation as a result of migration of carcinogenic substances from the SSFL.
- Dr. Morgenstern went further in his conclusions and expressed skepticism that "*any additional analyses or studies would be sufficient to determine whether operations and activities at Rocketdyne [SSFL] affected, or would affect, the risk of cancer in the surrounding neighborhoods.*"

Representative Statements

- In the 1990 [CDHS, 1990] study, it was concluded:

  *"Census tract age-adjusted incidence rates were found to be **significantly higher** than comparable county rates in **three comparisons…Three rates were found to be significantly lower.** Given the large number of comparisons made (**five census tracts, two time periods, eleven sites**), these findings **are consistent with random variation** in cancer incidence rates."*

- The 1992 study [CDHS, 1992] concluded:

  *"These follow-up analyses suggest that **people living near the SSFL are not at increased risk** for developing cancers associated with radiation exposure."*

- In 1997, the Tri-County Regional Cancer Registry issued a report [Tri-Counties Regional Cancer Registry, 1997] on cancer incidence in Simi Valley that concluded:

  *"residents of the study area seem to have **cancer incidence risk which is similar to that of the other residents** of the Tri-Counties Region, except **for leukemia in women which is significantly lower**, and **cancer of the lung and bronchus which is higher**."*

Independent Reviews

- In 1999, the Hazardous Materials Laboratory (HML) of the Department of Toxic Substances Control (DTSC) identified and reviewed the reported health studies, and convened an **expert panel of epidemiologists** to review these earlier studies. The panel concluded:

  "Whereas there were some differences in the geographic areas, time periods, case definitions and level of significance used in these three studies, ***the combined evidence from all three does not indicate an increased rate of cancer incidence in the regions examined.*** *The extremely modest cancer incidence increases associated with known radiosensitive tumors could be easily explained by uncontrolled confounding or imprecision in the data.* ***The results do not support the presence of any major environmental hazard."*** [DTSC, 1999]

- Also in 1999, in response to a petition request, the Agency for Toxic Substances and Disease Registry (ATSDR) of the U. S. Center for Disease Control (CDC) performed a comprehensive study and released its "Draft Preliminary Site Evaluation Santa Susana Field Laboratory (SSFL)." [ATSDR, 1999] During its studies ATSDR reviewed the above 1990, 1992 and 1997 cancer registry data studies conducted in response to community concerns about cancer occurrence surrounding the SSFL. Its report stated:

Independent Reviews, Cont'd.

- *"This study has several **limitations**; most of them inherent to this type of investigation. The **accuracy of the population estimates** at the census tract level is not known. Although standardized rates are useful as a summary measure, the rates are affected by **random variation**. Because multiple comparisons were made, the probability of **finding a significant association by chance** is increased even if there is no association at all. **No information was available on actual exposures to contaminants** from the SSFL sites. **A five-mile radius within the SSFL site is a weak surrogate for exposures and no information is available regarding how long the residents lived in the area.** No information was available on any **other risk factors**. This investigation serves the purpose of generating and refining questions on cancer incidence and cannot assess the cause and effect relationship of potential SSFL exposures… "The study methodology is generally sound, given the **limited data and lack of exposure information**. Most of the limitations of the 1990 study also apply to this study and they are acknowledged appropriately. The interpretation of the findings is reasonably cautious because **lung and bladder cancers are "strongly associated with other risk factors (smoking and non-radiation occupational exposures**), it is important to **consider alternative explanations**… However, this increase was small, and lung cancer was not significantly increased in men or women separately. The report acknowledged the **lack of appropriate census tract level population estimates**. If estimates of the base population are too low, the population-based number of expected cancer cases is also too low, which would lead to an overestimation of SIRs."*

Bell Canyon Studies

- In September 1999 and October 2006, the Tri County Cancer Surveillance Program, responding to calls from the same Bell Canyon resident expressing concern about the possible increase in cancer cases in their specific neighborhood, conducted cancer registry studies. [Tri-Counties Regional Cancer Registry, 1999 and 2006]. The first study concluded:

  " …Based on this analysis, I am confident to state that residents of census tract 75.03 in Ventura county that includes ***your neighborhood, are not at higher risk*** *of being diagnosed with cancer when compared to the rest of the population in the Tri-counties Region."*

- The second study was made after the release of studies suggesting possible increase in cancer cases due to the meltdown of the reactor at the Santa Susan Field Laboratory in the 1959 (Study Says Lab Meltdown Caused Cancer, Los Angeles Times October 6, 2006). It concluded that:

  "occurrence of newly diagnosed invasive cancers in census tract 75.03 in Ventura County that includes your neighborhood ***does not show any unusual pattern and has actually decreased by 7.5 percent from 1988 through 2004."***

Morgenstern Studies

- In March 2007, Dr. Hal Morgenstern of the University of Michigan (formerly of UCLA) issued the final report [Morgenstern, 2007] entitled "Cancer Incidence in the Community Surrounding the Rocketdyne Facility in Southern California." After he summarizes his numerical results, he states:

  *"It is important to recognize that associations observed between distance from SSFL and the incidence of specific cancers are based on **small numbers of cases in the region closest to SSFL**. Thus, these associations are **estimated imprecisely and may represent chance findings**. In addition, observed associations may have been biased by certain methodologic limitations—use of distance from SSFL as a **crude proxy measure** for environmental exposures, **mobility of the residential population** before and during the follow-up period, and lack of information on **other cancer risk factors, such as cigarette smoking and socioeconomic status**, that might distort the observed associations…Despite the methodologic limitations of this study, the findings suggest there may be elevated incidence rates of certain cancers near SSFL that have been **linked in previous studies with hazardous substances** used at Rocketdyne, some of which have been observed or projected to exist offsite."*

- In his summary, Dr. Morgenstern states:

  *"The **strongest and most consistent** association observed in this study was for **thyroid cancer**, which was associated with distance from SSFL in both follow-up periods. This finding **may have** public-health significance because perchlorate, a component of rocket fuel used in large quantities at SSFL, is known to disrupt thyroid function, it has been shown to induce thyroid tumors in laboratory animals, and there is evidence from two other investigations that perchlorate migrated offside to contaminate the groundwater in areas surrounding SSFL."*

- His rationale is undermined by two facts. While perchlorate is a component of solid rocket motor fuel, it is not a component of liquid rocket engine fuel, which was used almost exclusively at SSFL. Also, the DTSC Offsite Groundwater handout dated April 9, 2014 states **that perchlorate was not detected in any of 71 off-site samples near SSFL**, and that evaluation of surface and groundwater pathways of perchlorate offsite does not indicate a connection between the perchlorate detected in Simi Valley and perchlorate present in the soil and groundwater at SSFL. It should also be noted that perchlorate is produced naturally and has been used as a fertilizer and in many non-SSFL applications.

- Dr. Morgenstern also concludes:

  *"There is **no direct evidence** from this investigation, however, that these observed associations **reflect the effects of environmental exposures originating at SSFL**. Given these provocative findings and unanswered questions, it is tempting to recommend further analyses or future studies to address the health concerns of the community. Unfortunately, it **is not clear** at this time whether such additional analyses or studies **will be sufficient to determine whether operations and activities at Rocketdyne affected, or will affect, the risk of cancer in the surrounding neighborhoods."***

Retinoblastoma Studies

- Also in 2007, the Cancer Surveillance Section updated a 2005 analysis conducted by the University of Southern California (USC) Cancer Surveillance Program that included cases diagnosed through 2002 and showed no excess incidence of retinoblastoma in this area. The study [CCR, 2007] concluded:

  "incidence of retinoblastoma among children under age 5 residing in the area around the SSFL between 1988 and 2005 ***was slightly, although not statistically significantly, higher than expected based on incidence statewide. The relatively young age of the cases, and the high proportion of cases with bilateral disease, is suggestive of a genetic origin.*** *This analysis is consistent with the 2005 report that showed* ***no significant increased risk of retinoblastoma*** *between 1972 and 2002."*

Recent Epidemiological Overview and Summary by Dr. Thomas Mack of USC

- On April 8, 2014, Dr. Thomas Mack, epidemiologist and Professor of Preventative Medicine and Pathology at the USC Keck School of Medicine presented the results of his recent study, entitled "Cancer Occurrence in Offsite Neighborhoods near the Santa Susana Field Laboratory."[Mack, 2014] His presentation included the reasons for skepticism about previous cancer registry studies:

  "•Ambiguous and controversial exposure estimates

  •Absence of concrete dose-based hypotheses

  •Alternative explanations not seriously considered

  •Hard to explain how a sufficient dose would occur

  •Absence of historical precedents

  •Lack of any clear risk found by previous searches"

Dr. Mack's Bottom Line

After a presentation containing 102 charts,

Dr. Mack concluded:

"•It is not possible to completely rule out any offsite carcinogenic effects from SSFL

•No evidence of measureable offsite cancer causation occurring as a result of emissions from the SSFL was found."

- This conclusion seems to be consistent with all previous studies, and should be accepted by the community as a basis for cleanup decisions.

Worker Health Studies

- In June 1997, the University of California, Los Angeles (UCLA) released the first of two worker health studies, entitled "Epidemiologic Study to Determine Possible Adverse Effects to Rocketdyne/ Atomics International Workers from Exposure to Ionizing Radiation."[Morgenstern, H., et.al., 1997] . The UCLA study included **4, 607** employees who worked at Rocketdyne between 1950 and 1993. The study investigators found that among Rocketdyne workers who were monitored for external radiation, those who received higher doses (especially more than 200 mSv) had an increased risk of dying from cancers of the blood and lymph system (such as leukemia and lymphoma), and from lung cancer. As the dose of external radiation among Rocketdyne workers increased, the investigators also found **an increased risk of dying from all cancers**. They also found that among Rocketdyne workers who were monitored for internal radiation, those who received a relatively higher dose (especially more than 30 mSv**) had an increased risk of dying from cancers of the blood and lymph system, and upper aero-digestive tract cancers (mouth, throat, esophagus and stomach).**
- In January 1999, an Addendum Report entitled "Epidemiologic Study to Determine Possible Adverse Effects to Rocketdyne/Atomics International Workers from Exposure to Selected Chemicals" was released by UCLA. [Morgenstern, H., et.al., 1999] This final report for the second part of the DOE-funded occupational study focused on the chemical exposure portion, and included a cohort based on **presumed exposure to hydrazine (6,107 workers** with 176,886 person-years) and a cohort with **presumed exposure to asbestos (4,563 workers** with 118,749 person-years). Employing an internal comparison method described in the 1997 report, this study reported the observed **positive association between presumptive exposures to hydrazine and the rates of dying from cancers of the lung.**

ATSDR Evaluation of Morgenstern Reports

- Also in 1999, ATSDR reviewed the above UCLA worker health studies. The ATSDR report states:

  "This study is well designed and the data analysis is rigorous. The major strength of the study is the ability to examine the dose-response relationships by reconstructing internal and external doses received by the individual workers in the past… The study measured cumulative SSFL exposures, ***however exposures received before employment at SSFL could not be accounted for because of inconsistency in the recording practice.*** *Although the study attempted to control for the effect of other chemical exposures (i.e., hydrazine and asbestos),* ***misclassification of the chemical exposures is highly likely.*** *The use of the upper aerodigestive tract cancers group* ***is somewhat unusual****, although it is meant to take consideration the properties of internally deposited radionuclides.* ***Another problem of the study is the small number of cancer deaths****,…****Most of these limitations are acknowledged appropriately in the report…The observed positive relationship between external radiation and lung cancer mortality has not been reported consistently in other studies of nuclear workers****.*

  "The second occupational study is part of the 1997 study described above...The weakness of this study mainly stems from the ***unavailability of adequate information*** *on past exposures for individual* ***workers…information was not sufficient*** *to link individual workers with job locations…In addition to the* ***possible exposure misclassification, bias may also have been introduced by confounding****. Exposure information on* ***other risk factors****, such as exposure to other chemicals (e.g., trichloroethylene and nitrosamines) or* ***personal characteristics*** *is not available for the study. There is also a* ***possibility that the radiation exposures are misclassified****, hindering the ability to control for confounding by radiation exposures****. Despite the limitations, the observed increase in the lung cancer risk associated with presumptive hydrazine exposure is noteworthy…Given the uncertainties, the authors' recommendation that the worker group should be followed further is reasonable since the result shows a positive association, and health effects of exposure to these chemicals in humans are not well understood.***

Boeing Worker Study

- In 2006, the Boeing Company released the July 13, 2005 "Rocketdyne Worker Health Study, IEI Executive Summary," produced by the International Epidemiology Institute. [IEI, 2005] It states:

  *"A retrospective cohort mortality study was conducted of **46,970 Rocketdyne workers** employed for at least 6 months in either nuclear technology development or in rocket engine testing since 1948 at the Santa Susana Field Laboratory (SSFL) and at nearby facilities…The Comparison Cohort consisted of 32,979 workers employed at the other Rocketdyne facilities…Overall, the 46,970 Rocketdyne workers (including both radiation and chemical cohorts together) accrued 1.3 million person-years of observation (average 27.6 years). Vital status was determined for 99.2% of the workers: 11,118 (23.7%) had died and only 368 (0.8%) were lost to follow-up. Cause of death was determined for all but 280 (2.5%) of those who had died. **The overall mortality experience among all Rocketdyne workers was lower than that of the general population of California…No cause of death was significantly elevated.** There were **no notable increases in cancer deaths** over time since first hire, or by duration of employment at SSFL or at the other Rocketdyne facilities... **No statistically significant internal cohort dose-response relationship was seen for leukemia, lymphoma, or cancers of the esophagus, liver, bladder, kidney or any other cancer over categories of radiation dose or years of potential chemical exposure.** We conclude that radiation exposure has **not caused a detectable increase in cancer deaths** in this population and that work at the SSFL rocket engine test facility or as a test stand mechanic is not associated with a statistically significant increase in cancer mortality overall or for any specific cancer.*

Pathway Studies

- In 1999, the Agency for Toxic Substances and Disease Registry (ATSDR) released its "Draft Preliminary Site Evaluation Santa Susana Field Laboratory (SSFL)." [ATSDR, 1999] The Executive Summary states:

  "Considering these factors, it is unlikely that residents living near the site are, or were exposed to SSFL-related chemicals and radionuclides at levels that would result in adverse human health effects. Changes in site operations, such as reduced frequency of rocket engine testing, discontinuation of trichloroethylene use, and shut down of nuclear operations make it unlikely that future exposures to the offsite community will occur."

UCLA – Cohen Study

- In 2006, February 2, 2006 - UCLA's Center for Environmental Risk Reduction released the final report entitled, "The Potential for Offsite Exposures Associated with Santa Susana Field Laboratory, Ventura County, California."[UCLA, 2006] The study's pathway conclusions were:
- "*Migration pathways from SSFL to offsite areas include (**but cannot be limited to**):*

  ***Surface water runoff** (controlled and natural) to the **north, south and east**.*

  ***Groundwater** migration to the **northeast and northwest**.*

  Air dispersion and deposition.

  *In general, the contribution of **soil to offsite exposure was found to be low** compared to that of other pathways.*
- *"**Past community exposures of concern** include **(but cannot be limited to**):*

  Potential** chronic exposures to TCE and hydrazine resulting from emissions associated with rocket engine testing and open-pit burning between 1953 and early 1980s. **Potential** residential receptor locations of inhalation exposure include **West Hills, Bell Canyon, Dayton Canyon, Simi Valley, Canoga Park, Chatsworth, Woodland Hills, and Hidden Hills.

  *Chronic exposure to TCE and associated degradation products in groundwater from 1953 to the late 1970s via use of private wells east and north of SSFL. **Potential receptors** include **residents using private wells and residents who habitually ingested area-grown crops or livestock.***
- *"There is **potential** for chronic exposures, in areas within ~1-2 miles of SSFL, which include, **but are not limited to**:*

  *TCE, vinyl chloride, and 1, 1-DCE in the **northeast quadrant** off site of SSFL through use of **private groundwater wells or from habitual home-grown crop ingestion.***

  ***Arsenic (source unknown**) via habitual home-grown crop ingestion in **Bell Canyon, Brandeis-Bardin**, and potentially all areas north and east of SSFL, **including Simi Valley, Dayton Canyon, and West Hills**.*

  ***Lead (source unknown**) via incidental soil ingestion/inhalation or from habitual home- grown crop ingestion in **Bell Canyon and potentially areas east of the facility**; as well as extended use of private water wells or habitual home-grown crop ingestion."*

Boeing's Comments

- Late in 2006, The Boeing Company provided over 50 pages of detailed comments to Professor Cohen on the UCLA report. [Boeing, 2006] The Boeing general comments included the following:

*"The report includes **many worst-case assumptions and conservative toxicity factors**, which result in **overly inflated dose ratios**. **Multiple conservative assumptions**, when compounded, **result** not in a worst-case scenario but one that **is highly improbable, if not impossible**, and which **does not represent potential risk for any single individual or group of individuals**. Such overly inflated dose ratios may cause the reader to incorrectly conclude that the SSFL poses an unacceptably high risk, when in reality the actual risk is much lower and in many cases may be at or near zero. Thus, the result is a study that will be prone to misinterpretation and constitute a disservice to the reader.*

*"The UCLA report utilized essentially the same environmental data base used by the ATSDR study, yet it reached **very different conclusions without explaining the basis for such a departure.***

*"The report bases its analysis on the **maximum values of a small number of environmental positive detects for soil and water and ignores the totality of the environmental database that is comprised of mostly non-detects,** thereby providing inaccurate and misleading portrayals of potential exposure issues. For example, Figure 4-3 of the report presents a map of groundwater contaminants detected above health-based standards. The map shows the concentration of carbon tetrachloride at nine times the California Maximum Concentration Level. However, this representation is misleading because it fails to indicate that of the **895 offsite analyses** conducted for this chemical, there were only **2 off-site detections**. Identifying two detections, while **failing to mention 893 non-detections**, is not a fair and accurate portrayal of the groundwater data. The use of maximum detects to calculate dose ratios is a poor surrogate for estimating community exposures using the entire body of relevant data.*

Boeing's Comments, Cont'd.

- *"**The report ignores crucial facts** concerning the question of past exposures. For example, the study suggests that historical exposure to TCE emissions from rocket engine testing/degreasing is a potential concern for many lifelong residents living in eleven "receptor locales." Modeling results show that **TCE concentrations rapidly decline with distance** from the site (to approximately 2 µg/m^3 at just 1 mile). **Approximately 89% of TCE** emissions from rocket engine testing/degreasing occurred **before 1967**. Before 1967, **less than twenty residents resided in the census tract encompassing most of the 1- mile area surrounding SSFL**. Yet, the study inexplicably lists **elevated dose ratios at eleven "receptor locales," some of which are located 5 to 10 miles from SSFL. The report also incorrectly uses the large exhaust rates for large LOX-kerosene engines to estimate emissions from the much smaller hydrazine engines. This has resulted in an overestimate of hydrazine emissions by at least 100-fold.**

  *"The report **ignores the fact that background levels of some chemicals and radionuclides are found in all soils. The report fails to subtract background from off-site measurements prior to comparing to health based standards.** Consequently, off-site measurements of background chemicals and radionuclides are incorrectly identified as contamination from SSFL.*

Boeing's Comments, Cont'd.(2)

- *"**The report does not adequately establish exposure pathways.** Transport of specific contaminants should be traced from an identified SSFL source, through an air or water transport medium to a receptor (local resident). Specific effects on the food chain, if any, should be identified. Exposure modes should be established (e.g. inhalation, ingestion, dermal contact, etc.). Temporal changes in populated areas should be assessed. Finally, the likelihood of occurrence of the postulated exposure pathways needs to be quantified. Only, then can a realistic risk assessment be performed.*

  "The report repeatedly claims that assessing health risk impacts was not possible and beyond the scope of the study. Yet the report presents dose ratios based on overly conservative estimates of exposures, and then draws conclusions about public health significance.

Boeing provides over 50 pages of specific comments. One very important comment addresses the fact that the **study ignored plume rise in evaluating air pathways.** In Appendix I of the UCLA report, it is stated that sources modeled as point sources used the following parameters:

"Stack Height: 0 m

Stack Temperature: 273 K

Stack diameter: 1 m

Stack exit velocity: 0 m/s"

- Boeing correctly states"

  ***"The parameters used do not correctly represent the type of emissions release.** Using a stack temperature of 273K (32°F) is too low. Rocket engine testing is a **turbulent activity and will cause a plume of pollutants.** Depending on the size of the rocket, this plume can reach **several hundred feet into the air resulting in significantly more dispersion** in the atmosphere than modeled in the report. The exhaust from the engine is also at a significantly higher temperature than 273K. The higher exhaust temperature will also result in more dispersion in the atmosphere."*

- Boeing also notes *"Stripping towers use an aeration technique. This also results in emissions being released with some vertical velocity resulting in **more dispersion in the atmosphere."***

Warren's Comments and Cohen's Failure to Respond

- Also in 2006, Dr. Alan Warren, Program Director, Environmental Health Science, University of South Carolina Beaufort, was retained by The Boeing Company to comment on the above UCLA study. His comments, which are consistent with the Boeing comments, provide a thorough and thoughtful assessment. [Warren, 2006]
- Professor Cohen refused to respond to the Boeing comments and to questions posed by individuals more recently.

Opposing Views/Path Forward

- There appear to be **two diametrically opposing views** of the health impacts of SSFL operations.
  - The UCLA researchers directed by the SSFL Advisory Panel.
  - Everybody else.
- **Resolution of this contradiction is needed** if the community stakeholders are ever to come to some common understanding.
- The completely opposite conclusions of the UCLA researchers and the others exactly mirror the polarization within the community. Both views cannot be correct**. It would be extremely beneficial to the resolution of these health-related issues, to have a public workshop where the various authors of these health studies can meet and discuss the reports and the comments and see if there is a technically sound commonality.** The SSFL cleanup discussion needs to move beyond partisan advocacy into the realm of science-based decision-making.