Appendix F

Responses to DTSC Comments on Area IV Draft GW RI Report

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Responses to DTSC comments on the Area IV Draft GW RI Report

Comments	**Response**
General Comments	
1. The overall effects of the geologic structures need further evaluation. Specifically, the following items need to be addressed in the Report:	See below
a. The updated mapping of the North Fault should be reconciled with site-wide geologic maps and numerical groundwater model. The Report states "North of Area IV the North Fault dissipates into a wide zone of deformation bands which may be a partial hydraulic barrier contributing to a steep northward hydraulic gradient." The interpreted western extent of North Fault, as presented in the geologic maps, does not extend across Area IV. In the numerical model, however, it does extend to the Burro Flats Fault, to the western extent of Area IV. The assigned values in the numerical model of the Burro Flat Fault along its western extent are not clear. The Report should be revised to more clearly present the DOE's interpretation of the extent of and the hydrogeologic effects of the North Fault in Area IV. The systematic underprediction by the numerical model of heads in the vicinity of the previously mapped fault suggests that a low permeability structure exists in this vicinity.	Text has been changed to reflect the current understanding of the North Fault. See responses to the Appendix C modeling comments on how the fault and other geologic features are being handled in revised groundwater model runs.
b. The effect of the Burro Flats Fault on groundwater flow is not well characterized. In the area of WS-9A, the relatively dense number of monitoring points provide insight into the effects of the Burro Flats Fault, which has enhanced flow parallel to it and reduced flow across it. It should be noted that near WS-9A the Chatsworth Formation is present on both sides of the Burro Flats Fault. In Area IV, movement along the Burro Flats Fault has juxtaposed the Chatsworth and Santa Susana Formations. Section 3.3.13 (Fault Identification and Interpretation) states: *"There are no data on the geologic properties of the Burro Flat Fault within Area IV; however, the influence of the fault on groundwater is discussed in Section 4."* Section 4 states *"...the Santa Susana formation and Burro Flats fault are not controlling influences on groundwater movement north of the fault."*	Given the notably different geologic setting in Area IV, it is not felt that responses to pumping at WS-9A in the Chatsworth Formation can be directly correlated to Area IV. What is important to know is where groundwater contaminants exist at the FSDF and how to remediate the contamination. Impacted groundwater is harbored in bedrock fractures, most well above the groundwater table. During the pumping of RD-54A in 2002, there was no responses in RD-21 and RD-50, the closest wells to the fault. Therefore, it is highly unlikely that fault has a significant influence on groundwater present in fractures. The Burro Flats Fault is inferred to be a barrier to flow across the fault based on calibration requirements of the groundwater flow model. Preliminary sensitivity analyses with the flow model indicate that the hydraulic conductivity of the three segments of the Burro Flats Fault near the FSDF must be within a range of low conductivities to obtain an

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	acceptably accurate match to observations used in the model calibration.
It has been demonstrated at other faults at the site that there is considerable variation of the hydrogeologic effects of the faults along their lengths. It is therefore unreasonable to assume a uniform behavior of the Burro Flats Fault along its length, especially given that the geologic formations offset by the Burro Flats Fault in Area IV are different than those to the east.	DOE agrees that faults have differing hydrogeologic properties across SSFL. What is important is how knowledge of fault properties affect contaminant movement within Area IV, and more importantly, implementation of a GW remedy. None of the groundwater impact areas in Area IV are near to or straddle a fault, as is observed elsewhere at SSFL. The Burro Flats Fault is represented by a number of individual segments in the groundwater flow model, so uniform behavior of the fault is not assumed. Specifically, the Burro Flats Fault is divided into three segments in the western part of Area IV. Values of hydraulic conductivity for each fault segment are determined independently during calibration. Additional figures have been included in the Area IV Draft GW RI report illustrating the subdivisions of the Burro Flats Fault into these segments.
The particle tracks from RD-23 displayed in Figure 26 of Appendix C show a clear influence of the Burro Flats Fault, perhaps due to its orientation with respect to the Shale 3 unit. Geologic mapping and interpretation of hydraulic data that constrain the potential effects of the Burro Flats on plume behavior should be provided.	Particle paths from RD-23 are influenced by the Burro Flats Fault in the sense that the segments of the Burro Flats Fault near the FSDF have low values of hydraulic conductivity, tending to guide flow paths between the fault and Shale 3. Preliminary sensitivity analyses with the groundwater flow model show that the model calibration is sensitive to values of hydraulic conductivities for the Burro Flats Fault segments in this area. This indicates that the low values of conductivities along the fault are required to calibrate the flow model and are realistic of conditions along the Burro Flats Fault near the FSDF.
c. The SRE/RMHF lineament has been associated with the surface expression of lower unit of Shale 3. This is heavily based on an evaluation completed using the geologic model software, Leapfrog. The Report does not address the following information which appears contradictory to the interpretation that the SRE/RMHF lineament is a surface expression of Shale 3 instead of a fracture zone:	DOE added a discussion acknowledging the uncertainty associated with the geologic interpretation of the apparent SRE/RMHF lineament. DOE added information on the evidence supporting alternative interpretations, as described in the comment from DTSC. The revised report acknowledged that there is evidence for a zone of enhanced east-west fracturing and hydraulic conductivity in the area of the drainage to the north of the RMHF,

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	regardless of the geological interpretation of the lineament. Note that this was considered in the model by adding a zone of anisotropy in the upper model layers in this region. Preliminary sensitivity studies with the groundwater flow model have been performed to determine the impacts of values for hydraulic conductivity along the apparent SRE/RMHF lineament to the calibration of the groundwater flow model and to the simulated particle paths. Results of the sensitivity analyses showed only moderate sensitivity of the calibrated heads to the value of hydraulic conductivity of the SRE/RMHF lineament; however head gradients and seeps were notably impacted indicating that the feature must act as a barrier to flow to support the observed head gradients and seep flows in Area IV. Simulated particle paths from well RD-98 do not vary dramatically between the high- and low-value conductivity cases examined in the sensitivity analysis.
i. The Sodium Reactor Experiment Decommissioning Final Report (ESG-DOE-13403) stated "*The bedrock in this area consisted of multilayered sandstone. Numerous cracks and slip planes were visible. Individual cracks could be traced for 10 ft or more along the surface.*" RMHF Leach Field Decontamination Final Report (ESG-DOE-13385) stated "The site was left with a minor amount of radioactive material in three cracks in the sandstone rock (emphasis added). The cracks are more than 10 ft below the surface and have been sealed with a bituminous asphalt mastic to prevent the percolation of water through the cracks." Figure 11 of the Report show the three "cracks" orientated east-west (same as the lineament).	Report has been updated to address this observation.
ii. In the Well RD-63 Pilot Extraction Test – RMDF Area dated May 22, 1995, strong anisotropy was noted in the water level decline contour map (Figure 2) that was oriented parallel to the lineament.	DOE agrees with this for the near-surface bedrock observation. The observation of anisotropy in water level decline is discussed as evidence for a zone of enhanced east-west fracturing and hydraulic conductivity along the SRE/RMHF lineament.
iii. The Boring/well construction log for DD-143, located on the north side of the RMHF drainage, indicates that only sandstone was encountered during the drilling of the boring to a depth of 100 ft.	Well DD-143 is located approximately at the projected lower contact of Shale 3 with the Upper Burro Flats Member, as indicated in Figure 3-6. Consequently, the deeper part of DD-143 is

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	expected to penetrate the upper portion of Upper Burro Flats Member, which consists primarily of sandstone strata.
iv. Logs from piezometers PZ-150, PZ-160, and PZ-161, located within the SRE RFI site and within the lineament, indicate that sandstone was encountered during drilling. The interbedded siltstones, shale, and sandstone indicative of “shale” units at the site such as Shale 3 were not encountered.	PZ-150 is 27.5 ft deep. PZ-160 is 27 ft deep, and PZ-161 is 28 ft deep. These wells were all installed in the alluvium and fill materials disturbed during removal of the SRE buildings. The shallow borings could not have encountered competent sandstone.
v. Examination of the cross-sections generated through Leapfrog, a geological modelling program and cited in the Report, seems to show that the dip of Shale 3 may have been adjusted from the general dip of the adjacent beds to intersect the trace of the lineament.	Following consideration of the comment, figures and cross-section were revised to illustrate a general dip of 25°, the same dip used in the groundwater flow model. Adjustments of outcrop identification, thickness, longitudinal extent, and composition should be expected during the depositional system that this fine-grained deposit represent.
vi. For the lower member of Shale 3 to outcrop at the lineament trace one must assume that the member is continuous through this RMHF and the SRE drainages. It has been historically mapped as discontinuous and not present that far to the east.	Comment noted. The true thickness of the Shale 3 bed is maintained along the entire area when using the lineament as the lower Shale 3 bed boundary. Explicitly, the same bed thickness is present at the west, central (lineament), and east portions of mapped bed. Additional information and justification can be found in Specific Comment 12.
2. The evaluation of the contaminants in the soil/unsaturated bedrock and the risk to groundwater needs to be reassessed to account for the limitations of the soil and bedrock data in Area IV. Specifically, the following Area IV conditions/circumstances that present challenges and uncertainties in understanding the nature and extent of contaminant releases are:	See responses below, but with the more than 10,000 soil samples taken in Area IV and the NBZ, DOE does not feel that there are “limited soil and bedrock data”. This would also contradict the statements by DTSC that soil characterization is complete.
a. Deactivation & Decommission (D&D) activities have been conducted at several facilities in Area IV which have resulted in the removal of soil due to radiological contamination. In these cases, the soil was removed and no sampling was conducted to assess the nature of any associated chemical contamination. These areas were subsequently backfilled with imported soil and, as a result, there is no way to ascertain the nature of the removed chemically contaminated soil and the associated risk it would have posed on the underlying groundwater	DOE respectfully disagrees with the comment. There are numerous examples of soil removal due to chemical contamination during the decommissioning of facilities and these locations have been resampled. Although the focus of the earlier D&D of former rad facilities was on radionuclides, soil removal continued until the rad standard was met. The $40M soil study conducted by EPA demonstrated no rad contamination above cleanup standards associated with the D&D actions. EPA collected

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	over 3,200 soil samples focused at former facilities. EPA only identified eight locations with rad contamination related to spills. During the RFI 2,259 soil samples were collected across Area IV focused at prior facility locations. During the 2010-2012 AOC, an additional 5,854 soil samples were collected. Area IV has one of the most extensive soil characterization databases of any facility in California.
b. Similarly, several of the buildings removed from Area IV had deep foundations that extended into the bedrock. These foundations have been removed and backfilled with imported soil. As a result, data collected from the soil present at these locations is not representative of current or past risk to groundwater.	See response above, the commenter appears to be misinformed as it relates to current risk to groundwater, as stated above. Soil sampling included borings into former building fill materials.
c. Bedrock vadose-zone data are generally scarce at the RFI sites in Area IV. Bedrock vadose-zone data in the form corehole porewater analysis and discrete-depth bedrock vapor data has been invaluable and irreplaceable for the broader understanding of the nature and extent of contamination that posed past, current, and future risks to groundwater. Additional bedrock vadose zone data will be necessary for the assessment and/or development of remediation approaches for the site. The extent of the additional data needed is site-specific and dependent on the need to successfully design and implement a remedy.	Bedrock core samples have been collected at the FSDF and for the Tritium plume. Area IV does not have the serious VOC bedrock issues of Areas I/II and does not warrant parallel coring investigations. The SCM explains why VOCs are present in the bedrock vadose porewater analysis. Fractures containing impacted groundwater diffuse into bedrock pore spaces over time. Depending on several factors such as head, volume of water in the fracture, length, width, and fracture termination (i.e., dead-end), this diffusion of water from the fracture into the vadose may take a long time. As noted in the report, if water-filled fractures are intersected by an open borehole, they drain into the conduit ultimately ending up in the vadose zone (at and below the water table). Back diffusion of contaminants from the porewater to water-filled fractures is also expected and believed to be occurring now. Information pertaining to the vadose zone is being collected for the CSM.
d. Due to the thin soil overburden at the site, volatile organic compounds (VOCs) measurements using either soil gas or soil sampling are suspect due to volatilization and/or vertical migration	DOE agrees that the remaining sources of groundwater contamination are not vadose-zone soils, but contaminants in the

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into the underlying bedrock. The lack of detectable concentrations of VOCs in the soil and soil vapor is not a sole, decisive factor in determining the risk to groundwater.	bedrock matrix. Recent MIP and passive soil-gas studies confirm this.
Due to uncertainties that result from the conditions in Area IV, each RFI site should be reevaluated accounting for the challenges and uncertainties noted above. Any indicators that significant contaminants may be present in the vadose zone (i.e. presence of anthropogenic chemicals/radionuclides in the soil or groundwater OR the presence of naturally-occurring chemicals/radionuclides above established background concentrations) should trigger further evaluation in the Corrective Measure Study.	The descriptions of the RFI sites with groundwater impact have been revised to address the comment.
3. Discussion of the Chatsworth Formation is often unsupported with specific citations to data. With regard to groundwater flow in the Chatsworth, the Report states, for instance, "*Shorter duration pumping tests were performed using FSDF wells RD-23, RS-54, and RD-54A in 1994 (GRC 1995c). The affects (sic) to local hydrogeology were the same as observed during the pumping of wells RD-54B and RD-21; little or no response was observed in monitoring wells outside of the FSDF. These data demonstrate that bedrock groundwater elevation and flow are controlled by fine-grained units and fractures. Though fractures are present, the formation is relatively tight, and the rate of groundwater flow both laterally and vertically is slow.*" This statement on the Chatsworth Formation and in other portions of the Report present the groundwater in the western portion of SSFL as "tighter". There is not, however, a methodical presentation of the data to support this view. Specifically, how do estimates of hydraulic conductivity (K) at RFI sites in Area IV compare numerically to the remainder of the site? What are the relative characteristics of the Upper and Lower Burro Flats formations versus other members of the Chatsworth formation? In fact, there are data that seem to dispute the view that the groundwater flow is slower (or tighter) in Area IV due to different hydrogeologic conditions. For example, in the Boeing Technical Memorandum "Area IV Hydrogeology, Santa Susana Field Laboratory, Ventura County", dated March 2017, Table 3 lists FLUTe slug tests in RD-21 with K ranging from 1.4e-6 to 6.9e-5 centimeters per second (cm/s). It has been accepted that the K values in Area	Area IV geology is notably different from that in other areas, so direct correlation is not possible. DOE has updated the report providing data illustrating the differences.

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IV are lower than the rest of the site but these values are within the range of single well interval tests across the site. Existing hydraulic tests should be carefully reviewed and summarized quantitatively and if the K is lower in Area IV then the case should be clearly made and supported with data.	
4. The Report states that near-surface groundwater “accumulates” above the interbedded fine-grained SPA, ELV and Lot Beds but the near-surface groundwater is shown as continuous across these beds and the sandstone Upper and Lower Burro Flats members (Figures 4-1 and 4-2). The conceptual site model (CSM) on the occurrence of near-surface groundwater needs to be reconciled and clarified in the Report.	The text was revised to address the description of the presence of groundwater above and below competent bedrock. Prior to installation of PZ-162, PZ-163, and DD-144, insufficient water-level data existed to define water-level contours between fine-grained units. As new data from this area are gathered, contours will be adjusted.
5. The particle tracking/transport calculations results deserve a closer look to determine how particle movement relates to peak concentration arrival time. It is important to note that in 2011 DTSC directed the RPs to develop a Contaminant Transport Model work plan to refine the approach and model presented in the 2009 Sitewide GW RI. At this time, DOE should use a particle track distance of 1,000 meters when discussing and presenting particle movement. Additional refinement of a contaminant transport model/approach will be addressed during implementation of the groundwater cleanup remedy.	DOE prepared a contaminant transport model to go along with the NSMC uncertainty analysis of particle tracks.
6. The Report presents the view that the deeper contamination found in the Upper Burro Flats Formation is a result of open wells that provide a conduit for vertical migration of contaminants. Identify the wells that are potential conduits for contamination across confining units and recommended for corrective action. Alternative monitoring options should be proposed near these locations.	This is part of the well-network evaluation will be presented in the CMS.
7. There is a lack of agreement between core-measured VOC and straddle packer measured VOC, where it exists. Acknowledge the discrepancy and present a discussion of the viability and the limitations of the straddle packer results. Specifically, Table 4-1 notes that extraction tests using straddle packers in C-08 could not collect water from depths 0-65 ft. due to conductor casing and did not collect seeping water in the vadose between 65’-101’ and 128’-148’ intervals. Consequently, no VOC was detected in the zones. The core collected from C-08, however, had	DOE disagrees that the data reflect a lack of “agreement” between two differently collected data sets. What the data reflect is the tightness of the formation and the difficulty of extracting water from the formation. The presence of TCE in the bedrock matrix has little to do with the ability to obtain groundwater from bedrock fractures. In fact, this reflects the SCM of the area. Boreholes that intersect a water-filled fracture, result in the water draining into and along

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pore water TCE concentrations between about 104 and 105 ug/L in all these intervals.	the conduit until finally entering the vadose zone at the water table in the open borehole. TCE in core samples most likely reflects areas where a fracture containing impacted water resided until the fracture was drained by the borehole conduit or where contaminants diffused into the bedrock and became bedrock porewater. Downward migration of TCE in porewater is expected to continue through the vadose zone. However, this process is expected to be quite slow. Situations where Chatsworth Formation groundwater contamination is the result of artificial conduits (open boreholes) connecting shallow impacted fractures to the water table will be provided in a table and described in more detail in the text. Text was added to acknowledging that measured VOC concentrations in core differ from straddle packer measured VOC concentrations in the same intervals in borehole C-8. These alternative sampling methods measure different aspects of the contamination and are considered to be mutually complimentary. Straddle packer measurements of VOC concentrations can only be made for intervals producing sufficient groundwater from fractures. Core-measured VOC concentrations represent contaminants in the rock matrix that have been introduced by molecular diffusion and may be a function of water-level history and contaminant source variations. The apparent discrepancies in these measurements will be discussed and explained in the text.
8. There are only a few cluster monitoring wells in Area IV that delineate the vertical extent of contamination. Additional, deeper wells are necessary to further delineate and monitor the deeper groundwater at individual source areas and/or the performance of any groundwater remedy(ies).	Data collected from the existing cluster wells demonstrate that downward migration of contaminants is not occurring, and that deep boreholes only act as conduits for facilitating contaminant movement.
Specific Comments	**Response**

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1. 1.1 Purpose and Scope of DOE Area IV Groundwater RFI Report Page 1-1; 3rd paragraph "*Figure 1-1 shows specific locations of the divided responsibilities and Table 1-1 provides a listing of the responsibilities per Attachment 4 of the 2007 CO along with a summary of groundwater conditions at each groundwater investigation area (GIA)"* Table 1-1 lists the "Associated Wells" with each Area IV Location. In general, the association of these wells with a specific RFI site is based on its physical location and the interpretations of groundwater flow and source areas. These interpretations may change over time to include a different RFI site or more than one RFI site. It should be clear that the data quality objectives associated with a well are independent of ownership. The GSU understands why the associated wells are listed on the table, however text clarifying that the well's link to a specific RFI site is subject to change regardless of the associated responsibility (i.e. DOE or Boeing) needs to be added.	The text was revised to note that wells could serve to monitor more than the RFI site or GIA, but the table associates the well with its primary site.
2. 1.2 Area IV Historical Activities Page 1-8; 2nd paragraph *"Area IV groundwater remediation included 10-years of groundwater pumping using Radioactive Materials Handling Facility (RMHF) well RD-63 between 1994 and 2005 (approximately 4.3 million gallons of water were extracted). TCE concentrations in RD-63 were reduced from a high of 20 micrograms per liter (µg/L) in 1998 to 6 µg/L in 2005, with a small rebound to 11 µg/L following cessation of pumping."* It is not clear why groundwater extraction was conducted at RD-63 given the low concentrations of TCE relative to the rest of the site. Historical groundwater elevations have indicated that groundwater has been present at or near the ground surface. For transparency and completeness, the Report should state what the objectives were for groundwater extraction at RD-63.	The objective for pumping RD-63 was not clear in the records made available to DOE. One could presume that the pumping occurred as a response to the 50-µg/L contamination observed in RD-30 in 1989 with the goal of keeping groundwater contamination within the boundaries of SSFL.
3. 1.2 Area IV Historical Activities Page 1-8; 3rd paragraph *"Groundwater extraction tests were performed at the FSDF using wells RS-54, RD-54A, RD-54B, and RD-23. The pumping of RD-54A, 1996 to 1999 reduced TCE from nearly 600 µg/L to about 200 µg/L, with no observed rebound. TCE in RD-54A was 3.1 µg/L in 2016. The well at the FSDF with the highest TCE concentration is shallow well RS-54A*	The oversimplification was revised. Recent studies showed the highest TCE levels to be within fractures found in competent bedrock. Data collected from 2018 corehole investigation will be used to inform the CMS.

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which was 1,600 µg/L in 2014; the well was dry in 2015 and 2016. The RD-54A and RS-54 data indicate that the TCE source is harbored in the weathered bedrock." Please specify what data indicate that TCE is in weathered bedrock.	
4. 1.3 Overview of Area IV Groundwater Conditions Page 1-9; 3rd paragraph "*Groundwater in Chatsworth Formation primarily occurs in bedrock fractures. The amount of water produced at any one well is dependent on the number and size of fractures the well encounters. Across Area IV, well productivity varies greatly because the fracture network varies by location."* See General Comment 3.	See response to General Comment 3. This reinforces the SCM – water levels present in these open boreholes may be more reflective of the volume of water drained from the fractures into the corehole and tightness of the bedrock vs. an area/regional water table. Additional coreholes at FSDF will be used to evaluate this concept. Results will be used to inform the CMS.
5. 1.3 Overview of Area IV Groundwater Conditions Page 1-9; 6th paragraph *"Accumulated groundwater is found perched upon the bedrock where it then can enter the Chatsworth Formation groundwater via bedrock fractures."* See General Comment 4. Specify if this "accumulated groundwater" is related to, the same as, or unrelated to Near-Surface groundwater.	"Accumulated Groundwater" perched on bedrock is the same thing as "Near-surface groundwater."
6. 1.3 Overview of Area IV Groundwater Conditions Page 1-10; 1st paragraph *"Groundwater migration within fractures in the Chatsworth Formation groundwater moves either downward or laterally depending on trend of the fracture at the source location. Overall groundwater flow moves laterally from Area IV toward the sides of the Simi Hills. As groundwater flow moves closer to the hillside surface, the water can be taken up by phreatophytic plants (plants rooted into bedrock fractures) and/or released to the surface as seeps and springs."* This statement oversimplifies the complex groundwater flow system at the site which consists of dual-porosity, three-dimensional flow pathways that are influenced by bedding, fractures, faulting, and spatial variation of hydraulic conductivity, recharge, evaporation, and transpiration. It is clear from the data that not all groundwater that originates at the site terminates at phreatophytes "and/or" seeps/springs as may be interpreted by this statement. This statement	The text was revised accordingly.

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should be revised to acknowledge that groundwater originating at the site travels along varied flow paths, from short flow paths that discharge along seeps/springs to long flow paths that discharge, at depth, into the adjacent valleys.	
7. 2.1 Pre-2009 Groundwater Investigative Work Page 2-2; 5th paragraph *"This annual environmental report also states that ion exchange resin was used at the FSDF to remove perchlorate from extracted groundwater."* This statement refers to the 2002 environmental report which also stated that groundwater extraction at the FSDF started in 1995. The 1999 Annual Groundwater Report indicated the groundwater was only treated "for removal of VOCs by activated carbon adsorption and released to the #002 NPDES drainage." The Report should address when ion exchange resin was first used, if it was used in conjunction with carbon, and when perchlorate was first identified.	This level of information regarding past operations has not been made available to DOE. However, DOE believes that the understanding of operations at that time are not relevant to the understanding of groundwater conditions today.
8. 2.3 Area IV Monitoring Well Network Page 2-13; 2nd paragraph *"In some wells, the conductor casing may not have been advanced into competent, unweathered bedrock and, therefore, isolation of the alluvium/weathered bedrock zone at these locations is questionable."* These wells should be specifically identified and a work plan submitted for decommissioning or modification.	This issue is being addressed as part of the evaluation of the well network adequacy in the CMS. Additionally, isolation of unweathered bedrock using conductor casing was assumed to be sufficient to minimize impacts of near-surface contamination to deeper zones. Based on lessons learned from work at the FSDF, near-surface fractures can also impact the deeper zone and therefore do not isolate the systems. Thus, the statement should include "near-surface bedrock."
9. 2.4 Treatability Studies Please revise to include a discussion of the enhanced biological degradation treatability study	A summary of the results of this study was added to the revised report.
10. 2.5 FSDF Groundwater Interim Measure Page 2-15; 1st paragraph *"Because the FSDF no longer met the requirements for a GWIM, DOE requested and DTSC agreed to put the GWIM operation on hold until rainfall increases, water levels rise, and contaminant concentrations increase."* This statement is not correct. Although monitoring well RS-54 was dry	The statement as written in the Draft Report is correct. The GWIM was put on hold until RS-54 exhibited water. None of the other wells in the vicinity with TCE exhibited elevated TCE concentrations when the GW RI Report was written. RS-54 exhibited water after the 2016-2017 rainy season and DOE implemented the GWIM accordingly.

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for a prolonged period due to the drought conditions in Southern California (water was recently present after the regular rain season in 2016/2017), GWIM requirements remain because RS-54 had reported TCE concentrations over 1,000 µg/L. Dry conditions in the well did not indicate or prove that source zone contamination had attenuated. Groundwater extraction must be initiated when water is present in the well. The text should note the date range of the drought period.	
11. 3.1 Geology Overview Page 3-2; 1st paragraph *"It is important to note that Area IV differs geologically in three ways from other areas of the SSFL. First, the degree of bedrock fracturing in Area IV is less extensive than the other areas of the Site (Wagner and Perkins 2009; COLOG 2016). The bedrock in Area IV has been measured to have about 36% lower matrix hydraulic conductivity compared to the site-wide sample set (MWH 2006a). In addition, Area IV hydrogeology appears to be less influenced by faults and there is not a fault running through the center of Area IV."* See General Comment 3. The GSU does not disagree with the concept that Area IV differs from the remainder of the site, however, as stated in the general comment, the argument is mostly qualitative. It should be noted that MWH, 2006a," *Draft Report of Results Former Sodium Disposal Facility Groundwater Characterization, Santa Susana Field Laboratory, Ventura County, California*. *February*." was not received or reviewed by the GSU but the title implies that the focus was on the FSDF which is not representative of the hydrogeology of Area IV. The GSU requests a copy of above-referenced document and reiterates the need for a quantitative evaluation and presentation of the hydrogeologic conditions in Area IV relative to the remaining portions of the site.	There is a preponderance of evidence presented in the GW RI Report that documents the differences in geology between the subareas. For example, regarding well RD-54A at the FSDF, MWH (2006b) concluded: "The geometric mean of fracture hydraulic conductivity was 5.7 x 10^{-7} cm/s, about 150 times lower than the geometric mean value obtain from the C-1 pumping test in the northeast portion of the SSFL (8.9x10^{-5} cm/s)."
12. 3.2.1 Chatsworth Formation Page 3-3; 2nd paragraph *"To achieve the greatest correspondence between the upper and lower Shale 3 contact, the strike and dip was modified to N63°E and 25° to the northwest. This adjustment is based on a good general correlation of the projected upper and lower Shale 3 contact and the mapped Shale 3 fine-grained unit (Figure 3-6). Although there are areas on the geologic base map that do not show the Shale 3 as being present, lack of this unit may be explained by the steep and difficult*	Following additional review, the strike and dip for all presentation material was reverted to the original strike and dip. The groundwater flow model uses this strike and dip. Text has been revised to support the plausibility of the lineament representing the lower Shale 3 boundary and justification cited in the text and Table 3-1.

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terrain of the area, accessibility limitation, minor lithologic differences in the shale interval interbedded medium-grained sandstone and fine-grained units comprised of thin-bedded fine- and medium-grained sandstone, siltstones, and shale (Figure 3-4)]. Additionally, this area is located hydraulically downgradient and physically outside of the Area IV and NBZ, and thus was not extensively investigated. *Lines of evidence that support the adjusted strike and dip for Area IV included boring logs, groundwater conditions, and erosion features. Boring logs recorded during the installation of bedrock monitoring wells were evaluated for evidence of fractures, fine-grained units, rig chatter, and water production while drilling. These observations generally support the presence of fine-grained units at depth when compared to the model's projected geologic unit at depth.* *Fine-grained units control groundwater elevations throughout much of Area IV. When evaluating water elevations and geologic members/units, there is strong correlation between the model's projected geologic unit at depth and groundwater elevations.* *Erosion features such as slope changes, locations of drainages, and presence of capstones show a good correlation between the model's projected geologic unit and surface topography."* The statement describes the basis for moving the lower contact of Shale 3 through the lineament identified in the RMHF drainage. The support is non-specific and needs to be specifically cited such as: the depths and statement in the boring logs that indicate the presence fine-grained members and what water elevations, from which wells, supports the presence of a fine-grained member. It is not sufficient to speculate that due to difficult terrain that previous geologic mapping should be superseded by modeling results. The GSU disagrees with the Report's assessment and statement. The Report does not provide sufficient evidence regarding the lower Shale 3 contact to support the re-interpretation presented in the Report. DTSC's position is presented in General Comment 1.	
13. Table 3-1 The Table states that for DD-143 that from 0 to 22 feet below ground surface (bgs) the projected geologic unit is Shale 3. The boring log, however, indicates silty sand to 3 feet bgs and sandstone from 3 feet	Table 3-1 is provided as a general summary. Detailed information from any boring can be found in Appendix A. Examination of the log indicates a sandstone - very fine-grained from 3 to 12 feet, a

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bgs to the total depth of the boring (100 feet bgs). Please reconcile the discrepancy between the table and the boring log.	color change at 18.5 feet to gray, and shale clast noted at 20 feet bgs. Additionally, very fine-grained sandstone with near vertical fractures was observed at 23 feet followed by a transition to fine-grained at 30 feet until at 36 feet the sandstone became massive. In combination, these data suggest that the Shale 3 bed was encountered
14. 3.2 Geologic Formations and Structures In Figures 3-8, 3-10, 3-11, 3-12, and 3-13 the cross-section location labels (inset) do not correspond with the labels used in the cross-section. Also, text should specify if these cross-sections incorporate the updated mapping of Shale 3.	Because cross-sections are projected perpendicular to strike, the tops of wells and ground surface projected along such a cross-sectional line do not always match. Use of fence cross-sections will eliminate this issue. However, understanding may be lost when using cross-sections not perpendicular to strike. What is important is the screened (or open borehole) relationship to the dipping bed in Area IV.
15. 3.2.3 Structures Page 3-5; 11th paragraph *"It is reasonable to assume partial hydraulic barrier is fairly continuous along this well-developed fault along its eastern extent south of Area IV."* The GSU disagrees with this statement. See General Comment 1.	Additional discussion is presented in the revised RI Report. A reference will be provided that supports this reasonable assumption. As noted in the response to General Comment 1, the Burro Flats Fault is inferred to be a barrier to flow across the fault based on calibration requirements of the site-scale groundwater flow model. This conclusion is consistent with findings documented in the *Faults Report* (MWH 2016b) as cited in the Area IV Draft GW RI Report.
16. 3.2.3 Structures Page 3-6; 4th paragraph *"These low-permeability features reduce bulk permeability and may contribute to anisotropy where similarly oriented (Kolyukhin et al. 2009.)"* The GSU recommends clarification on this statement, specifically regarding the nature of the anisotropy	Anisotropy will be addressed in the CMS.
17. Page 3-6; last paragraph *"Joints in the sandstone beds were observed to terminate in relatively thin shale beds resulting in decreased connectivity of joint sets across lithologic contacts. Where multiple joint sets are present, there may be lateral connectivity but limited vertical connectivity due to the presence of shale beds. Wagner and Perkins (2009) measured joint density (the number of joints per 100 feet in a direction perpendicular to the trend*	Comment noted.

Comments	Response
of the joint set) from Google Earth™ imagery. Fracture density is lower in Area IV than other areas of the SSFL." The role of fractures and joints is discussed in general terms in the Report. Specifically, the reduced frequency of joints/fractures observed in Area IV is cited as the cause for an overall lower bulk hydraulic conductivity. Also, the truncation of fractures/joints at contacts between the sandstone and fine-grained members of the Chatsworth Formation is cited as reducing the degree of vertical flow. The following considerations are missing in the fracture and joints discussion and must be incorporated into the CSM discussion for the fate and transport of contaminants.	
a. It is widely observed that joint spacing (perpendicular to bedding) is proportional to bedding thickness, which accounts for the discontinuity of the joints/fractures between beds seen at the site. As a result, the relatively thinner interbedded shale beds would have a predicted higher frequently of joints/fractures even though these may not be as prominent and identifiable in outcrop in the sandstones.	Agree.
b. Analysis of the fractures orientations from core holes across the site indicate that bedding plane fractures are dominant. Bedding plane fractures may combine with vertical fractures to create a well-connected fracture/joint network that allows for both lateral and vertical flow and contaminant migration.	"Well-connected" does not suggest high hydraulic conductivity. Fractures/joints have been the subject of investigation and are well known and discussed in the report for Area IV. Refer to comment c below.
c. According to Pankow and Cherry (Dense Chlorinated Solvents and Other DNAPLs in Groundwater, 1996), "In low-permeability deposit that are not fractured, or have fractures of very small apertures, matrix diffusion plays a dominant role in determining the migration, even over short distances." This is further enhanced by the higher mass storage and sorption capacity of finer grained sediments. Consequently, fracture density does not necessarily dictate the potential for movement or migration.	Text was reviewed and modified where appropriate.
18. 4.3 Groundwater Evaluation by Hydrogeologic Area Page 4-4; 4th paragraph *"As was discussed in Section 3.0, Area IV was divided into four hydrogeologic study areas based on observed differences in geology and hydrogeologic properties. The first study area represents the Santa Susana Formation in southern Area IV (South Hydrogeologic*	Clarification is provided in revised report.

Comments	Response
Area). The second study area is the western and northern portions of Area IV characterized by tighter bedrock with few fractures. The third study area is central Area IV, with the observed groundwater mound/highest groundwater surface elevations. The fourth study area is eastern Area IV, which is an extension of the Central Hydrogeologic Area, but with greater bedrock outcrops. Descriptions of the hydrogeology and the data used to characterize these four areas are provided in the following subsections." Do these areas coincide with the Figure 3-9 and the descriptions in Section 3.0 (i.e. Northwest, South, Central, and East)? Please revise this paragraph for clarity and reference it to Figure 3-9, if appropriate.	
19. 4.3.1.2 Santa Susana Formation Groundwater Page 4-4; 6th paragraph *"As is discussed in Section 5.3 regarding the hydrogeology of the FSDF, the Santa Susana formation and Burro Flats fault are not controlling influences on groundwater movement north of the fault."* The GSU disagrees with this statement. The nature of the Burro Flats faults and the contact between the Santa Susana formation may influence groundwater flow north of it. See General Comment 1.	The Santa Susana Formation and the Burro Flats Fault play roles in the overall pattern of groundwater flow at SSFL, particularly by functioning as a barrier to cross-fault flow in the case of the Burro Flats Fault. However, there is no indication that the Santa Susana Formation or the Burro Flats Fault directly participate in contaminant migration from any of the source locations in Area IV. In particular, the highest TCE concentrations at the FSDF occur in shallow groundwater that is downgradient and isolated from the Santa Susana Formation or the Burro Flats Fault. Overall, while the site-wide flow directions are impacted by the Burro Flats Fault acting as a barrier, there is no indication that contamination is entering and traveling along the Burro Flats Fault or it acting as a conduit to flow.
20. 4.3.2.2 Chatsworth Formation Groundwater Page 4-5; 6th paragraph *"Chatsworth Formation groundwater generally flows to the northwest and southeast, and discharges to surface water via seeps or springs located in the lower elevations on the western and northern sides of the Northwest hydrogeologic area."* This statement implies all groundwater discharges from the seeps or springs, however, the Report states earlier "Groundwater discharges to canyon and hillslope springs/seeps are estimated to account for about one-half of all site groundwater under non-pumping conditions (MWH 2009a)."	Text modified as informed by the groundwater flow model. Text modifications indicate that approximately half of the groundwater discharges as seeps and springs while the remaining flux continues to travel as groundwater in a northwest and southeast depending on the location of the observation.

Comments	Response
Clarify the first statement to more accurately reflect the groundwater flow at the site.	
21. 4.3.2.2 Chatsworth Formation Groundwater Page 4-5; last paragraph *"Though exact flow pathways are difficult to predict as the contours near the Building 56 Landfill indicate a westerly flow direction before turning to the northwest."* It should be noted that this westerly flow is in the vicinity of the FSDF structures. The presence and nature of these structures has not been conclusively determined and may have a local effect on groundwater flow as evidenced by the shift of groundwater flow in this area. The uncertainty associated with the FSDF structures should be acknowledged.	Comment noted. Additional model sensitivity analysis (flow path) for these structures may be required. Uncertainty discussions provided in the groundwater modeling appendix.
22. 4.3.2.2 Chatsworth Formation Groundwater Page 4-6; 4th paragraph *RD-54B is open to only the Lower Burro Flats member. RD-23, RD-54A, and RD-64, open to Upper and Lower Burro Flats member and are in communication with each other as shown in pumping tests performed at RD-54B. Because of this communication, RD-54B and RD-23, RD-54A, and RD- 64 water levels have equilibrated. RD-54B should not be used to represent water levels in the Lower Burro Flats member. RD-54C has water levels that are similar to water levels measured in RD-54A, RD-54B, RD-64, and RD-23 (Figure 4-4). A plausible explanation is that RD-54C is in communication with these wells and the pumping test performed at RD-54B did not have a long enough duration to see the pumping effects in RD-54C.* Add text and clarify why RD-54B should not be used to represent water levels.	RD-54B should not be used for water levels because the pump test showed that it was connected to RD-64 (clearly contaminated from water present in upper fractures intersected by the open borehole) and RD-23 because of the length of the open borehole. RD-23 and RD-64 are open boreholes of 410 and 379 feet, respectively. RD-54B can be used to represent water levels above the ELV, but should not be used to represent water levels below the ELV. For a true water level represented below the ELV, a monitoring well isolated from open boreholes with open intervals both above and below ELV would be required.
23. 4.3.2.2 Chatsworth Formation Groundwater Page 4-6; 5th paragraph *"Downward gradients are expected within the Burro Flats plateau and along northwest-sloping escarpment that forms the border of the Burro Flats plateau."* Identify the location of the "plateau" and "escarpment" using a figure. Also, further discuss and explain why downward gradients would be expected at this location.	Information added to figure.

Comments	Response
24. 4.3.2.2 Chatsworth Formation Groundwater Page 4-8; 3rd paragraph *"Several aquifer tests were performed in the Northwest hydrogeologic area from 1994 to 2006 that provide valuable data regarding aquifer properties. The first testing was performed using well RD-63 in the drainage below the RMHF. The second testing included pumping of wells RS-54, RD-23, RD-54A, and RD-54B at the FSDF, and well RD-21 located near ESADA."* Please provide references for aquifer tests.	Reference provided.
25. 4.3.2.2 Chatsworth Formation Groundwater Page 4-8; 8th paragraph *"During and following pumping there were no responses in water levels in surrounding monitoring wells indicating no conductivity of groundwater at RD-21 with wells at the FSDF."* No response does not mean there is not connectivity. The argument here and in later statements seems to indicate that DOE believes there is some hydraulic disconnection between the groundwater at ESADA and at the FSDF. It is difficult to determine the specific cause as the Report states that the "groundwater elevation and flow are controlled by fine-grained units and fractures" without citing the specific fine-grained unit(s) and the unique nature of the fractures that is creating the hydraulic disconnection. Further discussion is needed.	Fine-grained units are shown on cross-section. As stated in the report, RD-21 has a separate contaminant signature (i.e., carbon tetrachloride) different from that detected in groundwater associated with FSDF structures and operations. Water levels indicate that RD-21 is upgradient of the FSDF. These lines of evidence suggest that RD-21 is hydraulically disconnected from the FSDF.
26. 4.3.3.2 Chatsworth Formation Groundwater Page 4-10; 1st paragraph *"After eight weeks of pumping the water level declined 12 inches. The report further notes that after eight weeks of pumping, water levels in RD-07, 400 feet to the west, had dropped about 7.8 feet, and 1.3 feet in RD-20 located 550 feet to the south."* From this analysis and some other well responses DOE concludes *"The responses in water level elevations in adjacent monitoring wells from the various pumping activities illustrated that the northern portion of the Central hydrogeologic area is hydraulically interconnected in a fairly uniform way in various horizontal directions."* This is a vague and qualitative conclusion where hydraulic data exist to make an estimate of permeability and anisotropy to support more	Table 4.1 showing hydraulic conductivities across SSFL was added.

Comments	Response
specific statements regarding the hydrogeology of the Central hydrogeologic area. Hydraulic conductivity estimates from well hydraulic tests should be provided so that they can be compared with results obtained from similar tests across the site.	
27. Figure 4-4 – Cross Section Through Western Area IV. Section line labels disagree with the section line location map and should be reconciled. The well RD-34A is incorrectly represented and should be corrected to reflect a total depth of 60 feet.	Cross-section revised.
28. Figure 4-5 – Cross Section of RMHF. Section line labels disagree with the section line location map and should be reconciled. The well RS-23 should be labeled.	Cross-section revised.
29. 5.1.1 Volatile Organic Compound Page 5-2. 5th paragraph The discussion of 1,4-Dioxane detections associated with installation of FLUTe™ liners needs to include a discussion of the potential contamination of FLUTe™ liners from use of "Dawn Dish Soap" during liner installation.	There is no information available on decon products used during that era. However, the text has been modified to acknowledge that 1,4-dioxane may be present in the wells due to incomplete decontamination or decontamination procedures (i.e., use of soaps that contain 1,4-dioxane).
30. 5.1.2 Metals Pages 5-3 to 5-4 This section provides the discussion of how metals were evaluated to determine if they are "contaminants of concern". The GSU refers back to General Comment #2 but has the following concerns:	See responses below:
a. Table 5.1-2 presents the frequency of metal detection in groundwater and frequency of groundwater screening level exceedances. Clarify and explain how this evaluation is used to determine if an operational area/structure resulted in a release of contamination to the soil which subsequently contaminated the groundwater or presents a threat to groundwater.	The evaluation of frequency is used as a first check on what has been observed in groundwater over time. It has nothing to do with a comparison to operations and soil data in establishing chemicals of concern.
b. The Report further states *"Metals differ from VOCs in that most metals naturally occur in groundwater. This was considered for determination of COCs because exceedence [sic] of a metals groundwater screening value does not specifically make a metal a COC. Natural background variability can attribute to screening level exceedence [sic location of well to a source area]. Professional judgment, including and presence of other groundwater contaminants in a well was used for identifying metals COCs."*	DOE does not agree with this comment. A random, non-replicated exceedance of a screening level does not make that exceedance a COC. Statistics cannot account for all field and analytical issues that can affect sample results. Unreplicated detection of a metal in soil does not make it a threat to groundwater.

Comments	Response
The GSU disagrees with this statement. The screening values were determined statistically and account for natural variability. An exceedance of a metal's groundwater screening value or a soil background value should make the metal a COC.	
c. The Report states, "*The comparison of the frequency of sample results above the soil background concentration for more than 5,800 samples identified antimony, cadmium, lead, mercury, selenium, silver, and zinc as soil COCs because concentrations exceeded background concentrations in more than 1 percent of total samples. Aluminum, beryllium, boron, magnesium, and vanadium exceeded soil background in less than 0.1 percent of soil samples and are not COCs for groundwater.* *Other metals were infrequently observed above background in soil include arsenic (0.14%sample results above soil background), barium (0.2%), chromium (0.2%), cobalt (0.14%), copper (0.37%), manganese (0.19%), molybdenum (0.78%), nickel (0.12%), strontium (0.87%), and thallium (0.2%) will be evaluated on a case-by-case basis as being a groundwater COC. That is, metals concentration in groundwater must coincide with an adjacent soil sample location that exhibited a metals concentration greater than background concentrations.*" Again, clarify and explain why the detection frequency is cited here. All exceedances of any metal must be evaluated on a case by case basis. Aluminum, beryllium, boron, magnesium, and vanadium cannot be eliminated as a COC based on a low frequency of detection in the soil above background. Further, metal concentrations in groundwater may not coincide with adjacent soil samples, see general comment 2.	Frequency of detection is used as a first-order check of what may be of concern for a COC. Use of frequency of detection does not preclude considering hotspots where COCs may be concentrated. However, DOE does not consider random exceedances with no evidence of source as the guideline to define a chemical as a COC for any well. Due to analytical and field error, DOE also relies on replicated results to draw COC conclusions. DOE is puzzled by DTSC's statement that "metal concentrations in groundwater may not coincide with adjacent soil samples." If the metals observed in groundwater are not associated with a source, to what are they associated with.
31. 5.1.4 Radionuclides Page 5-4; 7th paragraph Cesium is incorrectly abbreviated "Ce" and should be revised to "Cs".	The typographical error was corrected.
32. 5.1.6 Other Groundwater Chemicals Page 5-6; 3rd paragraph *"Fluoride has been detected in groundwater samples from Area IV wells only occasionally above its groundwater screening level. Fluoride was also part of the analytical suite for the soil investigation (CDM*	DOE disagrees. The presence of fluoride in wells outside of Area IV has nothing to do with DOE operations in Area IV.

Comments	Response
Smith 2017). Because detections of fluoride in soil were all below background, fluoride is not considered a groundwater COC for Area IV." Due to the elevated fluoride concentrations reported in the onsite and offsite wells, the GSU recommends that fluoride been retained as a COC.	
33. 5.1.7 Use and Interpretation of Historic Data Page 5-6; 4th paragraph *"Specifically, the purge and pumping procedures used for pre-2010 samples are not well understood."* Clarify this statement. Purge and pumping procedures prior to 2010 were conducted under DTSC-approved water quality sampling and analysis plans (WQSAPs).	The statement is a qualifier. Historical data from many investigations and monitoring programs exists in the database. Comparability of results is dependent on use of identical sampling procedures. There was a standardization of sampling methodology with the WQSAP, which is why DOE puts greater emphasis on the more recent data.
34. 5.3.2 Soils, Geology, and Hydrogeology Page 5-13; 5th paragraph *"Two other structures have been historically mapped east of the FSDF site and called the FSDF Structures. Investigations of the Western FSDF Structure Lineament and the Eastern FSDF Lineament Structure by MWH indicate that these structures are not faults (MWH 2013) (Section 3.0 Figure 3-3)."* The GSU believe the nature of the FSDF structures is still unclear as is their effect, if any, on groundwater flow. This uncertainty should be acknowledged in the Report.	Text was modified and uncertainty noted.
35. 5.3.3.5 Vertical Extent of Contamination Page 5-29; 11th paragraph *"The results from deep bedrock wells indicate the vertical extent of TCE contamination may extend 200 feet or more into bedrock; however, the vertical extent is more likely limited to groundwater within the Upper Burro Flats and ELV members."* The Report frequently refers to the potential of cross-contamination due to wells. In some cases, it is not clear how this is supported. RD-21, for example, is completed across the ELV but the water table is in or below the ELV. How did cross contamination occur? Is it assumed that the water table was higher in the past? In general, there is good	As discussed, there is plausible justification that open boreholes spanning the shallow impacted groundwater to the deeper groundwater are contributing to contamination detected in the deeper groundwater. This uncertainty will be investigated during the CSM.

Comments	Response
evidence that the Lower Burro Flats is contaminated (e.g. RD-21, RD-23, RD-54A, RD-64, RD-65); however, GSU does not concur that this is all due to cross-contamination.	
36. Figure 5.3-2 – Cross Section of FSDF. Section line labels disagree with section line location map and should be reconciled. The section should include new well DD-139.	DD-139 is shown on Figure 4.4. Figure 5.3-2 is an enlargement of the FSDF area. By including DD-139 on the cross section is outside of the FSDF window of interest.
37. 5.5.3.5 Vertical Extent of Contamination Page 5-39; 3rd Paragraph *"The deepest fracture sampled in RD-07 at 280 feet bgs showed TCE at 6 µg/L. This sample was collected from below the ELV Member and may be a result of vertical migration down the open well borehole.* Later in Section 5.5.4 (Fate and Transport) the Report states "*The contaminant profile for TCE in RD-07 is different from other monitoring wells in Area IV. The higher concentrations are not within the upper bedrock but deeper in the well. This indicates that the TCE present in RD-07 may have moved laterally in fractures from an adjacent source location and not vertically downward from the landfill site.* *The association of higher concentrations of TCE and bedding features and fractures indicates that the contaminant source is likely upgradient and along geologic strike from well RD-07."* The Report seems to present two conflicting explanations for the TCE concentrations seen in RD-07. Please provide clarification.	Reference to vertical migration down the open borehole has been removed in section 5.5.3.5. Section 5.5.4 was not modified.
38. Figure 5.6-3 – Vertical Extent of PCE Contamination at Building 4059/4057/4626 Please revise the figure to indicate the significance between the clear and blue-filled water level symbols.	Figure has been modified to show only water-level triangle with blue filling.
39. 5.7.3.3 Vadose Zone Mass Estimate Page 5-54; last paragraph *"It is likely that groundwater contamination in this area was caused by small spills in multiple locations and that there is not a centralized source for a TCE release. The RFI and subsequent soil and soil gas investigations did not identify the source or sources that contributed to the HMSA TCE plume. It is likely that the source of the TCE in groundwater is from the bedrock matrix and fractures. There are insufficient bedrock core data to determine how much residual TCE may remain."*	Additional passive soil gas work was performed in this area and no sources identified. Text was modified.

Comments	Response
Additional work will be required to better understand the nature and extent of the source area(s) that are contributing to groundwater contamination is this area. This additional work can be conducted during the cleanup technology evaluations in the CMS or during remedy implementation.	
40. 5.7.3.5 Vertical Extent of Contamination Page 5-55; 2nd paragraph *"Figure 5.7-3 provides a cross section illustrating the depth of the TCE-impacted groundwater at the HMSA."* There are only four points on the cross-section. One of the points, RD-29, has a relatively long open interval and also represents the only monitoring point screened below the ELV member. Additional characterization will be needed in this area to refine the extents of source area and to monitor the fate and transport of contamination as part of the groundwater remedy.	The text was clarified based on the findings of ongoing field work.
41. 5.7.4.1 Conceptual Site Model Page 5-55; 5th paragraph Building 4457 is identified as a source of the TCE found in the HMSA but Figures 5.7-1 and 5.7-2 show the building outside of the plume outline. This needs to be reconciled and/or explained in the text.	Building area was investigated. Text revised.
42. 5.8 Tritium Plume A description of RD-89 (in Section 5.8.3.1) is missing. Although the well was dry in 2016, no previous groundwater results are discussed. Core pore-water was reported but all relevant information from this well should be included. "*Although the depth of tritium contamination is not defined, groundwater elevation data for wells installed below the Lot Bed indicate an upward groundwater gradient thus further downward migration is not anticipated."* Identify the wells that indicate an upward flow and describe how the upward gradient is induced. Presumably the gradient was downward when the tritium release occurred.	Any relevant information for RD-89 was added. Cluster well and seep data were used to clarify statement. Agree that downward gradient was most likely present when the release(s) occurred.
43. 5.9.2 Soils, Geology, and Hydrogeology Page 5-66; 2nd paragraph *"Soil in the vicinity of the RMHF Leach Field AI-Z5 is typically less than 1 foot in depth."*	DOD does not have the data to confirm that soil thickness varies from that prior to soil excavation.

Comments	Response
The report should be revised to note that this area was previously excavated into bedrock and the soil thickness is greater where the excavation activities occurred.	
44. 5.10.1 Source Area Evaluation Page 5-75; last paragraph *"The ASTs were removed in 1999 and the berm was leveled over the area in 2002."* The GSU believes that the ASTs were removed after 2001. Please confirm the removal date.	The text was taken from the Group 6 RFI published by MWH in 2006. DOE has no means of checking the accuracy of the MWH document, but does not see the relevance of an action 18 years ago to today's groundwater-characterization activities.
45. Figure 5.10-1 Include the pipeline from the SRE.	Pipeline added to figure.
46. 5.10.4 Fate and Transport The low concentrations found in soil vapor and soil samples along with the TCE concentrations in groundwater indicate a release from this RFI site that has impacted groundwater. The Report states that "the amount of TCE remaining in shallow bedrock is unknown." This RFI site needs to be further evaluated during the cleanup technology evaluations in the CMS or during remedy implementation.	DOE disagrees. TCE in RD-14 has been <1 ppb since 2013. There is no need for any further investigation here.
47. 5.12 Building 4064 Leach Field Page 5-85; 1st paragraph *"The Building 4064 Leach Field (AI-Z2) is located about 20 feet northeast of former Building 4064 in the northeastern part of Area IV. Chatsworth Formation groundwater in the vicinity of the leach field had been monitored solely by well RD-92."* RD-92 is not shown on Figure 5.12-1 indicating the location of this RFI site. Please include a figure (or reference to a figure) showing its location.	RD-92 is located to east of DS-45/DS-47 and outside the figure frame. Text has been modified with a figure reference for RD-92 (Figure 3-7).
48. 5.12.1 Source Area Evaluation Page 5-85; 6th paragraph *"During demolition of the building in 1993, an area of Cs-137 impacted soil was excavated from the Building 4064 side yard."* Please verify the date of the demolition. Google Earth shows the building intact in May 1994.	Text was corrected. According to the Group 6 RI Report, some contaminated soil was removed in 1993, the leach field was removed in 1997, and all building D&D was completed by 1999.
49. 5.13.1 Source Area Evaluation Page 5-87; 2nd paragraph	Building 4035 location was added to figure.

Comments	Response
"The chemical storage yard at Building 4035 was the site of two releases in 1987 including 1,000 pounds of nickel chloride flake and 1 pint of Turco 3878 (sodium chromate)." The GSU was unable to locate Building 4035 on Figure 5.12.1. Please verify its location and refer to an appropriate figure for its location.	
50. 5.13.1 Source Area Evaluation Page 5-87; 4th paragraph *"In 1995, a radioactive High Efficiency Particulate Air (HEPA) filter was found in a pile of debris. Only the liquid waste could have threatened groundwater."* Further discussion is needed to support that only a liquid waste release "…could have threatened groundwater." The GSU disagrees with the statement without further explanation.	Impact from a pile of debris would have impacted surface soil. Soil investigation of the area (and or soil cleanup), does not indicated that contaminated soil still exists, and therefore, is not a threat to groundwater.
51. 5.14. Building 4133/Building 4029 Hazardous Waste Management Facility Page 5-91; 5th paragraph *"As part of the RCRA closure action for Buildings 4133 and 4029, the potential for groundwater contamination will be evaluated through the installation of new wells once the buildings and their foundations are removed. Any detected contamination will be addressed as part of the closure action. Therefore, these buildings are not evaluated further as part of this Area IV GW RFI Report."* The Report needs to describe how and when the characterization activities at Building 4133 and 4029 (and the RMHF), which are being addressed under RCRA closure action, will be completed. The Report also needs to address how the results of the characterization activities will be incorporated into the corrective measures process.	DOE has not formulated plans for groundwater characterization related to this RCRA unit.
52. 5.15.1 Source Area Evaluation Page 5-93; 5th paragraph "*UT-8, UT-9, and UT-64 were designed to store fission gases, but were not used for that purpose (CH2M Hill 2008)."* The reference cited (CH2M Hill 2008) simply repeats this statement with no references. Please indicate the origin of this statement.	DOE does not have all source documents used for preparation of the Group 5 Report. In a review of the EPA HSA, EPA has similar text regarding the non-use of these tanks. EPA references provide the following as a source for their HSA statement. [1]ORISE, Document No. ORISE 2000-1524, Verification Survey for the Land Area Formerly Supporting the Hot Laboratory, Santa Susana Field Laboratory, The Boeing Company, Ventura County, California, December 2000.

Comments	Response
	[2]Rockwell International, Document No. RI/RD90-118P, Decontamination and Decommissioning of Hot Laboratory, Building 020 SS, Volume 1, Technical Proposal for Complication of Task, March 31, 1990.
53. 5.15.3 Nature and Extent of Impacted Groundwater Page 5-94 The Rockwell International Hot Lab (RIHL) building and area were excavated up to 70 feet below current grade. Barium, beryllium, cadmium, chromium, cobalt nickel, selenium, silver, thallium, and vanadium were reported in groundwater samples at concentrations exceeding their respective groundwater screening levels. Aluminum, barium, cadmium, mercury, nickel, selenium, vanadium, zinc, and TPH were identified in soil during the RFI (CH2M Hill 2008). The Report, however, states "*The source for metals, if one exists, is not known*" and further states that there is no significant groundwater contamination below the RIHL. Data, however, supports the presence of metal contamination in both the soil and groundwater beneath or in the vicinity of the RIHL. Either further discussion is needed to justify this statement or the text should acknowledge the uncertainty.	Further analysis of the metals distribution was performed.
54. 5.16.4.1 Conceptual Site Model Page 5-96; 8th paragraph *"Building 4100 is a possible source for TCE observed in PZ-102."* The argument that Building 4100 is the source of groundwater contamination, when the Building 4009 leach field is adjacent to the well and no soil or soil vapor chemical data is presented for leach field, is unpersuasive. Building 4009 and the associated leach field should be further considered in CMS. This area will require additional groundwater data to better define the source area(s) and for remediating/monitoring the groundwater contamination. This additional work can be conducted either during the cleanup technology evaluations in the CMS or during remedy implementation.	The report was revised to include results of the soil-gas investigation for the B4009 leach field site. All passive soil gas results were non-detect for VOCs. Boeing has not discussed with DOE their plans for addressing the source of contamination at RD-91.
55. 7.3 Conclusions on Area IV Faults Page 7-6 The interpretation of the hydraulic influence of the Burro Flats Fault in the vicinity of the FSDF is vague and unsupported by data. The section states:	Sensitivity runs were made with the groundwater flow model where the hydraulic conductivities of the Area IV Burro Flats Fault segments and the SRE/RMHF Lineament were increased and decreased by an order of magnitude. Results indicate:

Comments	Response
"Hydrogeologically, the fault area is upgradient of Area IV (FSDF). However, groundwater flow in this part of Area IV is limited by tight bedrock. When well RD-21 upgradient of the FSDF was pumped, there was no response in well RD-50, located immediately south of the fault. When well RD-54A at the FSDF was pumped, there was no response in wells RD-21 and RD-50. This strongly indicates that groundwater flow is controlled by bedrock porosity/transmissivity (or lack thereof) and not the Burro Flats fault." It is not clear what hydraulic tests are referenced in this statement. In Section 4.3.2, pumping tests by GRC in the 1990's are cited: *"Shorter duration pumping tests were performed using FSDF wells RD-23, RS-54, and RD-54A in 1994 (GRC 1995c). The affects to local hydrogeology were the same as observed during the pumping of wells RD-54B and RD-21; little or no response was observed in monitoring wells outside of the FSDF. These data demonstrate that bedrock groundwater elevation and flow are controlled by fine-grained units and fractures. Though fractures are present, the formation is relatively tight, and the rate of groundwater flow both laterally and vertically is slow."* However, in the GRC summary of hydraulic tests (*Compilation of fracture data, pumping test data, and packer testing data, November 20, 1996*), it is noted that no sustainable pumping rate was obtained in the well test conducted in the Fall of 1993. In addition, RD-54 was bailed dry for a total extraction of less than 200 gal. RD-23 could not sustain a pumping rate of 1 gpm. Consequently, the hydraulic connections cited in 4.3.2 and repeated in the 7.3 are inconclusive. Furthermore, It is unclear how the interpretation of the Burro Flats Fault relates to these well tests. The Burro Flats Fault is not discussed in the passage from 4.3.2 but is introduced without supporting data in 7.3. This discussion and interpretation warrants thoughtful revision.	• Increasing the Burro Flats Fault hydraulic conductivity by an order of magnitude: Increased the total objective function by 22% and the component for the heads in Area IV (*heads8*) by 66%. This fault must act as a barrier to flow or it prevents the simulation from honoring water levels in Area IV. • Decreasing the Burro Flats Fault hydraulic conductivity by an order of magnitude: Increased the objective function by only 1% and *heads8* by only 2%. This indicates that the fault is acting as a barrier to flow and augmenting the barrier makes little difference to the calibration. • Increasing the SRE/RMHF Lineament hydraulic conductivity by an order of magnitude: Increased the objective function by 4% and that for heads by 9%. Head gradients (*grads17*) and seeps (*seeps19*) in Area IV, though, degraded by 24% and 20%, respectively. This feature must be a barrier to flow or it prevents the model from honoring the observed gradients and flows in Area IV. • Decreasing the SRE/RMHF Lineament hydraulic conductivity by an order of magnitude: Increased the objective function by 4% and that for *heads8* by 10% (about the same as the preceding sensitivity iteration). Head gradients in Area IV improved by –4% while seeps in Area IV degraded by 2%. While making this feature act as a stronger flow barrier degrades the overall calibration, it slightly improves the gradients in Area IV.

Comments	Response
56. Appendix C – Area IV Groundwater Numerical Modeling Section 1.3 Previous Groundwater Modeling The flow model, and the particle tracking and transport modeling derived from this flow model, are based upon the 2013 “Run 55”. As noted in Appendix C, this model was never documented in a report or formally presented to DTSC. Consequently, the updates to Run 55 completed by DOE are not fully documented. The hydraulic conductivity (K) Zones listed in Appendix A of Appendix C cannot be located. Provide a more comprehensive description of Run 55 and subsequent revisions. In addition, provide the geologic context for the calibrated K values. For example, the Upper Burro Flats calibrated hydraulic conductivities range from 10^{-10} to 10^{-4} m/s. The summary of bulk hydraulic conductivity tests given in Table 6-1 of the 2009 Site Wide Draft RI report gives a range of measured K of 8.3^{-10} to 8.1^{-7} m/s. Calibrated parameters that are outside the range of reasonable or estimated parameters should be flagged and investigated.	Boeing lists Run 55 as “incomplete,” but it was largely documented in the RI report. See page 18 of “15-09-09-2015-SSFL_GWFlowModelUpdate-Finalization-w-attach.pdf.” Run 55 was developed in late 2011. DTSC was provided all the model files and associated PowerPoint slides describing Run 55 according to “SSFL_GW Technical Data Request_ModelPres_Run55_NASA-DOE_submitted.pdf” on page 2. Run 55 documented in PowerPoints: “SSFL_ModelUpdateNov8.pdf,” “SSFL_Optimization_Run55.pdf,” “SSFL_ModelUpdateDec2011v2.pdf.” Page 163 of “Boeing SSFL FZ Transect Summary (Prelim) 4-24-14.pdf” show North and Burro Flats Faults calibrated hydraulic conductivities and identifiabilities. A summary of the updates in Run 55 of the site-scale groundwater flow model, relative to the fully documented 2009 Site Wide Draft RI Report was added to the Area IV Draft GW RI Report. This summary of the updates embodied in Run 55 augment the discussion of further updates to the flow model for the Area IV report.
57. Appendix C – Area IV Groundwater Numerical Modeling Section 3.1 Parameter Estimation Method The Report correctly notes that: A good model will extract maximum information content from site data during the calibration process while also reproducing historical site measurements. This leads to: 1) Predictions of future system behavior with decreased uncertainty. 2) The ability to quantify uncertainty. 3) The ability to examine the contribution of dataset members in reducing uncertainty to its current level. 4) The ability to quantify contributions to uncertainty from model parameterization. 5) The ability to quantify how additional data-collection activities could reduce model predictive uncertainty.	This analysis can be handled with PEST’s `genlinpred` utility to address these issues in a straightforward manner. In fact, the recent *White et al.* [2016] paper provides a Python framework to handle this analysis. The additional uncertainty analyses addressing items 3) to 5) are more appropriate to the planning and execution of potential corrective measures at specific locations of groundwater contamination. As such, additional uncertainty quantification covering these items will be included in the Corrective Measure Implementation Plan.

Comments	Response
Items 1 and 2 are addressed in the Report through the use of null-space Monte Carlo estimations of alternative, but equally likely, particle transport predictions. However, items 3 through 5 are not addressed. In general, the model is not used to quantify where uncertainly currently lies on the conceptual model of groundwater flow or what data could be collected to reduce this uncertainty. Ongoing work on the model should continue and include collaboration with DTSC to further refine the model.	
58. Appendix C – Area IV Groundwater Numerical Modeling Section 4 Groundwater Model Calibration Results The following DTSC comment on the Draft RFI (comment 74; page 28) has not been addressed in this modeling effort: 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?"* The uncertainty in the predictions is discussed in Section 4.3 in the context of Null-Space Monte Carlo methods. However, there is no discussion regarding the influence of observations of the model predictions. Nor is there discussion regarding the influence of super-parameter sets on head and head gradient residuals. In other words, the uncertainty in prediction is addressed but the sources of this uncertainty are not. Consequently, the model cannot be used to identify data gaps and errors in the conceptual model. For example, the NE-SW trending under-prediction of heads in the northwestern border of Area IV and the corresponding over prediction of heads in the southeastern border of Area IV (Figure 24) is not explained. Such residuals may result from the low-permeability stratigraphy or fault zones that have been misrepresented in the numerical model. These determinations may not be possible from null-space Monte Carlo and	PEST has different utilities than DFBETA and Cook's D, but they are just as good or better and yield a straightforward linear uncertainty analysis. Previously, AquaResource ran parameter identifiability studies to assess how well each model parameter was constrained by the calibration data set. This analysis can be repeated for DOE's new groundwater flow model calibration. If some assistance is sought in identifying well placement from the model, a hypothetical parameter uncertainty reduction analysis can be performed to identify where to locate wells to maximize reductions in model uncertainty.

Comments	Response
other optimization strategies may need to be employed. Ongoing work on the model should continue and include collaboration with DTSC to further refine the model.	
59. Appendix D – Assessment of Chemical Attenuation Page D-7, 3rd paragraph. The paragraph description discusses data listed in Table D-4 and acknowledges that the presence of PCE at well PZ-109 confounds the Compound Specific Isotope Analysis (CSIA) of the TCE. The presence of PCE and its degradation to TCE is the most likely explanation for the TCE in well PZ-109 to have the most negative (e.g. lightest) TCE isotope signature. The CSIA discussion should more clearly identify the TCE CSIA carbon 13 isotope signatures that are likely affected by the presence of PCE. The CSIA analysis should attempt to discern if groundwater contamination observed at PZ-109 is related to DD-104. The project team should also consider repeating the sampling and analysis of PZ-109 for CSIA to verify the anomalous DCE isotope signature.	It is not clear how linking PCE with TCE is important for the assessment of a groundwater remedy.
60. Appendix D – Assessment of Chemical Attenuation Page D-7 DOE should attempt to get CSIA data from Boeing-responsibility well RD-91 to compare to existing data from well RD-07 presented in Table D-4. The evaluation of CSIA data from RD-91 and RD-07 will be useful for evaluating source relationship and apparent attenuation associated with plume transport.	DOE has not had a discussion with Boeing on this issue.
61. Appendix D – Assessment of Chemical Attenuation Page D-7 DOE should attempt to get CSIA data from Boeing responsibility wells RD-21 and RD-150 for comparison with existing data from wells RD-64 and RD-65 presented in Table D-4. The project team should also consider sampling and analysis of RS-54 for CSIA to characterize the FSDF source area and for comparison to CSIA data from Boeing wells RD-21 and RD-150.	DOE has not had a discussion with Boeing on this issue.
62. Appendix D – Assessment of Chemical Attenuation DOE should include the Area IV CSIA data listed in Amanda Pierce	MS copy obtained and reviewed.

Comments	Response
2005 Master Thesis. CSIA data for RD-64, RD-65 (FSDF wells) and RD-21 and RD-23 (ESADA wells) are available and should be compiled and evaluated.	
63. Appendix D – Assessment of Chemical Attenuation The evaluation of CSIA data for TCE should attempt to calculate an upper and lower bound range of TCE fractionation. The calculation should incorporate range of TCE fractionation factors based on Hunkeler et al., 2008. The calculation should also include the $\delta^{13}C$ value for pure phase TCE of -24.3 based on the most conservative (enriched) value identified in Morison and Murphy 2013.	DOE will consider this recommendation as part of development of the design of corrective actions.

White, J. T., M. N. Fienen, and J. E. Doherty (2016), A python framework for environmental model uncertainty analysis, *Environmental Modelling & Software*, *85*, 217-228.