Department of Toxic Substances Control

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December 21, 2011

Mr. Tom Gallacher
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DEPARTMENT OF TOXIC SUBSTANCES CONTROL COMMENTS ON THE SITEWIDE GROUNDWATER REMEDIAL INVESTIGATION REPORT FOR SANTA SUSANA FIELD LABORATORY, VENTURA COUNTY, CALIFORNIA

Dear Mr. Gallacher:

DTSC reviewed the 2009 Sitewide Groundwater Remedial Investigation Report (RI Report). During the review, DTSC solicited and received public comments on the RI Report and has incorporated them, as appropriate, into the attached DTSC comments.

DTSC views the RI Report as a significant step towards completing characterization of the groundwater contamination at the Santa Susana Field Laboratory (SSFL). However, the large scale (over 2800 acres), number of release locations, large variety and volume chemicals released, and complex nature of fractured sandstone bedrock present significant challenges to completing the characterization and important information gaps remain. As a result, DTSC does not approve the RI Report.

DTSC's general comments deal with the report organization, representativeness of the contaminant transport modeling, identification and evaluation of individual release locations, and the characterizing of faults and fault zones. The detailed comments address other significant overarching issues associated with the characterization completed to date.

Given the scope of the comments, DTSC directs The Boeing Company (Boeing), U.S. Department of Energy (DOE), and National Aeronautics and Space Administration (NASA) to address each of the comments in a work plan or series of work plans to be submitted to DTSC for approval. Results from the work completed under the work plan(s) should be presented in separate technical memorandum(s) that can be incorporated into the revised RI Report (by reference if applicable).

DTSC would like to meet with Boeing, DOE and NASA representatives within 30 days to discuss the work plan development and implementation schedule. The initial work plan(s) must be submitted to DTSC within 90 days for approval.

If you have any questions regarding the comments, please contact Tom Seckington at (714) 484-5424 or at tsecking@dtsc.ca.gov.

Sincerely,

Mark Malinowski, P.G.
DTSC SSFL Project Manager

Attachment: *DTSC Comments on the 2009 Groundwater Remedial Investigation Report*

cc: via e-mail

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MEMORANDUM

To: Mark Malinowski
Project Manager
Brownfields and Environmental Restoration Program

From: Thomas M. Seckington, C.HG. TS
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Matthew Becker, PhD
Professor, Conrey Endowed Chair in Hydrogeology
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Date: December 20, 2011

Re: DRAFT SITE-WIDE REMEDIAL INVESTIGATION REPORT

PCA: 22120 Site Code: 530033-48 MPC: 37

Staff from the Department of Toxic Substances Control (DTSC) reviewed the Draft Site-Wide Remedial Investigation Report (RI Report) dated December 2009 along the companion document, Site Conceptual Model for the Migration and Fate of Contaminants in Groundwater at the Santa Susana Field Laboratory, Simi, California (SCM), also dated December 2009. Dr. Matthew Becker from California State University Long Beach also reviewed both the RI Report and SCM and provided input for this memorandum.

GENERAL COMMENTS

The characterization work summarized in the RI Report and the site-specific work presented in the SCM represents a considerable effort. The efforts conducted on the complex groundwater flow system and contaminant fate and transport have provided a better understanding of the fractured bedrock system at the Santa Susana Field Laboratory (SSFL) than a decade ago. However, the large scale of SSFL (over 2800 acres), the number of release locations, the large variety and volume of chemicals released, and the complex nature of fractured sandstone bedrock presents significant challenges. DTSC acknowledges the large amount of quality work that has been completed, but significant information gaps remain. Consequently, DTSC cannot approve the RI Report, due to the scope of the missing data. DTSC recommends that the information gaps be addressed in a series of technical memorandum at this time instead of revising the draft RI Report. Subsequently approved technical memorandum can be incorporated in the Final RI Report by reference if applicable.

The following are general comments regarding the RI Report.

1. **The RI Report is incomplete and is organized in a manner difficult to review.** The RI report is not a stand-alone integrated document, but is fragmented as it relies upon references to the site conceptual model (SCM) for site specific data or to explain and substantiate the RI data. The SCM is a series of reports/manuscripts divided into “elements.” The SCM reports/manuscripts are published in journals, submitted to journals, or written specifically and solely for inclusion in the SCM. Not all Elements in the SCM are referenced in the RI so it is not clear whether these Elements are to be considered supporting material for the RI Report. As stated in the SCM, “many of the reports/manuscripts contained in this version of the SCM report are in the process of being updated” and are therefore incomplete. DTSC recognizes the importance of peer review for technical methods, concepts and findings, but all relevant information in support of the RI should be integrated into the RI Report and be fully documented. Overarching concepts should be integrated into discussions contained in RI report.

2. **The transport of contaminants onsite and offsite cannot be predicted.** The contaminant transport modeling (i.e. Fractran) presented in the RI Report is a stylistic simulation and is not used as a predictive tool for the fate and transport at the site. Predictive modeling is crucial for determining potential pathways and rates of migration and the possible influence of matrix diffusion, reaction, sorption, and/or biodegradation. Although some of these transport mechanisms may be addressed using the two-dimensional Fractran model at representative

sites, the model as presented is not capable of performing a mountain-scale transport assessment. Furthermore, the current application does not correctly represent the expected frequency or aperture of fractures at SSFL nor utilize the vast borehole fracture data that have been collected to date. The model is based upon inadequately supported assumptions regarding the source term (20 year duration; see Attachment A for further discussion). Consequently, the RI fails to determine the rate of contaminant migration in a realistic manner.

The Site Conceptual Model document states *“natural processes over past decades have caused strong attenuation of the maximum plume concentrations and retardation of plume front migration, and are responsible for the lack of reported impacts to off-site receptors. These processes will continue to govern the bedrock contaminants in the future. The matrix-diffusion SCM can be used to reliably forecast the expectation of no off-site impacts in the future.”* Without complete characterization of the site, it is not possible to verify or demonstrate that this definitive statement is valid throughout the site or even portions of the site. The SCM is not a surrogate for collecting data to meet the primary RI objectives. These objectives are:

- define the nature and extent of contamination
- determine the rate of contaminant migration, and
- collect adequate data to support risk assessment and evaluation of remedial alternatives.

3. **The impact of numerous faults at the site on the groundwater flow and contaminant movement is not supported by site-specific field data and is oversimplified.** The SCM and site models must be validated by on-site data. Understanding the hydraulic impact of the faults at the site on groundwater is critical and has not been adequately addressed during the characterization activities. Surface geophysics has not been utilized at the site and fault trenching has only been completed in the LOX area for the North Fault. In addition, there is inadequate head control at most faults at the site.

   The fault structure model presented in the RI Report, based on a published paper (Caine, et al, 1996), has each fault composed of <u>both</u> a low-permeable fault core and an adjacent higher permeable damage zone. The paper is clear that either the fault core or the adjacent damage may be missing in any fault or fault segment. The RI Report, however, does not present any site-specific fault data or evaluation similar to that presented in the paper to support that the SSFL fault structures contain both low- and high-permeable zones. Nevertheless, the fault structure model, including a fault core and damage zone, was incorporated into the groundwater flow model with the fault core hydraulic conductivity set extremely low for all faults.

Due to the critical nature of the faults and their potential hydraulic impact, direct investigation of faults is necessary. This would include the installation of monitoring wells along faults to provide better head control, and the use of geophysics and fault trenching to better define the location and nature of the faults, and multiple well aquifer tests to better bound the hydraulic conductivity of the faults or sections of the faults. On-site data must be collected to support the low hydraulic conductivity values assigned to the faults.

As a test run, DTSC directs the facility to conduct, at minimum, an initial geophysical survey in the northeast portion of the site that would include two seismic-lines: parallel and perpendicular to the Shear Zone and three electrical resistivity tomography (ERT) lines. The seismic lines should be positioned such that they cross as many projected faults as feasible (ex. Happy Valley Fault, IEL Fault, Woolsey Canyon Fault, and the east-west oriented lineament identified to the south of the Woolsey Canyon Fault). The ERT lines should be positioned to cross the Happy Valley Fault, the IEL Fault, and the Woolsey Canyon Fault and above-mentioned lineament.

In addition, the C-1 pump test and the proposed aquifer test along the Happy Valley Fault in the Data Gap Work Plan were designed such that the pumping well is located within an identified fault zone. In order to collect data specific to the nature of groundwater flow across these faults in contrast with the groundwater flow distant from the faults, DTSC directs the facility to conduct additional aquifer tests with the pumping wells located sufficiently outside the target fault zone as to evaluate local effects of groundwater flow.

4. **There is insufficient characterization of release locations to determine if these areas can and/or should be remediated.** In general, the nature and extent of groundwater contamination from individual release locations/source areas have not been completed to allow for an adequate assessment of remedial alternatives. The RI Report and SCM argue that groundwater contaminant movement is effectively retarded through the natural processes at the site. It is assumed that the Boeing Company (Boeing), National Aeronautics and Space Administration (NASA), and the United States Department of Energy (DOE) believe that monitored natural attenuation (MNA) is the likely remedial approach for the site and that the natural processes at the site will effectively prevent contaminant movement and eventually contribute to the decay of the contaminants to benign by-products.

   Based on these assumptions, it could be argued that detailed characterization of each source area and contaminant plume would not be necessary. However, no remedial alternative can be selected or excluded until the groundwater characterization and an assessment of all viable remedial alternatives has been completed. Data are needed: to determine the feasibility and effectiveness of source removal or source containment; to predict the long term rate of release to the natural flow of groundwater and its effect on the overall aquifer restoration timeframe; and the feasibility of plume remediation. It should be noted that restoration timeframes are site-specific and are expected to be very long for SSFL. Given that, the analysis of restoration timeframes should be calculated to compare and evaluate different remediation alternatives; there is no arbitrary maximum restoration timeframe at which remediation would be considered infeasible.

The information presented in Section 7.0, Nature and Extent of Chemicals and Radionuclides in Bedrock Vadose Zone and Groundwater and in the associated Plates 7-2 through 7-19, which presents the chemical results on a site-wide scaled map, define the nature and extent of the contamination at a large scale. The manner in which the data is presented does not allow detailed assessment of individual plumes or release locations. A more detailed evaluation of individual plume source areas and associated plumes is needed to support the feasibility study of potential remedial alternatives. The GSU believes that the Surficial Media Operable Unit (SMOU) RI reports presents much of the needed surficial media and groundwater data to assess, at least in part, the potential impacts to groundwater from release locations. Unfortunately, the SMOU RI conclusions were limited in stating whether surficial contaminants had affected groundwater quality and did not define the nature or extent of the impacts. This information and the DTSC groundwater comments associated with the SMOU RI reports should be further evaluated as a starting point.

The Chatsworth Formation, as defined, includes the unweathered, unsaturated bedrock along with the saturated bedrock (i.e. groundwater). In practice, however, contaminants within the three defined zones of: overlying soil; weathered bedrock; and unweathered bedrock make up a continuum that comprises an indistinguishable source of groundwater degradation. Vadose zone contamination, within all three defined zones, should be viewed as a potential continuous source to groundwater through transport in recharge water or rising groundwater levels. Ultimately the presence of these contaminants will result in higher and more persistent contaminant concentrations in down-gradient waters. Therefore, removal of contamination within the vadose zone should be conducted where possible.

SPECIFIC COMMENTS

Section 1

1) The RI report fails to acknowledge the work performed at other bedrock sites with solvent contamination. In the SCM Overview (SCM Element Document 0-2, page 10) there is a statement that "The literature contains no well-documented cases of substantial industrial contaminant plumes in any type of fractured rock, except for the sites included in the academic research program that includes the SSFL". On the contrary, the EPA sponsored site CLU-IN.org (http://www.clu-in.org/products/fracrock/) lists over 50 profiles of DNAPL contamination of fractured bedrock, many of these have been very well studied such as Loring Air Force Base (AFB), Edwards AFB, Modern Landfill in Pennsylvania, Hooker Hyde Park and Bell Textron, near Niagara Falls, New York, and the Naval Air Warfare Center (NAWC) site in New Jersey. This last site is the subject of an intensive multidisciplinary research effort headed by the US Geological Survey Toxic Substances Hydrology Program (http://toxics.usgs.gov/sites/nawc_page.html). Research includes characterization methods, hydraulic testing, and investigation of natural attenuation of Trichloroethene (TCE) [Bradley et al., 2009; Chapelle et al., 2009; Lacombe and Burton, 2010; Tiedeman et al., 2010]. The RI Report should reflect the current knowledge of the technologies and approaches that have been applied at these sites and others and that may provide useful techniques for remedial investigations at SSFL. It should also be noted that although Discrete Fracture Network (DFN) approach was recently applied at SSFL, it was developed in the 1980's for both 2D and 3D problems [e.g. Long et al., 1982] and has been commonly applied in civil, environmental and reservoir engineering and other geoscience fields throughout the world [Jing and Stephansson, 2007].

Section 2

2) 2.4 RCRA Corrective Action Program
page 2-7; 1st paragraph

Please revise to include the Mixed-Waste RCRA permit for the Radioactive Materials Handling Facility.

3) page 2-8; 2nd paragraph
"As a result of the change in process from Chapter 6.5 to 6.8 described above, the RFI reports will be described under analogous Chapter 6.8 terminology of Remedial Investigation Reports, and Chapter 6.8 terminology will be used throughout the rest of this report."

Although the Chapter 6.8 terminology has been adopted, the goals and objectives of BOTH processes must be met. On page 2-9, the RI clarifies and states "the objectives of the RI are to characterize the nature and extent of chemical contamination in environmental media, evaluate risks to potential receptors, gather data for the Feasibility Study (FS, formerly CMS) and identify areas for additional work." "Determining the rate of contaminant migration" should be added to the stated objectives in order to meet all objectives under Chapters 6.5 and 6.8.

Section 3

4) **Climate and Precipitation**
page 3-2, 3rd paragraph
"A graph of the estimated precipitation at Santa Paula from about 1760 to 1872 and measured precipitation from 1872 to 1965 is also presented in the report. For reference, Santa Paula is about 23 miles west-northwest of SSFL at an elevation of about 250 feet msl and both Santa Paula and SSFL are about 13 miles inland from the Pacific Ocean. These graphs are reproduced here as Figure 3-6."

Figure 3-6 has references to the conditions at Lake Elsinore, which is located over 80 miles to the southeast of SSFL and 22 miles inland on the leeward side of the Peninsular Range. It is not clear as to the relevance of references in the figure to the historic conditions at Lake Elsinore for SSFL, if any. Please clarify and add appropriate footnote or references for the figure, as necessary.

5) **3.3 Surface Water and Drainages**
page 3-3, 2nd paragraph
"Figure 3-1 depicts the surface water drainages at and surrounding SSFL. Most surface water that collects and drains at SSFL is intermittent and is conveyed off-site via one of four drainages: the Northwestern Drainage, the Northern Drainage, the Happy Valley Drainage, and the Bell Creek Drainage."

The statement should be revised to include the "Eastern Drainage" shown on Figure 3-1 and the small unnamed drainage to the north. It should be clear that both drainages flow into the Woolsey Canyon drainage.

6) **3.5 Biological Conditions**
page 3-7

This section was not be reviewed as it is outside the reviewers' areas of knowledge.

Section 4

7) **4.5 Borehole Geophysical Logging**
page 4-6, 1st Paragraph
"Borehole geophysical logs were collected from coreholes C-2, C-7, C-12, C-13, C-14 and from both the initial C-15 pilot hole (50 feet – 881 feet, subsequently grouted and re-drilled) and the cored section of C-15 (890 – 14005 feet)."

The DTSC assumes the "14005 feet" should be "1405 feet." Please revise accordingly.

8) **4.6 High-Resolution Fluid Temperature Logging**
As part of the review of this section, the following Appendix and sections of the SCM were reviewed:
Appendix 4-E – Technical Memorandum, Methods and Results of High-Resolution Fluid Temperature Logs
SCM Element Document 5-4 – "Evidence from temperature profiles for deep groundwater flow in an interconnected fracture"

Appendix 4-E – Technical Memorandum, Methods and Results of High-Resolution Fluid Temperature Logs

The associated appendix to this section (Appendix 4-E) states that the IFG Corporation temperature probe (BTM-04) used in the study has a "resolution" of 0.0001 degrees Celsius (C ^{o}). The IFG Corporation refers to the "sensitivity" of the probe at 0.0001 C ^{o}. A discussion of the resolution and sensitivity of the study should be discussed (i.e. what temperature differences are considered flow related versus "noise"). Furthermore, at what level will readings reflect variation in the heat capacity within the sandstones and finer-grained rocks rather than the contrast between relatively stagnant and flowing fluids?

No conclusions are presented in the report or in the appendix based on the high-resolution fluid temperature data collected. In addition, the SCM Element Document 5-4 states "*Data analysis is in progress…*" Please clarify how this data, when available, will be incorporated in the characterization of the groundwater.

9) **4.7 Analysis of Rock Core Samples for Chloride**

Rock core samples from both the vadose zone and the saturated zone were analyzed for chloride. Samples were collected from coreholes C-1, C-3, C-6, and C-8. These samples represented the vadose zone and samples were taken from cores that were collected years previously. Results from these cores are not presented in the report and associated appendices.

Sample results are presented in Appendix 4-F for the saturated zone samples collected from C-15. The DTSC analyzed the data and the chloride mean and median were calculated to be 22.9 and 21.0, respectively. Due to the depth of the samples (greater 890 feet below ground surface), it is reasonable to assume that there would have been little, if any, influence from site operations on this chloride data. The mean chloride value presented in SCM Element Document 10-2 is 59 mg/L (2.6 times greater). The DTSC believes that site operations; specifically the use of large quantities of imported water with high chloride concentrations, the use of surface water impoundments, and the operation of waste water treatment systems, have contributed to artificially high chloride concentrations in the groundwater at portions of the site. The results from these areas were incorrectly included in the chloride analysis.

The data from C-15 were not discussed in the RI report in reference to recharge calculations at the site. The DTSC believes that the data from C-15 is a strong indication that the average chloride concentration used in the recharge rate calculation was too high. Recalculating the recharge rate using the data from C-15 results in a rate that is approximately 5 to 19% of average precipitation instead of the 2 to7% (4.6% average) presented in the RI report.

Further, does the distribution of chloride in the rock core provide any insight to the effects of matrix diffusion or to the equilibrium of the chloride in groundwater system? Please provide some discussion, if applicable.

4.8 Additional Degradation Studies in Chlorinated Ethenes

As part of the review of this section, the following Appendix and sections of the SCM were reviewed:

- Appendix 4-G – Methods and Results of Laboratory TCE Degradation Study
- SCM Element Document 20-1 – “Biotic and Abiotic Anaerobic Transformation of Trichloroethene and cis-1,2-Dichloroethene in Fractured Sandstone”
- SCM Element Document 20-2 – “Anaerobic Abiotic Transformations of cis-1,2-Dichloroethene by Minerals in Fractured Sandstone”
- SCM Element Document 20-3 - “Field Evidence for Trichloroethylene Degradation Mechanisms in Fractured Sandstone”
- SCM Element Document 20-4 – “Contribution of multiple depth point sampling of unpurged well water columns to the understanding of TCE degradation in fractured sandstone”
- SCM Element Document 20-5 – “Numerical Modeling of Chlorinated Solvent Plume Atttenuation due to Matrix Diffusion and Degradation in Fractured Sandstone”

- SCM Element Document 20-6 – "Possibility of Natural Attenuation of Perchlorate with Pyrite as Energy Source; A Literature Review"

10) The microcosm studies presented in Appendix 4-G and the in section 20 of the SCM were conducted to answer very specific questions. They indicated the occurrence of biotic and abiotic transformation of solvents at SSFL in the laboratory, although the rates appear to be slow. A comprehensive evaluation of the range of the rates and completeness of transformation at the site, however, were not presented in the RI report. It is unlikely that the rates are constant across the site and no assumption can be made that abiotic and/or biotic transformation is occurring at all portions of the site or at a constant rate across the site based on information collected to date. The RI report should include discussion of how the results of these bench scale studies can be or have been applied and tested at the scale of the site.

11) **SCM Element Document 20-3 - "Field Evidence for Trichloroethylene Degradation Mechanisms in Fractured Sandstone"**
Page 10; 4th paragraph
"However, biodegradation has a significant effect on the isotope composition of precursors and byproducts of the biodegradation of TCE."

It is not clear whether abiotic degradation would or would not affect isotope composition of the TCE. Is the study by Liang et al (2007) of abiotic degradation experiments with sulphide minerals applicable to the conditions at SSFL? The study seems to conclude that abiotic degradation is not significant at the site but the studies from Clemson University concluded that the abiotic degradation pathway is significant to the breakdown of cis-Dichloroethene (cDCE). Please clarify.

In addition, the differences cited regarding the distribution of the $\delta^{13}C$ values between the high and low concentrations of TCE in the Northeast which are different than the other test area at STL-IV seem to be problematic. On page 12, the report states *"The apparent lack of correspondence between the concentration and isotope composition is likely due to the complexity of groundwater flow in fractured bedrock and the fact that the wells capture groundwater from diverse fractures where different geochemical regimes occur."* Given this complexity, which is not unique to this portion of the site, can anything be inferred from this information? Please clarify.

12) **SCM Element Document 20-3 - "Field Evidence for Trichloroethylene Degradation Mechanisms in Fractured Sandstone"**
Page 13; 2nd paragraph
"Therefore, based on size considerations it is possible that microbes are present within the rock matrix, but most likely in the larger pore spaces and along the

fracture surfaces. Thus, degradation processes are most likely occurring along the fracture surfaces and the products diffusing into the rock matrix."

It seems that this would have implications to the distribution of TCE and daughter products seen in the rock core samples and would affect the degradation rates. Is there sufficient residence time at the fracture surface for significant degradation to occur? The Clemson studies were bench-scale studies using crushed rock. The DTSC recommends that the factors that differ between the bench scale studies and the site conditions be acknowledged and their potential impacts be discussed.

13) **SCM Element Document 20-3 - "Field Evidence for Trichloroethylene Degradation Mechanisms in Fractured Sandstone"**

Figures 7a and 7b, referenced in these sections, lack a legend making it difficult to interpret the point being made in the figure.

14) **SCM Element Document 20-3 - "Field Evidence for Trichloroethylene Degradation Mechanisms in Fractured Sandstone"**
page 4; 1st paragraph
"Evidence that the fractures are ubiquitous and strongly interconnected comes from large-scale hydraulic tests of contaminant distributions…"

The DTSC requests clarification on the tests referred to in this statement.

4.12.1 Geologic Field Mapping

15) **Appendix 4-J – Technical Memorandum, Summary of Findings from Geologic Mapping at the SSFL in 2008, Santa Susana Field Laboratory**
page 2, 6th paragraph
"Northeast striking carbonate veins (either dolomite or calcite) are associated with the Box Canyon and Dayton Faults…"

The carbonate precipitated from aqueous solutions flowing along these faults at some time and may indicate how the faults formed, evolved, and affected the flow of groundwater. The precipitation of calcium carbonate in the fractures associated with the faults would have a profound effect on the groundwater flow. These faults are generally parallel to the onsite Shear Zone fault and represent a similar formation history. The RI Report should include an evaluation of the faults, joints, and other fractures in reference to the regional stresses and development.

There is no discussion regarding the differences in the landscape between the lower and upper Chatsworth members at the site. The occurrence of the predominant ridges in the northern and operational portions of the site contrasted with the relatively flat Burro Flats area in the western portion of the site is not addressed. Is it associated with faulting or the relative abundance of fine-grained units, or variation in cementation? A better understanding of the evolution of the site and factors controlling the landscape of the site would go further in understanding the variability across the site and would help in inferring the hydrogeologic conditions to other portions of the site.

4.12.5 Additional Sampling and Analysis of Groundwater for Geochemical and Isotopic Parameters

As part of the review of this section, the following Appendix and sections of the SCM were reviewed:

- Appendix 4-H – Geochemical and Isotopic Sampling of Wells and Seeps
- SCM Element Document 9-2 – *"Insights from Atmospheric Tritium Concerning Groundwater Recharge and Solute Transport in Fractured Sandstone at the Santa Susana Field Laboratory, Simi, California"*
- SCM Element Document 12-1 – *"Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California"*
- SCM Element Document 12-2 - "*Use of Strontium Isotopes in Groundwater Flow Pathway Analysis in Fractured Sandstone"*
- SCM Element Document 12-3 – "Carbon-14 as an Environmental Tracer in Fractured Sandstone with Matrix Diffusion Effects"
- SCM Element Document 12-4 – "Technical Memorandum: Origin of Minor Constituents in the Chatsworth Formation at the Santa Susana Field Laboratory, Ventura County, California"

16)*SCM Element Document 12-1 – *"Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California"

Page 1, 2nd Paragraph

"Chloride (mean = 58.5 mg/L, std dev=37.6 mg/L) is derived exclusively from rainfall and dry fallout…"

The DTSC has evaluated chloride data from the site. The mean of 58.5 mg/L includes chloride data likely impacted by site operations, specifically; the use of large quantities of imported water with high chloride concentrations, the use of surface water impoundments, and the operation of waste water treatment systems. The DTSC evaluated the chloride data and removed data potentially impacted by site operations. Recalculation of a mean chloride concentration is approximately 23 mg/L which is similar to the mean from the data collected from C-15. As a result, the recharge value of 6% total rainfall is considerably underestimated and may be as high as approximately 20%. The effects of significantly higher recharge rates on the SCM and the numerical flow model need to be carefully evaluated.

17)*SCM Element Document 12-1 – "Hydrochemical Processes in *Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California"
Page 2, 1st Paragraph
"The great depth to which groundwater with very low total major ion concentrations extends beneath this mountain is exceptional for the general area, given that petroleum exploration holes in areas beyond, but near the mountain, show brackish or saline water at much shallower depths and much higher elevation (range: -750.0 to 3223.2 ft amsl). This suggests that groundwater flow involving water recharged on the mountain has been an active flushing fluid to great depth over a long period of time (Chatsworth Formation uplifted <6 million years ago [MYA])."

This statement does not acknowledge the inherent bias of this information. The focus of petroleum exploration holes is to locate oil reservoirs. This includes locating local geologic structural "traps" and petroleum source rocks. The "traps" consists of faults or folded rocks where oil gets trapped underneath due to pressure, buoyancy, and heating and therefore accumulates. In preventing the upward movement of oil, these traps also prevent the downward movement of recharge waters resulting in the shallow occurrence of saline or brackish water below them. Petroleum exploration holes are located to target suspected traps. Structural "traps" are not located at the site and therefore the downward movement of recharge and groundwater would not be obstructed. As a result, no conclusions should be inferred by the shallow occurrence of saline or brackish water in petroleum exploration holes "in the areas beyond, but near the mountain."

18)SCM Element Document 12-1 – *"Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California"*
Page 4, 2nd Paragraph
"The much larger volume of groundwater is present within the rock matrix, and it is likely that the fracture and matrix pore water chemistries are at disequilibrium."

Given the age of the formation and groundwater, please clarify why the water chemistries would be at disequilibrium at the scale of the site.

19)*SCM Element Document 12-1 – *"Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California"
Figure 6 – Distribution of Major Cations in the Chatsworth Formation Groundwater

Please add units to the x-axis of the figure.

***20)*SCM Element Document 12-1 – *"Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California"*
Figure 9 – Bicarbonate**

"b) Similiarly, no trend in depth is noted for the stable carbon isotopic ratio for DIC in the Chatsworth Formation groundwater. Values of δ^{13}C of DIC in the range of -10 to -12‰ indicate closed-system dissolution of carbonate, -13 to -15‰ indicate open-system dissolution of carbonate, and -18 to 20‰ indicate DIC is being added to the system during microbial mediated reactions, such as redox reactions."

Please discuss the implications, if any, to the absence of values below -18‰ to the occurrence of biodegradation at the site.

***21)*SCM Element Document 12-1 – *"Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California"*
Figure 9 – Bicarbonate**

"d) A slight increase in bicarbonate concentrations is noted with continued depletion of the δ^{13}C values, suggesting both open-system dissolution and microbially mediated processes are contributing substantially to DIC concentrations."

The DTSC assumes the trend described above was identified through subjective visual inspection of the δ^{13}C versus Bicarbonate Concentration graph (i.e. Figure 9). The trend, however, is somewhat ambiguous in the figure and should be evaluated statistically to objectively assess if a trend actually exists. In general, the identification of trends in this and other figures in this element document should be objectively assessed through statistical evaluation rather that subjective visual inspection.

***22)*SCM Element Document 12-1 – *"Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California"*
Figure 11 – *δ^{18}O of Sulphate versus δ^{18}O of Groundwater***

How the conclusion, "pyrite oxidation is occurring within the vadose zone" was reached based on this figure is not clear. The five (5) lines shown on the graph are not explained. Additional information and explanation are needed.

23)*SCM Element Document 12-2 – *"Use of Strontium Isotopes in Groundwater Flow Pathway Analysis in Fractured Sandstone"

The document only provides a summary of results and does not provide any conclusions or relevance to understanding the groundwater flow pathway.

24)**SCM Element Document 12-2 – *“Use of Strontium Isotopes in Groundwater Flow Pathway Analysis in Fractured Sandstone”***

The header on several pages indicates that this is SCM Document 12-4 instead of 12-2. Please correct.

25)**SCM Element Document 12-2 – *“Use of Strontium Isotopes in Groundwater Flow Pathway Analysis in Fractured Sandstone”***
Page 5, 1st paragraph
“The strontium concentrations range from 0.175 to 1.950 mg/L in the on-site Chatsworth Formation groundwater, 0.005 to 0.650 mg/L in the off-site wells, and 0.230 to 0.871 `mg/L in the seeps groundwater.”

This statement does not appear to agree with Figure 4 (Strontium Concentration Distribution) which shows Strontium concentrations for seeps at concentrations as high as 4.250 mg/L. This apparent discrepancy should be addressed. Further, the groundwater comparison concentration (GWCC) for strontium, which is viewed by DTSC to be essentially equivalent to the background concentration, is 0.8 mg/L. Some discussion must be added to address the reported strontium concentrations that exceed this level. The locations of elevated strontium should be identified and evaluated for evidence of potential release or association with other groundwater contaminant plumes.

26)**SCM Element Document 12-4 – *Technical Memorandum: Origin of Minor Constituents in the Chatsworth Formation at the SSFL***

During the establishment of the GWCCs, all the groundwater metal data for the site were evaluated. Concentrations of barium, boron, fluoride, and strontium, along with several other metals, were identified that were in excess of their respective GWCC. Therefore it should be noted that these four metals, described in this document, are also considered potential groundwater contaminants at the site.

27)**SCM Element Document 13-1 – “Origin and Hydrochemistry of Seeps and Springs Issuing from Fractured Bedrock in the Simi Hills”**
4.3 Major Ion Hydrochemistry

The seepage flow rates are described as low, medium, or high. These terms are vague and subjective especially given that the total discharge from the seeps/spring is cited very specifically in reference to the groundwater flow model. Please revise with estimated quantitative flow rates. In addition, a comparison between the flow rates from seeps emerging directly from bedrock outcrops and the flow rates from seeps emerging from alluvium/colluvium is made for each geographic area but no comparison is made between fault-controlled and stratigraphy-controlled seeps. The DTSC recommends that this comparison also be made and the results presented.

28) SCM Element Document 13-1 – "Origin and Hydrochemistry of Seeps and Springs Issuing from Fractured Bedrock in the Simi Hills"

Page 10, 3rd paragraph
"Stable sulphur isotope values between -5 and -20‰ indicate the source of sulphate is pyrite oxidation."

Please clarify if pyrite oxidation is the only source of sulphur isotope values between -5 and -20‰ and why.

29) **SCM Element Document 13-1 – "Origin and Hydrochemistry of Seeps and Springs Issuing from Fractured Bedrock in the Simi Hills"**
Page 10, 4th paragraph
"During the field geological mapping and seeps reconnaissance work, increased amounts of dolomite ($CaMg(CO_3)_2$) *were noted in this area (Personal Communication (Dr. J. Ross Wagner))."*

The DTSC request another reference for the increased amounts of dolomite in the area (i.e. map, previous technical memorandum, etc.). There should be a more appropriate reference than a personal communication with a employee of the consultant company that authored the report.

30) **SCM Element Document 13-1 – "Origin and Hydrochemistry of Seeps and Springs Issuing from Fractured Bedrock in the Simi Hills"**
Page 12, Bell Canyon Study Area

There is no discussion of the potential effects on the groundwater flow and hydrochemistry from the faults. For example, the RI report indicates that "three of the seeps in the Bell Canyon area have similar hydrochemistry to the on-site Chatsworth Formation groundwater", but the seep data was not evaluated spatially in terms of the Burro Flats Fault or other faults present in this portion of the site.

31) SCM Element Document 13-1 – "Origin and Hydrochemistry of Seeps and Springs Issuing from Fractured Bedrock in the Simi Hills"
Page 14, 2nd paragraph
"The fluoride concentration in off-site well OS-2, located in the North Study Area is 6.0 mg/L."

The following table does not include seep data or the most recent well data but the data indicates a correlation between elevated fluoride concentrations (i.e.

well above GWCC or the MCL), pH, and sodium at OS-02. Further evaluation of this offsite well is needed. Fluoride was used at the site in areas upgradient of this well. Please see data below.

	OS-02	**OS-03**	**OS-04**	**OS-05**	**RD-59A**	**RD-59B**	**RD-59C**
Fluoride (mg/L)	*4.6 to 5.4*	0.74	0.52	0.64 to 0.67	1.3	1.1	1.1
pH	*8.02 to 8.36*	7.45 to 7.9	6.98 to 7.55	7.06 to 7.54	6.80 to 6.99	7.27 to 7.80	7.41 to 8.12
Sodium (mg/L)	*169 to 180*	95 to 110	75 to 86	88 to 101	97 to 110	92 to 100	130 to 140

Section 5

32) 5.2.1 Geologic Units

Page 5-5; 4th paragraph

"Mappable geologic units within the boundaries of SSFL include the Chatsworth, Simi Conglomerate, Santa Susana, Los Virgenes, and Calabasas Formations and Quaternary alluvium."

As shown in Figure 5-4, taken from Dibblee (1992 b,c,d,f,g,h), the Simi Conglomerate and Los Virgenes Formations are designated as <u>members</u> of the Santa Susana Formation (i.e. Simi Conglomerate Member and Las Virgenes Sandstone Member). All occurrences of "Simi Conglomerate Formation" and "Las Virgenes Sandstone Formation" in the RI Report should be changed accordingly.

<u>5.2.2.1 Faults</u>

As part of the review of this section, the following Appendix and sections of the SCM were reviewed:
Appendix 4-K – Technical Memorandum, Characteristics of Joints at Santa Susana Field Laboratory

33) Page 5-10; 1st paragraph

"*Additionally, the site has been subjected to local stresses, including faulting and erosional unloading. Given this complex and locally variable stress history, a comprehensive accounting of the orientation and magnitude of past stresses affecting SSFL is not practical"*

The stress history of the site is certainly complex, but stress history can be determined, in part, by master and abutting relationships between fractures. Given the numerous outcrop and mapped lineaments, it should be possible to determine the historical rotation of the stress field in a relative sense. For example, it appears that the Shear Zone predates the Woolsey, IEL, and Happy Valley faults as the latter abuts the former.

34) Page 5-11; 4th paragraph

"In lithified bedrock, the structure of a fault zone typically consists of a fault-plane core and adjacent damage zone. Controls on the development, nature, and scale of these structures include the nature and magnitude of deformation, the lithologic and mechanical properties of the rock, fault-zone geometries, and fluid-rock interactions. Clay-rich gouge, breccias, and cataclasite typically form within the fault core. Damage zones consist of a network of subsidiary structures including minor faults, fracture sets, cataclastic deformation bands, mineralized veins, cleavage, and folds. Damage zones may be effectively absent where strain in highly localized along the fault core (Caine et al., 1996) "

Caine et al. (1996) presents the terms "fault core" and "damage zones" as part of a conceptual fault zone model. It further states, "Whether a fault zone will act as a conduit, barrier, or combined conduit-barrier system is controlled by the relative percentage of fault core and damage zone structure and the inherent variability in grain scale and fracture permeability" and, "fully characterizing the fluid flow properties of fault zones involves obtaining permeability data for each fault zone component and clearly documenting the component of the fault zone from which samples and related data are collected."

The paper also presents the following:

"F_a *(fault zone architectural index) = damage zone width / total fault zone width*

When F_a *is 0 the damage zone is absent and the lower permeability of the fault core cause the fault zone to act as a barrier to flow. When* F_a *is 1, the fault zone core is absent and the presence of a higher permeability damage zone causes the fault zone to act as a conduit to flow."*

The RI report states that "some fault-zone segments are hundreds of feet wide and contain multiple fault traces" and "other fault-zone widths are tens of feet wide." Further the RI report states, "fault-core gouge has been observed at one or more locations along nearly all of the named faults, ranging from 0.5 to 18-inches thick." Assuming the fault gouge represents the fault core, the calculations of fault zone architectural indices for the faults at SSFL approach 1 indicating more conductive fault zones contrary to the SCM presented in the RI Report and companion document that proposes faults that are effective flow barriers. Again, the DTSC does not support the generalized fault zone conceptual model presented in the RI Report and used in the numerical groundwater flow model for the faults until field data can be collected at each fault to verify the conditions. To date, the DTSC is not aware of any permeability data for any of the faults/fault components at the site. The DTSC recommends that adequate data be collected from each fault/fault zone segment and component to assist in understanding how fluid flow is affected in the vicinity of the faults.

5.2.2.2.1 Joints Observed from Field Mapping and Aerial Photographs
As part of the review of this section, the following Appendix and sections of the SCM were reviewed:

- Appendix 4-K – Technical Memorandum, Characteristics of Joints at Santa Susana Field Laboratory
- Appendix 4-L – Technical Memorandum, Ground Truthing and Interpretation of Discrete Feature Data from Core, Optical Televiewer, and Geophysical Logs.
- SCM Element Document 4-1 – *"Technical Memorandum: Characteristics of Joints at the Santa Susana Field Laboratories, Simi, California"*
- SCM Element Document 4-2 – *"Technical Memorandum, Ground Truthing and Interpretation of Discrete Feature Data from Core, Optical Televiewer, and Geophysical Logs at the Santa Susana Field Laboratory (SSFL), Ventura County, California"*
- SCM Element Document 4-3 - "*Determination of Fracture Density and Fracture Set Orientations from Geophysical and Geologic Logs from the Chatsworth Formation at the Santa Susana Field Laboratory, Simi, California""*
- SCM Element Document 12-4 – "Technical Memorandum: Origin of Minor Constituents in the Chatsworth Formation at the Santa Susana Field Laboratory, Ventura County, California"

It should be noted that Appendix 4-K and SCM Element Document 4-1 are the same document. Also Appendix 4-L and SCM Element Document 4-2 are the same document.

35) The DTSC requests clarification on the discussion in section 5.2.2. The terms: fracture, fault, and joint are often generalized. According to the Glossary of Geology (Bates and Johnson, 1987), the definitions of faults, fractures, and joints are:

fracture: a general term for break in a rock, whether or not it causes displacement, due to mechanical failure by stress. Fractures includes cracks, joints, and faults.

fault: a fracture or a zone of fractures along which there has been displacement of the sides relative to one another parallel to the fracture.

joint: a surface of fractures or parting of rock, without displacement; the surface is usually plane and often occurs with parallel joints to form part of a joint set.

The RI Report needs to specifically define what these terms mean in reference to the characterization of the site. In addition, the relationship between the joint and fracture data is not clearly presented in the report. The RI Report does not integrate joint data with the fracture and fault data collected at the site. The DTSC recommends that all fracture data, including faults and joints, be evaluated with regard to geologic history of the site and the overall effect on the groundwater flow and contaminant movement. The overall biases in the measurements should also be considered such as those associated with aerial photos and vertical coreholes.

The separate discussions and separation in treatment of joints and fractures are evident in Figure 5-7 in the RI Report and Figure 4 in Appendix 4-K which are different stylistic representations of the fracture network and joint orientations, respectively. Again, the relationship between the joints, faults, and other fractures needs to be clearly presented in the RI report.

36) Page 5-14; 6th paragraph
"Orthogonal joint patterns are more common at SSFL."

DTSC requests clarification of this statement. Specifically, what is the comparison for "more common". Also it is assumed the orthogonal joint patterns refer to joints associated with bedding and those perpendicular to bedding. Figure 1 of Appendix 4-K consists of a stereonet plot of joints showing steep joint sets both parallel and normal to strike. Absent in the stereonet is a joint set parallel to the dip of the beds. Please provide further discussion of the distribution of the joints and fractures.

37) 5.2.2.2.2 Bedding-Parallel Fractures
Page 5-15; 4th paragraph
"*Additionally, bedding-parallel fractures are more likely to "heal" under lithostatic loading in the absence of an effective component of extension."*

Please provide a reference for this statement and/or identify the site-specific data that supports this statement. Would this type of healing occur in a tectonically active area?

Section 6

6.1.1 Hydrogeologic Boundaries

As part of the review of this section, the following Appendix and sections of the SCM were reviewed:

- SCM Element Document 12-1 – *"Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountains, Simi Hills, California"*

38) Page 6-1, 6th paragraph

" As shown in Figure 6-1, the selected boundaries of this area are (a) where the Simi Hills meet the floor of Simi and San Fernando valleys, (b) where groundwater tends to discharge to seeps and phreatophytes along portions of Bell, Las Virgenes, and Box Canyons, and (c) over the watershed divide from Las Virgenes Canyon and down Runkle Canyon, along which seeps are absent."

It was the understanding of the DTSC that no geologic mapping has been conducted in Runkle Canyon. Therefore, please confirm that potential seep locations within Runkle Canyon have been evaluated and field verified. Also, please provide maps indicating those areas within Runkle Canyon that have been mapped or reconnoitered.

39) Page 6-2, 2th paragraph

"…For the purpose of this study, the base of fresh groundwater is assumed to occur at approximately sea level."

There is no data to support the assumption that the essential base of the groundwater flow at the site is at sea-level. The DTSC recognizes the difficulty and expense to determine the base of groundwater flow at the site, therefore, the DTSC recommends that the RPs evaluate the sensitivity of this assumption on the groundwater flow model.

40) SCM Element Document 12-1 – "Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountains, Simi Hills, California Page 5, 2nd Paragraph

"Similar to granular aquifers, the composition of groundwater in fractured sedimentary rock is influenced by the chemistry of the recharge waters, mixing of water along the flow path, and input of elements via pollution. As groundwater in granular media is influenced by the composition of that granular media, the chemical composition of groundwater in fractured sedimentary rock is influenced by the mineralogy of the aquifer matrix and the chemical process during water-rock interaction."

Appendix B of the 2000 technical memorandum, "Conceptual Site Model Movement of TCE in the Chatsworth Formation", has the following statement:

"In addition to groundwater pumping, the water supply available at SSFL has been augmented by water from the Calleguas Water District since 1964. Water importation from the district has continued to the present at an annualized average rate ranging from about 50 to 130 gpm, providing a total water supply at SSFL of 300 to 350 gpm."

Imported water is significant at the site and would have had an impact on the groundwater chemistry at the site. It should be noted that site operations including the use of numerous unlined surface impoundments, leach fields, discharge from waste treatment facilities, and quench water for rocket tests. It would be unreasonable to assume no impact from the imported water on the site given that a large percentage of the water used at the site was imported. An evaluation and discussion of the impact that imported water and reclaimed water has on site groundwater chemistry should be included in the conceptual site model.

***41)*Figure 4**

Figure 4 from SCM Element 12-1, Hydrochemical Processes in Groundwater in a Late Cretaceous Fractured Sandstone Mountain, Simi Hills, California, presents $\delta^{18}O$ and $\delta^{2}H$ data from groundwater data, local precipitation, and from Callegus Water. The caption of the figure states "*The isotope results for the Chatsworth Formation groundwater and near-surface groundwater are very different from the values measured in samples collected from the Callegus Water District, indicating purchased water is not a major source of groundwater at the site."*

The DTSC disagrees. A distinction between the Callegus Water District and Chatsworth Formation groundwater should be expected when analyzed separately. However, given the large storage in the aquifer, it is not possible, with the given data, to discern what impact imported Callegus Water District water has on the deuterium and Oxygen-18 values in the groundwater as it would represent blended values and data on groundwater not impacted by imported water is not available.

42)6.1.2.2 Aquitard Units
Page 6-7; 2nd paragraph

"Other potential aquitard units include the predominantly fine-grained Las Virgenes, Santa Susana, and Llajas formations, which may retard groundwater flow north of SSFL toward Simi Valley."

The Las Virgenes Sandstone Member of the Santa Susana Formation is described by Dibblee (1992) as "light gray to light brown sandstone; includes some cobble conglomerate locally."

The Llajas formation has two members. The lower unit (i.e. closer to SSFL) is described as "basal conglomerate, gray to brown, composed of cobbles of granitic, metavolcanics and quartzite rocks in sandy matrix." The upper unit, which is located adjacent to the alluvial deposits of the Simi Valley floor and are discontinuous along the south boundary of Simi Valley are described as "gray micaceous claystone-siltstone and light gray to tan soft to semi-friable sandstone, mostly fine-grained…claystone predominantes south of Simi Valley."

There are four members of the Santa Susana Formation: Las Virgenes Sandstone member, Simi Conglomerate Member, and two unnamed members (designated members Tsu and Tsus). Only member Tsu is a fine-grained member described as "claystone and siltstone, few minor thin sandstone beds"

It is not clear how these rock units would affect groundwater flow but with the exception of the one member of the Santa Susana formation, the term "potential aquitard" is not an accurate description. No retardation of groundwater flow to the north should be assumed.

43) 6.2.1.2 Fracture Porosity, Hydraulic Aperture, and Interconnectivity page 6-10; 2nd paragraph

"The bulk fracture porosity if the Chatsworth Formation is small (~0.01 percent; Montgomery Watson, 2000a) and contributes little to total porosity (`14 percent)."

The statement refers to the 2000 Conceptual Site Model Technical Memorandum which uses 50 microns for the hydraulic fracture aperture and ranging from 1 to 10 fractures per meter. The calculations present in the 2000 Conceptual Site Model Technical Memorandum are:

Cubic Matrix Blocks: Fracture Porosity = 3 ε / L or
Tabular Matrix Blocks: Fracture Porosity = ε / L

where ε = aperture and L equals the spacing between fractures.

As presented, 3 times 50 microns divided by 100,000 microns (assuming 10 fractures per meter) equals 0.015%(assuming the cubic matrix bock calculation).

The RI Report states on page 6-10 the following: "The results of straddle-packer testing on two wells indicated hydraulic apertures with arithmetic means of approximately 90 to 125 microns (Sterling, 2000). FLUTe@-liner transmissivity profiling conducted in five SSFL boreholes indicates fracture hydraulic apertures ranging from approximately 15 to 800 microns, with an overall mean hydraulic aperture of about 90 microns...These estimates are corroborated by calculations based on other hydraulic tests and site-wide mean fracture spacing from core data an formation microimager (FMI) and televiewer logs (SCM Element 9 in Cherry, McWhorter, and Parker, 2009)"."

On page 6-11, the RI Report states "The frequency of inferred active fractures is typically 1.5 to 3 per foot, ranging up to 4.5 to 6 fractures per foot over short intervals. Fractures with the highest apparent flow capacity occur more sporadically, about 0.5 per foot on average, ranging up to 1.5 per foot over short interval."

Using 90 microns for the fracture aperture and 6 fractures per foot (or 20 fractures per meter) calculates to a fracture porosity up to 0.5% or 33 times greater than presented in this statement (using the cubic matrix block equation). The DTSC recommends that variability and uncertainty associated with fracture bulk porosity calculations be clearly discussed. A discussion regarding additional studies that might clarify effective fracture porosity at the plume scale should be included in the RI Report.

The corroboration of FLUTe estimates by other methods at the site should be explained specifically, with side-by-side comparison of data rather than a general statement. SCM Element 9 presents summary of FLUTe, geophysics, and other data, but it is not interpreted with respect to formation and trends across the site. It would be useful to know, for example, if observed reductions in bulk hydraulic conductivity are supported by the fracture data. In particular, is permeability reduction a result of aperture reduction, mean spacing reduction, or both? A comparison of fracture statistics between sandstone units and fine-grained units would also shed some light on the potential effect of fine-grained units on hydraulics and transport. These data should be utilized for DFN model presented later in the report.

44) Hydraulic Conductivity

On page 6-13 Figure 6-6 is referenced as it shows the "distribution of bulk hydraulic conductivity measurements across SSFL." It would be useful to map average hydraulic conductivity values overlaid on a geologic map so that trends in hydraulic conductivity can be interpreted.

6.2.2.2 Bulk Hydraulic Conductivity

As part of the review of this section, the following SCM Elements were reviewed:

- SCM Element Document 6-1 – *"Draft Bulk Hydraulic Conductivity, Santa Susana Field Laboratory, Ventura County, California"*
- SCM Element Document 6-*2* – *"Decreased Hydraulic Conductivity with Depth at the SSFL"*
- SCM Element Document 6-*3* – *"Multiple Lines of Evidence Concerning Anisotropy in the Chatsworth Formation"*

45) Page 6-14; 2nd paragraph

"The geometric means of bulk hydraulic conductivity estimated by these methods range from $8x10^{-6}$ to $7x10^{-4}$ cm/s about one to three orders of magnitude greater than the geometric mean of estimated matrix hydraulic conductivity. No simple trend is apparent relative to measurement scale."

and

Page 6-15; 5th paragraph
"Estimates of SSFL bulk hydraulic conductivity appear to peak at relatively local scales, i.e. smaller than the zone of influence of SSFL pumping tests. This suggests that SSFL bulk hydraulic conductivity is ultimately limited by the cumulative influence of lithologic heterogeneities and other permeability structures. Conversely, bulk hydraulic conductivity is not enhanced at larger scales by the cumulative influence of fracturing."

An aspect left out of the data interpretation is spatial distribution of bulk hydraulic conductivity as measured by slug, single, and multi-well tests. A map demonstrating the variation in hydraulic conductivity across the site would quantify the generally perceived trend in decreasing hydraulic conductivity toward the western end of the SSFL.

It should be noted that the transmissivity (T) and storativity (S) values calculated in the RI Report are often geometric averages of various numerical solutions generated by available software. The various types of aquifer test solutions have important assumptions associated with them and some are inappropriate for the conditions at the site. Professional judgment should be used to determine the most appropriate aquifer test solutions that should be used rather than indiscriminately averaging all the results from all available solutions.

46) **SCM Element Document 6-1 – *"Draft Bulk Hydraulic Conductivity, Santa Susana Field Laboratory, Ventura County, California"***
Table 4 shows estimated hydraulic conductivity values for core samples at the lower end of the typical range for a sandstone. During sample selection for analysis, preference was likely given to more intact rock samples which are the more cemented, indurated samples. This would bias results toward lower hydraulic conductivity values.

6.2.2.4 Variation of Hydraulic Conductivity with Depth

As part of the review of this section, the following SCM Elements were reviewed:

- SCM Element Document 6-*2 – "Decreased Hydraulic Conductivity with Depth at the SSFL"*
- SCM Element Document 6-*3 – "Multiple Lines of Evidence Concerning Anisotropy in the Chatsworth Formation"*

47) **Page 6-16; 5th paragraph**
"This relationship [of decreasing hydraulic conductivity with depth] is not yet confirmed by available SSFL hydraulic conductivity data, which generally represents depths considerably shallower than 2,000 feet. However, the relation is considered reasonable in light of indirect evidence and studies elsewhere."

There is a lack of site-specific evidence to support the concept that the fractures are closing with depth to a degree that would affect the movement of contaminants or groundwater at the site down to MSL. The RI report essentially relies on empirical equations for the Bardon-Bandis model which may not be applicable to SSFL. The available measurements from FLUTe profiling determined that "Variability of hydraulic apertures sizes appears to be more laterally variable than with depth" (SCM 8-2, p.8).

The DTSC identified three potential factors that need careful consideration:

(1) This concept that fractures will close due to lithostatic pressures may not be applicable in a tectonically active region such as the Simi Hills where the tectonic events work to open and/or create new fractures.

(2)The effective stress value normal to the plane of the near vertical fractures would essentially equal the confining stress of the rock since the principle stresses (due to the weight of the overburden) would be near zero as the fractures are oriented in the same direction as the stress. As part of the evaluation of the groundwater and fracture system, the different effects of the lithostatic pressure should be evaluated for each primary fracture orientation (i.e. bedding parting fractures and the orthogonal near-vertical fractures) along with changes in lithostatic pressure with depth and proximity to the flanks of Simi Hills.

(3) Chloride data collected from corehole C-15 to over 1,400 feet depth does not indicate any change in the groundwater flow regime with depth.

48)6.2.2.5 Fault Zone Hydraulic Conductivity

On page 6-18 the RI report states "Inspection of SSFL hydraulic conductivity estimates in relation to their proximity to SSFL fault suggests that exceptionally high values of hydraulic conductivity do not occur preferentially near faults". This statement should be supported by references to specific hydraulic tests or drawdown data.

.

6.3.1.2.1 Faults

As part of the review of this section, the following SCM Elements were reviewed:

- SCM Element Document 7-1 – *"Evaluation of Fault Zone Permeability Structures"*
- SCM Element Document 7-2 – *"Indications of the Bulk Hydraulic Conductivity of Faults from the Three- Dimensional Mountain-Scale Groundwater Flow Model of the Santa Susana Field Laboratory"*

49)SCM Element Document 7-1 – *"Evaluation of Fault Zone Permeability Structures"*

Page 7; 3rd paragraph
"Based on groundwater-level offsets, Haley & Aldrich (2000) estimated a hydraulic conductivity of 1x10^{-7} cm/sec for the low permeability boundary that occurs along the SSFL "Shear Zone" fault. Analysis of the C-1 pump test estimated a Shear Zone hydraulic conductivity of 1x10^{-8} cm/sec (MHW,2004)."

The DTSC reviewed Appendix K – C-1 Pumping Test Results from *Report of Results – Phase I of Northeast Investigation Area Groundwater Characterization, Santa Susana Field Laboratory, Ventura County, California* (2004)" There was no reaction of the monitoring wells across the Shear Zone from the pumping well (C-1) therefore no value could be calculated directly from the pump test data. The data was also modeled using Modflow but the hydraulic conductivity value for the faults, including the Shear Zone, was set at 1x10^{-8} cm/sec for the model. It is assumed that this value is considered valid as the model was able to be calibrated using this value. Additional data needs to be collected to support the low hydraulic conductivity value assigned to it. Did the drawdown curve from C-1 indicate that the area of influence from the test had encountered a boundary condition?

50) SCM Element Document 7-1 – *"Evaluation of Fault Zone Permeability Structures"*
Page 7; 4th paragraph
"Although not explicitly monitored, this segment may serve as a partial barrier to flow given the low-permeability mineralization commonly associated with such features."

Please provide further discussion regarding the mineralization.

51) SCM Element Document 7-1 – *"Evaluation of Fault Zone Permeability Structures"*
Hydraulic Conductivity versus Proximity to Faults; pages 9-10

The RI Report states (p.10) "The available data do not indicate that exceptionally high values of hydraulic conductivity occur preferentially near faults". Figure 16 is referenced in support of this statement. However, most of the measurements are too scattered in the presentation to evaluate trends. In addition, the distance from the fault far exceeds the radius of influence of the majority of these measurements. Packer tests do show a significant increase at distances of approximately 12 feet from a fault (which fault is not specified). The relationship between hydraulic conductivity measurements and distance from faults should be revised to reflect reasonable radii of influence of particular measurements and separated into measurement techniques to better assess the possible change in hydraulic conductivity in the vicinity of faults.

In general, the RI Report assumes the fault concept model that includes a fault core and adjacent damage zones. However, there is no detailed permeability data or other data, beyond some field mapping, at the site sufficient to support this condition exists at any of the faults. Detailed assessment of the faults needs to be conducted at the site to adequately assess how the faults or portions of the faults are influencing the flow of groundwater at the site.

52)6.3.1.4 Recharge Influence
Page 6-22; 4th paragraph
"*Ánalysis of stable oxygen isotopes indicate that precipitation is the primary source of groundwater recharge and that water imported from the Callegus Water District has contributed negligibly to recharge."*

see comment #41.

53)6.3.3.1.1 Water-Supply Well Long-Term Hydrographs
Page 6-29; 4th paragraph
"It [WS-4A] is approximately 1,900 and 2,900 feet to the southeast and southwest of WS-5 and WS-6, respectively."

It should read "approximately 1,900 and 2,900 feet to the northwest and northeast of WS-5 and WS-6, respectively." Please revise.

54) 6.3.4.4 Influence of Faults
Page 6-41; 5th paragraph
"Although not explicitly monitored, this segment may serve as a partial barrier to flow given the low-permeability mineralization commonly associated with such features."

See general comment #3

55)6.3.4.4 Influence of Faults
Page 6-42; 3rd paragraph
"The occurrence of low yielding wells and elevated water levels along portions of the Coca Fault provide possible indications that it may serve as a low-permeability zone."

Several factors may result in low yielding wells and elevated water levels. The DTSC recommends that the hydraulic properties of the Coca Fault and the numerous faults across the site be further assessed through aquifer/pump tests.

56)6.3.4.4 Influence of Faults
Page 6-43; 2nd paragraph
"This test involved the injection of 40,000 gallons of 9,000 µmhos/cm salt solution

into the 400-foot deep RD-10 during a 15-hour period on October 13, 1994, which rapidly diluted into a slug of groundwater with an electrical conductivity of about 3,000 µmhos/cm…On March 10, 1995, approximately five months after the tracer was introduced, the electrical conductivity of the water pumped from RD-1 rose and fell over a 19-hour period, peaking at greater than 2,000 µmhos/cm, more than double typical background levels."

This test is impossible to explain using advection dispersion theory. The peak did not broaden appreciably over a distance of 600 feet and a time of 200 days, neither did the concentration decrease as much as would be expected. This transport behavior should be explained because it is contrary to the standard advection, dispersion, matrix diffusion, retardation methods that are the basis for all transport calculations at the site. It is possible the salt exhibited a non-linear adsorption isotherm with the geologic material which led to a self-sharpening front in the breakthrough curve.

57)6.4.1.2.1 Chloride Mass Balance

Please see comment #16

Please clarify how an average Chloride rainfall concentration of 0.49 mg/L is obtained from Table 1 in SCM 10-2. Based upon the values the average appears to be 0.71 mg/L.

The recharge estimates based upon chloride mass balance do not correctly treat uncertainty. The calculation of a 4.6% recharge rate with a range of 2 to 7%, is based only on the range in precipitation chloride measurements. There is also error (estimated with standard deviation) in the groundwater chloride measurements. These errors must be compounded in the calculation. Furthermore, the deposition of chloride measurements are based upon addition of dry and wet deposition, which are measured separately, so these errors also must be compounded in the calculation. An attempt to repeat these calculations described in SCM 10-2 resulted in standard deviations that near the mean recharge value, suggesting a much lower certainty in recharge estimates based upon the chloride balance.

The DTSC requests that the calculation of recharge from chloride balance be revisited with a more rigorous error analysis.

6.5 Groundwater Flow Model

As part of the review of this section, the following Appendix was reviewed:

- Appendix 6-A – "*SSFL Groundwater Flow Model Updates, Optimization, and Application*

58) 6.5 Groundwater Flow Model

Several of the subjects presented in the RI Report and commented on in this memorandum are the basis for the input parameters to the groundwater flow model. Each comment should be evaluated as to its potential effect on the inputs and assumptions used in the groundwater flow model.

The DTSC acknowledges the complexity and the value of the groundwater flow model and the extensive work that went into its development. At best, however, it is only an approximation of the groundwater flow system. The purpose of the model should be limited to: being predictive of future conditions; being interpretive for studying the dynamics of the groundwater system and organizing the data; and for analyzing hypothetical systems. It cannot be used as a surrogate to field data collection.

The DTSC has stated the following issues regarding the Groundwater Flow Model:

- Recharge calculations – see specific comments #9, 16, 40, and 41
- Hydraulic Conductivity Values Assigned to Faults – see general comment #3 and specific comments #34, 49, 50, 51
- Bottom of the model – see specific comments #17 and #39.
- Decreasing K with depth due to fracture closure – see specific comment #47.
- Lack of sensitivity to fault permeability.
- Need to investigate influence of observations and map poorly monitored locations across the site. .

Appendix 6A

59) Appendix 6-A – "SSFL Groundwater Flow Model Updates, Optimization, and Application

Page 12, 1st paragraph

"All particle tracking presented in this report uses a default porosity of 1.0 that allows for comparison of the Darcy flux (relative velocity) along flow paths in different areas of the model. The particle tracks illustrated in this report are

intended to only depict flow direction in a given model simulation."

Using a default porosity of 1.0 makes the Darcy flux equal to the seepage velocity and minimizing pore water velocities. Would the particle tracks therefore be considered the minimal distance/speed expected for a given model simulation?

60) Page 12

"Analysis of contaminant transport distance and travel times utilizes a Discrete Fractured Network (DFN) model rather than an Equivalent Porous Media (EPM) model to represent the appropriate transport mechanisms. This work is documented in Draft Appendix 8-A."

There is no Appendix 8-A in the RI document.

61) Page 16; 3rd paragraph (#5)

"A number of additional fine grained beds were identified between the Burro Flats and Bell Canyon Faults that are part of the Lower Chatsworth Formation and have characteristics consistent with the other Lower Chatsworth Shale beds mapped closer to and east of the site. An additional Lower Chatsworth Shale bed was mapped southwest of the Bell Canyon Fault (Figure 2-3)."

Figure 5-5 of the RI Report "SSFL Geologic Map" shows attitudes that deviate significantly from the typical northeast strike and 25 degree dip to the northwest. The DTSC was unable to locate a cross-section showing how the structure and bedding is being depicted in this area. Please provide a cross-section showing the interpretation of the subsurface geology in this area.

62) Page 16, 10th paragraph

"There were three additional potential faults identified by the DTSC (DTSC Potential Fault 1, 2, and 3) based in their evaluation of airphotos. The location of these faults was refined using existing topography and airphotos, and digitized in a meeting with Tom Seckington (September 2008). Previous geologic field mapping in these areas did not identify any exposures of a fault to confirm their existence (Wagner, personal communication, September 2008 meeting)."

Please confirm if a concerted effort was made to assess the presence of these three potential faults after they were identified by DTSC. If so, please provide a description of the work completed.

63) Page 17, 5th paragraph

"If a geologic contact was not observed, the well was not included in the comparison."

This statement needs clarification. Please indicate if the wells referred to should have intersected inferred geologic contacts at depth but did not. Otherwise, are the wells referred to in this statement located and constructed such that they were not expected to intersect specific geologic contacts?

64) Page 18, 11th paragraph

"The fault elements are assigned the properties of the fault material (e.g. gouge). The length of each of these elements is approximately 3 m, such that the core of the fault has a total model width of 6 m. Additional "rows" of elements having a length of 3 m were added on either side of all fault core elements."

There is no basis for a nearly 20-foot zone of gouge for the faults or for the 10-foot "damage" zone. See previous comments on the conceptual fault structure. Detail work, as outlined previously in this memorandum needs to be completed, to support the treatment of the faults in the model. The DTSC views these 20-foot gouge zones along the entire trace of the faults to the depth of the model as unrealistic.

65) Page 22, 1st paragraph

"In Step 2, two specific alternative conceptual models are explored that seek to find the maximum supported hydraulic conductivity value for the fault damage zone (parallel to core of the fault)…These specific alternative conceptual models have been discussed previously with the DTSC as simulations requiring further evaluation."

Is the fault structure conceptual model with the fault core and damage zone an alternative conceptual model? If so, the RI report is not clear on how the faults were represented in the model previously. Please note that DTSC has requested that higher hydraulic conductivity value be assigned to the entire fault zones not just the "damage zones.

66) Page 24, 6th paragraph

"The lower and upper bounds for ʌ supplied to PEST were 0.002 to 0.01; allowing for representation of essentially no variation with depth to a large variation with depth"

No information regarding how PEST adjusted this parameter was found in the RI Report. A discussion of how hydraulic conductivity versus depth was resolved in the groundwater flow model is necessary. The results should be evaluated considering DTSC concerns stating in specific comment #47.

67) Page 25 1st Paragraph

"The observation groups' weights also reflect the overall quality of each type of observation and the number of available observations. The group weights, in order of importance, are: heads, head differences, pumping rates, and seep and phreatophyte discharge...”

Please explain how the “quality” of each group was determined and how that was expressed in the observation weighting. In particular, why are pumping rates considered less reliable than head measurements? The spatial distribution of these weighting factors should be presented in map form so the areas of the SSFL that are not well represented by confident observation can be identified. A table should be provided in which the weighting for each observation is provided and explained (e.g. screen length, variance in head, perceived quality).

68) Page 26, 1st paragraph

“The initial parameter values, used for regularization, were consistent with the base case parameter values determined from manual calibration.”

The regularization process restricts changes in these parameters during the calibration using PEST. As a result, the model calibration may be more biased towards these initially assigned values.

69) Page 26, 4th paragraph

“The optimized hydraulic conductivity of Shale 2 (zone 1810) of 2.9×10^{-18} m/s is lower than expected lower limit of 1×10^{-9} m/s.”

The hydraulic conductivity value of 2.9×10^{-18} m/s is not realistic and represents a real problem area for the model. The hydrogeologic framework at this portion of the site needs careful scrutiny.

70) Page 26, 6th paragraph

“If additional optimization was undertaken such that Shale 2 and FSDF structures hydraulic conductivity values were adjusted closer to their expected range, through the additional (sic) *of new regularization information, it is unlikely that groundwater flow directions would be significantly different…Therefore the current representation is considered conservative.”*

It is disconcerting that the groundwater flow model identified an area where the hydrogeologic framework needs evaluation and it is simply dismissed because it is believed that it is “unlikely” that the groundwater flow direction would differ if the “expected” parameter values that the RPs believe should be there were forced in (as regularization information).

DTSC expects that the groundwater flow model is well supported and that all areas and parameters are appropriately vetted. An important application of this groundwater flow model is interpretative, that is, to provide insight into the system dynamics. The view that it doesn’t matter why the groundwater model is not calibrating in this area because the results (i.e. groundwater flow directions) are essentially predetermined is not acceptable.

71) Page 26, 6th paragraph

The optimized recharge rates should be discussed here but are not. Figure 4-28 shows the optimized values with much higher values in the western portion of the site (lowland areas) and along the shear zone. Please explain these order-of-magnitude larger values of recharge, especially in light of the fact that fault recharge is considered negligible in other simulations (e.g. p. 59, High Recharge Conceptualization). Are these recharge values considered realistic or an artifact of the calibration process? It is well known that hydraulic conductivity and recharge correlate during model optimization.

72) Page 27, 2nd paragraph

"*Fault. Wells WS-04A, WS-13, RD-51B/C and RD-52B/C have heads that are simulated higher than observed values in the optimized Pumping simulation. This same trend was evident in the manual model calibration (AquaResource and MWH, 2007). The wells with larger residuals have long open intervals, or are completed within the complex North Fault, which is represented in the model as a vertical fault. The long open screens and the fault zone make assigning the well to a discrete location within the model domain challenging..*"

There is no presentation or discussion of the spatial distribution of these larger residuals, i.e. which area of the SSFL are not well represented by the model. A map of residuals should be presented, along with the weights applied to the head observations, and a table describing how these weights were determined (e.g. from screen length, interference with a specific fault etc.).

How can the faults be better represented in the model? Please explain how this fault geometry can be better constrained in the model so that heads in the vicinity of faults (e.g. the North Fault and the Shear Zone) may be better represented in the numerical model.

Although it is not referenced in the RI or Appendix 6-A, SCM 7-2 presents calibration of the fault permeability in the numerical model. Identifiability estimates for fault segments are listed in Table 2 of SCM 7-2. Only 17 out of the 90 fault segments have identifiability greater than 0.1. The IEL, Tank, Skyline, IEL-S, Pond, IEL-N, Box Canyon, Santa Susana Pass, North Drainage, Happy Valley, and Lakeside faults have no segments for which identifiability exceeds 0.1. The optimization indicates, consequently, that fault hydraulics are not well constrained across much of the site. Section 4.0 in SCM 7-2 suggests that a map of fault identifiability will be created in the future. Such a map will be useful. Another useful investigation would be to use the model to propose further monitoring that would constrain fault hydraulics, particularly in sensitive areas in proximity to known contaminant plumes. These studies should be incorporated in the RI Report.

73) Page 28

"*The current optimization fits the criteria of a minimized objective function and optimized parameter values that are physically reasonable and generally lie within the expected range derived from field data."*

Please specify the criteria of a minimized objective function to which is being referred. Optimized parameter values should be compared statistically to specific measurements (e.g. hydraulic conductivity from slug tests, pump tests etc) wherever possible. Stating that the optimized parameters generally lie within measured values is not a valid basis for determining the applicability of a model.

74) Page 28 Need for further analysis of optimization

The optimization procedure should take advantage of statistics of influence that are available in PEST. These statistics, such as DFBETA, Cook's D, and/or leverage statistics indicate the importance of individual observations on the model optimization. Such an analysis helps determine bias in the model. For example, how important are seep measurements to the model determination when they are considered somewhat unreliable? Which head measurements influence large sections?

Furthermore, the model can be used in predictive mode to determine where additional observations would be most beneficial to model confidence. The essential procedure is to propose hypothetical monitoring wells and determine statistics of influence on those wells. This can also be implemented in PEST.

Finally, it is not clear why a calibration to the C-1 Pump test was not evaluated in these optimizations, as was discussed in Appendix L of the 2007 MWH modeling study. Also, why is the 1996 Hydraulic Communication study not a subject of these optimization studies? The Hydraulic Communication study, for example, showed a strong response to pumping shut down along the North Fault which is inconsistent with the calibration of the fault conductivity that has been determined in this section of the RI. These datasets provide a very useful basis for testing the dynamic response of the model to hydraulic stresses and may improve confidence in the optimized parameters. They should be the subject of further model calibration studies with an emphasis in testing confidence in the determined parameters.

75) 5.0 Optimized Non-Pumping Simulation

It is not clear how the non-pumping production wells and long-screen monitoring wells at the site are represented in the groundwater flow model. Given the general downward gradient at the site, DTSC would expect that each was treated as a sink in the model. Please clarify how the groundwater flow model handled these wells.

76)6.0 Transient Simulation, Page 33

The EPA HELP (Hydrologic Evaluation of Landfill Performance) Model, developed for landfill cap modeling, requires soil textures to predict water balance in soil layers. The RI notes that “Six soil/geologic profile types were simulated” but how these were characterized and distributed across the site is not explained. Default soil textures are available in the model, but these are intended to be disturbed soils, placed over a landfill cap. The soil moisture curves are not intended for natural soils with vegetation. The use of the HELP models as appropriate for this application should be justified. The soil properties used in the model, and their source, should be also justified.

The HELP model predicted recharge that was “2 to 50 times higher than the Pumping and Non-Pumping Simulations.” HELP or other vadose zone model estimates of recharge should be made for all three scenarios, so that the HELP and calibrated recharge estimates can be compared for the Pumping and Non-Pumping scenarios. Presently, it is not known if the recharge variation among scenarios is due to actual changes in precipitation, or just the estimation methodology. According to the RI, the “1995 to 1998 time period represents a period of above average precipitation, 23 inches/year compared to the long-term average of 18.6 inches/year.” So, although precipitation increases only 28%, recharge increases by 200 to 5000%. As is noted in the RI, the relationship between precipitation rate and recharge is non-linear. Chaparral covered hillslopes are observed to have a threshold precipitation below which little or no recharge will occur. However, this disparity between precipitation and estimated recharge is much larger than is typically observed in Southern California.

Later in the document, on page 36: “It is likely that the recharge through these units (FSDF and the west end Burro Flats) is lower and less variable than other sandstones due to the larger fracture spacing.” Is there any additional evidence to back up the statement that recharge is reduced with wider fracture spacing? Wider fracture spacing does not necessarily lead to reduced recharge. Vertical permeability is sensitive to aperture and spacing of fractures. Where does runoff go if it is not recharged to the subsurface? Note that Figure 4-27 indicates that vertical hydraulic conductivity is closer to horizontal conductivity in the western portion of the site, which would suggest that recharge would not be lower toward the west.

77)Page 36, 2nd paragraph

”The current simulations do not explicitly incorporate recharge from imported

water; however, the optimized pumping conditions model does implicitly account for this influence by adjusting net recharge to match water levels influenced by recharge from precipitation and imported water. In the transient recharge scenario, recharge is based on the precipitation inputs only; therefore some of the variation in water levels not represented by the simulation, especially when simulated water levels are lower than observed, may be attributed to underestimating contribution of imported water. In years where the proportion of imported water is greater than the 1995 to 1998 period, the constant recharge will also underestimate the total recharge."

See specific comments #8, #37, and #38. Please clarify the significance of imported water on the groundwater quality data and recharge estimates at the site.

78) Page 40; 9th paragraph

"The potential discharge locations are shown on Figure 7-1."

Figure 7-1 shows hundreds more discharge locations than the seeps on Figure 4-3 from the RI Report. The seeps in Figure 4-3 represent the seeps verified in the field. The discrepancy between the two figures is assumed to be the addition of phreatophytes identified in the drainages. Additional information is needed to support these locations as they were likely identified through remote sensing.

79) Page 40, 10th paragraph

"The 200 m is the greatest depth of interpreted TCE penetration and is used for all key RI areas."

TCE porewater concentrations from corehole C-15 indicate much deeper penetration (greater than 400 meters). Please clarify.

80) Page 42, 5th paragraph

"The 1000 m distance was selected to illustrate general flow conditions during a steady-state simulation because preliminary Discrete Fracture Network (DFN) modeling of contaminant transport, using FRACTRAN , suggested contaminants moving in the groundwater system are highly attenuated and would likely only travel 1000 m or less from an input location before the concentrations would be reduced to values below water quality standards."

The FRACTRAN models mimic plume transport only in a "stylistic" manner and do not correctly represent biodegradation, according to the RI. It is not appropriate to represent transport based upon these simulations. However, it seems reasonable to use 1000 m as an arbitrary cutoff point of particle transport for practical purposes.

81) Page 45; 4th paragraph

"Table 8-1 presents a summary of the quantities of on-site recharge that discharge at each type of discharge feature group (e.g. pumping wells, seeps, etc.)."

Please clarify if the seeps include the phreatophytes.

82) Page 47; 9th paragraph

"In the pumping conditions scenario 4,398 flow paths are analyzed, while 6,549 are analyzed in the non-pumping conditions scenario. The same particle release locations are used in each, however, flow paths with a length less than 750 m are not considered, to avoid skewing the results based on higher velocities around pumping wells…"

With the effective porosity arbitrarily set at 1 and particle tracks that are less than 750 m not considered in the evaluation, what biases are created in the evaluation of these particle tracks? Is the 750 m criteria limited to particle tracks that terminate at pumping wells? Why was this criteria used under non-pumping conditions? If effective porosity is maximized at 1, it therefore minimizes seep velocity and the particle tracks lengths. Further discussion in needed and the limitations of this evaluation need to be clearly stated.

83) Page 52, 1st paragraph

"The monitoring well network provides a monitoring function for all key RI areas except the B064 Landfill, Metal Clarifier, and CTV-V under one both (sic) conditons."

As stated previously, a groundwater model is an approximation of the groundwater flow system even when properly vetted through calibration and sensitivity analysis. It is not the sole factor that will be used to determine if the monitoring well network at the site is adequate.

84) Page 57

"To evaluate the plausibility of a damage zone adjacent to all mapped faults in the model a new single hydraulic conductivity zone was specified on both sides of existing modeled faults to represent the damage zone (nominal element width of approx. 3 meters on either side)."

This approach seems overly constrictive if the purpose is to determine if faults can be a high permeability feature. By forcing all faults to have a large hydraulic conductivity, and not allowing them to vary, a poor optimization is nearly assured. It would seem more reasonable to institute a higher range of K values along specific faults one at a time to determine if a high-K fault zone is plausible.

85) **Page 62., last sentence**
"plausibility of the double recharge conceptual model comes into question when you consider two key pieces of information: 1) that simulated recharge is not supported by best field estimate based on the Chloride Mass Balance method; and 2) poor fit to lower weight observations including pumping rates and seeps."

The double recharge scenario produces a better match to head observations, but a poor match to pumping rates. As would be expected, doubling the recharge approximately doubles the pumping rate. However, confidence intervals for the pumping rates are not provided. Pumping rates are given lower weights in prior model optimization. Error bars should be place on the pumping rate estimates for analyses such as shown in Figure 12-5.

Although a double recharge scenario may not be considered plausible as a result of this modeling exercise, it does suggest that recharge could be significantly higher than the optimized value and still produce reasonable flow models. As noted previously, the DTSC believes the error in the chloride balance estimates of recharge is larger than portrayed in the RI document. Pumping rates have been assigned lower optimization weights than heads throughout Appendix 6A, suggesting confidence in these rates is not high. Recharge estimates should be carefully examined in light of potential error in both the chloride balance and pumping rates.

Section 7

7.1 Chemical Nature and Extent Information Contained in Surficial Media Reports

As part of the review of this section, the following Appendix was reviewed:
Appendix 7-A – "Assessment of Chemical Impacts to Groundwater at RI Sites"

Please note as stated in General Comment 4, detailed evaluation of each RI Release location will be required. Although this comment is overarching and applicable throughout Section 7, it is not repeated below for the sake of brevity.

86) The RI Report discusses rock core data and vertical contaminant distribution for both the vadose and saturated zones at most locations. In the discussions of the results, however, the variation of the water levels during pumping activities and the effects on the contaminant distributions are not addressed.

An example is the rock core data from C3. Figure 7-3A shows groundwater elevation at below 350 feet below ground surface (bgs). In Appendix B of the 2000 Conceptual Site Model of TCE in Chatsworth Formation (2000 CSM) the hydrograph from WS-3 is shown. In June 1949, the water level in WS-3 was 61 feet bgs, approximately 200 feet higher than reported in a nearby well (WS-4A) in

1999. Corehole C3, WS-3, and WS-04A are screened on the west side of the Shear Zone and wells in these areas have been shown to track together closely. Although the timing between the release(s) in the vicinity of C3 and the pumping activities (there are no records found prior to 1951) cannot be known for certain, the distribution of contaminants should be evaluated with the recognition that the water table may have been much higher when the contaminants, especially the dense non-aqueous phase liquid (DNAPL), were released. Similar consideration should be made for all rock core data across the site since the vadose zone thickness is cited as a factor that affects the distribution of contaminants (see page 7-8; 1st paragraph).

87) Vertical Extent of Contaminants in Groundwater

The vertical extent of contamination for each of the constituents is based on all or some of the following:

(1) Rock core results from 23 locations. The rock core results were generally limited to TCE, cis- and trans- isomers of 1,2-DCE, 1,1-DCE; and chlorofluorocarbon (CFC)-113. Choroform, 1,1,1-TCA, extractable fuel hydrocarbons, and perchlorate were also included in some coreholes. Approximately five percent (5%) of the samples were also analyzed for a full suite of compounds using EPA analytical method 8260, but the distribution of these data provided very limited information regarding the vertical extent of contaminants.

The rock core results do not meet the data quality objective for defining the vertical extent of contamination. First of all, the rock core data is limited to a few contaminants only. Secondly, the RI report states earlier that “sampling results [from rock core sampling] discussed below are all presented in equivalent rock porewater concentrations in units of micrograms per liter and should be considered as approximate values due to the assignment of standard parameters that are used to calculate the equivalent porewater values.” Since these concentration values are approximate, they cannot be compared to regulatory screening levels as a straightforward measurement of determining the adequacy of vertical characterization.

(2) Groundwater sampling results from 21 vertical monitoring well clusters. Much weight is placed on the data from the 21 vertical monitoring well clusters. For several contaminants, these wells provide the only basis for defining the vertical extent of impact to groundwater. The vast majority of the well clusters are not located at release locations. Therefore, in most cases, the clusters are not located in the area where the contaminants are anticipated to be deepest. It isn’t clear why data from single deeper wells located and constructed appropriately at or near release locations were not evaluated.

(3) Groundwater sampling results from vertically-discrete intervals in multi-level monitoring systems subsequently installed in 4 of 21 continuously-cored locations. Groundwater sampling results from vertically-discrete intervals in multilevel monitoring systems are also cited in the evaluation of the vertical extent of TCE impacts but no discussion of the data is presented.

The data evaluated to determine the total depth of contamination is not adequate. Twenty-three coreholes, 21 well clusters, and several multilevel well installations over the site are not adequate especially considering that most are not located at release locations. As a minimum, the RI Report should have provided a discussion of the groundwater data in the context of the site conditions and different manners that contaminants were released (i.e. instantaneous or continuous) to provide an explanation as to the variability seen across the site (e.g. corehole C-15). If the site conditions and release history provide a reasonable explanation to the distribution seen, some extrapolation of the data may be justified. Without any additional information, any statements regarding the vertical distribution of contaminants, especially DNAPL, is speculative. One clear question related to this issue is information from corehole C-15: Is the deep occurrence of TCE at C-15 unique at the site and, if so, why; or is it indicative of conditions at the site and evidence to the difficulties in properly locating a representative exploratory borehole?

88) Page 7-2, 2nd paragraph

"Chemicals identified in surficial media RI site reports as a groundwater impact exceeding groundwater screening levels" and *"Chemicals exceeding the groundwater screening levels described in Section 7.3.2 in the groundwater screening performed for this report."*

If we refer back to the objectives: characterizing the nature and extent of contaminants; determining the rates of contaminant migration, and collecting sufficient data to support risk assessment and cleanup alternatives analysis; it is evident that these objectives cannot be met if characterization is limited to regulatory levels. An example in the RI report is the treatment of tritium. The regulatory level for tritium is 20,000 picocuries per liter (pCi/L) but the background concentration expected at the site is well below 100 pCi/L. As a result, the depiction of the tritium plume (the extent set at 20,000 pCi/L) only provides insight into the location of the hot spots or release locations. If the plumes were defined at the background concentration the extent of the plumes would not only reflect the release locations but also the transport pathways and the relative transport rates.

By assessing the contaminant plumes to regulatory limits, the data needed to complete the risk assessment is not being collected. The risk assessment must be based on the cumulative toxicity of multiple contaminants.

89)Page 7-3, 3rd paragraph

"Currently, the vast majority of VOC mass is present in the rock matrix blocks of the vadose zones, with very little being present in the fractured network. VOC concentrations in the fracture network are in close equilibrium with concentrations present in the rock matrix near the fracture faces."

This, and similar statements, are conclusions of the RI Report therefore they should refer to the sections that discuss this part of the site conceptual model.

90)Page 7-4, 2nd paragraph

"All locations where bedrock samples have been collected for contaminant characterization are discussed below even though vadose zone samples were not collected from some locations as the data will be used in subsequent sections of this report."

Please clarify what "*the data*" is referring to.

91)Page 7-5, 5th paragraph

"Extractable fuel hydrocarbons (EFH) was measured however as a target analyte in the EPA method 8260 list (i.e. in 5 percent of the samples)."

EFH is not a target analyte in EPA Method 8260, please clarify. Should it be EPA Method 8015?

92)\Page 7-9; 1st paragraph

"Chloroform was found in five coreholes. Most of the concentrations detected were close to the method detection limit (MDL) and similar to what was observed in many of the blanks. This indicates that these detections may be the result of cross-contamination during storage and/or prior contamination of methanol used to decontaminate sampling equipment."

The DTSC assumes that all appropriate quality assurance/ quality control (QA/QC) measures were taken during sampling and analysis of the samples. This would have included duplicates, field blanks, equipment blanks, and trip blanks in the field and standard QA/QC procedures in the laboratory. Proper data validation utilizing information from the appropriate QA/QC procedures are meant to uncover any sample contamination issues. Absent any evidence that specific results are suspect, the statement above is simple speculation and will not be accepted by DTSC. All detects for this chemical and, indeed, any chemical detected throughout the groundwater investigation will be considered real, unless results from the appropriate QA/QC measures call into question the results through a well-documented and detailed data validation process.

93)Page 7-14; 2nd paragraph

"Additionally, there are areas where impacts may have occurred based on historical site activities or operational history, but where the potentially impacted unsaturated lithologies were removed due to excavation, closure or interim measure activities and hence were not sampled. Excavated areas include:.. Accelerated site cleanups (1993)…*"*

Clarification is needed for "accelerated site cleanups (1993)." What area(s) was involved? Was this work presented in a report, and, if so, please provide the reference. Also, several Department of Energy (DOE) sites such as the Sodium Reactor Experiment (SRE) have gone through deactivation and decommissioning (D&D) activities and should be added since chemical sampling was not conducted at these areas. A figure(s) showing all the areas would helpful.

94) 7.3.2 Groundwater Data Screening and Figure 7-5 – Screening of Chemical Groundwater Data

The use of risk-based screening levels (RBSLs) above background concentrations or method reporting limits (MRL) could be construed that groundwater restoration is not the goal for the site or that a determination has been made that restoration is not feasible. No decisions regarding groundwater restoration or specific cleanup standards have been made or can be made for the site at this time. As a result, characterization of the site must be completed with data that allows for ALL potential remediation alternatives to be evaluated. DTSC would recommend that characterization be conducted to the level of the background concentrations for naturally-occurring chemicals and to levels sufficient for all other contaminants that allows for the appropriate evaluations. This may require characterization to MRLs. Again, at this phase of the investigation, the potential to completely restore the aquifer, portions of the aquifer, or restore the aquifer for specific contaminants has not been evaluated.

95)7.3.3 Groundwater Evaluation
Page 7-18; 2nd paragraph

"Chemicals that are common laboratory contaminants (e.g. methylene chloride and bis(2-ethylhexyl)phthalate) and those that are naturally occurring and for which there is no known site-related anthropogenic source (e.g. sulfate) were also not included, even if they had concentrations exceeding screening values at five or more locations."

See comment #90. Again, no data should be removed from consideration just because they are "common laboratory contaminants." In addition, please provide a complete list of the naturally occurring chemicals referred to in this statement and a summary of the data.

96) 7.3.3 Groundwater Evaluation
Page 7-20; 4th paragraph
"FS Areas for Group 9 have not been included, as the report was submitted just prior to this report and there was insufficient time to incorporate its findings."

How and when will the figures be revised to incorporate this information?

97) 7.3.3 Groundwater Evaluation
Page 7-20; 3rd paragraph
"Statistical probability distribution plots are included on the upper right corner of the plates depicting the maximum concentration detected in each groundwater monitoring location in the historical dataset. All groundwater monitoring locations in SSFL monitoring network, on-site and off-site, are included…"

It is not clear what the significance of the distribution plots are. Please clarify.

98) 7.3.5.1 Extent of TCE in Groundwater
Page 7-21; 4th paragraph
"The RBSLs were evaluated for protection of groundwater by modeling the transport of TCE from vadose zone soils to groundwater using the modeling code SESOIL as presented in Appendix 7-F."

After reviewing Appendix 7-F, DTSC has numerous concerns and questions regarding the information presented and conclusions made. Foremost, the Appendix is not clear on how the conclusions will be used at the site. The appendix states "This modeling exercise was implemented to gain a better understanding of potential chemical and physical processes involved in the movement of these chemicals in the vadose zone soils and shallow alluvial groundwater at SSFL". Please provide clarification if this information will be used to support or establish clean-up levels for soils that are protective of groundwater or to support that existing RBSLs are also protective of groundwater.

99) 7.3.5.1 Extent of TCE in Groundwater
Page 7-22; 2nd paragraph
"Surficial media sampling results may not indicate the presence of historical releases as certain areas may not have been sampled due to the lack of soil or because sufficient time has lapsed whereby the mass remaining in the soil profile has been transferred either deeper into the subsurface or volatilized to the atmosphere."

This statement seems to indicate that there may be conditions where a release may have occurred and there may be no indication of the release due to complete volatilization or complete migration of contaminates out of the area. In the absence of vigorous biotic and/or abiotic degradation or physical excavation, it is unlikely that contamination would be completely transferred deeper or volatilize. The example RI sites presented in this paragraph where “sources are suspected but were not confirmed by surficial media sampling results” are more likely the result of inadequate characterization. In the absence of soil or bedrock data, DTSC recommends rock coring and the installation of groundwater monitoring wells.

100) 7.3.5.1 Extent of TCE in Groundwater
Page 7-22; 4th paragraph

“The data indicate that boundaries encompassing concentrations of TCE in excess of the screening level of 5 µg/L can be drawn over eight distinct areas of the site.”

The extent of the TCE groundwater plume contamination shown on Plate 7-2 is not well controlled and the boundaries of the plumes could be drawn numerous different ways and still honor the data. The interpretation on Plate 7-2 raises the issue that there is inadequate data to bound the extent of the plumes in detail sufficient to evaluate remedial approaches. Large areas between the defined plumes and between release locations within the plumes have no data. The RI report states that “more than 350 piezometers and wells are monitored within and surrounding SSFL” but given the number and size of the releases at the site, this is not a large number of wells. For example, the area between the plume in the northeast (i.e. IEL, APTF, Bowl areas, etc.) and the plume encompassing the Alfa and Bravo Test stands (among other sources areas) is over 170 acres with a single well (RD-47) providing control. DTSC cannot accept this level of resolution in the groundwater data at the site. Individual plumes and release locations should be sufficiently defined so that remediation alternatives can be assessed. The size of the plume, the range of concentrations, and the contaminants present are necessary information to evaluate any remedial alternative.

101) 7.3.5.1 Extent of TCE in Groundwater
Page 7-24; 3rd paragraph

“Transport modeling using 2D fracture porous block representation of hydrogeologic conditions at the site commonly found that plume boundaries (defined as a reduction in source concentrations of five orders of magnitude (a factor of 100,000) generally extended only about 1000 m from the source areas.”

This assumption of 1000 m is not adequately supported. See general comment #2.

102) 7.3.5.2 Extent of PCE in Groundwater
Page 7-25; 2nd paragraph
"PCE was found to be a chemical of concern in surficial media at three RI sites (LOX, Ash Pile/Bldg 515 STP, and ELV) but has not been found in groundwater samples at concentrations above PCE's screening level."

DTSC compared Plates 7-2 (TCE) and 7-3 (PCE). The distribution of contamination in the soil and soil vapor are different for the TCE and PCE and so are the detections in the nearby wells. In the LOX area, for instance, the PCE detections in soil are limited to the areas above or north of Shale 2. The TCE concentrations are also present south of Shale 2. The nearby RD-52 well cluster only has TCE detections, presumably from the LOX area. The absence of PCE in the RD-52 cluster may be a result of lower PCE concentrations at the release location in the groundwater but it may also be due to a more complex groundwater flow system in this area than is presented in the RI Report. The lack of PCE detection in the groundwater may simply be the lack of monitoring well coverage.

The presence of TCE and the absence of PCE in the wells near the Ash Pile/Bldg 515 STP and ELV may also indicate complexities in the groundwater flow that is not presented in the RI report. Although PCE and TCE were detected in the surficial media in both areas, the detections in the wells in the vicinity have had TCE but no PCE concentrations detected. Again, this may be a result of lower PCE concentrations at the release locations but it may also be due to a more complex groundwater flow system.

Comparing assemblages of the contaminants at release locations in both the soil/rock and groundwater should be carefully evaluated as tracers of the transport pathways between soil/rock and groundwater and within the groundwater.

103) 7.3.5.22 Assessment of Groundwater Monitoring Network
Page 7-60; 1st paragraph
"This method is conservative in that it does not account for any widening of the contaminant distribution as it expands through the flow field (i.e., dispersion)."

As stated previously, a groundwater flow model, at best, approximates the groundwater flow system. DTSC, therefore, will not accept the groundwater flow model as the final determination of the monitoring well network's adequacy. Each individual release location and plume must be sufficiently characterized through the collection of field data.

104) 7.3.5.22 Assessment of Groundwater Monitoring Network
Page 7-60 2nd Paragraph
Figures 7-7 and 7-8 show particle tracking predictions of transport and are used here to denote those sources of TCE contamination which are potentially not intercepted by monitoring wells. However, there is no explanation as to why many areas in which particle tracking show plumes should exist are not currently detected by monitoring wells. For example, the "doughnut hole" in the TCE plume map surrounding ECl as depicted in Figure 7-7 is densely populated with theoretical particles. Are the particle tracks in error or are the monitoring wells not detecting TCE concentrations in this region?

105) 7.4 Nature and Extent of Radionuclides in Bedrock and Groundwater

The United States Environmental Protection Agency (US EPA) is currently conducting a comprehensive radiological survey of Area IV including groundwater. The DTSC believes that it is prudent to wait until these results are available before assessing the nature and extent of radionuclides at the site.

Section 8

Section 8.0, Transport and Fate, summarizes the information presented previously in the RI Report and in the related SCM sections. For brevity, similar comments previously made in this memorandum are not repeated. Specifically, general comment #2 provides the major overarching concern of DTSC on the transport and fate discussion.

106) 8.1 Transport Routes
Colloidal transport and co-transport does not appear to be considered in the Draft RI. Colloids can have an important influence on metal transport, especially radionuclides and should be considered in characterization of fate and transport.

107) 8.5 Chemicals within the Groundwater System
Page 8-15; 2nd paragraph
"This fundamental difference is attributed to the transfer of VOC mass from the groundwater flowing through the fracture network into the nearly stagnant groundwater that is resident in the porous rock matrix by molecular diffusion."

As stated above, the groundwater flow and associated contaminant flow in the unfractured sandstone is essentially dismissed.

108) 8.5.2.1 Field Assessment of TCE Transport
"Mean porewater concentrations of TCE in 3 source zone transect coreholes are more than a factor of 100 higher than mean TCE concentrations in 2 plume

transect coreholes….These data provide compelling and conclusive evidence of the strong attenuation effect of matrix diffusion on contaminant transport in the Chatsworth Formation at SSFL."

Comparing the mean porewater concentrations in source zone with coreholes at the more distal portion of the plumes is not informative as it does not account for the narrowing preferred transport pathways which are more dominant in the chemical data away for the source zones. In this case, specifically, the reported TCE concentrations occurred within a narrow vertical range in the distal plume coreholes. The mean calculated from this data included a large amount of "non-detect" data points which would have significantly decreased the mean.

Although DTSC does not argue that matrix diffusion is not important for transport at the SSFL, this is a gross oversimplification of the problem. Dilution and biotransformation also are expected to have a significant impact on concentration.

109) 8.5.2.4 Two Dimensional Model Domain and Fracture Network

This section of the document refers to the SCM, but does not specifically reference the simulation(s) or even the specific section in the SCM. If conclusions are to be drawn in the RI based upon these simulations, the simulations should be documented in an appendix. The simulations are not conceptual background but are being used as a characterization tool.

This section discusses the Fractran fracture network and notes that (page 8-20) "*The average spacing of horizontal and vertical fractures, based on fracture counts along four lines in each direction… was determined to be about 1.5 and 3.8 m, respectively."* The histogram for fracture spacing is not provided, but these spacings are much larger than generally recorded in the acoustic televiewer logs and the sampling of VOCs in cores. SCM 19-5 is not cross-referenced in this section specifically, but the Fractran model is discussed in this section of the SCM. On page 11 of SCM 19-5 (section 3.4, item 4) it is stated that:

*"**Simulations incorporate generally lower fracture density than expected in the field due to computational limits**. For accurate simulation of DFN contaminant transport, the grid density has to be very tight to capture processes of matrix diffusion. In general, field data indicates that the actual fracture spacing is smaller than that applied in the numerical simulations. The effect of maintaining the same q with tighter fracture spacing would provide higher surface area for diffusion of mass from fractures to the rock matrix and therefore cause greater plume front attenuation, unless fracture spacing becomes too close whereby diffusion profiles from adjacent fractures overlap"*

Consequently, the model as currently implemented not only fails to capture the fine detail of plume migration, as indicated in section 8.5.2.4, but may also not capture local diffusive exchange between fracture and matrix. An effort should be placed upon either providing bulk parameters that correctly capture the diffusive exchange rates, including correct surface area and averaged spacing, or refining the Fractran network to capture the realistic fracture spacing and connectivity.

Please see Attachment A for a discussion of the Fractran models and concerns regarding how it treats the source term.

110) 8.5.2.5. Groundwater Flow Conditions in the 2-Dimensional Model Domain

Page 8-21; 2nd paragraph

"Based on the numerical flow solution, values for bulk hydraulic conductivity can be estimated, in both the horizontal and vertical directions, using the following variation of Darcy's Law…"

It is not clear what "numerical flow solution" is referenced here. Please provide details regarding how these flow parameters were calculated. The details are not complete either in the RI or in SCM 19-5.

111) 8.5.2.5 Groundwater Flow Conditions in the 2-Dimensional Model Domain

Page 8-22; 1st paragraph

"This calculation assumes that all flow occurs in fractures and does not take into account the lack of flow in dead-end fractures or flow in the matrix, and therefore, provides a rough estimate of average flow velocities through the fracture network. This calculation is considered conservative as the accounting for the two conditions described above would result in a slower groundwater flow rate across the domain."

Since the fracture distribution is artificially forced to have the same bulk hydraulic conductivity as that determined from the FEFLOW model, adding dead-end fractures would not affect flow. Rather, it would provide "dead end" pore volumes that would behave in a similar manner to the rock matrix in transport. These dead-end fractures may be penetrated by DNAPL during infiltration due to overpressure resulting from the development of a DNAPL column. They may, therefore, serve as a long term source of DNAPL and reduce the rate of dissolution to the matrix. Consequently, it would be useful if these could be represented in the model.

112) 8.5.3 Linking EPM Flow Hydraulic Characteristics with DFN Hydraulics and Contaminant Transport

There is an inconsistency between the field data and the modeled transport behavior as represented in the DFN. DFN models are based upon FEFLOW particle tracking. The cross-sections along particle paths used for the 2-D DFN simulations demonstrate a large head gradient across faults, implying that they are optimized to a low hydraulic conductivity. Figure 8-18, for example, shows a large drop in head across the Woolsey Fault. This appears to be consistent with optimized hydraulic conductivity for the Woolsey Fault which is given to be less than 10^{-7} cm/sec (see figure 4-16 in Appendix 6A). However, the discussion in Section 6.3.4.4 of the RI states (p.6-41):

“In northeastern SSFL, both the 1997 RD-73 and 2004-05 C-1 pumping tests demonstrated that the IEL Fault, and apparently the Woolsey Canyon Fault do not act as significant barriers to groundwater flow. Figure 6-30 provides a set of groundwater level hydrographs for 13 wells along, between, south, and north of these two faults over the past two decades. These hydrographs exhibit similar patterns, most significantly in response to the C-1 pumping test.”

Furthermore, contours of measured heads do not show a significant change in hydraulic gradient (see Figure 6-27 in the RI). It is likely that the FEFLOW model is not properly representing hydraulic conductivity of the Woolsey fault, and therefore, head, as the optimized head residuals are upwards of 30 meters in the vicinity of the Woolsey Fault (Figure 4-22).

Similarly, the ELV and Delta DFN simulations show a 15-20 m drop in head across the North and Burro Flats Faults, respectively. Table 6-10 lists the western North Fault and Burro Flats faults as possible barriers to flow, but there is no evidence of barrier effects presented directly from the head data. Regarding the North Fault, on page 6-41, it is stated that “The western segment lacks mappable traces, but rather consists of a wide zone of closely spaced deformation bands. Although not explicitly monitored, this segment may serve as a partial barrier to flow given the low-permeability mineralization commonly associated with such features.” The DFN models shows a 60 m head loss across this fault.

Regarding the Burro Flats Fault, on page 6-42 it is stated that “As discussed in Section 5, as much as a mile of lateral off-set is interpreted to have occurred along the Burro Flats fault. Furthermore, low-permeability gouge as much as 1-foot thick has been observed to occur in places along the fault. However, the distribution of monitoring wells and hydraulic testing are insufficient for demonstrating the impact of this fault on groundwater levels and flow.” The DFN model shows a 15 m head loss across this fault.

As expressed previously in these comments, the DTSC is concerned that fault hydraulics are not understood in general at the SSFL. In particular, fault hydraulics are not understood along the pathways used for detailed DFN modeling, i.e. the IEL, ELV, and Delta sites. As a consequence, the plume models created along these pathways must be considered unreliable and will require refinement before conclusions can be drawn from them, even at a "stylistic" level.

113) 8.6 Chemical Fate
Page 8-41

"Anthropogenic releases of other chemicals and their subsequent transformation may also affect local geochemical conditions and enhance the potential and rate of transformation of other chemicals (e.g., acetate production from the abiotic transformation of 1,1,1-TCA (Vogel & McCarty, 1987) that can serve as an electron donor to enhance reductive dechlorination of chlorinated ethenes)."

Earlier sections describe 1,1,1-TCA abiotically transforming to 1,1-DCE, and the transformation to 1,1,1-TCA to acetate is not well supported for the site. Consider using a compound other than 1,1,1-TCA as an example of an electron donor.

114) 8.6 Chemical Fate
Page 8-41

"A summary of the redox conditions at the site is provided in Table 8-7 and is described in further detail in the complementary Site Conceptual Model document (2009) and by Pierce (2005). It is within this context that the following discussion of chemical fate is considered."

A summary of the redox conditions at the site necessary for the reduction of the chemicals of concern should be included.

115) 8.6 Chemical Fate
Page 8-41

"Chlorinated ethenes have been the primary focus of the field and laboratory studies because of their occurrence in SSFL groundwater and the potential for their complete transformation to non-hazardous by-products under the appropriate geochemical environment (Freedman & Gossett, 1989)."

Laboratory studies may indicate the potential for their complete transformation to non-hazardous by-products, but the text should acknowledge that incomplete transformations to hazardous and non-hazardous by-products are the major processes.

116) **8.6.1 1997 Field Study**
Page 8-42
"Field data supporting reductive dechlorination included low concentrations of dissolved oxygen (DO), the continual presence of partial dechlorination products such as 1,2-DCE and 1,1-DCA, and the presence of complete dechlorination products (ethene and methane) from samples collected during a February 1997 monitoring event."

In order to use methane as an indicator of reductive dechlorination, the report should support that the methane source is not orogenic.

117) 8.6.1 1997 Field Study
Page 8-42
"Study authors concluded that reductive dechlorination was a major process that was occurring at the site…"

The studies have concluded that the reduction of TCE to DCE is a major process. Reduction pathways past DCE are minor processes.

118) 8.6.4 2008 field Study
Page 8-45
The study has been completed. The text should be revised to present the final product.

119) 8.7 Summary of Transport and Fate
Page 8-55
"The transport of metals from anthropogenic sources in alluvium groundwater is strongly retarded with the smallest retardation factor being 14 (boron) leading to very short transport distances (i.e. less than 10 m)."

Consideration should be given to how the metals were released. Metals that are released with other constituents or in solutions with extreme pH values can greatly reduce the "published retardation factor". Also consideration should be given to hexavalent chromium and selenium which can have relatively low retardation factors.

Section 9

120) 9.1 Consideration of On-site Groundwater Contaminant Impacts
Page 9-1, 2nd paragraph
"It is anticipated a groundwater use prohibition will be imposed on the site to

restrict access to groundwater in perpetuity, thus controlling drinking water and other direct exposure pathways."

It should be clear that neither Boeing, NASA, nor DOE have any administrative or legal control to prevent the installation of production wells offsite and immediately outside the SSFL property boundaries. It should be acknowledged that drinking water wells could be placed near the SSFL boundary and that pumping from these wells could pull groundwater offsite from essentially anywhere at the site. A realistic assessment of the effectiveness of restricting access to groundwater in perpetuity should be carefully evaluated.

121) 9.2. Groundwater Investigation Findings Concerning Potential Off-site Impacts
Page 9-2; 3rd paragraph
"These data show plumes are nearly stationary and of limited extent."

This is not a quantitative statement and should be replaced by more descriptive terminology of plume behavior. "Nearly stationary" is another way of expressing "moving slowly" and should be described as such. For example, SCM 18-1 Figure 2 clearly shows that total equivalent TCE concentration in some portions of plumes is increasing and in other portions is decreasing. "Limited extent" has no meaning in this context; the plume logically must be limited. Perhaps the idea being relayed here is that the extent of the plume has been delineated by the monitoring network so that the extent is known. The DTSC does not necessarily agree with this statement, but is here suggesting that, for clarity, summary statements be more accurately expressed.

Section 10

Similar to Section 10.0, Summary and Conclusions, summarizes the information presented previously in the RI Report and in the related SCM sections. For brevity, similar comments previously made in this memorandum are not repeated.

122) Section 10.9.1 Answers for decision questions, Question 1: " Is the subsurface mass of chemicals present consistent with the estimated mass of TCE that may have been released and consistent with the conceptual site model (i.e. highest concentrations adjacent to the input locations)?"

"Based on these profiles the total estimated in situ mass was computed by using reasonable assumptions of the source area volume (a cylindrical volume centered on each corehole).

> Please explain where these calculations are made. It does not seem that SCM 15 (Table 7) address this question, exactly. This Table 7 does indicate that the bulk of the TCE mass has not been identified. For example, core C-5 sampled at Alfa site indicates an equivalent TCE concentration of 3 g/m^2 (SCM-15, Table 7) The monitored extent of the major concentration of the contaminant plume is about 500 m in diameter (SCM 15 Fig 3), which accounts for only 590 kg or 1/50 of the total estimated subsurface mass (32,000 kg).

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