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BOEING

November 3, 2006

Panel Members and Consultants
Committee to Bridge the Gap
1637 Butler Avenue, Suite 203
Los Angeles, CA 90025

Subject: Comments of The Boeing Company on the Reports of the Santa Susana Field Laboratory Advisory Panel: *the Panel Summary Report*, *An Assessment of Potential Pathways for Release of Gaseous Radioactivity Following Fuel Damage During Run 14 at the Sodium Reactor Experiment,* David A. Lochbaum, *Feasibility of Developing Exposure Markers for use in Epidemiologic Studies of Radioactive Emissions From the Santa Susana Field Laboratory,* Jan Beyea, Ph.D., *Geologic Features and their Potential Effects on Contaminant Migration, Santa Susana Field Laboratory,* Howard G. Wilshire, Ph.D., *An Analysis of the Design and Performance of the Clay Cap Used to Control Groundwater Recharge into the Fractured Bedrock Beneath the Former Sodium Burn Pit (FSDF) at the Boeing-Rocketdyne Santa Susana Field Laboratory,* William C. Bianchi, Ph.D., and *Land-use Conversion and its Potential Impact on Stream/Aquifer Hydraulics and Perchlorate Distribution in Simi Valley, California,* M. Ali Tabidian, Ph.D.

Dear Panel Members and Consultants:

The Boeing Company appreciates the opportunity to comment on the reports of the Santa Susana Field Laboratory (SSFL) Advisory Panel (AP). Our detailed comments on each report are provided in an attachment to this letter. However, Boeing has a number of general comments which are set forth below. Taken as a whole, these comments seriously question the validity of claims the AP has made; claims that are flawed, without scientific merit, and a great disservice to our employees and the community.

Over the years, we have provided many surveys and reports to the local, state, and federal agencies overseeing the cleanup of the site. These reports have extensively documented the effects of past site operations through detailed monitoring of air, water, and soil, and the data included in these reports have been used by government agencies to determine the health implications of SSFL operations for our employees and the community. We regularly prepare reports and provide data to the regulatory agencies. This information is available to the public.

Sodium Reactor Experiment

Evidence from the Sodium Reactor Experiment (SRE) post-accident measurements of sodium and cover gas indicate that no iodine-131 or cesium-137 escaped from the sodium into the cover gas, and therefore neither of these fission products was released to the environment. This evidence is supported by a large amount of operational history and research into the retention of fission products (including I-131 and Cs-137) in sodium coolant, including experience from the Fermi-I and EBR-II fuel damage incidents.

The AP reports ignore the fact that measurements of the SRE cover gas indicated only xenon-133 and krypton-85 noble gases and no iodine-131 and no cesium-137. The AP reports ignore the fact that activity measurements of the gas hold-up tanks prior to venting, indicated only approximately 28 curies of Xe-133 and Kr-85 gases were released.

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Both the Lochbaum and Beyea reports provide estimates of fission product release fractions that are nothing more than guesses. Mr. Lochbaum reasoned that if 30% of the fuel elements were damaged then an upper bound for fission product release was 30%. He acknowledged that a lower bound would be closer to 0%, so the best estimate or average would be (30% + 0%)/2 = 15%. He did not estimate release in terms of curies. Mr. Lochbaum does not account for the fact that evidence from other sodium cooled reactors has shown that iodine-131 and cesium-137 released from the fuel would be retained in the sodium coolant. Dr. Beyea's estimate was little better, instead relying on the 1957 Windscale release. Dr. Beyea omits the facts that Windscale was a once-though, air-cooled system, and that when the core was burning, there was an open release pathway directly to the environment. Dr. Beyea omits the fact that the SRE fuel was continually immersed in a closed-loop pool of sodium coolant which trapped iodine and cesium, as discussed above.

The Department of Health Services (DHS)[1] made the following statement in 1992 following the second of their cancer registry studies of the communities surrounding SSFL:

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

An expert panel of nationally-renowned epidemiologists was hired by the Department of Toxic Substances Control (DTSC) to review the three DHS cancer studies[2]. Their conclusion:

> *"Three studies of cancer incidence in the vicinity of SSFL were reviewed...the combined evidence from all three does not indicate an increased rate of*

[1] California Department of Health Services, *Cancer Incidence Near the Santa Susana Field Laboratory (1978-1989)*, March 27, 1992.
[2] Cal/EPA Department of Toxic Substances Control, *Rocketdyne Inquiry – Summary of Findings and Report*, August 1999.

cancer in the regions examined. The results do not support the presence of any major environmental hazard."

Environmental sampling studies[3,4,5,6,7,8,9,10] performed over the last 14 years have unequivocally demonstrated that cesium-137 is not in the soils of communities surrounding SSFL at levels that differ significantly from local background. These studies demonstrate that cesium-137 releases of the size postulated by Dr. Beyea could not have occurred. Many of these studies have been conducted by organizations independent of Boeing. Those studies conducted by Boeing have been under the oversight of numerous regulatory agencies, including DHS, DTSC, and the Environmental Protection Agency (EPA).

Geologic Features

Groundwater characterization work at the SSFL has been on-going and continues today. The result of this work continues to support that groundwater plumes sourced from the SSFL lie within a few thousand feet of where the contaminants entered the ground because of the attenuating effects of molecular diffusion, sorption, dispersion, and degradation. This finding is supported by thousands of rock core samples that have been collected to evaluate the occurrence and distribution of trichloroethylene (TCE).

The AP report is very narrow in its focus, but broad in its conclusions. The author(s) opine(s) on contaminant migration at SSFL by focusing on only one aspect of the site, the geology. By ignoring the vast majority of the scientific data that has been collected for the site from multiple scientific perspectives, the report arrives at conclusions that are contrary to the vast quantity of evidence that has been collected over the past 20 years.

Former Sodium Disposal Facility

The stated purpose of the Former Sodium Disposal Facility (FSDF) Interim Measure (IM) was to reduce the potential for soil and sediment containing the Constituents of

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[3] McLaren/Hart, *Additional Soil and Water Sampling at the Brandeis-Bardin Institute and Santa Monica Mountain Conservancy*, January 19, 1995 (http://apps.em.doe.gov/etec/7727_1995_0119_MHI_AddSoilandWaterSamp.pdf.pdf).

[4] Environmental Protection Agency, *EPA Update, The U.S. EPA Announces Results of Rocketdyne's Off-Site Sampling Program for the Santa Susana Field Laboratory*, July 1995 (http://apps.em.doe.gov/etec/EPAFS.PDF).

[5] Lawrence Livermore National Laboratory, *Soil Sampling for Cesium-137 at the Rocketdyne Recreation Center*, 1997.

[6] Ogden Environmental Services, *Bell Canyon Area Soil Sampling Report, Ventura County, California*, October 1998.

[7] Foster Wheeler Environmental Corporation, *Final Report, Runkle Ranch Site Investigation, Simi Valley, CA*, October 1999.

[8] QST Environmental, *Results of Preliminary Soil sampling at Runkle Ranch in Simi Valley, California*, February 5, 1999.

[9] Kleinfelder, Report *of Environmental Sampling, Ahmanson Ranch Project, County of Ventura, CA*, January 27, 2000.

[10] Essentia Management Services, *Final Site Investigation Report – Soil Suitability Evaluation - Chatsworth Reservoir, Chatsworth, California*, Prepared for the Los Angeles Department of Water and Power, July 22, 2004.

Potential Concern from migrating from the FSDF and drainage channels offsite. This purpose has been achieved, and was accomplished through the (1) removal of soil and weathered bedrock at the soil/bedrock contact containing COPCs above the IM cleanup levels, and (2) backfilling, grading, and revegetating the IM remedial area.

Nowhere have SSFL technical reports stated that the IM fill would be impermeable or that no moisture would reach the soil moisture instrumentation. The DTSC approval letter of the infiltration monitoring work plan notes the backfill of the IM to be a "low permeability backfill cover." Finer grained soils (clays and silts) are lower in permeability than coarser grained soils (sands). The soil used was a finer-grained soil consistent with the classification requirements of the IM work plan.

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Data shows that the agency-approved, low permeability backfill cover is performing as designed.

Storm Water

For clarification on this issue, storm water runoff from the area does leave the site, but extensive monitoring conducted both on-site and off-site has shown that concentrations in storm flows from the SSFL are typical of or even cleaner than concentrations in storm flows offsite. Monitoring conducted at other undeveloped off-site locations has shown exceedances of many of the same limits that are exceeded at the SSFL. Yet, these sites are nowhere near SSFL and have no history of contamination. In addition, several areas of the site with known perchlorate surface contamination have undergone extensive cleanups. The Happy Valley area is one example. There have been no exceedances of permit limits for perchlorate in storm flows at any site outfalls that leave the facility.

Perchlorate

The analysis contained in the AP report is purely speculative in that it attempts to relate the current occurrences of perchlorate in Simi Valley groundwater to the SSFL. This attempt to link the SSFL to the perchlorate occurrences in Simi Valley without a trail of detections from the SSFL to Simi Valley is purely conjecture and an unproven hypothesis. In fact, extensive data have been collected to evaluate the potential for perchlorate to have been transported from the SSFL into Simi Valley. Various types of samples of environmental media have been collected that include soil matrix, soil leachate, rock chips, bedrock, groundwater, seeps/springs, and surface water. These samples have been analyzed for perchlorate and demonstrate that the SSFL is not responsible for the detections of perchlorate in Simi Valley groundwater.

The Boeing Company appreciates your thorough consideration of all of our comments and looks forward to their incorporation in the final report. Should you have any questions concerning these comments, please contact Blythe Jameson at 818/466-8793.

Sincerely,

Phil Rutherford

for Thomas D. Gallacher
Director
SSFL - Safety, Health & Environmental Affairs

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BJ:je

cc:
The Honorable Barbara Boxer, United States Senator
The Honorable Dianne Feinstein, United States Senator
The Honorable Tom McClintock, California State Senator
The Honorable Sheila Kuehl, California State Senator
The Honorable Lloyd Levine, California State Assembly Member
The Honorable Fran Pavley, California State Assembly Member
The Honorable Keith Richman, California State Assembly Member
The Honorable Audra Strickland, California State Assembly Member
The Honorable Michael Antonovich, Los Angeles County Supervisor
The Honorable Greig Smith, Los Angeles City Council Member
The Honorable Judy Mikels, Ventura County Supervisor
The Honorable Linda Parks, Ventura County Supervisor
The Honorable Glen Becerra, Mayor Pro Tem, City of Simi Valley
Ms. Laura Behjan, City of Simi Valley
Mr. Burt Cooper, Agency for Toxic Substances and Disease Registry
Mr. Mike Lopez, Project Manager, Department of Energy
Mr. Gary Butner, Department of Health Services, Radiologic Health Branch
Mr. Watson Gin, Deputy Director, Department of Toxic Substances Control
Mr. Allen Elliott, National Aeronautics and Space Administration
Mr. John Beach, Environmental Protection Agency, Region IX
Mr. Jonathan Bishop, Executive Officer, Los Angeles Regional Water Quality Control Board
Mr. Michael Levy, State Water Resources Control Board
Mr. Michael Villegas, District Executive Officer, Ventura County Air Pollution and Control District
Mr. Brendan Huffman, President, Valley Industry and Commerce Association
Ms. Arlene Levin, Eastern Research Group
Ms. Carol Henderson, Bell Canyon Association
Mr. Gary Brennglass, Executive Director, Brandeis-Bardin Institute
Mr. John Fitzpatrick, Sr. Project Manager, Centex Homes

Ms. Sheila Rozsa, Mountain View Estates
Mr. Randy Wheeler, President, Runkle Ranch
Mr. Luis Porga, Summit Mobile Homes
Ms. Rorie Skei, Santa Monica Mountains Conservancy
Mr. Tim Miller, Sage Ranch

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Boeing's Comments on the Advisory Panel Reports

"Report of the Santa Susana Field Laboratory Advisory Panel",

"An Assessment of Potential Pathways for Release of Gaseous Radioactivity Following Fuel Damage During Run 14 at the Sodium Reactor Experiment", David A. Lochbaum,

"Feasibility of Developing Exposure Markers for use in Epidemiologic Studies of Radioactive Emissions From the Santa Susana Field Laboratory", Jan Beyea, Ph.D.,

"Geologic Features and their Potential Effects on Contaminant Migration, Santa Susana Field Laboratory", Howard G. Wilshire, Ph.D.,

"An Analysis of the Design and Performance of the Clay Cap Used to Control Groundwater Recharge into the Fractured Bedrock Beneath the Former Sodium Burn Pit (FSDF) at the Boeing-Rocketdyne Santa Susana Field Laboratory", William C. Bianchi, Ph.D.,

"Land-use Conversion and its Potential Impact on Stream/Aquifer Hydraulics and Perchlorate Distribution in Simi Valley", California, M. Ali Tabidian, Ph.D

November 3, 2006

The Boeing Company
Santa Susana Field Laboratory

Contents

Comments on the Advisory Panel Reports on the 1959 Sodium Reactor Experiment Incident (including the Panel Summary Report, the Lochbaum Report, and the Beyea Report)

No.	Section	Comments
R-1	General	Each of the three reports (referred to hereafter as the Panel Report, the Lochbaum Report, and the Beyea Report) alleges that the 1959 Sodium Reactor Experiment (SRE) incident released large quantities of iodine-131 and cesium-137, with resulting health impacts on the neighboring communities. This claim is inconsistent with the historical record, and is based on assumptions that are contrary to scientific principles and decades of environmental monitoring. The historical documents[1, 2, 3] and recent reviews[4] of the incident, demonstrate in fact that the SRE incident did not result in the release of iodine-131 or cesium-137 outside the reactor, let alone into the ambient environment. Boeing's recent analysis[4] of the incident concluded that only 28 curies of noble gases (xenon-133 and krypton-85) were released in a controlled manner, in compliance with federal airborne release limits. This release would have resulted in a *maximum* off-site radiation exposure of 0.099 millirem, and an exposure at the location of the nearest resident of 0.018 millirem. To put these doses in context, the average person in the United States receives 360 millirem per year in *background* radiation exposure (most of which is from natural sources). This equates to 1 millirem daily dose received by the average person in the United States every day from background radiation. Thus, the *maximum* off-site radiation exposure from the SRE incident of 0.099 millirem was 10 times lower than the average person's daily exposure to background radiation. These estimated maximum doses from the SRE incident are also low compared to the protective annual dose limit set by the Nuclear Regulatory Commission (NRC) and Department of Energy for unrestricted areas surrounding nuclear facilities (100 millirem/year) as well as the EPA limit for airborne releases (10 millirem/year). In 2005, two independent studies were completed that confirmed Boeing's earlier findings that only small quantities of noble gases were released following the accident and that no iodine-131 or cesium-137 was released. • "Chemical Behavior of Iodine-131 During the SRE Fuel Element Damage in July 1959. Response to Plaintiff's Expert Witness, Arjun Makhijani", Jerry D. Christian Ph.D., May 26, 2005 • "Investigation of Releases from Santa Susana Sodium Reactor Experiment in 1959", John A. Daniel Sr., May 27, 2005 Dr. Jerry Christian is a past Scientific Fellow from the Idaho National Engineering and Environmental Laboratory (INEEL) and is an expert in nuclear fuel chemistry and the behavior of fission products in nuclear fuel. John Daniel participated in the decontamination and recovery of the Three Mile Island (TMI) nuclear plant. He is an expert on nuclear power plant safety analysis and fission product transport and behavior.

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		The principal conclusions of these two independent studies were: • Only very limited melting of an iron-uranium eutectic (alloy) occurred, causing failure of the steel cladding. • Nearly all of the iodine-131 in the reactor stayed in the fuel as uranium tri-iodide, a solid. No elemental iodine-131 vapor was released. • Approximately 1% of the iodine-131 (16 curies) was released from the fuel into the sodium coolant in the reactor core. It then formed sodium iodide, a solid, and stayed in the reactor coolant system. • Approximately 1% of cesium-137 (28 curies) was released from the fuel into the sodium coolant in the reactor core, and all of this cesium-137 stayed in the reactor coolant system. • Measurements of the reactor cover gas indicated only noble gases (xenon-133 and krypton-85) were present. No iodine-131 or cesium-137 was detected in the cover gas, which is contrary to the alleged pathway for release through the stack, as theorized by the Lochbaum Report. • Only very limited quantities of noble gases (xenon-133 and krypton-85) were released to the environment from the stack. Several quotes from the historical record reinforce these conclusions: *"Even though iodine is very volatile, it did not escape to the cover gas because it undoubtedly combined with the sodium as rapidly as it was evolved. No iodine was ever detected in reactor cover gas samples,"* (NAA-SR-4488[1], page IV-C-5). *"Only Xe and Kr isotopes were identified in the reactor cover gas system. This confirms the previously held premise that the sodium coolant forms an effective trapping agent for all but rare gas [noble gas] isotopes,"* (NAA-SR-6890[3], page 23). *"Examination of the recovered fuel slugs from damaged [fuel] elements showed no evidence of significant melting,"* (NAA-SR-6890[3], page 21). *"With the exception of inert gases, Xe-133 and Kr-85, all of the fission fragments remained in the sodium …"* (NAA-SR-4488-Suppl[2], page III-20). (1) NAA-SR-4488, "SRE Fuel Element Damage – Interim Report", A. A. Jarrett (Editor), November 15, 1959 (2) NAA-SR-4488 (Suppl.), "SRE Fuel Element Damage – Final Report", 1961 (3) NAA-SR-6890, "Distribution of Fission Product Contamination in the SRE", R. S. Hart, March 1, 1962 (4) Letter to Elizabeth Crawford from Phil Rutherford, "Sodium Reactor Experiment (SRE) Original Release Data", January 21, 2005

No.	Section	Comments
R-2	General	Several key quotations from the "Introduction and Overview" section of Dr. Christian's report[1] follow, • *"The increased temperature with uranium fuel slugs in contact with the stainless steel cladding caused rapid diffusion of uranium into and alloying with the stainless steel. At locations where the temperature exceeded the melting point of the iron-uranium eutectic, 1337 °F (725 °C), this diffusion resulted in the formation of an alloy with some liquid phase present. This alloying ultimately resulted in failure of the cladding of some of the fuel elements, though the fuel did not melt … The melting temperature of uranium, 2075°F (1135 °C), was not reached."* • *"As explained in the text below, the incident did not result in significant release of any fission products, including gases, from the failed-cladding fuels. Of the small quantities released from the fuel, most, including all of the released iodine, were trapped in the sodium. Only small fractions of xenon and krypton escaped from the fuel and through the sodium into the cover gas. Xenon and krypton are not soluble in or chemically reactive with sodium. About 1% or less of failed element fission product inventory of non-volatiles, including iodine as a salt, was found in the sodium. No iodine-131 was found in the cover gas."* • *"The conclusion from all these considerations is that fission product iodine formed uranium tri-iodide and/or cesium iodide in the metallic fuel and was not released from the fuel as a gas. Based on considerations of the chemistry of iodine in the fuel that would make it behave similarly to other non-volatile fission products, on I-131 measured in the sodium, and on the lack of I-131 in the cover gas, only between 0.3 and 1.3 percent (depending on the assumed date of release) of the iodine-131 was released from the failed fuel elements. Of that released, all was captured and retained in the sodium coolant. No iodine was released to the stack. Details of the analyses are provided in the report."* (1) "Chemical Behavior of Iodine-131 During the SRE Fuel Element Damage in July 1959. Response to Plaintiff's Expert Witness, Arjun Makhijani", Jerry D. Christian Ph.D., May 26, 2005
R-3	General	**Industry Experience for the Retention of Iodine-131 and Cesium-137 in Sodium** Evidence from the SRE post-accident measurements of sodium and cover gas indicates that no iodine-131 and cesium-137 escaped from the sodium into the cover gas, and therefore neither of these fission products was released to the environment. This evidence is supported by a large amount of operational history and research into fission product behavior in sodium coolant. The International Atomic Energy Agency (IAEA)[1] stated in 1973, *"Because of its chemical nature, iodine has a very high affinity for sodium. Thus it would be expected that essentially all of the iodine entering the primary coolant would immediately react with the sodium and be retained in the primary system. Experience with operating LMFBRs [liquid metal fast*

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		breeder reactors] indicates that this is in fact the case." [p. 19] Castleman[2] observed in 1970 that, *"The results of BR-5, SRE, Fermi and EBR-II incidents showed that most of the iodine released from the fuel is retained in the liquid sodium." [p. 381]* The Fermi-I fuel element damage incident[3, 4] provides evidence that both iodine-131 and cesium-137 that may be released from fuel is retained in the sodium. The Enrico Fermi reactor had a sodium-cooled metal core like the SRE. On October 5, 1966, a broken off piece of zirconium baffle from the inlet area at the bottom of the core vessel resulted in flow restriction of the sodium and melting of one or more fuel elements [4, pp. 31-37]. This was a more severe condition than during the SRE incident in terms of higher fuel temperature, actual melting of the fuel, and severe boiling of the sodium around the failed fuel, all of which would have been more conducive to iodine releases from the fuel and through the sodium than in SRE. Qualitative and quantitative measurements of the fission products contained in the primary sodium coolant and the primary argon cover gas were made periodically after the Fermi incident. The only radioisotopes reported were xenon and krypton, both of which were used to estimate the amount of fuel damage [3, p. 80]. Iodine-131 was not reported as having been observed in the cover gas. Analysis of the sodium in Fermi showed the presence of cesium-137, iodine-131, and other radioisotopes. The percents of fuel inventory of Cs-137 and I-131 found in the Fermi sodium were identical, and similar to what was observed in SRE [3, Table VII, p. 82]. The conclusion was that about 1 or 2 percent of the available nonvolatile solid gamma-emitting fission products were released during melting in the Fermi incident. This is similar to the fractions of failed fuel inventories, including I-131, found in the SRE sodium. The cesium remains in the sodium because it is released from the metal fuel as elemental cesium metal or, possibly some as cesium iodide, CsI. When present at very low concentrations in excess sodium, thermodynamic calculations show that CsI will readily react with sodium to form sodium iodide, NaI and elemental cesium. This is borne out by experiments by Castleman, Tang, and Mackay. [2, p. 382; 401]. Sodium iodide is soluble in sodium and retained in solution at low concentrations [2, p. 382; 411]. Similar thermodynamic considerations show that uranium iodide in sodium converts to uranium and NaI. Cesium is very soluble in its sister alkali metal sodium. These observations from the Fermi fuel melting incident are consistent with observations of the SRE incident that show that no I-131 reached the cover gas and, just as significantly, the amount of I-131 captured by the sodium was similar to cesium, only 1 to 5 percent. The fact that only a fairly small fraction of iodine was found in the sodium and none in the cover gas demonstrates that very little iodine was released from the metal uranium fuel. The conditions in the Fermi incident would have been more conducive to iodine release from the fuel and, also, to bubbling through sodium into the cover gas than in the SRE. Iodine-131 was not found in the Fermi reactor cover gas nor substantially in the sodium.

No.	Section	Comments
		(1) IAEA, "Control of Iodine in the Nuclear Industry", International Atomic Energy Agency, Technical Reports Series No. 148, June 1973. (2) Castleman A. W., "LMFBR Safety I – Fission Product Behavior in Sodium", Nuclear Safety , Vol. 11, No. 5, Sept. – Oct. 1970 (3) "October 5, 1966 Fuel Damage Incident at the Enrico Fermi Atomic Power Plant - Status as of February 24, 1967," NP- 16750 (1967). (4) "Report on the Fuel Melting Incident in the Enrico Fermi Atomic Power Plant on October 5, 1966," APDA-233 (December 15, 1968).
R-4	General	The Advisory Panel (AP) reports fail to acknowledge numerous conclusions that State and Federal agencies have made concerning SSFL and the surrounding communities. These are enumerated below. Taken as a whole, these statements by State and Federal agencies confirm that no environmental health hazard, or any elevated cancer rates, has been observed as a result of the activities at the Santa Susana Field Laboratory.
R-5	General	The Agency for Toxic Substances and Disease Registry (ATSDR), in their 1999 study (http://www.atsdr.cdc.gov/HAC/PHA/santa/san_toc.html), concluded: • *"ATSDR has not identified an apparent public health hazard to the surrounding communities because people have not been, and are currently not being exposed to chemicals and radionuclides from the site at levels that are likely to result in adverse health effects."*
R-6	General	The Environmental Protection Agency's (EPA) conclusion following the 1995 Off-Site Multimedia Study of the Brandeis-Bardin Institute and Santa Monica Mountains Conservancy (http://apps.em.doe.gov/etec/EPAFS.PDF) immediately to the north of the location of the SRE, was that, • *"The radionuclides do not pose a threat to human health and the environment."*
R-7	General	The conclusion of EPA's 2003 Hazard Ranking Assessment of Area IV of SSFL (http://apps.em.doe.gov/etec/EPA-HRS.pdf) stated that … • *"Radionuclides associated with historic Area IV research are not present at concentrations significantly above background in the soils surrounding residential communities."*
R-8	General	The Department of Health Services made the following statement in 1992 following the second of their cancer registry studies of the communities surrounding SSFL, *"These analyses suggest that people living near the SSFL are* <u>*not*</u> *at increased risk for developing cancers associated with radiation exposure."*

<table>
<tr><th>No.</th><th>Section</th><th>Comments</th></tr>
<tr><td></td><td></td><td>“Cancer Incidence Near the Santa Susana Field Laboratory (1978-1989)”, California Department of Health Services, March 27, 1992.

An expert panel of nationally-renowned epidemiologists was hired by the Department of Toxic Substances Control (DTSC) to review the three DHS cancer studies. Their conclusion was,

“Three studies of cancer incidence in the vicinity of SSFL were reviewed ..... the combined evidence from all three does <u>not</u> indicate an increased rate of cancer in the regions examined. The results do <u>not</u> support the presence of any major environmental hazard.”

“Rocketdyne Inquiry – Summary of Findings and Report”, Cal/EPA Department of Toxic Substances Control”, August 1999.</td></tr>
<tr><td>R-9</td><td>General</td><td>The EPA’s conclusions following its own 2000-2001 surveys of 11 prior radiological facilities stated …
• "Previous DOE/Boeing surveys sampled in appropriate and representative locations."
• "Measurements made in previous surveys were accurate."
• "EPA concurs with the conclusions made by the Department of Energy (DOE) and Boeing Rocketdyne about the locations and levels of residual radioactivity."
"Residual radioactivity does not exceed DOE and Nuclear Regulatory (NRC) established limits for unrestricted use."</td></tr>
<tr><td>R-10</td><td>General</td><td>The AP reports purport to be “independent” reviews of the SRE incident, but this is not a fair or accurate characterization. Dan Hirsch, the AP co-chair, is president of the Committee to Bridge the Gap (www.committeetobridgethegap.org), a group which has long opposed regulated activities at the SSFL. In fact, Mr. Hirsch’s organization presently is suing The Boeing Company in federal court regarding activities at the SSFL, seeking declaratory and injunctive relief, imposition of civil penalties, and costs and attorneys fees. The AP turned to the Union of Concerned Scientists (www.ucsusa.org), an organization which opposes nuclear power, for the preparation of the Lochbaum Report. Jan Beyea is with an organization called Consulting in the Public Interest (www.cipi.com), whose web site advertises its services to “plaintiff’s attorneys.”</td></tr>
<tr><td>R-11</td><td>General</td><td>Some reports in the news media have stated that the AP studies used computer modeling to calculate how much radioactivity was released from the SRE accident. This is not correct. Neither Mr. Lochbaum nor Dr. Beyea used computer modeling to derive their estimates of radiation releases. Rather, Mr. Lochbaum simply chose the half-way point between 0 and 30 percent, and chose this percentage as his “release fraction” for the incident (which is then used by Dr. Beyea to derive his estimate regarding SRE releases).</td></tr>
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No.	Section	Comments
R-12	Panel Report, Pages 5 and 6	Reference is made to the 1997 and 1999 UCLA reports of Rocketdyne radiation workers and rocket test stand workers. No reference is made, however, to the more extensive report, sponsored by Boeing and the United Aerospace Workers (UAW), that was released in April 2005. The Boeing/UAW study was performed by experienced radiation epidemiologists. The principal investigator was Dr. John Boice of the International Epidemiology Institute (IEI), and the study was overseen by a Science Committee of epidemiology and public health experts headed by Dr. John Peters of the University of Southern California. The IEI Research team found no consistent or credible evidence that employment at Rocketdyne had adversely affected worker mortality. The Science Committee likewise concluded that, based on the results of the study, • The Rocketdyne workforce had a much lower overall mortality than the rate observed in the California population • There is no evidence that working conditions caused increased mortality in the Rocketdyne workforce The report can be found at: http://www.boeing.com/aboutus/environment/santa_susana/healthstudy.html.
R-13	Panel Report, Page 10	Reference is made in the Panel Report to several reactor incidents at SSFL. The incidents are discussed below. **AE6** In March 25, 1959, a release of fission gas within the AE-6 reactor occurred when an operational error was made during the transfer of gases from the reactor core to the holdup tank. This resulted in the release of a small amount of fission products into the reactor room and in the contamination of three members on the operating staff. The contamination was cleaned up quickly and effectively, and there were no measurable radiation exposures to any of the personnel involved. Calculations based on the operation of the reactor prior to the incident show that maximum release of fission gas in the reactor room would have been less than approximately 10 millicuries, principally Xe-135, and the building volume was sufficient to dilute the activity to a concentration essentially equal to the occupationally permitted concentration for continuous 40-hour/week exposure. There was no indication of any release to the environment. NAA-SR-MEMO 3757, “Release of Fission Gases from the AE-6 Reactor.”

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		S8ER (1964) During the operating life of the reactor core, 80% of the fuel swelled and the cladding developed cracks. This resulted in a slow escape of fission products into the coolant. All radioactivity was retained in the coolant system and cleaned up with the normal coolant cleaning systems. This was not an accident (or even incident), but was reported in the literature on sodium-cooled fuel rod operating experience. No release to the environment occurred. AI-AEC-MEMO-12790, "Survey of Fission and Corrosion Product Activity in Sodium or NaK Cooled Reactors", February 28, 1969. AI-AEC-13070. "SNAP 8 Summary Report." September 24, 1973. **S8DR (1969)** As with the above discussion on S8ER, similar fuel rod failures (e.g. clad swelling and cracking) occurred in the S8DR reactor. This was not an accident, and did not result in any release of radioactivity from the NaK coolant. No release to the environment occurred. Letter from M. Klein (USAEC) to J. J. Flaherty (AI), Untitled, 3206AT, October 29, 1969. AI-AEC-13071. "Summary of SNAP 8 Developmental Reactor (S8DR) Operations." June 22, 1973. AI-AEC-13070. "SNAP 8 Summary Report." September 24, 1973.
R-14	Panel Report, Page 10	Reference is made to plutonium allegedly detected in offsite soils immediately to the north of the SSFL. One location just to the north of the SSFL boundary had detectable, but low levels of plutonium-238 during the 1992 Brandeis Bardeen Institute/Santa Monica Mountains Conservancy sampling project. Subsequent sampling in the same location, however, failed to confirm any detectable plutonium-238. The land is now owned by Boeing. See report at … http://apps.em.doe.gov/etec/7727_1995_0119_MHI_AddSoilandWaterSamp.pdf.pdf
R-15	Panel Report, Pages 13	Reference is made in the Panel Report to the 1989 Dempsey review of the SSFL radiological monitoring program.

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	and 14	It is Boeing's view that the criticisms of the program in the Dempsey review were addressed, corrected, or answered in a Rockwell report, N001SRR140115, "Recent Reviews of Rocketdyne Environmental Monitoring Program," June 28, 1991. This document also contains two additional independent reviews of the program which in general respond to the Dempsey criticisms. ATSDR and UCLA were provided with a copy of this report for their studies.
R-16	Panel Report, Page 14	Reference is made to the filtering of water samples. The following addresses the issue of filtered vs. unfiltered water. Water with low turbidity (low suspended solids) has been shown to have no statistical difference between filtered and unfiltered samples (EPA groundwater study[1], DHS groundwater study[2], and Boeing surface water studies). Water with high turbidity (high suspended solids, muddy water) does result in significant differences in gross alpha activity (Boeing groundwater study[3]). However, subsequent uranium isotopic analysis has demonstrated that the uranium content of the suspended solids accounts for the difference. When uranium is subtracted from the gross alpha (as EPA protocols require) then alpha maximum contaminant levels (MCLs) are met. Inspection of the uranium isotopic ratios also demonstrates that the uranium is naturally occurring and not enriched or processed. 1. "Rocketdyne Technical Support/Field Oversight - Groundwater Split Sampling Report," prepared by Tetra Tech for EPA, Region 9, June 23, 1998. 2. "Ahmanson Ranch Groundwater Sampling of June 2003," Department of Health Services Radiologic Health Branch. 3. "SSFL Groundwater Monitoring Report for SSFL – Second Quarter 2006," Hailey & Aldrich, September 2006.
R-17	Panel Report, Page 17	The Panel Report reiterates Mr. Lochbaum's claim of large fractions of the reactor's fission product inventory being released. Mr. Lochbaum starts with the observation that 13 of 43 (or approximately 30%) of the fuel elements were damaged. He assumes that all of the parts of these 13 fuel elements were damaged and/or melted (although this assumption is not supported), and he therefore assumes that 30% of the core's fission product inventory was released to the environment. This is his "upper bound" estimate. He then acknowledges that a large fraction of the fission products would have been retained in the reactor system by a variety of means. He derives an unsupported estimate that the fraction of radioactivity released from the fuel into the sodium coolant would be 10%, and he then assumes that the release fraction from the cover gas to the environment would be 10% (for cesium-137) and 100% for iodine-131. Thus, the lower bound release therefore appears to be 0.3 x 0.1 x 0.1 = .003 = 0.3% for cesium-137 and 0.3 x 0.1 x 1.0 = .03 = 3% for iodine-131. He then says that the best estimate release would be the average of the upper and lower bound, or $\underset{\sim}{}$ 15%. Mr. Lochbaum's release fractions do not account for the fact that any iodine-131 or

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		cesium-137 released from the fuel would have been retained by the sodium coolant. Because the sodium coolant would bind up any iodine-131 and cesium-137 upon contact, this coolant acted as a six-foot deep protective barrier between the reactor core and cover gas. Yet Mr. Lochbaum assumes that 100% of these fission products would have somehow migrated up through this pool of sodium above the core without coming into any contact with it.
R-18	Panel Report, Page 18	Mr. Lochbaum does not provide an estimate of iodine-131 or cesium-137 inventory, or an estimate of number of curies released. The Panel Report uses Mr. Lochbaum's release fraction estimates to imply the upper bound number of curies released was 13,000 curies of iodine-131 and 2,600 curies of cesium-137, and a best estimate release of 6,500 curies of iodine-131 and 1,300 curies of cesium-137. This would require a total core inventory of iodine-131 and cesium-137 to be ~43,000 curies and 8,700 curies respectively. The Panel states that these inventories are based on Atomics International data, but that is not entirely correct. Table IV of NAA-SR-6890[1] gives the iodine-131 and cesium-137 core inventories as 16,800 curies and 8,700 curies respectively. Thus the Panel has used the correct 1962 estimate for cesium-137, but has used a value for the iodine-131 that is a factor of 2.6 too large. Hence, the Panel's estimates of iodine-131 releases are too large by a factor of 2.6 even if Mr. Lochbaum's release fractions are correct, which they are not. (1) NAA-SR-6890, "Distribution of Fission Product Contamination in the SRE", R.S. Hart, March 1, 1962.
R-19	Panel Report, Page 18 and 19	The Panel report compares its estimated release of iodine-131 with that of TMI (which released 17 curies of iodine-131). The implication is that the SRE was worse than TMI. The Panel Report claims that 6,500 curies of iodine-131 and 1,300 curies of cesium-137 were released following the SRE accident. Dr. Beyea offers yet another set of estimated releases of between 1,500 and 4,000 curies of iodine-131 and about 400 curies of cesium-137. Both sets of estimates are incorrect. Boeing's documented measured release data shows that a total of 28 curies of noble gases (9 curies of krypton-85 and 19 curies of xenon-133) were released following the SRE accident. The reported iodine-131 release from TMI[(1)] was 17 curies and the reported noble gas release was 2.4 million to 13 million curies. Therefore, TMI was actually at least 86,000 to 460,000 times worse than the SRE release[(2)]. The expected number of total additional cancer deaths from TMI was calculated to be 0.7 in a population of 2,000,000 living within 50 miles. This means that possibly zero, and most likely one person, would be expected to die of cancer from TMI.

<table>
<tr><th>No.</th><th>Section</th><th>Comments</th></tr>
<tr><td></td><td></td><td>Considering the much smaller SRE release of 28 curies of noble gases, there is no evidence that the SRE incident could have had any impact on community incidence of cancer.

(1) All TMI data has been taken from the President's Commission on TMI. http://www.pddoc.com/tmi2/kemeny/index.html.</td></tr>
<tr><td>R-20</td><td>Panel Report, Page 19 and 20</td><td>The Panel argues that the risk from radiation exposure is an order of magnitude higher than that assumed by regulatory agencies.

If the Panel's assertion were correct, the cancer risk from background radiation would be approximately 50% of the total cancer risk in society.

The BEIR VII committee (http://www.nap.edu/books/030909156X/html) confirmed the position of the earlier BEIR V committee that the linear no threshold (LNT) model of radiation risk is appropriate and that there is no threshold.

• BEIR VII defines low doses of ionizing radiation as less than 100 mSv (10,000 mrem).

• BEIR VII states that "at doses of 100 mSv (10,000 mrem) or less, statistical limitations make it difficult to evaluate cancer risk in humans."

• BEIR VII states that "at low doses the number of radiation induced cancers is small."

• BEIR VII states that "approximately one individual in 100 persons would be expected to develop cancer (solid cancer or leukemia) from a dose of 100 mSv (10,000 mrem) while approximately 42 of the 100 individuals would be expected to develop solid cancer or leukemia from other causes."

• BEIR VII establishes fatal cancer risk of ~0.0056 per 100 mSv (10,000 mrem) for solid cancers and leukemia (average of male and female risks). This is almost identical to the fatal cancer risk from ICRP 60 (1990) of 0.005 per 100 mSv derived from BEIR V.

Nonetheless, it is important to understand that the LNT model is a hypothetical statistical model, and that its use at low dose rates is extremely conservative. There is little or no scientific evidence that small variations in radiation exposure, much less than the variability in natural background radiation levels, result in any real or measurable increase in cancer risks. The following scientific, professional, and governmental bodies support the concept of a threshold at about 5,000 to 10,000 millirem above background, below which there is no cancer risk from radiation exposure.

• The National Academy of Sciences states, "With few exceptions, however, [cancer] effects have been observed only at relatively high doses and high dose rates. Studies of populations, chronically exposed to low level radiation, such as those residing in regions of <u>elevated</u> natural background radiation [10 - 100 times average US levels], have not shown</td></tr>
</table>

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		consistent or conclusive evidence of an associated increase in the risk of cancer." Health Effects of Low Levels of Ionizing Radiation. Committee on the Biological Effects of Ionizing Radiation (BEIR V), page 5. National Academy of Sciences, 1990. (http://newton.nap.edu/books/0309039959/html/5.html#pagetop) • The **Health Physics Society** states, "The Health Physics Society recommends against quantitative estimation of health risk below an individual dose of 5,000 millirem in one year or a lifetime dose of 10,000 millirem in addition to background radiation. There is substantial and convincing evidence of health risks at high dose. Below 10,000 millirem (which include occupational and environmental exposures), risks of health effects are either too small to be observed or are non-existent." Health Physics Society Position Statement on "Radiation Risk in Perspective." March 2001. (http://www.hps.org/documents/radiationrisk.pdf) • The **General Accounting Office** states, "According to a consensus of scientists, there is a lack of conclusive evidence of low level radiation effects below total exposures of about 5,000 to 10,000 millirem." GAO/RCED-00-152, Radiation Standards. Page 10. June 2000. (http://www.gao.gov/new.items/rc00152.pdf) • The **American Nuclear Society** states, "It is the position of the American Nuclear Society that there is insufficient scientific evidence to support the use of the Linear No Threshold Hypothesis in the projection of the health effects of low-level radiation." Health Effects of Low-level Radiation. American Nuclear Society Position Statement No. 41. June 2001. (http://www.ans.org/pi/ps/docs/ps41.pdf)
R-21	Panel Report, Page 19 and 20 and Beyea Report, Pages 5 and 6	The historical record and scientific literature demonstrates that only small quantities of xenon-133 and krypton-85 gases were released following the SRE accident and that large quantities of iodine-131 and cesium-137 were not released as claimed by the AP reports. There is no evidence that the SRE incident resulted in adverse health effects in the community. Nevertheless, it is important to acknowledge the statement made in the Panel report on page 20 at the end of section 3. It is repeated in its entirety here. *"At the same time, the reader must be reminded that these cancers, if they occurred, would have been amidst a population of several million people and over a time period of many decades (life time of residents exposed to the 1959 releases or to cesium remaining in soil). Dr. Beyea's analysis concludes that much of the population dose could have been delivered at significant distances from the site – such as Los Angeles – where many more people live than live nearby. Although the estimated individual doses, and cancer risks, are smaller at greater distances, the total number of cancers produced are larger due to the population size. The ability of epidemiological studies to identify these cancers, if they exist, in a population that large, is limited, given the uncertainty about where the exposures occurred and the great mobility in the population."*

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		This statement is a rewording of Dr. Beyea's cautionary statement on page 5 and 6 of his report. This also is repeated in its entirety here, *"These cancers would have occurred among a background of millions of cancers in the population exposed in the LA Basin, including a contribution from natural background radioactivity that would have exceeded the contribution from SSFL in aggregate."* These statements acknowledge that estimated theoretical cancers were calculated based on computed population doses (in person-rem). This is a consequence of misapplying the LNT model of radiation risk. The model says that if 1,000 people receive 10 rem exposure each (10,000 person-rem) then 10 radiation induced cancers would result. The model also says that if 10,000,000 people receive 0.001 rem (1 millirem) exposure each (also 10,000 person-rem) then 10 radiation induced cancers would also result. Thus, the LNT model potentially can predict large numbers of theoretical cancers if very large numbers of people are exposed to very low levels of radiation. This is counter-intuitive and is the reason why radiation professionals avoid using population doses to compute theoretical cancers. It is also instructive to expand upon the cautionary words in these paragraphs. Let us assume that the population in the Los Angeles area over the four and a half decades since the SRE accident is 8,000,000. This is consistent with the population data used by Dr. Beyea. In a population of that size we would expect approximately 3,360,000 cancers to occur during their collective lifetimes (the risk of contracting cancer in the US is approximately 42%). Assuming that the LNT model of radiation risk is valid at exposures similar to background radiation, the number of theoretical cancers induced from exposure to background radiation in 8,000,000 lifetimes is approximately 168,000 (~5% of total cancer rate). As Dr. Beyea acknowledges on pages 5 and 6 of his report, his predicted 260 additional cancers are low compared to not only the actual expected number of total cancers in the population but also low compared to the theoretical number of cancers that the LNT model would attribute to background radiation exposure. Looking at it from another perspective, the population thyroid dose from iodine-131 of 65,000 person-rem and population whole body dose from cesium-137 of 75,000 person-rem, is low compared to the population dose of 112,800,000 person-rem from 300 millirem/year background radiation to 8,000,000 people for 47 years since the accident. Finally, if Mr. Hirsch's assertion that radiation risk is actually an order of magnitude higher than that assumed by regulatory agencies, one would have to conclude that 1,680,000 people would develop cancer from background radiation.
R-22	Lochbaum Report, Title Page	The title of Mr. Lochbaum's report is "An Assessment of Potential Pathways for Release of *Gaseous* Radioactivity Following Fuel Damage During Run 14 at the Sodium Reactor Experiment," (emphasis added). But the Lochbaum Report discusses the release of iodine-131, which forms a <u>solid</u>, uranium tri-iodide, when produced by U-235 fission. Even if small quantities of

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		molecular or atomic iodine were to be released directly into liquid sodium, it is well known that iodine readily reacts with sodium to form a solid sodium iodide, which stays in the sodium system until it either plates out or is removed by the cold trap. Elemental cesium is also solid as are its various molecular salts. Thus, Mr. Lochbaum does not attempt to estimate the release quantities of the only gaseous fission products that were released during the incident.
R-23	Lochbaum Report, Page 1	Mr. Lochbaum starts with the observation that 13 of 43 (or approximately 30%) of the fuel elements were damaged. He assumes that all of the parts of these 13 fuel elements were damaged and/or melted (although this assumption is not supported), and he therefore assumes that 30% of the core's fission product inventory was released to the environment. This is his "upper bound" estimate. He then acknowledges that a large fraction of the fission products would have been retained in the reactor system by a variety of means. He derives an unsupported estimate that the fraction of radiation released from the fuel into the sodium coolant would be 10%, and he then assumes that the release fraction from the cover gas to the environment would be 10% (for cesium-137) and 100% for iodine-131. Thus, the lower bound release therefore appears to be 0.3 x 0.1 x 0.1 = .003 = 0.3% for cesium-137 and 0.3 x 0.1 x 1.0 = .03 = 3% for iodine-131. He then says that the best estimate release would be the average of the upper and lower bound, or $\simeq$ 15%. Mr. Lochbaum's release fractions do not account for the fact that any iodine-131 or cesium-137 released from the fuel would have been retained by the sodium coolant. Because the sodium coolant would bind up any iodine-131 and cesium-137 upon contact, this coolant acted as a six-foot deep protective barrier between the reactor core and cover gas. Yet Mr. Lochbaum assumes that 100% of these fission products would have somehow migrated up through this pool of sodium above the core without coming into any contact with it.
R-24	Lochbaum Report, Page 5 and 7	Several quotes from the original AI reports[1, 2, 3] are made including, "… no radiological hazard was presented to the environs," and "… no radiological emergency of any nature occurred." These statements reflected the facts known at the time (which have been confirmed by later analyses such as those by Christian[4] and Daniel[5]), that only low levels of gaseous Xe-133 and krypton-85 had been vented in compliance within federal airborne limits such that off-site doses would be low, and not represent a hazard to the community. (1) NAA-SR-4488, "SRE Fuel Element Damage – Interim Report", A. A. Jarrett (Editor), November 15, 1959 (2) NAA-SR-4488 (Suppl.), "SRE Fuel Element Damage – Final Report", 1961 (3) NAA-SR-6890, "Distribution of Fission Product Contamination in the SRE", R. S. Hart, March 1, 1962 (4) "Chemical Behavior of Iodine-131 During the SRE Fuel Element Damage in July 1959. Response to Plaintiff's Expert Witness, Arjun Makhijani", Jerry D.

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		Christian Ph.D., May 26, 2005 (5) "Investigation of Releases from Santa Susana Sodium Reactor Experiment in 1959", John A. Daniel Sr., May 27, 2005
R-25	Lochbaum Report, Page 9	The report states, *"Unfortunately, no data was found in the documents reviewed regarding the number of (or absence of) discharges from the gaseous storage tanks following the July 13th event. Thus, it is impossible to confirm or refute the assertion that "no radiological hazard was present to the reactor environs" via the gaseous storage tank pathway."* There is well-documented evidence of what was vented through the hold-up tanks. Contemporaneous records[(1)] from November 1959 indicate that 17 separate ventings of the gaseous hold-up tanks occurred between the date of fuel damage in July and September 30th, when hold-up tank activity reached normal levels. This inter-office letter documents the fact that approximately 28 curies of noble gases were released during a 10-week period. Activity concentration of the hold-up tanks (in terms of μCi/cc) was measured prior to each venting operation. With knowledge of the volume of each hold-up tank, the total activity released in each vent operation could be calculated (in terms of μCi). By summing each vent operation the total release in terms of Ci (curies) could be calculated. This inter-office letter was made available to Elizabeth Crawford (Staff Assistant to Ventura County Supervisor, Linda Parks) on January 21, 2005. Judy Mikels (Ventura County Supervisor) and Mary Weisbrock (Save Open Space) were also sent copies of the letter[(2)]. The inter-office letter was probably not available to Mr. Lochbaum during the conduct of his study. (1) Atomics International Inter-Office Letter from G. Borg to W. L. Fisher, "Quarterly (July through September 1959) Report of Activity Released to Atmosphere," November 20 1959. (2) Letter to Elizabeth Crawford from Phil Rutherford, "Sodium Reactor Experiment (SRE) Original Release Data," January 21, 2005.
R-26	Lochbaum Report, Page 10 and 13	Lochbaum quotes the 1959 AI report, *"… the results of a high bay air sample showed that the high bay activity level was 2 x 10^{-9} μCi/cm^3."* and reproduces the High Bay Airborne Area Activity chart. Mr. Lochbaum uses this information in reference to his argument that high activity readings in the high bay above the reactor refueling deck were evidence of an additional pathway for release through the HEPA filtered ventilation system. Lochbaum states, *"That large amounts of radioactivity reached the high bay area is illustrated in the figure titled, High Bay Area Airborne Activity."* The high-bay activity readings used by Mr. Lochbaum are not particularly high and are, in general, less than the <u>current</u> NRCs 2,000 working hour averaged occupational airborne limits (10 CFR 20 Appendix B, Table 1,

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http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-appb.html).

<table>
<tr><th rowspan="2">Phase</th><th rowspan="2">Isotope</th><th rowspan="2">NRC 2,000 working hour averaged occupational limit (μCi/cm³)</th><th colspan="4">High Bay Activity (μCi/cm³)</th></tr>
<tr><th>July 12</th><th>July 13</th><th>July 21</th><th>July 23</th></tr>
<tr><td>Gas</td><td>Xe-133</td><td>10^{-4}</td><td rowspan="4">10^{-6}</td><td rowspan="4">3.6 x 10^{-8}</td><td rowspan="3">10^{-6} – 10^{-5} (gaseous)</td><td rowspan="4">1.3 x 10^{-7}</td></tr>
<tr><td>Gas</td><td>Kr-85</td><td>10^{-4}</td></tr>
<tr><td>Vapor</td><td>I-131</td><td>2 x 10^{-8}</td></tr>
<tr><td>Particulate (solid)</td><td>Cs-137</td><td>6 x 10^{-8}</td><td>2 x 10^{-9} (particulate)</td></tr>
</table>

The only day with differential airborne activity for particulates and gaseous radionuclides was July 21. The particulate activity is less that the 2,000 working hour NRC occupational limit, and the gaseous activity is less than the likely major source of gaseous activity namely Xe-133 and Kr-85.

The relative concentration of particulates vs. gases is small at 1 in 500 to 1 in 5,000, showing that particulates (e.g. potential cesium-137) were present in much lower quantities than gases (e.g. most likely Xe-133 and Kr-85).

The other activity values are not identified as either gaseous or particulate. An air sample collected using an air pump to collect contamination on filter paper would be measuring particulates only. An air sample collected using an air pump to collect contamination on activated charcoal would be measuring gases and particulates. A grab air sample would measure combined gaseous and any still-suspended particulates. Assuming these activities are particulate and gas combined, then all non-differentiated values are much less than the noble gas occupational limit of 10^{-4} μCi/cm³. Assuming the ratio of particulate to gaseous activity is similar to the July 21 sample, then the particulate contribution will be less than the Cs-137 2,000 working hour NRC occupational limit. It should also be noted that the periods of elevated high bay activity as indicated by the count rate graph are relatively brief, which means that when averaged over the 2,000 working hour year, the airborne activities are very low compared to the occupational limits.

As Mr. Lochbaum describes the ventilation system at the top of page 10, the SRE is designed as a negative pressure system such that air flow travels from the outside environment, through office and administrative areas, to reactor areas such as the high bay re-fuelling deck. Furthermore, air from the reactor areas is exhausted to the outside through high efficiency particulate air (HEPA) filters.

In summary, the relatively low airborne activity in the high bay, coupled with the negative pressure building design and the use of HEPA filters, preclude any significant activity from exiting the high bay.

<table>
<tr><th>No.</th><th>Section</th><th>Comments</th></tr>
<tr><td></td><td></td><td>The NRCs current public airborne limits (10 CFR 20 Appendix B, Table 2 are 5 x 10^{-7} μCi/cm^3 for Xe-133 and 7 x 10^{-7} μCi/cm^3 for Kr-85 averaged over a calendar year (8,760 hours). Thus the policy of maintaining vented noble gas effluent to < 1 x 10-7 μCi/cm^3 was protective even by today's standards.</td></tr>
<tr><td>R-27</td><td>Lochbaum Report, Page 13</td><td>Mr. Lochbaum claims "That large amounts of radioactivity reached the helium cover gas above the reactor pool is evident from the table titled Activity History of the Reactor Cover Gas."

The 1962 AI report[(1)] which was available to Mr. Lochbaum states that only Xe-133 and Kr-85 were identified in the cover gas. Table VII of the report includes the following measured data.

<table><tr><th>Isotope</th><th>Cover Gas Concentration (μCi/cm^3)</th><th>Total Cover Gas Inventory (curies)</th></tr><tr><td>Xe-133</td><td>7.4</td><td>47</td></tr><tr><td>Kr-85</td><td>0.016</td><td>0.2</td></tr></table>
If iodine-131 and cesium-137 had been released to the cover gas as alleged in all three AP reports, then these would have been readily detected in the various cover gas samples taken following the accident. Mr. Hirsch, Mr. Lochbaum, and Dr. Beyea claim that all the iodine-131 and cesium-137 had escaped though the cover gas system without leaving any detectable amount by the time samples were taken. This is unrealistic.

(1) NAA-SR-6890, "Distribution of Fission Product Contamination in the SRE", R. S. Hart, March 1, 1962</td></tr>
<tr><td>R-28</td><td>Lochbaum Report, Page 13</td><td>Mr. Lochbaum states,

"That large amounts of radioactivity reached the gaseous storage tanks is evident from the table titled "Radioactive Concentrations in Gas Decay Tanks," and

"No data was found on either the radiation levels at the stack release point or on the number, timing, and radioactivity levels of releases from the gaseous storage tanks."

There is well documented evidence of what was vented through the hold-up tanks. Contemporaneous records[(1)] from November 1959 indicate that 17 separate ventings of the gaseous hold-up tanks occurred between the date of fuel damage in July and September 30th, when hold-up tank activity reached normal levels. This inter-office letter documents the fact that approximately 28 curies of noble gases were released during a 10-week period. Activity concentration of the hold-up tanks (in terms of μCi/cc) was measured prior to each venting operation. With knowledge of the volume of each hold-up tank, the total activity released in each vent operation could be calculated (in terms of μCi). By summing each vent operation the total release in terms of Ci (curies) could be calculated.

This inter-office letter was made available to Elizabeth Crawford (Staff Assistant to</td></tr>
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		Ventura County Supervisor, Linda Parks) on January 21, 2005. Judy Mikels (Ventura County Supervisor) and Mary Weisbrock (Save Open Space) were provided copies of the letter[(2)]. (1) Atomics International Inter-Office Letter from G. Borg to W. L. Fisher, "Quarterly (July through September 1959) Report of Activity Released to Atmosphere", November 20 1959. (2) Letter to Elizabeth Crawford from Phil Rutherford, "Sodium Reactor Experiment (SRE) Original Release Data", January 21, 2005
R-29	Lochbaum Report, Page 13	Mr. Lochbaum states, *"The only information [relative to potential releases from the hold-up tanks] – albeit indirect – covered the radiation levels inside the ventilation system ductwork. This data, from 1966, indicated the radiation levels measured in ductwork upstream of filters was 2 to 20 times the radiation levels measured downstream of the filters. The data clearly demonstrate (a) the ventilation system filters were effective in removing radioactivity from the process flows, and (b) the ventilation system filters did not remove all radioactivity from the process flows."* The "radiation levels" to which Mr. Lochbaum refers are actually "contamination levels." They are measures of radioactive material not measures of radiation levels. The upstream contamination levels (before the filter) range from 756 to 10,181 dpm/100 cm^2. The downstream contamination levels (after the filter) range from 129 to 1,293 dpm/100 cm^2. Assuming that the contamination was due to cesium-137 with a 30-year half life, these levels would not have decayed appreciably in the 7 years since the accident (1959 to 1966). These levels either lower than, or equivalent to, the acceptable levels for "release for unrestricted use" found in Regulatory Guide 1.86[(1)] of 5,000, 15,000, and 1,000 dpm/100 cm^2 for average, maximum, and removable, β/γ contamination respectively. These relatively modest levels of contamination are not indicative, as Mr. Lochbaum implies, of the passage and release of thousands of curies of cesium-137. dpm/ 100 cm^2 = disintegration per minute per 100 cm^2 (1) U.S. Nuclear Regulatory Commission Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors."

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R-30	Lochbaum Report, Page 17	Mr Lochbaum ends his report as he starts it, with a description of his scientific method of estimating the percentage of iodine-131 and cesium-137 released. Mr. Lochbaum makes his observation that 13 of 43 (or approximately 30%) of the fuel elements were damaged. He assumes that all of parts of these 13 fuel elements were damaged (although this assumption is not supported), and he therefore assumes that 30% of the core's fission product inventory was released to the environment. This is his "upper bound" estimate. He then acknowledges that a large fraction of the fission products would have been retained in the reactor system by a variety of means. He derives an unsupported estimate that the fraction of radiation released from the fuel into the sodium coolant would be 10%, and he then assumes that the release fraction from the cover gas to the environment would be 10% (for cesium-137) and 100% for iodine-131. Thus, the lower bound release therefore appears to be 0.3 x 0.1 x 0.1 = .003 = 0.3% for cesium-137 and 0.3 x 0.1 x 1.0 = .03 = 3% for iodine-131. He then says that the best estimate release would be the average of the upper and lower bound or, $\underset{\sim}{}$ 15%. Mr. Lochbaum's release fractions do not account for the fact that any iodine-131 or cesium-137 released from the fuel would have been retained by the sodium coolant. Because the sodium coolant would bind up any iodine-131 and cesium-137 upon contact, this coolant acted as a six-foot deep protective barrier between the reactor core and cover gas. Yet Mr. Lochbaum assumes that 100% of these fission products would have somehow migrated up through this pool of sodium above the core without coming into any contact with it.
R-31	Beyea Report	Dr. Beyea's report contains accusations of deliberate withholding of data, destruction of data, falsification of data, and cover-up by the plant owners and operators. Specific allegations and personal comments are made regarding Dr. Chauncey Starr, the president of Atomics International at the time of the accident. Boeing does not consider these comments by Dr. Beyea to be appropriate for a scientific study, and therefore will not respond to them.
R-32	Beyea Report, Page 4	Dr. Beyea makes the statement, *"existing radiocesium measurements are not adequate to determine the magnitude of any elevated releases."* Environmental sampling studies performed over the last 14 years have unequivocally demonstrated that cesium-137 is not in the soils of communities surrounding SSFL at levels that differ from local background. These studies demonstrate that cesium-137 releases of the size postulated by Dr. Beyea could not have occurred. Many of these studies have been conducted by organizations independent of Boeing. Those studies conducted by Boeing have been under the oversight of numerous regulatory agencies, including the California Department of Health Services (DHS), the California Department of Toxic Substances Control (DTSC) and the Environmental Protection Agency (EPA). The studies include but are not limited to, (1) McLaren/Hart, "Additional Soil and Water Sampling at the Brandeis-Bardin Institute and Santa Monica Mountain Conservancy", January 19, 1995 (http://apps.em.doe.gov/etec/7727_1995_0119_MHI_AddSoilandWaterSamp.pdf)

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		(2) Environmental Protection Agency, "EPA Update. The U.S. EPA Announces Results of Rocketdyne's Off-Site Sampling Program for the Santa Susana Field Laboratory." July 1995. (http://apps.em.doe.gov/etec/EPAFS.PDF) (3) Lawrence Livermore National Laboratory, "Soil Sampling for Cesium-137 at the Rocketdyne Recreation Center," 1997. (4) Ogden Environmental Services. "Bell Canyon Area Soil Sampling Report. Ventura County, California," October 1998. (5) Foster Wheeler Environmental Corporation. "Final Report. Runkle Ranch Site Investigation. Simi Valley, CA," October 1999. (6) QST Environmental, "Results of Preliminary Soil sampling at Runkle Ranch in Simi Valley, California," February 5, 1999. (7) Kleinfelder, "Report of Environmental Sampling. Ahmanson Ranch Project. County of Ventura, CA," January 27, 2000. (8) Essentia Management Services, "Final Site Investigation Report – Soil Suitability Evaluation - Chatsworth Reservoir, Chatsworth, California," Prepared for the Los Angeles Department of Water and Power, July 22, 2004. With one exception, no samples from the above studies have exceeded the local cesium-137 background established by Reference 1 above. The one exception identified in Reference 1 was one localized area immediately to the north of the prior Building 4059 in Area IV of SSFL. The cesium-137 background established in Reference 1 above (Table 38, 1995 report) is, Range <0.03 to 0.213 pCi/g Mean 0.087 pCi/g St. Deviation 0.062 pCi/g 5^{th} to 95^{th} percentile <0.03 to 0.21 pCi/g Using non-parametric statistical tests to compare background distributions to sampled area distributions, McLaren-Hart determined that only one area (Building 4059 watershed) was contaminated with cesium-137 with the following statistics, Range <0.077 to 0.385 pCi/g Mean 0.20 pCi/g St. Deviation 0.08 pCi/g 5^{th} to 95^{th} percentile 0.04 to 0.36 pCi/g Thus the mean cesium-137 was approximately twice that of local background. The EPA stated in a fact-sheet (Reference 2) following the BBI/SMMC sampling that these low levels of radionuclides are less than the 1-in-a-million cancer risk level. EPA stated that, *"EPA has determined that the radionuclides do not pose a threat to human health or the environment."* Boeing has since purchased this land from the Brandeis Bardin Institute.

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		Dr. Beyea does not reference any of these studies in his extensive list of almost 200 references. He does not cite any support for his statement that *"existing radiocesium measurements are not adequate to determine the magnitude of any elevated releases."*
R-33	Beyea Report, Page 5	Dr. Beyea states *"the average number of predicted cancers was 260 with a 95%-confidence range of 0 to 1800."* This statement has been reported in the Los Angeles Times as: *"predicted cancers were between 260 and 1800,"* (LA Times October 6, 2006).
R-34	Beyea Report, Pages 5 and 6	Dr. Beyea states, *"These cancers would have occurred among a background of millions of cancers in the population exposed in the LA Basin, including a contribution from natural background radioactivity that would have exceeded the contribution from SSFL in aggregate."* These statements acknowledge that estimated theoretical cancers were calculated based on computed population doses (in person-rem). The figures reported misapply the LNT model of radiation risk. The model says that if 1,000 people receive 10 rem exposure each (10,000 person-rem) then 10 radiation induced cancers would result. The model also says that if 10,000,000 people receive 0.001 rem (1 millirem) exposure each (also 10,000 person-rem) then 10 radiation induced cancers would also result. Thus the LNT model potentially can predict large numbers of theoretical cancers if very large numbers of people are exposed to very low levels of radiation. This is counter-intuitive and is the reason why radiation professionals avoid using population doses to compute theoretical cancers. It is also instructive to expand upon the cautionary words in these paragraphs. Let us assume that the population in the Los Angeles area over the four and a half decades since the SRE accident is 10,000,000. In a population of that size we would expect approximately 4,200,000 cancers to occur during their collective lifetimes (the risk of contracting cancer in the US is approximately 42%). Assuming that the LNT model of radiation risk is valid at exposures similar to background radiation, the number of theoretical cancers induced from exposure to background radiation in 10,000,000 lifetimes is approximately 210,000 (~5% of total cancer rate). Dr. Beyea states on pages 5 and 6 of his report that his predicted 260 excess cancers (which is based on his incorrect estimates of radiation exposure) are low compared to not only the actual expected number of total cancers in the population, and are also low compared to the theoretical number of cancers that the LNT model would attribute to background radiation exposure. Looking at it from another perspective, the population thyroid dose from iodine-131 of 65,000 person-rem and population whole body dose from cesium-137 of 75,000 person-rem, is low compared to the population dose of 141,000,000 person-rem from 300 millirem/year background radiation to 10,000,000 people for 47 years since the accident.

<table>
<tr><th>No.</th><th>Section</th><th>Comments</th></tr>
<tr><td>R-35</td><td>Beyea Report, Page 9</td><td>Dr. Beyea states, "before undertaking an expensive epidemiological study, it would seem wiser to first undertake measurements of radiocesium in soil at locations around the plant, so as to narrow the great uncertainties that make current dose estimates of marginal usefulness for epidemiology. In particular, the existing radiocesium measurements are not adequate to determine the magnitude of any elevated releases."

Many Boeing sponsored and independent studies have been conducted at locations around the plant that included cesium-137 soil analysis. No evidence of cesium-137 soil contamination, that would have resulted from the release thousands of curies of cesium-137, has been found. See comment on Beyea Report page 4 above.</td></tr>
<tr><td>R-36</td><td>Beyea Report, Page 13</td><td>Dr. Beyea states,

"From the beginning, management played down the seriousness of the event, as indicated by the press statement that was issued by Atomics International on August 29, 1959 and circulated by the US Atomic Energy Commission (AI 1959).

"During Inspection of fuel elements on July 26 at the Sodium Reactor Experiment…..a parted fuel element was observed. The fuel element damage is not an indication of unsafe reactor conditions. No release of radioactive materials to the plant or its environs occurred…"

In the press release, the number of damaged fuel elements was understated and the leakage of radioactivity from the stack was not mentioned."

Boeing acknowledges that the Atomics International press release following the accident was vague and not fully informative.</td></tr>
<tr><td>R-37</td><td>Beyea Report, Page 13</td><td>Dr. Beyea states, "No post-event analysis of the amount of radioactivity on the ventilation filters is available, which is the first place one would look to get an idea of the amount released, taking into account filter efficiency …. Yet, measurements made after decommissioning of the amount of surface contamination before and after the filters imply that there was a filter in place."

These statements are somewhat contradictory. The important facts about the measured data related to the HEPA filter system ventilation ducts are as follows. The upstream contamination levels (before the filter) range from 756 to 10,181 dpm/100 cm^2. The downstream contamination levels (after the filter) range from 129 to 1,293 dpm/100 cm^2. Assuming that the contamination was due to cesium-137 with a 30-year half life, these levels would not have decayed appreciably in the 7 years since the accident (1959 to 1966). These levels either lower than, or equivalent to, the acceptable levels for "release for unrestricted use" found in Regulatory Guide 1.86[(1)] of 5,000, 15,000, and 1,000 dpm/100 cm^2 for average, maximum, and removable, β/γ contamination respectively. These relatively modest</td></tr>
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		levels of contamination are not indicative of the passage and release of thousands of curies of cesium-137.
R-38	Beyea Report, Page 15	Dr. Beyea cites the 1957 Windscale reactor accident in the U.K. as his primary source by which to estimate the SRE release. Windscale released 20,000 curies of iodine-131. By using the ratio of the thermal power levels (9-to-1), the 50% retention factor for the Windscale filters and the alleged non-operation of SRE filters, Dr Beyea calculates that the SRE released 4,400 curies of iodine-131. This assessment overlooks several crucial differences between the Windscale accident and the SRE accident. (1) Windscale was air-cooled and following the accident there was a direct pathway from the damaged core to the outside environment through the stack filters, which became inoperable due to the intense heat. In contrast, the SRE uranium fuel continued to be immersed and cooled in a 50,000 gallon pool of liquid sodium. (2) The graphite moderator surrounding the Windscale uranium fuel actually burned in the air "cooling" flow for several days. The air coolant therefore became an oxidant which exacerbated and prolonged the fire. The SRE graphite did not burn since there was no oxygen in the system to initiate a fire. The SRE graphite and uranium fuel continued to be cooled and immersed in a 50,000 gallon pool of liquid sodium. (3) The burning graphite in Windscale led to significant melting of uranium fuel. In contrast, very little of the uranium fuel in the SRE melted (*"Examination of the recovered fuel slugs from damaged [fuel] elements showed no evidence of significant melting,"* (NAA-SR-6890, "Distribution of Fission Product Contamination in the SRE", R.S. Hart, March 1, 1962, page 21). (4) *"Even though iodine is very volatile, it did not escape to the cover gas because it undoubtedly combined with the sodium as rapidly as it was evolved. No iodine was ever detected in reactor cover gas samples,"* (NAA-SR-4488, "SRE Fuel Element Damage – Interim Report," A. A. Jarrett (Editor), page IV-C-5, November 15, 1959). In contrast, iodine-131 escaping from the Windscale fuel had a direct pathway to the outside environment. The Windscale data, therefore, is not useful for estimating releases from the SRE.
R-39	Beyea Report, Pages 18 and 19	Dr. Beyea further supports his estimate of iodine-131 release by reference to three other studies either commissioned by the AP or commissioned by plaintiff's attorneys in the litigation, *"O'Connor et. al. vs. The Boeing Company."* (1) Dr. Beyea refers to "Releases of Hazardous Material from the Santa Susana Field Laboratory," Gordon Thompson, Executive Director of the Institute for Resource and Security Studies (http://www.irss-usa.org/). IRSS is another anti-nuclear organization. This document was commissioned by the AP but has not been published either on the IRSS website or the Advisory panel website. Boeing is therefore not able to comment on its assumptions or methodology.

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		(2) Dr. Beyea uses the estimates of Mr. Lochbaum of the anti-nuclear Union of Concerned Scientists. Mr. Lochbaum's report has already been critiqued above. (3) Lastly Dr. Beyea uses newspaper reports of estimates made by another anti-nuclear expert hired by plaintiffs' attorneys' in the litigation, *"O'Connor et. al. vs. The Boeing Company."* The sources used by Dr.Beyea to estimate the distribution of iodine-131 and cesium-137 releases cannot be considered unbiased. The use of these reports skews Dr. Beyea's modeling of exposure and cancer risk.
R-40	Beyea Report, Page 30	Dr. Beyea claims that cesium-137 has been measured at 240 times background (24 pCi/g) outside the SSFL fence. This is incorrect. The 2003 Annual Site Environmental Report page 5-13 (http://apps.em.doe.gov/etec/ASER2003.pdf) to which he refers is discussing the Radioactive Material Handling Facility (RMHF) fence, not the SSFL fence. The area was on-site, not off-site. The discussion included the fact that the area was remediated.
R-41	Beyea Report, Page 30	Dr. Beyea postulates a situation where 1,000 curies of cesium-137 is spread over 10,000 square kilometers and would result in an average concentration of 0.25 pCi/g, which would be 2.5 times the average background of 0.1 pCi/g. He then claims that he was not able to find any evidence of the 0.1 pCi/g in the literature. Local cesium-137 background was established by the McLaren-Hart study[1] (Table 38) and is, Range <0.03 to 0.213 pCi/g Mean 0.087 pCi/g St. Deviation 0.062 pCi/g 5^{th} to 95^{th} percentile <0.03 to 0.21 pCi/g This is considerably below literature sources for U.S. cesium-137 in soil. Argonne National Laboratory (ANL)[2] states, *"The concentration of cesium-137 in surface soil from [weapons test] fallout ranges from about 0.1 to 1 picocurie (pCi)/g, averaging less than 0.4 pCi/g."* The EPA[3] quotes 0.7 pCi/g as an average U.S. background, with a range of 0.1 to 3.5 pCi/g. EPA derived its background data from NCRP 94[4] which was published in 1987. Therefore, these data may need to be decayed by a factor of $e^{-19/30}$ or 0.64. Dr. Beyea's reliance on 0.1 pCi/g does not recognize that the upper range of local background is 0.2 pCi/g. This is very close to his postulated contamination level of 0.25 pCi/g. Furthermore, the further from SSFL we go, the more we need to rely on the literature values for U.S. cesium-137, which are considerably more variable and considerably higher than local background. Therefore Dr. Beyea's expectations of being able to distinguish his postulated contamination level of 0.25 pCi/g above

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		background will be problematic at best and impossible at worst. (1) McLaren/Hart, "Additional Soil and Water Sampling at the Brandeis-Bardin Institute and Santa Monica Mountain Conservancy," January 19, 1995, http://apps.em.doe.gov/etec/7727_1995_0119_MHI_AddSoilandWaterSamp.pdf.pdf. (2) Argonne National Laboratory, "Human Health Factsheet – Cesium," August 2005, http://www.ead.anl.gov/pub/doc/cesium.pdf. (3) EPA 402-R-96-011A, "Technical Support Document for the Development of Radionuclide Cleanup levels in Soil," Appendix O, Table O-, page O-9, http://www.epa.gov/radiation/docs/cleanup/402-r-96-011a.htm. (4) NCRP-94, "Exposure of the Population in the United States and Canada from Natural Background Radiation," National Council on Radiation Protection and Measurements, 1987.
R-42	Beyea Report, Page 30	Dr. Beyea claims that 0.25 pCi/g in soil gives an exposure of 0.1 rem or 100 millirem over a period of 30 years, without providing a source for his statement. The EPA's Dose Compliance Concentration website (http://epa-dccs.ornl.gov/dose_search.shtml) allows us to compute the effective exposure as a function of soil contamination for residential scenarios (which is appropriate for suburban Los Angeles). This EPA online calculator computes that 0.25 pCi/g of cesium-137 in soil will give a first year dose of 0.1777 millirem. The 30th year dose will be ~ 0.0888 millirem. The average dose over 30 years will be ~0.1333 millirem/y or a total dose of 4 millirem over a 30 year period, not 100 millirem. Dr. Beyea has therefore overestimated exposures by a factor of 25.
R-43	Beyea Report, Page 30	Dr. Beyea claims that 0.25 pCi/g in soil gives an exposure of 0.1 rem or 100 millirem over a period of 30 years, which is equivalent to a cancer risk of 1-in-10,000 to 1-in-3,000, without providing a source for his statement. The EPA's Preliminary Remediation Goal website (http://epa-prgs.ornl.gov/radionuclides/prg_search.shtml) allows us to compute the theoretical cancer risk as a function of soil contamination for residential scenarios (which is appropriate for suburban Los Angeles). This EPA online calculator computes that 0.0597 pCi/g of cesium in soil will give a cancer risk of 1-in-1,000,000 for a 30 year exposure period. By ratioing, 0.25 pCi/g of cesium-137 will give a cancer risk of 4.2 x 10^{-5}, or 4.2-in-100,000. Therefore, Dr. Beyea has overestimated cancer risks by a factor of between 2.4 and 7.9.
R-44	Beyea Report, Page 30	Dr. Beyea claims that radiation risk coefficients are either 0.0015 or 0.003 cancers per rem. Actually, he apparently meant to say "per person-rem." These figures appear to be in disagreement with the radiation risk coefficients from both BEIR V and BEIR VII. BEIR V (http://www.nap.edu/books/0309039959/html/) risk coefficients were 0.0005 fatal cancers per person-rem, and 0.0006 cancer incidence per person-rem. The more recently published BEIR VII report (http://newton.nap.edu/catalog/11340.html and

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		http://newton.nap.edu/execsumm_pdf/11340) reported coefficients of 0.00057 fatal cancer per person-rem and 0.00114 cancer incidence per person-rem.
R-45	Beyea Report, Page 30	If Dr. Beyea has used the same dose and risk coefficients (discussed above) in his computer modeling as he used in his "back of the envelope" calculations then the hypothetical public exposures and cancers are grossly exaggerated even assuming the releases are correct, which they are not.
R-46	Beyea Report, Page 40, Table 3-1	In Table 3-1, the maximum hypothetical individual thyroid exposure from a release of 10,000 curies is given as 6.18 rem. Using the ICRP 60 risk coefficient for fatal thyroid cancer of 0.000008, the maximum hypothetical individual fatal risk is 0.000049. This is small compared to the U.S. fatal risk of thyroid cancer of 0.0005.
R-47	Beyea Report, Page 41, Table 3-4	In Table 3-4, the maximum hypothetical individual whole body exposure from a release of 300 curies is given as 7.36 rem. Using the ICRP 60 fatal risk coefficient for all cancers of 0.0005, the maximum hypothetical individual fatal risk is 0.0037. This is small compared to the U.S. fatal cancer risk of 0.23.
R-48	Beyea Report, Page 54, Table 4-2	Table 4-2 provides the hypothetical cancers from exposure to cesium-137 as function of distance from the SSFL up to 100 km. A similar table was not provided for iodine-131. Inspection of the numbers shows that the larger the annulus modeled (or distance from the site), the larger the number of hypothetical cancers. Thus, even though individual doses would tend to decrease with distance from the SSFL site, the population increases with distance. Therefore, the collective or population dose in person-rem increases without bound. If Dr. Beyea had expanded his analysis to 500, 1,000, or 5,000 km, he would have calculated even more hypothetical cancers. This illustrates the fallacy of modeling large populations exposed to very small doses to calculate pubic health effects. The Health Physics Society (HPS) has issued two position papers on radiation risk in which they caution against the use of population doses to estimate public health effects. http://www.hps.org/documents/radiationrisk.pdf http://www.hps.org/documents/riskassessment.pdf The HPS states, *"Collective dose (the sum of individual doses in a defined exposed population expressed as person-rem) has been a useful index for quantifying dose in large populations and in comparing the magnitude of exposures from different radiation sources. However, collective dose may aggregate information excessively, for example, a large dose to a small number of people is not equivalent to a small dose to many people, even if the collective doses are the same. Thus, for populations in which almost all individuals are estimated to receive a lifetime dose of less than 10 rem above background, collective dose is a highly speculative and uncertain measure of risk and should not be used for the purpose of estimating population health risks."*

Comments on the Advisory Panel Reports on the Geologic Features of the Santa Susana Field Laboratory (including the Panel Summary Report and the Wilshire Report)

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G-1	Panel Report Page 16	The Panel Report states that “Rocketdyne has argued that there is no risk from contaminated groundwater migration and that it need not clean up the groundwater contamination on site because earthquake faults and fine-grained geologic units prevent the contaminated groundwater from moving.” The above-statement is an inaccurate portrayal of Boeing’s understanding of groundwater contamination at the SSFL. The current understanding of contaminant transport in groundwater beneath the SSFL, as articulated in a number of technical reports, is that contaminants are within a few thousand feet of where they entered the ground because of natural physical and chemical processes. The processes that cause the contaminants in groundwater to be relatively close to where they entered the ground include molecular diffusion, sorption, dispersion, and degradation. The site geology descriptions provided in technical reports were intended to provide a framework for evaluating the direction in which the contaminants are transported and to evaluate the presence of potential through-going rapid transport pathways.
G-2	Panel Report Pages 24 and 25	Pertaining to the topic titled “Geologic Features and Their Potential Effects of Contaminant Migration….” The section of the Panel Report entitled “Geologic Features and Their Potential Effects on Contamination Migration, Santa Susana Field Laboratory,” states that “the Panel asked him [Howard Wilshire, Ph.D.] to examine the geology of the SSFL site and in particular evaluate claims made by Rocketdyne that contaminated groundwater at the facility could not migrate because of earthquake faults and fine-grained units that would act as barriers to groundwater movement.” The above statement does not accurately describe the analyses of these geologic features that are made in SSFL technical reports. These reports have not characterized the influence of faults and fine-grained units as barriers to groundwater flow nor as preventing migration. The analysis of available data, which continues to be collected, indicates that these features appreciably influence the three-dimensional groundwater flow system beneath the SSFL. Furthermore, the SSFL technical reports point out that the transport of contaminants at the SSFL is greatly slowed compared to the groundwater velocity in the fracture network due to physical and chemical processes that include primarily molecular diffusion, followed by sorption, dispersion, and degradation. Additionally, groundwater characterization work at the SSFL has been on-going and continues today. The results of this work continue to support the conclusion that groundwater plumes sourced from the SSFL lie within a few thousand feet of where the contaminants entered the ground because of the

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		attenuating effects of molecular diffusion, sorption, dispersion and degradation. This claim is supported by thousands of rock core samples that have been collected to evaluate the occurrence and distribution of trichloroethene (TCE).
G-3	Panel Report Page 25	The Panel Report states that "Rocketdyne has also argued that TCE and perchlorate are held up in the rock matrix of the sandstone at the SSFL and thus can not move." The above statement does not accurately state Boeing's position on contaminant transport. SSFL technical reports have not stated that contaminants cannot move, but that "TCE plume fronts advance at rates that are orders-of-magnitudes slower than the average linear groundwater velocity", and that "inspection of …TCE in rock core…indicates that the plumes at the SSFL are most likely…migrating very slowly and becoming stable." These conclusions are based on sound science and supported by the analysis of thousands of rock core samples for TCE and a much smaller subset of rock core samples for perchlorate.
G-4	Panel Report Page 25	The Panel Report states that "A recent study by a UCLA team disputes that assertion [that TCE and perchlorate are held up in the rock matrix of the sandstone at SSFL and thus cannot move] as well" and that Dr. Thomas C. Harmon "experimentally tried to get TCE into the rock matrix of a sample of SSFL sandstone; very little was absorbed." Boeing believes that these statements are erroneous. The study referenced by the UCLA team actually produced results that indicate that the magnitude of TCE sorption onto the rock particles is far greater than that used by the SSFL. These results would indicate that the magnitude of the coupled affects of molecular diffusion and sorption on TCE in the rock matrix from the UCLA study would be greater than that used by the SSFL team. Furthermore, as previously stated, Boeing's position regarding the transport of TCE in the bedrock matrix is based on analytical results of thousands of samples of rock core taken from coreholes at the SSFL.

Comments on "Geologic Features and Their Potential Effects on Contaminant Migration, Santa Susana Field Laboratory"

1.0 INTRODUCTION

On October 5, 2006, the Santa Susana Field Laboratory Advisory Panel issued a report discussing interpretations of the relationship between geology and hydrogeology at the Santa Susana Field Laboratory (SSFL). The report was entitled "Geologic Features and Their Potential Effects on Contaminant Migration, Santa Susana Field Laboratory" and was authored by Howard G. Wilshire, Ph.D. (Wilshire Report).

The Wilshire Report is very narrow in its focus, but broad in its conclusions. The title limits the focus to geologic structure and stratigraphy. From this narrow focus, the author makes the following assertion:

> "I conclude that Rocketdyne's model of compartmentalized groundwater units bounded by faults and fine-grained units, which are supposed to prevent contaminated groundwater from moving to surrounding areas, is not supported by the preponderance of evidence and cannot be considered viable," (Page 3).

This broad conclusion relating to groundwater flow and contaminant transport at SSFL is derived from a very small portion of the available scientific data for SSFL, which the author misrepresents as "the preponderance of evidence." In fact, the preponderance of evidence is not addressed in this report.

A scientifically sound review of groundwater flow and contaminant transport at SSFL must address the large volume of available scientific data for the site – the real preponderance of the evidence, not just a limited geologic database. The available data includes, but is not limited to:

- Hydrologic Data
  - rainfall and recharge studies
  - water balance calculations
  - single and multiple well pumping tests (over 300 wells and stratigraphic intervals have been evaluated)
  - packer testing
  - slug testing
  - seep and spring studies
  - temporal monitoring of hydraulic head from over 400 monitoring locations
  - streamflow measurements
  - spatial distribution of hydraulic conductivity
  - spatial distribution of storage coefficient
  - spatial distribution of porosity

- Rock Properties
  - Matrix and Fracture Porosity
  - Water content
  - organic carbon content
  - thin section analyses
  - Chemical analyses of over 5,000 feet of rock core

- Aqueous Geochemistry Data
  - major ion chemistry
  - oxygen and carbon isotope data
  - chloride ion accumulation as a measure of recharge
  - pH
  - dissolved oxygen

- temporal variability
- impact of imported water

- Chemical Properties
  - Behavior solubility of the specific compounds
  - diffusion coefficients
  - persistence
  - dissolution
  - degradation
  - partitioning coefficients

- Distribution of Contaminants
  - where contaminants are not found, and why
  - relation to characteristics of release
  - stratigraphy

- Contaminant Release Factors
  - Source locations and release characteristics
  - Temporal variability
  - Estimated Release volumes
  - Contaminant characteristics
  - The release of co-solvents, including water

- Other Groundwater Factors
  - Spatial distribution of temperature
  - Artificial recharge
  - Spatial and temporal variability of groundwater extraction since 1948

- Vadose Zone Properties
  - Variability with depth and stratigraphy
  - Residual saturation
  - Behavior of groundwater and contaminants
  - Recharge transmission

This list is not fully inclusive of the data that has been gathered for the site. Without consideration of these factors, and other available data, conclusions on groundwater flow and contaminant transport based solely on geologic features are not scientifically sound.

2.0 SPECIFIC COMMENTS ON GEOLOGIC INTERPRETATIONS

As noted above, the Wilshire Report is over-reliant on structural and stratigraphic data to draw conclusions on groundwater flow and contaminant transport at SSFL. Within the narrow focus of the Wilshire Report, there are significant misunderstandings and misinterpretations of both the site data, and of the SSFL's interpretations of the data. This section is intended to focus on a small number of the many misinterpretations present in the Wilshire Report.

What is an Aquitard?

Many of the misunderstandings of the data and misinterpretations of the SSFL's reports derive from an apparent lack of understanding by the author of the term "aquitard." The Wilshire report

> ". . . focuses on the geologic evidence for on-site containment of pollutants….Many of these reports [commissioned by Boeing/Rocketdyne] contend that natural geologic barriers prevent the off-site migration of contaminants in groundwater," (Wilshire Report Page 2, 1st paragraph).

The SSFL technical reports do not interpret natural geologic features at the site to preclude the movement of groundwater. The naturally occurring features are interpreted to be aquitards. Aquitards are defined as features with a hydraulic conductivity that is lower than that found in adjacent rocks. By definition, an aquitard retards, but does not stop, groundwater flow. Two definitions of aquitards from different sources are presented below:

> An aquitard is "A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer; a leaky confining bed. It does not readily yield water to wells or springs, but may serve as a storage unit for groundwater," (Dictionary of Geologic Terms, 1984).
>
> "In recent years the term aquitard has been coined to describe the less-permeable beds in a stratigraphic sequence. These beds may be permeable enough to transmit water in quantities that are significant in the study of regional groundwater flow, but their permeability is not sufficient to allow the completion of production wells…The definition of aquifer and aquitard are purposely imprecise with respect to hydraulic conductivity. This leaves open the possibility of using the terms in a relative sense," (Freeze and Cherry, 1979 page 47).

Although these definitions focus on the aquitards created by lower hydraulic conductivity beds, the definitions also apply to other geologic features (for example, faults) that can also create an aquitard.

Although aquitards (leaky confining beds or faults) are not absolute barriers to groundwater flow, because of their relatively low hydraulic conductivity they often have a significant impact on groundwater flow direction and hence on the distribution of contaminants. In areas with multiple, intersecting aquitards (aquitards that bound areas in which the rocks generally have a higher hydraulic conductivity), the proportion of groundwater flow that passes through a particular aquitard is dependant on a variety of factors. Some of the aquitard characteristics that can influence the direction of groundwater flow include properties such as the relative bulk hydraulic conductivity of different aquitards, their distribution with respect to one another, and hydraulic head.

Additionally, factors that are at least partially independent of the aquitard can also influence the proportion of groundwater that moves across a particular feature. Differences in hydraulic head across two aquitards, for example, can influence the proportion of groundwater moving through the different aquitards. These changes in groundwater elevation can be induced by pumping or can be a result of the natural interaction between the aquifer system, the topography, and other hydrologic factors.

<u>Groundwater Flow and Contaminant Transport are Not the Same</u>

Contaminant transport is not analogous to groundwater flow, and comments on the behavior of contaminants cannot be made solely on the commonly conceived hydrogeologic properties of "aquitards." Contaminant transport must consider at least the partial list of factors mentioned previously.

<u>The Role of Fractures at SSFL</u>

The misunderstanding of the nature of aquitards also leads to misunderstandings as to the characteristics and hydrologic role of fractures at the SSFL. The Wilshire Report states:

> "All rock types at the site are fractured, including fine-grained units…Fractures in fault zones show evidence of circulation of meteoric water…Thus the evidence strongly favors transmission of water, with or without contaminants, preferentially through many fractures…The fractures associated with faults and finer-grained units are just as capable of transmitting water as fractured sandstone," (Wilshire Report Page 3 1st Paragraph).

Field observations made during the evaluation of the SSFL support the interpretation that all of the rocks within the Chatsworth Formation are fractured, including rocks found in areas influenced by faults and within finer-grained stratigraphic units. The SSFL technical reports do not interpret differences in hydraulic conductivity as resulting from the absence of fractures in the faults and finer-grained units and their presence in sandstone. These reports do interpret the change in hydraulic characteristics to be the result of systematic differences in the characteristics of the fracture system. Within a fractured rock environment, there are a number of fracture characteristics that will influence the bulk hydraulic conductivity of a feature. These characteristics include the aperture and spacing of fractures as well as the degree of connection between the fractures. Hydrologic data provide the most effective way of assessing the relative characteristics of fracture systems, and hence the best way of establishing whether a particular geologic feature is an aquifer or aquitard.

At the SSFL, the bedrock is fractured, and that the fractures are part of an inter-connected network that influences groundwater flow (at a local scale) and affects contaminant transport. Within this interconnected fracture network, there are areas and units that exhibit lower hydraulic conductivity, which exert a strong influence on the rate and directions of groundwater flow. There are also likely areas at the SSFL where the fracture network imparts little additional permeability to the bedrock matrix. Where these conditions exist, groundwater flow and transport are governed more by porous media flow with low hydraulic conductivities (e.g., 10^{-7} centimeters per second).

If fine-grained units and faults are viewed as leaky, but possessing a relatively low hydraulic conductivity (rather than viewed as absolute barriers to groundwater flow), the interpretation of these features as aquitards is consistent with the presence of groundwater-derived stains and caliche. In aquitards created by systematic differences in fracture characteristics (rather than the absence of fractures), groundwater will still move through fractures within the aquitard. However, the lower bulk hydraulic conductivity of an aquitard may strongly influence the direction of groundwater flow, and may significantly reduce flow across a specific aquitard.

<u>The Role of Physical Rock Properties in Groundwater Flow Assessment</u>

The Wilshire Report suggests that assessing the hydrologic properties of aquitards would be best approached with detailed descriptions of the physical characteristics of the geologic feature interpreted to be an aquitard. Using descriptions of the physical characteristics is an indirect approach to understanding the hydrologic characteristics, and it results in significant ambiguities. In contrast, the most direct way of assessing the hydrologic characteristics of a geologic unit is by using hydrologic data. The hydrologic data include significant changes in groundwater elevation across a fault or fine-grained unit, differences in changes in groundwater elevation in wells located on opposite sides of an aquitard during a pumping event, and significant changes in groundwater chemistry across the aquitard.

The use of detailed descriptions of physical characteristics suffers from a number of problems in an area of poor exposures and variable physical characteristics. As has been discussed, variations in fracture spacing, aperture, and the degree of connection between fractures all influence the bulk hydraulic conductivity of a rock, and all of these characteristics can be difficult to assess in outcrop and core.

Assessing fracture apertures in outcrop is also problematic for at least two reasons. First, outcrops are typically weathered, and the aperture of a fracture in the weathered zone is probably (and in some cases certainly) larger than the apertures found below the water table. Secondly, because of discontinuous exposures, there are legitimate concerns about how representative a limited number of aperture measurements would be.

<u>The Nature of the Fine-Grained Units at SSFL</u>

There are numerous erroneous statements in the Wilshire Report relating to the nature of the fine-grained units at SSFL that serve as the basis for its erroneous conclusions. Page 9 states:

> "Fine-grained units commonly are cited as being aquitards on the basis of very low hydraulic conductivities. This property is, however, measured only on unfractured samples."

The hydraulic conductivity of the fine-grained units has been tested in-situ using packer and slug testing methods. The values presented represent the hydraulic conductivity of the *fractured* fine-grained units, not laboratory samples.

The Presence of Iron and Manganese Halos

Page 9 of the Wilshire Report continues:

> "That fractures in fine-grained units are avenues for circulation of groundwater is shown by iron and manganese staining of fracture surfaces, commonly reported in drill logs; such fractures also track meteoric water movement, and show that pathways through fine-grained rocks are as common as those in sandstones"

The occurrence of such staining is cited in SSFL technical reports as evidence of groundwater flow through fractures. The major difference is that the Wilshire Report appears to infer that this flow is rapid, rather than acknowledging that these mineral halos develop over geologic time. As the definition states, an aquitard "retards but does not prevent the flow of water to or from an adjacent aquifer."

The Importance of Fractures in Fine-Grained Units

Page 9 of the Wilshire Report continues:

> "Studies elsewhere indicate that the presence of hydraulically active open fractures in fine-grained deposits are extremely difficult to spot during field assessments. Aquifers below clayey confining layers commonly are contaminated, indicating preferential movement of water through the aquitards in fractures, root holes, and stratigraphic windows such as cut and fill structures and pinchouts of aquitards. Lab experiments with large (1.6 foot diameter) naturally fractured clay samples demonstrated entry and rapid flow of trichloroethylene (TCE) dense non-aqueous phase fluid (TCE; the most widespread contaminant at the SSFL) in fractures with apertures of 17 µm or larger (for scale, a typical human hair is 20 µm in diameter); this study notes that dense non-aqueous phase liquids (DNAPL) are a problem in the subsurface because they do not dissolve in water. They migrate as nonwetting liquids and commonly pool on top of clayey strata where fractures allow easy entry and provide pathways for downward DNAPL flow. Migration of contaminants in fractures is controlled by the fracture aperture, fracture network geometry, and fluid conditions. Numerical simulations indicate that fractures with apertures as small as 10 µm can greatly accelerate transport of dissolved contaminants through clayey aquitards into underlying aquifers. The presence of fractures in fine-grained deposits at the SSFL, and direct evidence that they have provided avenues for fluid movement, are clearly inconsistent with the Rocketdyne model of groundwater barriers, yet they receive no critical analysis in the reports, nor were they the subjects of comprehensive site characterization."

Several observations are noteworthy regarding this section of the Wilshire Report. First, the author does not appear to be aware that the study on DNAPL behavior in clays cited above was conducted and written by members of the SSFL's team of scientists that are investigating SSFL, namely Drs. Parker and Cherry from the University of Waterloo. Secondly, DNAPL does not "flow" into fractures in the sense that water flows. It moves under a gravity gradient and displaces the water because it is more dense. This is the primary mechanism for DNAPL migration, and the reason why TCE has been detected at depth at SSFL. Thirdly, contrary to the statement: "nor were they the subjects of comprehensive site characterization," the SSFL has conduced extensive studies of the role of fractures in DNAPL migration at SSFL, at a scale not conducted anywhere else in the United States. These studies have been conducted under the direction of Drs. Parker and Cherry, the same individuals that conducted the study that Dr. Wilshire relies on in the statement quoted above. Interpretations of the results of these extensive studies indicate that TCE was taken to depth by gravity, not by groundwater transport. Contaminant transport in groundwater takes over as the TCE dissolves in groundwater, and starts diffusing into the matrix of the rock. The vast majority of the solvents released at SSFL have diffused into the rock matrix, where hydraulic conductivity is low. It is the well documented occurrence of matrix diffusion at SSFL that has limited contaminant transport. The presence of aquitards can affect the groundwater flow direction. Taken together, these two fundamental properties have limited contaminant migration at the site.

3.0 COMMENTS ON SPECIFIC GEOLOGIC FEATURES

The Shear Zone

Earlier SSFL technical reports interpret the Shear Zone to be an aquitard for three reasons. First, there is a significant change in the elevation of groundwater across the structure. Secondly, there are significant differences in the concentration of TCE and perchlorate on opposite sides of the structure. Finally, wells located on opposite sides of the structure show systematic variation in groundwater elevation changes during pumping events. The discussion found in the Wilshire Report does not adequately characterize the groundwater elevation differences across the fault. It also does not take account of differences in contaminant chemistry

The Wilshire Report questions whether there is a change in groundwater elevation across the Shear Zone. The first issue of concern presented by the Wilshire Report is,

> “A big problem with this interpretation (that there is a groundwater elevation difference across the Shear Zone) is the very limited data available from wells on the west side of the Shear Zone, and the offset relies on a selected but not fully representative data set on water levels in wells on the east side of the Shear Zone,” (Page 17, 1st Paragraph in the section called Shear Zone).

In the northeastern part of the site there are 6 wells and 2 coreholes located west of, and less than 350 feet from the Shear Zone, and the groundwater level in these wells and corehole is consistently different from wells located on the east side the Shear Zone. The groundwater elevation in the wells to the west of the Shear Zone in the 1st quarter of 2006 ranged (to the nearest foot) from 1577 to 1542 feet. Groundwater elevation data from a corehole (C-11,located near WS-14) is less precise, but it is estimated to be approximately 1,554 feet, very similar to the wells in the area. This corehole was installed as part of work performed as governed in a work plan (MWH, 2005) approved by DTSC for implementation.

In contrast, groundwater elevations found in 6 wells located in the area to the east of the Shear Zone and bounded by the Happy Valley Fault, the Woolsey Canyon Fault, and the Happy Valley Member are much higher. During the 1st quarter of 2006, groundwater elevation in the 6 wells ranged from approximately 1,818 feet to 1,824 feet, or about 250 feet higher than the elevations found in wells to the west of the Shear Zone.

There are sufficient exposures of the Shear Zone in the northeastern part of the site to locate its position with respect to these wells. The groundwater elevation differences between wells located on opposite sides of the Shear Zone require very steep groundwater gradients, indicating that a low hydraulic conductivity feature is present.

North of the Woolsey Canyon Fault the groundwater elevation in wells located east of the Shear Zone and screened in the Sage Member are consistently higher than the groundwater elevation observed in wells located to the west of the Shear Zone. In the 2nd quarter of 2001, five of the six wells screened in the Sage Member had groundwater elevations that were at least 200 feet higher than those found in WS-14 and RD-37. The groundwater elevation found in the sixth well was approximately 20 and 50 feet higher than those found in WS-14 and RD-37.

The Wilshire Report notes that four wells on the east side of the Shear Zone have groundwater elevations that are close to those found to the west of the fault. This is true, but these wells are screened within or to the east of a major aquitard, and two of them are located on the east side of the ridge and at a ground surface elevation that is approximately 140 feet lower than the surface elevation at wells RD-37 and WS-14.

The results of a pumping test conducted using Corehole C-1 (east of the Shear Zone) are consistent with the conclusions reached in the 2002 MWH report. The C-1 pumping test results are reported in MWH, 2004. The results of this test showed that an aquitard is present between wells RD-72 (located east of the Shear Zone) and well RD-37 (located west of the Shear Zone).

The hydrologic relationships found in the RD-45 cluster are discussed in the Wilshire Report in the section of the report entitled the Shear Zone, however there is an apparent misunderstanding of the interpretations presented in the 2002 MWH geology report. The Wilshire Report correctly describes the stratigraphy and hydrologic responses of the three wells in the RD-45 cluster, however the discussion concludes with the statement that,

> "The behavior (of groundwater elevation changes in the RD-45 well cluster) is perplexing, but it is difficult to see how, at least at the screen interval of RD-45C, the Shear Zone can be acting as an aquitard," Page 19, end of 1st paragraph).

The 2002 geology report interpreted the groundwater elevation differences in the RD-45 well cluster to be the result of the presence of the fine-grained Woolsey Member, not the Shear Zone. The data concerning the RD-45 well cluster are presented in the 2002 geology report in a section entitled "The Hydraulic Effect of the Woolsey Member West of the Shear Zone." Consistent with the interpretation that the Woolsey Member is an aquitard, the 2002 report shows that hydrographs of wells screened above the Woolsey Member (RD-45A and RD-45B) show distinctly different patterns of groundwater fluctuations than does RD-45C (screened below the Woolsey Member). These differences can be attributed to the location of pumping wells with respect to the aquitard created by the Woolsey Member.

Woolsey Canyon Fault

The Wilshire Report does not adequately address the data used to define the Woolsey Canyon Fault as an Aquitard. It states,

> "A pump test run on RD-38B recorded no response in adjacent RD-38A…This is interpreted to mean that there is…"a significant aquitard between …225 and 235…," (Page 21, 1st Paragraph in section entitled Woolsey Canyon Fault Zone).

The pumping test was only a small part of the data used to suggest that the Woolsey Canyon Fault is an aquitard. These data were presented in Appendix C of the 2002 MWH report, and they included:

- An approximate 200 foot difference in groundwater elevation between well RD-38A and RD-38B.
- TCE concentrations measured in well RD-38A are typically in between 100 and 1,000 parts per billion, while those in well RD-38B are almost all below the detection limit. A TCE concentration of less than 1 part per billion was reported in 1999.
- The rock between the screen of RD-38A and RD-38B was reported to be dry during drilling. This indicates that groundwater is not continuous beneath the bottom of well RD-38A, and that a low hydraulic conductivity feature separates the groundwater in well RD-38A from that in RD-38B.

The Wilshire Report also states:

"The only evidence to support the claim that the Woolsey Canyon Fault Zone is an aquitard is a large difference in TCE concentration in well RD-72…and RD-53," (Page 21, last paragraph on the page).

This statement is not correct. Figure 8 of the 2002 MWH geology report shows that there are significant differences in groundwater elevation across the Woolsey Canyon Fault. These groundwater level differences are found for at least 2,000 feet along the strike of the fault, and they range from a difference of as little as 45 feet to as much as 220 feet.

Happy Valley Fault

The Wilshire Report suggests that groundwater elevation data are insufficient to assess whether the Happy Valley Fault acts as an aquitard. However, only a part of the hydrologic data are presented. The Wilshire Report states,

> "Pumping in well RD-1 was stopped in October of 2000 with the result that the water levels in RD-10 rose, but those in HAR-1 did not. Whether this is a meaningful comparison is open to question because HAR-1 is located very close to, and possibly within the Shear Zone…"

While it is true that HAR-1 is located near the Shear Zone, there are three other wells near HAR-1 (one of the wells is located approximately 500 feet from the Shear Zone), and all of these wells show a pattern of groundwater fluctuation that is consistent with what is seen in HAR-1. The groundwater fluctuations are also consistent with the interpretation that both the Shear Zone and the Happy Valley Fault are aquitards. Pumping began in wells RD-1 and WS-5 in 1988 and 1989. By early 1993, groundwater elevation in well RD-1 had fallen somewhat less than 100 feet while level in WS-5 had fallen slightly more than 200 feet. During the same period of time the groundwater level in wells HAR-1, HAR-16, HAR-24, and HAR-25 showed only seasonal fluctuations that resulted in groundwater elevations being modestly higher in early 1993 than in 1988 and 1989.

Shale 2

The 2000 hydrogeology report interprets Shale 2 to be an aquitard based on differences in groundwater elevation in wells screened on opposites of the unit. The Wilshire Report suggests that the data supporting the interpretation that Shale 2 is an aquitard are inadequate, and suggests that other wells should have been used in the analysis.

Using all of the wells suggested by the Wilshire Report shows the same pattern of groundwater elevation differences. In the 1st quarter of 2006, groundwater the groundwater elevation difference measured across Shale 2 was in excess of 150 feet.

The Wilshire Report indicates that the pattern of groundwater elevation changes observed in the central part of the SSFL during the Hydraulic Communication Study were not as stated in the 2000 MW report. The Wilshire Report misunderstands what is referred to as the central part of the site.

The Wilshire Report suggests that the change in groundwater elevation across Shale 2 is the result of a very steep cone of depression (see Exhibit 6 of the Wilshire Report). This interpretation is, however, inconsistent with data derived from the RD-49 well cluster. Well RD-49A is screened within Shale 2, while well RD-45B is screened in the underlying Sage Member. Groundwater has been consistently present in well RD-49A, typically in an elevation range of between 1,845 feet and 1,855 feet. In contrast, the groundwater elevation in well RD-49B is typically from below 1,570 feet to approximately 1,620 feet. Over periods of years the water elevation in this well has been below the bottom of the well. As a result, there is an unsaturated zone that separates the screen of RD-49A and that of RD-49B. This requires an aquitard to perch groundwater in well RD-49A.

The Upper Line Bed

The Wilshire Report does not address the data presented in the 2002 geology report. Instead, it raises a question concerning whether the limited well data from the vicinity of the RD-39 well cluster provides a sufficient…"basis for the broader role of the Upper Line Bed," (Page 28, 1st paragraph).

The goal of the discussion of the Upper Line Bed in the 2002 MWH geology report was to evaluate the source of a large change in groundwater elevation that occurred during installation of the deeper well of the two well RD-39 cluster. The data are entirely consistent with the interpretation that the groundwater elevation change occurs at the Upper Line Bed (a finer-grained unit), and that the Upper Line Bed is an aquitard. These data were presented in detail in Appendix B of the MWH 2002 report.

During the drilling of well RD-39B (the deeper well of the cluster) groundwater in the borehole remained at approximately the same elevation as in RD-39A until the Upper Line Bed was penetrated. After penetration of the Upper Line Bed, groundwater elevation in the borehole fell; eventually stabilizing at an elevation that was more than 150 feet lower than that found in RD-39A. The difference in groundwater elevation between RD-39A and RD-39B has stayed approximately the same since installation of the RD-39B in 1997.

In addition to the groundwater elevation differences in the RD-39 cluster, pumping test data are consistent with the interpretation that RD-39A and RD-39B are separated by an aquitard. Shortly after installation, well RD-39B was pumped. No change in groundwater elevation was observed in well RD-39A.

Conclusions

The Wilshire Report again appears to misunderstand the interpretations that have been presented in the SSFL technical reports. On the topic of groundwater units, it states:

> "…there appears no compelling basis for distinction of Groundwater Units, which supposedly compartmentalize groundwater in independent volumes bounded by faults and fine-grained units."

The groundwater units presented in earlier reports are not interpreted to keep contaminants contained on the SSFL. They do provide an analytical framework to structure discussions and analyses of the details of the groundwater system at the SSFL, and provide insight into the direction that contaminants are migrating at the site. The presence of groundwater units, which consist of bodies of rock bounded by lower hydraulic conductivity features, is supported by groundwater elevation changes across these features, changes in hydraulic response during pumping tests and changes in groundwater chemistry.

The Wilshire Report further concludes that "[t]his notion [of groundwater units] is cited as support for the belief that contaminants are contained on the SSFL, but is based on little credible evidence."

This statement is an inaccurate portrayal of the SSFL team's understanding of the site conditions. The SSFL has acknowledged over many years that TCE in groundwater extends off of the property northeast of the main gate at the SSFL. Furthermore, the basis for the SSFL's statements that contaminants remain within a few thousand feet of where they entered the ground is due to the retardation of these contaminants due to physical and chemical processes that include: molecular diffusion, sorption, dispersion, and degradation. Large amounts of data have been collected at the SSFL documenting the diffusion of TCE and other VOCs into the fractured bedrock. Furthermore, these data are supported by samples from monitoring points located throughout the SSFL and on adjacent properties.

The Wilshire Report also concludes that "This situation could be substantially improved with a drilling program specifically designed to test the roles of these important features."

The author does not reference the 2004 MWH report that presents the Phase 1 results of the northeast area groundwater characterization. The Phase I northeast report served as a basis for a MWH 2005 work plan that was partially designed to further evaluate some of these features (submitted to DTSC in October 2005 and subsequently approved for implementation). Hence, such a drilling program noted above by the author has been implemented at the SSFL.

The Wilshire Report concludes that “critical gaps in information bearing on migration of contaminants at the SSFL…are likely never to be known in sufficient detail to predict contaminant migration with any certainty.”

It should be pointed out that the features noted by the author as influencing contaminant migration are both a function of scale and other properties of the physical system (e.g., permeability and hydraulic head). As such local variations in the groundwater flow field may occur. However, there should be no doubt, based on thousands of rock core samples, that the transport of these contaminants is strongly attenuated along the flow path due primarily to molecular diffusion and to a more limited extent the other aforementioned physical and chemical processes.

Finally, the Wilshire Report concludes that “[t]he best option, then, is a comprehensive remediation program to remove or appropriately treat known contamination and to establish a long-term comprehensive monitoring system to identify contamination that has escaped detection.”

It is critically important to note that a thorough understanding of the contaminant transport and fate processes and the groundwater flow field is required prior to even being able to consider the role, if any, that remediation might have at the site. It is these features that the SSFL team has been aggressively pursuing since the mid-1990s and that are described in various documents (Montgomery Watson, 2000; MWH 2002; SSFL Groundwater Advisory Panel, 2004; MWH 2004) and continue to be developed (MWH, 2005). One can not credibly critique the magnitude and quality of the work performed to date and then quickly conclude that a comprehensive remediation program is the best option.

Comments on the Advisory Panel Reports on the Former Sodium Burn Pit (FSDF) Clay Cap Interim Measure (including the Panel Summary Report and the Bianchi Report)

No.	Section	Comments
FC-1	Panel Report, Page 16	The report at item 3 on page 16 states: "Rocketdyne claims that the direction of soil moisture is upward, not downward, so that groundwater cannot be affected by soil contamination." The DTSC approval letter of the infiltration monitoring work plan dated September 29, 2000, notes the backfill of the Interim Measures (IM) to be a "low permeability backfill cover." Boeing did not make any claims that the IM fill is impervious or the overall direction of the soil moisture is upward, not downward. The effect of evapotranspiration (ET) is one of the design elements of the IM engineered fill. ET moves significant amount of moisture upward but is not designed to cancel the moisture movement downward. Furthermore, existing available documents prepared on behalf of the SSFL (Montgomery Watson, 2000 and MWH, 2003), explicitly state just the opposite and acknowledge that the groundwater system is recharged by rainfall, hence a certain portion of the precipitation penetrates through the soil and unsaturated bedrock and reaches the groundwater system. These documents are referenced by Drs. Wilshire and Tabidian, who authored specific reports for the Tides Center study. As this comment does not accurately represent published information on the FSDF IM, it should be removed from the Panel Report.
FC-2	Panel Report Page 21	The report notes that the IM excavated contaminated soil down to bedrock. It then states: "The critical question then became what to do to prevent the contaminants that had already migrated into the fractures in the bedrock from migrating further and contaminated groundwater more." The stated purpose of the FSDF IM was to reduce the potential for soil and sediment containing Constituents of Potential Concern (COPCs) to migrate from the FSDF and drainage channels offsite. The IM has accomplished this objective by removing the soil and sediment above the established cleanup levels for the COPCs, and backfilling the remedial area with finer-grained soil (than previously present, which retards vertical water infiltration) graded to facilitate rapid surface water drainage and to shunt surface water from upslope of the site around the former Ponds and Western Area. The Panel Report and the Bianchi Report should accurately cite the purpose and scope of the IM. Otherwise, a comparison of the results of Dr. Bianchi's evaluation to any other purpose than the one stated for the FSDF IM is misleading.
FC-3	Panel	The report asserts that the "supposed impermeable clay material is not

No.	Section	Comments
	Report Page 21	impermeable at all," that the soil is "silty clay to silty clay loam soil class with water transmitting properties in the class of a poor aquifer," and that the soil "particle size analysis indicates that it is not capable of preventing percolation of rainfall into the crack matrix of the bedrock." Nowhere have SSFL technical reports stated that the IM fill would be impermeable or that no moisture would reach the soil moisture instrumentation. The DTSC approval letter of the infiltration monitoring work plan notes the backfill of the IM to be a "low permeability backfill cover." Finer grained soils (clays and silts) are lower in permeability than coarser grained soils (sands). The soil used was a finer-grained soil consistent with the classification requirements of the IMWP, taken from the Soil Borrow Area developed outside the boundaries of the FSDF. Of the soil instrumentation in place at the FSDF, the lysimeters provide the best qualification of the amount of water reaching the fill just above the bedrock surface. The large majority of moisture accumulated by the lysimeters is generally captured in the late summer and fall of the year (July through November). This flux of moisture is taken to be the arrival of moisture from the prior rainy season. The winters of 2003-2004 and 2004-2005 produced about 60.0 inches of rain at the SSFL site. The total moisture which arrived at Lysimeters L-1 and L-2 since the start of July 2004 has totaled 16.2 liters (4.3 gals) and 6.8 liters (1.8 gals), respectively. These represent total moisture fluxes at the level of the lysimeter of just 0.07 inches and 0.03 inches, respectively. These flux values are about 0.1% of rainfall or less, and demonstrate that the soil fill is quite effective at reducing infiltration to the bedrock. The average percentage of rainfall taken up as surface infiltration across the site has been estimated to be about 5%. Thus, the flux observed by the lysimeters is about 1/50th of this average rate. This data shows that the 'low permeability backfill cover' is performing as designed and the report should present this performance data and the appropriate conclusion.
FC-4	Panel Report Page 22	The report states that the annual infiltration monitoring reports show that moisture is reaching the detection devices in the fill. It then asserts that these instruments are "supposed to remain dry if the fill overburden were performing as advertised." The annual infiltration reports do indeed show that some modest downward moisture movement is occurring, but the amount of moisture reaching the lysimeters, as described above, is very minor. The fill was placed moist in order to achieve the soil compaction level specified. The instruments thus began in moist soil, and have never been "dry."
FC-5	Panel Report Page 22	The report notes that it is the opinion of Dr. Bianchi that "fast pathways for water migration that the detectors are unlikely to measure" may exist. Tree and plant cover roots are cited as examples. It is notable that the lysimeter collection pans are sizable (10 ft by 10 ft). The

No.	Section	Comments
		surface conditions above the lysimeter pans are the same as the surrounding area in terms of sloping and vegetation. Yet the lysimeters exhibit very modest moisture capture as discussed above. The planting of oak trees in the fill of the former Ponds and Western Area was required as an offset under a California Department of Fish Game Streambed Alteration Permit.
FC-6	Panel Report Page 23	The report suggests that a rise in shallow groundwater into the bottom of the fill “means that the fill overburden with vegetation isn’t performing as advertised and moisture is continuing to move into the system and carry pollutants further into the fractured bedrock and aquifer.” In the last two annual reports, measurable water has been noted in one or more of the piezometers which monitor the bedrock/fill interface. A comparison of these observations with groundwater levels taken in nearby shallow groundwater wells, which are located 50 feet to 140 feet from the piezometers, suggested that the presence of water at the bedrock/fill interface was rather was due to the rise of the piezometric surface of shallow groundwater into deeper portions of the fill section. This observation in no way suggests that the fill “isn’t working.” Rather, the fill area is a very small portion of the site where recharge occurs. The fluctuation of the shallow groundwater levels is a reflection of the much broader groundwater system. It is also notable that verification samples were collected of the bedrock bottom of the Interim Measure excavation covering the Ponds and Western Area. These samples found no levels above the IM cleanup levels for the COPCs. Perchlorate analyses of these samples were also performed, with all results being “non-detect.”
FC-7	Panel Report Page 23	The report states that Dr. Bianchi concludes that “Boeing’s own data demonstrates that the interim measure for the Area IV burn pit has failed.” This is an incorrect statement. The IMs stated purpose of reducing the potential for soil and sediment containing the COPCs to migrate from the FSDF and drainage channels offsite has been achieved. This was done through (1) removal of soil and weathered bedrock at the soil/bedrock contact containing COPCs above the IM cleanup levels; and (2) backfilling, grading, and revegetating the IM remedial area to promote rapid drainage of the remedial area and to shunt surface water from upslope of the remedial area around the footprint of the former Ponds and Western Area. The data indicates that the amount of infiltration reaching the bedrock interface is minor. The rise of shallow groundwater into the base of the fill is a reflection of piezometric levels within the broader bedrock groundwater system. The Panel Report and the Bianchi Report should accurately cite the purpose and scope of the IM. Otherwise, a comparison of the results of Dr. Bianchi’s evaluation to any other purpose than the one stated for the FSDF IM is misleading.
FC-8	Bianchi Report Page 1,	Dr. Bianchi asserts that the IM soil cover now in place was “designed to isolate pollutant materials in the bedrock,” and that the IM “is defined as a ‘clay cap.’”

No.	Section	Comments
	Paragraph 2	The stated purpose of the FSDF IM is discussed above in Comment FC-2. The DTSC approval letter notes the backfill of the IM to be a "low permeability backfill cover." It is not specifically designed as an impervious "cap" to "isolate pollutant materials in the bedrock. Further, the purposes of the infiltration monitoring program are clearly stated in the Infiltration Monitoring Work Plan to be to "monitor moisture changes in the soil column of the FSDF fill" and to "assess the possible contribution of the lateral migration of water along the rock contact to the moisture conditions within the fill." The Bianchi Report should accurately cite the purpose and scope of the interim measure. Otherwise, a comparison of the results of Dr. Bianchi's evaluation to any other purpose than the one stated for the FSDF IM is misleading.
FC-9	Bianchi Report Page 1, Paragraph 1	The report states that a 'considerable inventory of pollutants' is in the bedrock. The FSDF Characterization report clearly describes the contaminants in soil, many of which were not detected in the bedrock beneath the ponds or in groundwater. Only a few contaminants are present in groundwater beneath the FSDF. As this comment does not accurately represent published information on the FSDF IM, it should be removed from the Bianchi Report.
FC-10	Bianchi Report Page 1, Paragraph 1	The report states that the 'thickness of the soil mantel over the bedrock in many places was less than a foot and at its greatest five feet'. This statement demonstrates that the author has not thoroughly reviewed the various cleanup actions (i.e., soil removals) at the site. While the statement describes a portion of the FSDF site at the time of the IM, it does not describe the site during operations. Large volumes of soil were removed and it was the residual soil that was described and the subject of the IM. This comment should be removed or edited to accurately reflect site conditions during periods of operation.
FC-11	Bianchi Report Page 2, Paragraph 2	The Bianchi Report states that the "vegetative cover was to provide a pathway for any accumulated moisture in the soil profile to be transpired by the plants out of the vegetative root zone depth and thus diminish the net recharge into the back fill and prevent deep percolation into the fractured bedrock." While the vegetation will transpire appreciate moisture from the root zone, the use of the phrases "any accumulated moisture" and "prevent deep percolation" are too absolute, and such claims were not made by Boeing. The transpiration effect from the vegetation moves the moisture upward, but it is not designed to cancel out the moisture movement downward. The purpose of the vegetation cover was to provide stability to the surficial soil.

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		This area is in a natural drainage and soil erosion common without the stability provided by the plants.
FC-12	Bianchi Report Page 2, Paragraph 2	The Bianchi Report states that "Two natural low spots in the bedrock which would channel flow off site were gravel packed to enhance possible flow off site if water were to reach that depth." This statement does not accurately describe the purpose of the piezometers. The piezometers were intended to detect the presence of free water at the backfill-rock interface. Details of the configurations of the two piezometers installed in gravel packs were specifically formulated in discussion with the DTSC on September 26, 2000, as noted in DTSC's approval letter for the monitoring work plan of September 29. The gravel packs were placed to enhance the chances for free water to be captured, if present, and detected in these deeper channel in the rock. Neither gravel pack is drained, nor were they intended to enhance flow off site.
FC-13	Bianchi Report Page 3, Second paragraph.	Regarding a performance standard for the "clay cap", the Bianchi Report states that "Conceivably this standard should be no discharge into the fractured bedrock out of the cap." As noted in several of the preceding responses, the fill of the former FSDF was intended as a "low permeability backfill cover." The requirement for infiltration monitoring is a direct reflection of the expectation that some quantifiable infiltration to bedrock would occur. As discussed above in Comment FC-3, the lysimeter data clearly demonstrates that the soil fill is quite effective at reducing infiltration to the bedrock to a very minor amount. This paragraph of the Bianchi Report does not contain any facts to support its conclusion, is based on the author's misinterpretation of the purpose of the IM, does not add to the scientific evaluation of the backfill performance, and therefore should be removed from the Report.
FC-14	Bianchi Report Page 4, Top Paragraph	The Bianchi Report discusses the possible interpretations for the observation of free water in the piezometers set in gravel packs in deep channels in the bedrock. After correctly interpreting the implications of Boeing's conclusion that it is due to a rise in groundwater in the shallow fractured rock, the Report asserts that alternate explanation that "the graveled lows are functioning as lysimeters and indicate that the cap is not functioning when rainfall over the fill area is excessive and recharge through the cap becomes significant." Stated directly, the lysimeter data shows no indication (0.1% of rainfall or less) that such "significant recharge" is occurring. The lysimeter data does show that the rate of moisture arrival at the bedrock contact is so low that moisture accumulation on the contact should not occur. Also, the groundwater levels in adjacent shallow soil/bedrock wells support the interpretation that the occurrence of free water in these piezometers is due to a rise in groundwater in the bedrock to a level above the bedrock/fill contact. Any alternative explanation proposed in the Report should be accompanied by

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		an evaluation of that alternative using the available data. As explained above, the data do not support this alternative explanation. This fact should either be stated in the Report or the alternative explanation removed.
FC-15	Bianchi Report Page 4, Second Paragraph	In discussing the ’04-’05 rainfall season, the Report notes that both lysimeters responded with “significant accumulations” after a delay until late August. It is correct that both lysimeters captured water, but the characterization of the amount collected as significant is not accurate. As noted above in Comment FC-3, the winters of 2003-2004 and 2004-2005 produced about 60.0 inches of rain at the SSFL site. The total moisture which arrived at Lysimeters L-1 and L-2 since the start of July 2004 has totaled 16.2 liters (4.3 gals) and 6.8 liters (1.8 gals), respectively. These represent total moisture fluxes at the level of the lysimeter of just 0.07 inches and 0.03 inches, respectively. These flux values are about 0.1% of rainfall or less, and demonstrate that the soil fill is quite effective at reducing infiltration to the bedrock. The average percentage of rainfall taken up as surface infiltration across the site has been estimated to be about 5%. Thus, the flux observed by the lysimeters is about $1/50^{th}$ of this average rate.
FC-16	Bianchi Report Page 6, Second Paragraph	The Bianchi Report notes that there is no indication of where the rainfall station is located. Rainfall is measured at the SSFL by a meteorological station located just a couple hundred yards east of the former FSDF.
FC-17	Bianchi Report Page 6, Paragraph 3	The Bianchi Report discusses in general terms the possible deleterious effects deeper and more developed tree roots might have on the fill permeability. The inverse effects (i.e. the deepening of the effective root zone and the increase in overall transpiration) are not noted as favorable results of these same developments. Also, given that the potential ET far exceeds the average precipitation, an increase in infiltration capacity does not compromise the function of the soil fill cover. It is notable that neither of the lysimeters are in the immediate vicinity of an oak tree cluster, and there are currently only fourteen oak trees present in the FSDF fill area.
FC-18	Bianchi Report, Page 8, Second Paragraph and Page 9, Bottom Paragraph	The Bianchi Report provides conclusions on the flow systems in the fractured bedrock relative to the IM fill in these two sections. If a membrane cap were implemented over the IM fill area, it may have the effect of eliminating virtually all vertical moisture flux to bedrock beneath its footprint. However, the vertical flux through the IM fill is already demonstrated to be trivial. We are in agreement with the author that the occurrence of shallow groundwater is likely due to peripheral flow into the area from outside of the IM fill. A membrane cap over the IM fill area would have little or no impact on the shallow bedrock groundwater system. The occurrence of impacted shallow groundwater, infiltration through impacted

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		fractured, unsaturated, unweathered bedrock, and their effect on the further transport of contaminants in the saturated bedrock system are currently being, and will continue to be, evaluated as part of the Chatsworth Formation characterization program.
FC-19	Bianchi Report, Page 8, Second Paragraph	The Report's 'Conclusions' section begins with the introduction of an issue that is not covered in the body of the main text or evaluation. The discussion of any issue that is not so addressed should be removed from the Conclusions section of the Report.
FC-20	Bianchi Report, Page 9, First Paragraph	The Report 's 'Conclusions' section further makes the statement regarding the presence of landscaping to mobilize the 'pollutant inventory under the entire Field Laboratory into regional water resources.' As was stated above in Comment FC-19, this statement introduces an issue that is not covered in the body of the main text or evaluation. There is no discussion in the report's evaluation about the potential connection of water under the FSDF, or the SSFL, to regional groundwater. The discussion of any issue that is not covered in the body of the main text or evaluation should be removed from the Conclusions section of the Report.
FC-21	Bianchi Report, Page 9, Second Paragraph	In commenting on the finding of water underneath the plastic tarp at the FSDF, it is apparent that the author has not thoroughly researched, and thus does not fully understand, the conditions of the site. The tarped areas of the site included both areas with limited soil (post-partial excavation (up to 5 feet, see previous comment) in some areas and no soil in others. The comment about vapor phase soil moisture would not be relevant to the areas of the site that were bedrock. Instead, what was observed was that during the rainy periods, water entering the soil in areas upgradient of the FSDF (a large area compared to the FSDF itself) would migrate along the soil bedrock interface (i.e,, lateral migration) and enter the excavation area. This fact is acknowledged in the last sentence of this paragraph stating '…reinforces the importance of lateral flow component into the burn pit area and fill.' These observations about lateral flow are indeed correct and form part of the reasoning for not needing an 'impermeable' cap because it is the lateral flow that is critical. The Report ignores this key issue of lateral water migration as the major contribution of water into the FSDF in its criticism of the soil cap. The overall conclusions regarding the necessity, purpose, function, and effectiveness of the cap should be changed to reflect the observation of lateral water migration as the major source of water at the soil-bedrock interface.

Comments on "Land-Use Conversion and Its Potential Impact on Stream/Aquifer Hydraulics and Perchlorate Distribution in Simi Valley, California" by M. Ali Tabidian, Ph.D., Dated October 2006

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P-1	Title Page	The title of this report is misleading. The report primarily provides a description of a hypothesis that the SSFL is the source of the sporadic perchlorate detections in groundwater underlying Simi Valley. Furthermore, the report infers, without citing any supporting facts, that the SSFL could cause degradation of the groundwater beneath Simi Valley in the future. Finally, the report also discusses geographic areas unrelated to Simi Valley. It is recommended that the author re-title the report to more accurately reflect its content.
P-2	Abstract, Page 1, Third Paragraph	The report fails to discuss the general degradation of Simi Valley groundwater from all other chemicals associated with the urbanization of the valley. This degradation is likely the result of both point and non-point sources, but the author chooses to selectively discuss only certain non-point sources. Other chemicals detected in Simi Valley groundwater due to releases from assorted industrial and commercial activity, including but not limited to the gasoline components of benzene, ethylbenzene, toluene, xylenes, and MTBE are not discussed or referenced in this section. This selective focus leads the reader to incorrectly conclude that perchlorate is the only chemical that has degraded the quality of the groundwater beneath Simi Valley.
P-3	Abstract, Page 1, Fourth Paragraph	This paragraph states that "All of the locations on the valley floor where perchlorate has been detected are within a mile of Arroyo Simi." About 75% of the land area of the valley floor lies within a mile of Arroyo Simi.
P-4	Abstract, Page 1, Fourth Paragraph	The report states: "Based on available data, this may be indicative of Arroyo Simi as a source of perchlorate to these areas in contrast to point and diffusive sources…" The above conclusion is speculative and not based on fact. The remainder of the report provides little to support this conclusion. As an example, there is no presentation, nor a discussion, of the three-dimensional groundwater flow field that existed throughout the history of Simi Valley. Additionally, the sole inferred line of evidence to support this claim is that Arroyo Simi changed from a gaining stream to a losing stream. While this indeed may be true, the effect on the groundwater flow system that losses of surface water along the length of Arroyo Simi is not presented or discussed.
P-5	Introduction, Page 2, Second	The report states "that the SSFL is located in a groundwater recharge zone" and "that groundwater flows in several directions including a

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	Paragraph & Page 3, First Paragraph	north/northwesterly direction with a downward component towards the groundwater discharge regions of the valley floor." The above statements are overly broad and likely not representative of the actual conditions. First, groundwater beneath the SSFL was extracted to support the facility during much of the active periods through the early 1960s. Extraction was also resumed in the mid-1980s when TCE was discovered in groundwater. These periods of groundwater extraction affected the flow system beneath the SSFL with the net effect being a reversal in groundwater gradients over much of the facility. Second, the discharge of groundwater from beneath the SSFL at times likely occurs at springs and seeps around certain portions of the perimeter. This last point is acknowledged elsewhere by the author in later sections.
P-6	Page 2, Last Paragraph	It would be useful for the author to provide figures depicting the piezometric surface map of groundwater in Simi Valley (particularly over time) and vertical hydraulic head profile(s) to support the statements made in this report.
P-7	Page 3, Last Paragraph	The report states "Some of these contaminants have migrated to surrounding areas. For example,…,200,000 gallons of TCE were used for various purposes…" The first statement is unsupported by any facts. The SSFL acknowledges and has known and reported the fact that TCE is dissolved in groundwater whose extent reaches beyond the SSFL property boundary in the northeast area near the main entrance to the SSFL. The second sentence is completely unrelated to the first sentence.
P-8	Page 5, Figure 3	The scale on the abscissa should be uniform so that the data are accurately represented.
P-9	Page 6, Third Paragraph	This paragraph contradicts the paragraph contained in the abstract as this paragraph references both point and non-point sources of water quality problems. Additionally, this paragraph points out where the water quality beneath Simi Valley has been degraded by other contaminants (nitrate, chloride, phosphate and "other" contaminants) in addition to perchlorate. In contrast, the abstract only names perchlorate as having degraded water quality.
P-10	Page 7, Second Paragraph	The author points out in this paragraph that the "Hydrogeologic characteristics of the areas aquifer systems are strongly anisotropic and hetereogeneous (horizontally and vertically)." This statement appears to be in stark contrast with the author's simplistic conclusion in the report (3rd paragraph, page 46) that "perchlorate contamination of Simi Valley's groundwater reservoir in the 1950s and 1960s is supported by this model" (i.e, Arroyo Simi acting as a line source for

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		depositing perchlorate that was transported by surface water from the SSFL).
P-11	Page 7, Fifth Paragraph	The report states “High yielding localized conduits with a dual porosity system have been developed…..” This statement is not supported by any references or data.
P-12	Page 8, First Paragraph	The report states “…it has been stated [by Seaton and Burbey, 2005] that fault zones in crystalline rocks ’…may dominate the flow characteristics of a region…’” It should be pointed out the author notes correctly on the previous page that the SSFL lies above fractured sedimentary rocks. It is important to note that the influence of fault features on groundwater flow in crystalline rock may not have any relation to such behavior in sedimentary rock formations. The comparison then is not directly applicable.
P-13	Page 8, First Paragraph	The author references an undated publication by Adams and Bainer. It is uncertain as to whether the quote extracted from this publication has anything to do with the SSFL.
P-14	Page 8, Second Paragraph	Reference is made in this paragraph to an off-site well OS-14. Based on our knowledge, the sample collected from this location was likely a surface water sample and was not a groundwater sample collected from a well.
P-15	Page 9, First Paragraph	The author references the types and sorting of stream bed materials. However, there are no references or measurements provided to support the general statements made.
P-16	Page 10, Top Partial Paragraph	The author concludes with little supporting evidence that “stream losses and gains are not likely as significant as in the central and western portions of Arroyo Simi.” The lack of evidence renders this conclusion speculative.
P-17	Page 10, Second Paragraph Under Regional Recharge	The report states “In mountainous recharge zone areas, in general, the deeper the well screen intervals are, the lower the groundwater levels in those wells, which indicates a downward hydraulic gradient and confirms the area is a recharge zone.” A table is provided (Table 1) that according to the author contains information supporting this conclusion. The statement made above is partially correct for well clusters that have been installed at and around the SSFL. Well clusters also contain upward hydraulic gradients as reported in numerous SSFL quarterly and annual groundwater monitoring and sampling reports.

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P-18	Page 10, Second Paragraph Under Regional Recharge	The last sentence of this paragraph states that "higher groundwater levels shown on hydrographs likely reflect the fast recharge rates…" The rapid response shown on hydrographs can be attributed to the low storativity of the bedrock matrix. The response should not be interpreted to be reflective of large amounts of recharge.
P-19	Page 11, Last Paragraph	The last sentence of this paragraph does not appear to be related to anything in the paragraph.
P-20	Page 12, Text	It is unclear what the author of the report is trying to communicate in this paragraph, other than the system is truly chaotic and not easy to understand.
P-21	Figures 4, 5, 7, 8, 9,	These figures are lacking the type of information that would allow the reader to understand the issues being addressed by the figure. The following information should be added to the figures: the magnitude of the vertical exaggeration, a cross-section location line in a plan view map, lithologic and stratigraphic information, well numbers, depths and completion intervals (ground surface elevation, gravel packs and well screens), date/year of the water level measurement, and whether a well was used for pumping. Also, the figures should not mix the dates of the depth to water measurements since, as the author notes, there were or may have been appreciable changes.
P-22	Page 13, First Paragraph	The report states that SSFL contaminated groundwater can potentially move towards local hillsides and valley floors through advection and contaminants may episodically emerge on hillsides through intermittent seeps and springs. The author fails to mention or reference analytical results from spring/seep samples collected around the periphery of the SSFL that show both perchlorate and TCE as being non-detect (see MWH Perchlorate Source Evaluation and Technical Report, February 2003 and MWH Spring and Seep Sampling and Analysis report, March 2003).
P-23	Page 13, First Paragraph	The report states that "advection is the likely dominant mode of contaminant movement" (referring to perchlorate) and "…the process of diffusion will not slow or stop the movement or spread of contaminants, especially the non-reactive and conservative anions such as perchlorate in higher conductivity and extensive preferential flow zones like those in fractured and sheared rocks of the Chatsworth Formation." These statements are completely unsupported by any data, references to scientific journals, or experiments and are pure speculation.
P-24	Page 20, Last Sentence of Paragraph Above	The author here concludes "…the quantity of water and contaminant losses from Arroyo Simi in the 1950s and 1960s to local aquifer units and in turn the quality of domestic water supplies is unknown."

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	Figure 10	Based on this statement, it is unclear how the author can then conclude in the 3rd paragraph on page 45 that Arroyo Simi acted as a line source that transported perchlorate from the SSFL and deposited it in the groundwater at the western end of Simi Valley.
P-25	Page 24, Fourth Paragraph	The author references a California Department of Water Resources 2003 report as to the source for supporting the statement "…local residents have become concerned about their level of exposure to the contaminants and the quality of their tap water due to this recent discovery of perchlorate and radionuclides with concentrations above the MCL." A cursory review of the reference did not indicate this to be a source supportive of the statement. The reference appears to be misplaced in the context of this sentence.
P-26	Page 24, Fifth Paragraph	The author references the detection of trichloroethylene in wells at concentrations below the MCL and detection limit. It is unclear if the author is inferring that the SSFL is the source of reported detections. If so, this should be clearly stated. If not, a clarifying statement should be added.
P-27	Page 25, Bottom of First Text Section	The author references that gross alpha and manganese, in addition to high TDS, were detected in drinking water supply wells (whose use has been discontinued) that are located along Arroyo Simi and that served a mobile home park. It is unclear if the author is inferring that the SSFL is the source of reported detections of gross alpha and manganese. If so, this should be clearly stated. If not, a clarifying statement should be added.
P-28	Page 28, Fourth Paragraph	This paragraph is difficult to follow. A schematic diagram depicting the processes that the author is attempting to explain would prove very useful.
P-29	Page 28, Last Paragraph and Continuing on to Page 29	The discussions of total dissolved solids in groundwater appears to have little value in helping to understand the relationship (or lack thereof) between groundwater at the SSFL and groundwater in Simi Valley.
P-30	Page 32, First Paragraph	The last sentence states that groundwater from the SSFL could appear as seeps, springs and flowing (artesian) wells and in hillsides and surrounding valley floors. The author does not note that samples collected from seeps/springs and flowing (artesian wells) around the periphery of the SSFL have been non-detect for perchlorate as documented in various reports (MWH 2003a & B

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		and quarterly and annual SSFL groundwater monitoring and sampling reports).
P-31	Page 32, Second Paragraph	The author identifies detections of perchlorate that have reportedly been found at off-site locations surrounding the SSFL. However, when samples were collected subsequent to the initial reported detections, no repeatable detections could be confirmed. Additionally, analytical laboratories clarified inaccurate lab reports and the Los Angeles Regional Water Quality Control Board wrote to state that additional sampling and analysis were not required based on the lack of repeatable detections. Furthermore, at one location on the Brandeis-Bardin Institute, samples of groundwater were collected nearly every week and no perchlorate was detected. At this same location, a new well was drilled to a depth of about 405 feet immediately adjacent to a tributary to Arroyo Simi and a multi-level monitoring system was installed with 16 discrete sampling ports. Samples were collected from each discrete interval at this location on a quarterly basis for one year and all were non-detect for perchlorate. The author fails to identify a similar singular detection of perchlorate from a well near a service station at the east end of Simi Valley near the corner of Stearns and Barnard. For completeness and to present all of the data, it is recommended that the author also acknowledge this detection if references to single, non-repeatable detections are to be presented and discussed in the report.
P-32	Page 33, First Paragraph	This paragraph states that certain areas require long-term short interval sampling. Such a system has been installed on the Brandeis-Bardin Institute (referred to as OS-9R, reported in MWH May 2005) as noted in the comment immediately above. Again, all saturated intervals were sampled and analyzed for perchlorate every calendar quarter for one year and perchlorate was non-detect (see SSFL quarterly and annual groundwater monitoring reports during 2005). However, the author never acknowledges these results and their corresponding implications to his hypothesis.
P-33	Page 33, Fourth Paragraph	The author states that “the presence or lack of clay minerals on the fate and transport of perchlorate are unknown.” The facts are that samples of bedrock from the SSFL have been collected from within the area where perchlorate was used (Building 359) and analyzed for perchlorate. Perchlorate was found to be present in the bedrock matrix pore water as reported in MWH, 2004. These data provide direct evidence of molecular diffusion of perchlorate and have been incorporated into describing the transport of perchlorate in the bedrock beneath the SSFL.
P-34	Page 33, Last Sentence Continuing to Page 34	As a clarifying point, diffusion of perchlorate plays no role in limiting its transport in unconsolidated sediments (i.e., the soil profile). Furthermore, the thickness of the unsaturated bedrock where perchlorate is primarily found in groundwater at the SSFL (i.e., Building 359 and Happy Valley

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		Areas) is typically between 50 and 150 feet. Therefore, the transport distance for perchlorate to reach the Chatsworth formation groundwater is quite short. The SSFL has acknowledged that perchlorate has been transported 1,000 feet or so from release locations within the SSFL.
P-35	Page 35, Second Paragraph	As stated previously in these comments, the detections of perchlorate within one mile of Arroyo Simi is not a surprising finding as about 75% of the valley floor lies within this area. Additionally, perchlorate has also been detected at the intersection of Sycamore and Chochran near Arroyo Tapo, which drains the northern flank of Simi Valley.
P-36	Page 35, Third Paragraph	The report states "Upward leakage, including bedrock leakage, has likely diluted contaminant concentrations…." The above statement is speculative and the magnitude of the potential dilution is unquantified, and therefore one can also conclude that it is small to negligible.
P-37	Page 35, Last Paragraph, Continuing to Page 36	The author infers that contaminants may move quickly through groundwater stored in fractured, sheared and faulted bedrock units in parts of the SSFL. However, the author provides no data supporting this supposition other than speculation. The author then ponders the extent of "such conduits in Pleistocene/Pliocene bedrock units." There are no references or facts provided that support such a statement.
P-38	Page 36, Last Paragraph	This paragraph appears misplaced in context of the topic heading (Potential Sources of Perchlorate) as the paragraph presents a cursory and incomplete review of the health effects of perchlorate and has nothing to do with potential sources of perchlorate.
P-39	Page 37	Perchlorate has also been detected in both bottled and natural waters (Snyder, et al, Environmental Science & Technology, Volume 39, Number 23). Perchlorate has also been found in natural materials in the earth's crust in the western United States and in kelp (United States Geologic Survey, Open File Report 03-314).
P-40	Page 38, Bottom of Page	The report states that "no perchlorate has been detected in the topsoil and surface waters of the Simi Valley floor area." This is not a surprising finding, as the author points out elsewhere in the report that perchlorate is highly soluble in water.
P-41	Page 41, Bottom of Page	The author infers that there have been intermittent and episodical releases of perchlorate to Dayton Canyon. However, Table 6 of the report indicates that when surface water flowed through the Happy Valley outfall that leads to Dayton Canyon perchlorate was detected on each of the sampling events. This timeframe was prior to implementation of the interim measure that

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		resulted in the removal of soils containing perchlorate from the Happy Valley area. This data do not support the conclusion of intermittent and episodical releases.
P-42	Page 45, Third Paragraph	The author speculates that to satisfy demand for water by the increasing population in the area, "…local aquifer systems will become an important component of local water supplies, but they will remain at risk because contaminants' sources in the area will persist for decades …due to "reverse diffusion" of contaminants along fracture zones." This statement is unsupported by facts. It is true that that contaminants at the SSFL will persist for decades and that reverse diffusion of contaminants in the rock matrix to the groundwater flowing in the fracture network will occur. However, the magnitude of this effect on the downgradient transport distance is quite small (about 100 meters after 50 years, See MWH Perchlorate Source Evaluation and Technical Report, 2003).
P-43	Page 46, First Paragraph	The author states "…it is difficult to confirm the source(s) of perchlorate in the groundwater resources of Simi Valley and other areas surrounding the SSFL…," then states, "However…based on available data, the primary source of perchlorate detected in soils and waters of the area has likely occurred through various activities at the SSFL." These two statements are contradictory on the face. One can not make such a concluding statement absent supporting evidence, which has not been presented in this report.
P-44	Page 46 and 47	Much of the remaining text on these pages are speculative hypotheses and are not supported by data, experiments or references to scientific literature.

Comments on Surface Water Issues addressed in the "Advisory Panel Summary Report"

No.	Section	Comment
SW-1	Panel Report, Page 23	In paragraph 1, the Panel Report states that "*Surface water pathways could have allowed perchlorate migrate offsite SSFL in runoff".* Several areas of the site with known perchlorate surface contamination have undergone extensive cleanups. The Happy Valley area is one example. There have been no exceedances of permit limits for perchlorate in storm flows at any site outfalls that leave the facility.
SW-2	Panel Report, Page 23	In paragraph 3, the Panel Report states that "*Dozens of violations of Rocketdyne's NPDES permit in recent years, including for perchlorate, indicate numerous pathways for contaminated surface runoff to offsite areas".* For clarification on this issue, storm water runoff from the area does leave the site, but extensive monitoring conducted both on-site and off-site has shown that concentrations in storm flows from the SSFL are typical of or even cleaner than concentrations in storm flows offsite. Monitoring conducted at other undeveloped off-site locations has shown exceedances of many of the same limits that are exceeded at the SSFL. Yet, these sites are nowhere near SSFL and have no history of contamination. Lastly, the author <u>incorrectly</u> states that there have been NPDES permit violations for perchlorate. There have been no NPDES perchlorate violations at the SSFL.