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March 15, 2018

Responses to Vermont Agency of Natural Resources Comments on December 2017 Draft Interim Conceptual Site Model Site Investigation Report and February 2018 Draft Conceptual Site Model Site Investigation Report

Enclosed are responses prepared on behalf of Saint-Gobain Performance Plastics (Saint-Gobain) to comments provided by the Vermont Agency of Natural Resources (VT ANR) on the *Draft Interim Conceptual Site Model Site Investigation Report: Bennington, Vermont* (December Draft CSM SI Report) and the *Draft Conceptual Site Model Site Investigation Report: Bennington, Vermont* (February Draft CSM SI Report). Comments were submitted by VT ANR on February 21, 2018 and February 26, 2018, respectively. Responses to comments are provided below. Where noted, revisions have also been made to the *Conceptual Site Model Site Investigation Report: Bennington, Vermont* submitted March 15, 2018 (Final CSM SI Report) to further address VT ANR comments. Unless otherwise noted, referenced figure, table and section numbers in the below responses correspond to their given number in the draft report being referenced by the VT ANR comment. Acronyms and abbreviations used in the text and references cited in the text are provided in Attachment A and B, respectively.

February 21, 2018 Comments on December 2017 Draft Interim Conceptual Site Model Report

Comment 1: *Hydrogeologic conditions are similar to those used in the conceptual site model (CSM) –*

VT ANR does not agree with this conclusion because the new SI data show that there are sufficient differences in the hydrogeologic conditions that warrant an update to the CSM and the applicable numerical models prepared by Barr Engineering. The specific comments section provides details about the updates to the CSM and the applicable numerical models that VT ANR believes are warranted.

> **Response:** Data collected for the CSM Site Investigation (CSM SI) support the hydrogeologic conditions simulated in the conceptual site model as discussed further in specific comments below.

Comment 2: *Relationship and trends in PFOA concentrations are not indicative of historical releases from the former Chemfab facilities and the measured soil concentrations across the investigation area are generally consistent with background concentrations and may also be indicative of localized sources of PFAS-*

The VT ANR does not agree with these conclusions, primarily for the following reasons:

a) *Air modeling, completed by both Barr and VT ANR, show PFAS depositions throughout CAA II which originated from the former Chemfab facilities. The ANR models shows higher PFAS deposition rates further away from the former Chemfab Water Street facilities than the Barr model. The VT ANR considers the input parameters used in the ANR model to be more representative of actual conditions than those used in the Barr Model. As documented in previous comments on the air model, the VT ANR does not agree with many of the input parameters in the Barr model that effect emissions rates and the distance PFAS travels from the former Chemfab facilities.*

Response: VT ANR and Barr both used the AERMOD dispersion model to estimate deposition throughout Corrective Action Area II (CAAII). VT ANR provided their AERMOD modeling input and output files (WaterSt_98.adi and WaterSt_98.ado, respectively) for review. Barr and VT ANR used the same meteorological data (William H. Morse State Airport, 2006 – 2010 processed by VT ANR), the same AERMOD Method 2 deposition parameters, and similar air deposition model domains (14 km x 14 km, VT ANR; 13 km x 13.8 km, Barr). While there are some differences in the stack parameters used, the primary difference between the VT ANR model and the Barr model is the modeled emission rate.

VT ANR modeled only the peak emission year (1998) and used an emission rate of 1,000 pounds per year (lbs/yr) of perfluorooctanoic acid (PFOA). A PFOA emission rate of 1,000 lbs/yr is not supported by facility dispersions usage records provided by the former Chemfab facilities (Attachment 21 – Tilgner Investigation Materials Page 56; Dispersions Usage Data from C. Zipprich) and does not account for the PFOA air partition factors or abator control efficiencies as presented in Appendix A of the *Draft Conceptual Modeling of PFOA Fate and Transport: North Bennington, Vermont* (Draft CSM Report; Barr, 2017c). Based on VT ANR comments that emissions were underestimated for the Water Street facility operations, Barr assumes that VT ANR used an assumed emission rate of 1,000 lbs/yr for the entirety of the Water Street operations (1978 – 2002), although 1998 is clearly the maximum dispersion usage year as supported by facility records. However, because VT ANR has not presented detailed calculations of their air emission estimates, it is not possible for us to provide further comment. An analysis of VT ANR model results provided in the response to Comment 2c below demonstrates that the PFOA soil mass measured at the background sampling locations of the CSM SI cannot be explained by air emissions simulated by the VT ANR model, despite a PFOA air emission rate that is significantly higher than supported by facility records.

As shown in Table A-1 of the Draft CSM Report (Barr, 2017c), Barr modeled 307 pounds (lbs) of PFOA emissions for 1998. Barr modeled each emission year with annual emission rates ranging from 26 to 307 lbs/yr with an average of 145 lbs/yr from the Water Street facility. These emission rates were based on facility records including dispersions usage, the amount of PFOA in the dispersion formulations, the fraction of PFOA released to the air, and the abator control efficiency.

Previous VT ANR comments covered many modeling aspects which Barr addressed in the Draft CSM Report (Barr, 2017c) and in Barr’s June 30, 2017 letter to Richard Spiese (Responses to Vermont Agency of Natural Resources Comments on October 2016 and February 2017 versions of the Draft CSM Report). The June 30, 2017 submittal provided substantial details (and several revisions to incorporate VT ANR comments) with respect to emission rate calculations and model input parameters. The VT ANR did not provide additional comments on those submittals. Therefore, it is unclear what other issues VT ANR may have with the Barr Model.

b) *The SI report indicates that most of the soil samples collected for the area-wide site investigation were collected from town right-of-way, which consisted primarily of disturbed soil. The concern is that the soil sample results from predominately disturbed areas compromise the ability to evaluate relationships and trends in PFAS distribution and to assess the measured distribution of PFAS in soils and groundwater against the predicted distribution based on modeling of air emissions from the former Chemfab facilities.*

Response: The comment assumes that, by definition, all soils in the town right-of-way (ROW) are disturbed, and that disturbing the soil alters the total organic carbon (TOC) and per- and polyfluoroalkyl substances (PFAS) content of the soil. The intent of the investigation was to avoid areas with thick fill sequences or deeply excavated soil, such as the Vermont State Highway 279 corridor. In addition, Barr collected samples at a distance from roadways or other obvious areas of disturbance or fill. Field classification and the boring logs indicate that native, undisturbed soils are present at many of the soil boring locations, and that native, but potentially disturbed soils were present in other locations.

The disturbance of shallow soils in the ROW (where present) would likely result in redistribution of TOC and PFAS compounds within the soil near the land surface. This material redistribution would not substantially alter the bulk organic carbon content (and sorption capacity) or concentration of PFAS from that of the undisturbed native soil. In addition, Appendix D.1a of the Final CSM SI Report evaluated soil in the top 1.5 feet as a single depth class ("surface soil") and soil from 1.5 to 5 feet as a different depth class ("shallow soil"). The resulting data are deemed suitable for comparison to the modeled results against the measured distribution of PFAS in soils and groundwater due to the following: efforts made to avoid areas with thick fill sequences; bulk organic carbon and PFAS content would not be altered if shallow disturbances occurred; and the way the data was statistically evaluated.

c) *The background concentration assessment is flawed, particularity the application of Rankin et al. 2016 to support an average PFOA soil" background" concentration of 1.2 ng/kg. For example, the SI report states that long range transport (regional background) appears to be a significant source of PFAS, using Rankin et al. 2016 to support this claim, which ignores the influence that the former Chemfab facilities have on "regional background." These facilities emitted many tons of PFAS compounds to the environment, and they are only 8 to 22 miles away from the "four" background sampling locations, which are in the prevailing downwind direction of these facilities. To presume that all of the PFAS in these samples comes from other regional sources that are many more miles away from these sampling locations is not supported by the CSM or SI Report. The VT ANR air deposition model estimates approximately 65% of the PFAS emitted from the Water Street facility leaves the model domain and travels further afield to be deposited in other areas of the state, the nation, and perhaps the world. Some of these PFAS compounds most certainly would be expected to have been deposited in the soils that were sampled as part of the background study presented in the SI report. Additional comments on why ANR considers the assessment flawed are provided in the specific comments section.*

Response:

The response to this comment is provided in two parts: an analysis of background soil concentrations from the CSM Site Investigation data and a comparison of mass deposition simulated by the VT ANR air deposition model to mass measured during the CSM Site Investigation at background locations.

<u>Analysis of Background from CSM Site Investigation Data</u>

Comment 2c suggests that the background discussion in the CSM SI Report is flawed, because the historical emissions from the former Chemfab facilities were not considered. The former Chemfab facilities were not ignored in this analysis; however, the time since emissions ceased at each facility and leaching of PFOA from shallow soil during that time do not support former emissions from the Chemfab facilities as a contributor to background soil concentrations measured as part of the CSM SI.

The emissions from the former Water Street Chemfab facility stopped in 2002 and the time required to flush PFOA out of the superficial soils, which depends on the soil's TOC content (flushing times are provided below), are less than or equal to the 15 years between the end of emissions and soil sample collection and analysis. As discussed in Section 4.5.3 of the December Draft CSM SI Report and subsequent versions, it was expected that PFOA potentially emitted by the former Chemfab facilities would no longer be present in shallow soils at the time of the investigation. After emissions ceased from the former Chemfab facilities, flushing of the upper soils would quickly reduce concentrations of PFOA in the upper soil provided there is not continuing deposition from other PFOA sources. The investigation soil data do not show a spatial trend with distance from the former Water Street facility outside of Corrective Action Area I (CAAI) that would be indicative of historical (Chemfab) deposition. Instead, the PFOA concentrations measured in surficial soils outside of CAAI show no trend, which strongly supports the presence of background (non-Chemfab) deposition.

A revised approach to evaluating background deposition based on characteristic flushing times for surficial soils was developed to complement the background deposition analysis presented previously and to address this comment and related comments. The revised assessment is described below and discussed in detail in Section 4.4.1 and Appendix D.2 of the Final CSM SI Report.

The background parameter of interest for the complementary analysis is the background deposition rate rather than the background soil concentration. This is the rate at which PFOA is deposited on the soil surface. Unlike the emissions from the former Chemfab facility that stopped about 15 years ago, the background deposition continues to supply PFOA to the soil surfaces. This background deposition rate, in combination with the infiltration of precipitation and the retardation of PFOA by the soil, influences the PFOA concentration found in the superficial soils, *i.e.*, the upper 6 inches of the soil column. The partitioning of PFOA between the water and soil phases can be indexed by the TOC content of the soil. Under constant deposition rates and constant water infiltration rates, a pseudo-steady-state condition develops where the soil PFOA concentration is a linear function of the TOC content. Thus, a collection of soil samples that show a linear correlation between soil TOC content and soil PFOA concentrations would be indicative of a relatively constant background deposition rate and relatively constant water infiltration rate.

Surficial soil samples (upper 6 inches) collected at the four background locations located between 8 and 22 miles from the Chemfab facility showed a range of soil TOC and PFOA concentrations. As illustrated in Figure 1 below, the observed PFOA soil concentrations can be characterized as a linear function of the soil TOC content. The superficial soil samples from location BG3 had a PFOA concentration less than the Method Detection Limit (MDL) and for these samples the concentration was assumed to equal the MDL for purposes of this analysis. Because the four background locations were miles apart, the observed linear correlation between TOC content and superficial soil PFOA concentration suggests that the continuing deposition rate was spatially uniform across the region that encompassed the four background sampling locations. This continuing deposition creates measurable PFOA concentrations in surficial soils.

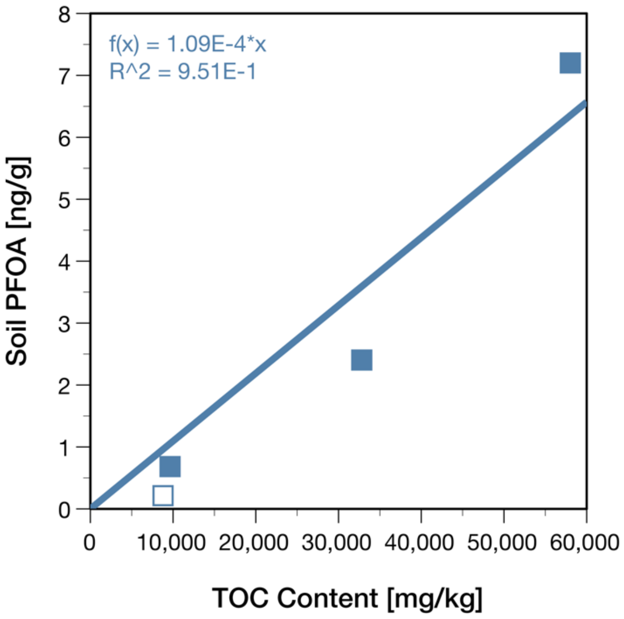


Figure 1. The linear relationship between soil TOC content and PFOA concentration for four surficial soil samples (0-6 inches below ground surface) collected between 8 and 22 miles from the Chemfab facilities suggests a relatively constant PFOA deposition rate across the region. The open-square symbol is the MDL concentration for the soil sample collected at location BG3.

The time required to flush 95 percent of the initial PFOA out of the upper 6 inches of soil for the four samples were calculated using the soil TOC contents provided in Figure 1. Based on an infiltration rate of 19.5 inches/year (Barr, 2017c) and assuming that the infiltrating water initially contained no PFOA, the simulated time required to flush the PFOA from the soil ranged from about 2.6 years for a TOC of about 10,000 mg/kg, to about 8.5 years for a TOC of about 33,000 mg/kg, to about 14.9 years for a TOC of about 58,000 mg/kg. Assuming a TOC at the high end of the range measured (58,000 mg/kg) and an initial soil PFOA concentration of about 1.6 ng/g when the Chemfab emissions stopped (which is the soil concentration that is predicted near the edge of the air model domain at that time multiplied by the correction factor of 7.7 to account for differences in TOC content between the locations of the air model node and background location BG2 and the higher emission rate used in the VT ANR air quality model), the present-day maximum residual soil concentration would be less than 0.08 ng/g. This concentration is below the typical detection limit for the CSM SI analyses. The fact that there are detectable superficial soil PFOA concentrations when none should exist, based on the time required to flush PFOA last deposited at least 15 years ago, strongly supports a continuing source of PFOA. The magnitude of the measured PFOA concentrations and the distance between the four sampling locations suggest a significant regional background PFOA deposition rate.

<u>Comparison of PFOA Soil Mass: Background Location Measurements and VT ANR Air Deposition Model</u>

The modeling results from both the Barr Model and the VT ANR Model demonstrate that PFOA concentrations in CAAII are attributable to background sources, not historical air emissions from the former Chemfab facilities. While Barr disagrees with the emission rates used in the VT ANR Model, even utilizing those emission rates demonstrates that the PFOA concentrations detected at background locations are not associated with the former Chemfab facilities. In this regard, the potential for the mass of PFOA in soil observed at background locations BG1 and BG2 to be a result of air emissions from the former Water Street facility and subsequent deposition of PFOA was evaluated using the results of the VT ANR air model. This analysis shows that significantly more mass has been observed at the background sampling locations than even the VT ANR Model predicts would have been deposited at those locations as a result of historical air emissions from the former Chemfab facilities. This analysis further supports a significant background deposition source evidenced by the soil concentrations measured during the CSM Site Investigation. Samples from BG1 and BG2 were chosen for purposes of this analysis as they are the closest of the background sampling locations to the air model domain.

The analysis was performed using the following approach and conservative assumptions:

- Samples from BG1 and BG2 were chosen for purposes of this analysis as they are the closest of the background sampling locations to the air model domain.
- The analysis was based on the results from the VT ANR air model, which Barr believes overstates historical emissions from the former Chemfab facilities. The VT ANR model simulates higher emissions than determined by Barr 2017. The assumption of higher emissions rate and the issues with these rates are discussed in the response to Comment 2a.
- The peak emission rates from 1998, which is the only year simulated in the VT ANR model, were applied to each year of facility operations. The Water Street facility operated for 24 years, from mid-1979 to February 2002. During many of these years, emissions were substantially lower than in 1998.
- The simulated mass deposition value for the analysis was selected from the air model node closest to the background sampling locations (BG1 and BG2), which is 3 and 6 miles closer to the Water Street facility than BG1 and BG2, respectively. The model domain of the VT ANR model does not extend to the background sampling locations. If the model were extended to cover the background sampling locations, the simulated deposition at these locations would be even less than the value simulated for the node selected for this analysis.
- Soil sample results for the 0-6 inch below ground surface (bgs), 6-12 inch bgs, and 12-18 inch bgs depth intervals at the background locations and a soil bulk density of 1.5 g/cm3 were used to determine the mass of PFOA within each 6-inch depth interval. Sampling results from depths greater than 18 inches bgs were not considered in the analysis.
- No transport of PFOA to depth below 1.5 feet (18 inches) was considered; all mass deposited at the background locations was assumed to remain in the upper 1.5 feet. Under this conservative assumption, the mass that deposits at the background locations remains in the upper 1.5 feet of soil due to the assumed inability of the PFOA to leach from the soil. Partition coefficients, soil organic carbon content, and recharge rates do not factor into the analysis.

As shown below, the total simulated mass estimated through this conservative analysis to have been deposited at the background locations is only 35% (at BG 1) and 19% (at BG 2) of the mass of PFOA measured in the upper 1.5 feet of soil at these locations. As discussed elsewhere, in the 15 years since emissions stopped, a significant fraction of PFOA that may have been deposited at these locations would have flushed to deeper in the soil column. Accordingly, this analysis substantially overstates the mass of PFOA that potentially may be present at these locations today as a result of historical air emissions from the former Chemfab facilities.

The results of this analysis support the observation that the mass of PFOA observed in shallow soil at the background sampling locations cannot be explained by emissions of PFOA from the former Chemfab facilities. The PFOA mass observed in soil must be from a different source.

BG1

Evaluation of Total Measured Mass in Upper 1.5 feet (18 inches)				
	Measured Soil PFOA (ng/g)	Bulk Density (g/cm^3)	Total PFOA Mass in Interval (ng)	Total PFOA Mass in Interval (g)
0-6"	0.68	1.5	1.55E+05	1.55E-04
6 to 12"	2.00	1.5	4.57E+05	4.57E-04
12 to 18"	3.30	1.5	7.54E+05	7.54E-04
Total Measured Mass in Upper 1.5 Feet			**1.37E+06**	**1.37E-03**

Evaluation of Potential Total Mass Deposition at Location BG1	
Deposition of PFOA at nearest model node from VT ANR model (g/m^2/yr)[b]	2.0E-05
Total simulated mass deposited after 24 years over a 1m^2 area (g)[c]	4.8E-04
Percent of Measured Mass in upper 1.5 feet	35%

[a] Assumes a representative area of 1m^2

[b] Nearest node is 3 miles from sample location for B1 and 5 miles from Water Street Facility

[c] Assumes peak rates from 1998 applied to all 24 years of Water Street operation

BG2

Evaluation of Total Measured Mass in Upper 1.5 feet (18 inches)	Measured Soil PFOA (ng/g)	Bulk Density (g/cm^3)	Total PFOA Mass in Interval (ng)	Total PFOA Mass in Interval (g)
0-6"	7.2	1.5	1.65E+06	1.65E-03
6 to 12"	2.9	1.5	6.63E+05	6.63E-04
12 to 18"	1.1	1.5	2.51E+05	2.51E-04
Total Measured Mass in Upper 1.5 Feet			**2.56E+06**	**2.56E-03**

Evaluation of Potential Total Mass Deposition at Location BG1	
Deposition of PFOA at nearest model node from VT ANR model (g/m^2/yr)[b]	2.0E-05
Total simulated mass deposited after 24 years over a 1m^2 area (g)[c]	4.8E-04
Percent of Measured Mass in upper 1.5 feet	19%

[a] Assumes a representative area of 1m^2

[b] Nearest node is 6 miles from sample location for BG2 and 5 miles from Water Street Facility

[c] Assumes peak rates from 1998 applied to all 24 years of Water Street operation

d) *Barr's effort to normalize the soil samples to account for background fails to adequately explain significant variability in the data. The TOC-normalized background created by Barr assumes a uniformity throughout background concentrations for the study area that is not reflected by the data. For example, soil results in part of the site have elevated levels in areas where drinking water wells are not impacted (SO1, SO3, SO4, SO5, S44, S48, and D24) whereas other areas of the site have soil results showing no elevated levels of PFASs but have elevated levels of PFOA in drinking water wells (samples south of the Water Street facility, S36, D20, D21 and D23, and areas around the landfill, D12, D16, S30, S10, and areas along Chapel Road, S09, S32, S37, S39, and S42). This variability in data does not support Barr's basis for applying a background adjustment to explain why their model-simulations under-predicted the measured PFOA concentrations found in area-wide groundwater.*

Response: Comment 2d suggests that the measured variability in soil and water PFOA concentrations relative to the model-simulated concentrations does not support the use of a background soil concentration adjustment. The use of a background soil concentration to account for the continuing deposition of PFOA should not be dependent on the degree of variability between measured and modeled concentrations, but on whether the process of deposition significantly influences the mass loading of PFOA. As discussed in the response to Comment 2c, the continuing deposition of PFOA has a significant impact on present-day soil PFOA concentrations. The continuing mass loading of PFOA needs to be included in the CSM, because it is an important process. The fact that the resulting CSM does not calculate PFOA concentrations in perfect agreement with measured concentrations is no reason to claim that background PFOA soil concentrations should not be included in the CSM.

e) *No proof is offered to support the premise made throughout the SI report and in Appendix H that the Chemfab facilities only emitted PFOA and if other PFAS compounds, particularly PFOS, are present, then the source of PFAS is not from the Chemfab facilities. With a few exceptions, a majority of the PFOS concentrations in the monitoring wells installed as part of the area-wide SI and in the drinking water wells are at low concentrations, with many of the area-wide SI results having a J qualifier (which the laboratory is estimating a concentration that is below their reporting limit but above their detection limit). Also, if PFOS was an indicator for another source for an area, then why wasn't PFOS found in all the surrounding wells? PFAS compounds were found in groundwater and soils throughout Corrective Action Areas I and II, including near the Water Street facility. In addition, CT Male provided soil data collected at the Water Street Facility. PFOS was detected in soil samples collected at three locations (soil borings from three monitoring wells (MW-2, MW-6, and MW-7) in testing done as part of the Water Street SI. Furthermore, the SI report needs to include a definition for what is meant by PFAS. According to the literature, PFAS are all compounds that contain a CnF2n+1- moiety (Buck et al. 2011). This would include PTFE, which suggests that Barr is claiming no Teflon was emitted from their stacks. The Taconic Plastics 2016 stack tests results also strongly suggest that many different PFAS are emitted from a similar process, including sulfonated PFAS.*

Response: No information has been identified to suggest that PFOS was in the dispersions used at either the Water Street Facility or the Northside Drive Facility. Dispersion inventory data indicate that PFOA (as APFO) was the only PFAS used by Chemfab, and PFOS is not a known impurity of PFOA. Stack testing from Taconic Plastics in 2016 is not representative of PFAS use and operations at the former Chemfab facilities in part because operations at the Chemfab facilities ceased before 3M and DuPont phased out production of PFOA between 2002 and 2006 and turned to replacement chemistries.

If PFOS was a significant component in the emissions from the former Chemfab facilities, PFOS detections in soil and groundwater would be expected to be similar in pattern to PFOA in areas where modeling indicates measurable deposition took place; however, this is decidedly not the case. The general absence of detectable PFOS in soil in the area at and near Water Street is illustrated by the figures included in Appendix I of the Final CSM Report. The detections of PFOS in soil at Water Street referenced in the comment are isolated (one sample out of seven or eight total samples for the boring) and qualified due to levels detected below the reporting limit. Additionally, PFOS was not detected in any samples from the four other borings completed at the facility as part of the CSM SI. As shown on the figures included in Appendix I of the Final CSM Report, detections of PFOS in groundwater at Water Street are similarly isolated and at concentrations substantially lower than would be expected for an air emission source.

f) *Appendix H identifies many possible sources of PFOA throughout the area. The wide-spread distribution of PFAS in the groundwater and soil in the Bennington area points supports a localized air-borne source not "countless" point sources as suggested in the SI report. The emissions from the models developed by Barr and VT ANR predicting PFOA deposition from the Water Street facility further support an area-wide distribution of PFAS, including the presence of PFOA found in CAA II.*

VT ANR reviewed existing files and records, particularly from the air permitting and engineering services program, and did not find any evidence or records that suggest other businesses or industries emitted PFAS compounds into the atmosphere at the scale of the two Chemfab facilities. VT ANR did identify one Bennington facility, the Eveready Production Facility downtown, that may have had an air-emitting process in the past that used PFAS as a dispersant. VT ANR requested Eveready to perform an initial investigation at the facility as well as at a former facility in Saint Albans. Eveready collected groundwater samples at existing monitoring wells associated with the facilities. Three monitoring wells at and near the Bennington Eveready facility were sampled. The groundwater results showed low levels of PFOA, with PFOA concentration ranging from 2.2 ng/L and 20 ng/L. PFOS was detected at 2.1 ng/L in one monitoring well. At the former Saint Albans Eveready Facility, PFAS was found at low concentrations. The highest PFOA concentrations at that facility was 3 ng/L. The low concentration found in these three monitoring wells at or near the Bennington Eveready facility are consistent with the decreasing concentrations of PFOA in groundwater away from the two former Chemfab facilities. Due to the low concentration found in these monitoring wells and the lack of a concentration trend emitting from the Bennington Eveready facility, VT ANR concluded that this facility is not a substantive source of the PFAS to the local area directly around the site or the hundreds of drinking water wells on the eastside of Bennington that have been shown to be contaminated with PFOA. Lastly, even if the Eveready facility was a source of the low concentrations of the PFOS, the results of the investigations at their two facilities provide clear evidence that they are not the source of the PFOA in CAA II. It is because of the elevated levels of the PFOA in CAA II that site remediation is necessary.

Response: The December Draft CSM SI Report was updated in the February submittal to provide additional information regarding potential PFAS sources in the area, specifically contributors to the Bennington Landfill (Appendix H-2 of the February Draft CSM SI Report). The appendix includes a summary of investigative work from the U.S. Environmental Protection Agency (EPA) to identify industrial landfill users; reported manufactured products and/or waste products; and an inventory of PFAS-containing products commercially available to the manufacturing industry. Additional information can be found in Appendix H-2 of the Final CSM SI Report.

g) The SI report neglects to address the potential impacts of PFAS emissions from the Northside Drive facility on the distribution of PFAS in CAA II.

Response: Site-specific data is currently not available for Northside Drive. This is discussed further in Section 4.4.2 of the Final CSM SI Report.

Section 2 Background

<u>Comment 3:</u> *Section 2.1-Either remove the word countless in the phrase... "While it is likely that there are countless sources of PFAS within the investigative area" or substantiate why stating "countless" sources is justified. Appendix H is speculative with respect to other potential sources, whereas the two former Chemfab facilities are known air-borne sources.*

Response: The sentence was revised to substantiate the reference to additional potential PFAS sources in the investigation area.

Comment 4: *Section 2.1.-Former Chemfab Facilities-The SI report states that PFOA is understood to be the only PFAS compound in the air emissions from the former Chemfab facilities. There is no reference or statements supporting this statement. Either remove these statements or provide evidence that supports it. In addition, this statement appears inconsistent to the discussion in Section 2.2 Barr Environmental's draft CSM dated June, 2017 about the presence of another PFAS found near the facility and the soil results reflected in Chart 2 of CT Male's shallow soil report dated July 20, 2017, which shows total PFCs as well as PFOA decreasing with concentration with distance away from the Water Street facility.*

> **Response:** We have not seen information to indicate that any PFAS compounds other than PFOA may have been contained in air emissions from the former Chemfab facilities. The absence of sulfonated PFAS compounds in air emissions from the former Chemfab facilities is evidenced by the fact that these compounds are not uniformly detected in groundwater in the vicinity of the former facilities and do not consistently increase in groundwater with increasing proximity to the former facilities.
>
> Detections at the Water Street facility of sulfonated PFAS compounds and longer-chained carboxylic acids (e.g., perfluorotetradecanoic acid (PFTeDA or C14)), compounds mentioned in Section 2.2 of the Draft CSM Report (Barr, 2017c), are not by themselves indicative of an air emission source, given the potential other sources of PFAS from industrial activities, including fire-fighting, at the former Chemfab facilities and other operating and closed facilities across the investigation area, including Johnson Controls and Eveready. A revised analysis of the trend in total PFAS concentration with distance from the former Water Street Chemfab facility is provided in Section 4.3.1.2 of the Final CSM SI Report and incorporates data from C.T. Male's 2016 soil and groundwater investigation at the facility.

Comment 5: *Section 2.1.2- Bennington Landfill-Add a phrase or sentence in this section that specifically mentions that an interceptor trench was installed as part of the 1999 capping activities to divert groundwater from entering the landfill.*

> **Response:** A discussion of the interceptor trench was added to Section 2.1.2 and Section 4.4.2 of the Final CSM SI Report.

Comment 6: *Section 2.2.1- Regional Geology and Hydrogeology-Barr states in the report that, "Runoff in upland areas is focused to seasonal streams that typically lose discharge in areas in which they flow over stratified drift at the margins of the larger valleys." However, the CSM modeling effort showed all streams in the model domain to be gaining streams. How does this statement conform with the modelling effort?*

> **Response:** The statement is consistent with the modeling effort in that soil-water-balance (SWB) was used to simulate runoff to low areas, where seasonal streams would form, and infiltration of that water into the unsaturated zone. As noted, the MODFLOW drain package only allows simulation of gaining of discharge from an aquifer layer. This is consistent with the CSM modeling effort, in that steady-state simulation of flow to a given drain reach indicates a perennial stream, not a seasonal stream.

Comment 7: *Section 2.3- On page 8- Barr states that "In saturated, unconsolidated deposits and fractured rock media, they [PFOA and PFOS] are mobile and migrate as an unattenuated solute in flowing groundwater." This statement seems to be contradicted by the literature (Zareitalabad et al, 2011), which shows that PFOA and PFOS (and other anionic surfactants) exhibit electrostatic interactions between Fe-*

oxide surfaces. Electrostatic interaction would support a pH dependent retardation factor, further classification of rock types, as well as consideration for other contaminants competing for adsorption sites (especially around the landfill). Barr seems to confirm these interactions are taking place in appendix D1 – Table 6.

> **Response:** The use of "unattenuated" is consistent with the limited adsorption of the compounds to surfaces with low organic material content.
>
> The literature review of Zareitalabad *et al*. (2013) provides references that indicate the potential for the electrostatic interactions between the anionic forms of PFOA and PFOS, and cationic functional groups on inorganic surfaces. However, Zareitalabad *et al*. (2013) provides no guidance describing when electrostatic interactions start to dominate over adsorption on inorganic surfaces. In addition, Zareitalabad *et al*. (2013) also cites references indicating that the hydrophobic interactions with the fluorinated carbon chain of PFOA and PFOS dominate over electrostatic interactions. Retardation appears to be influenced more by the hydrophobicity of the surface area than by surface charge density.

<u>Comment 8:</u> *Section 2.4- PFOA Fate and Transport Conceptual Modeling Approach and Results- the VT ANR does not concur that the modeling approach constituted a conservative model, given that the simulated results are consistently and significantly lower than the measured results.*

> **Response:** As discussed in the Draft CSM Report (Barr, 2017c) the modeling approach was conservative in that air deposition parameters were set to maximize mass deposition relative to alternative methods for defining these parameters. As also discussed in the Draft CSM Report, the assumed PFOA content in dispersions used in the emission calculation was twice the likely actual content. The assumed PFOA content (0.2%) was based on the average high-PFOA content dispersions and twice the typical ammonium perfluorooctanoate (APFO) content (0.1%) for the industry (Drobny, 2001 and Ebnesajjad, 2000). The fact that the modeling approach was conservative and that simulated results are consistently lower than measured is one of many lines of evidence that additional sources of PFOA are present within the investigation area that were not accounted for in the model (i.e., only emissions from the former Chemfab facilities were simulated as a PFOA source in the model).

Section 3 – Work Plan Implementation Activities and Results

<u>Comment 9:</u> *Section 3.0- The SI report indicates that soil investigations were intended to target areas that have been undisturbed since the 1960s. As stated in the general comments, VT ANR is concerned that soil sample results from the undisturbed areas will not provide insight into the distribution of PFOA is soils from past air emissions from the two facilities. The SI report must include a table, or tables, with a description of each boring location identifying whether it is disturbed or undisturbed and an explanation for its given designation. The SI report must also include an evaluation of disturbed versus undisturbed soil results and determine if the outcome of this evaluation has compromised the ability to evaluate relationships and trends in PFAS distribution and assess the measured distribution of PFAS in soils and groundwater against the predicted distribution based on modeling of air emissions.*

> **Response:** For the reasons mentioned in the response to Comment 2b above, the results from soil samples collected within the public ROW are considered representative of the distribution of PFAS in soils.

Comment 10: *Section 3.0- Include a figure that shows all the soil borings and monitoring wells (shallow, deep, and bedrock) on one map. An inset is needed for the Water Street facility, such as was done for landfill, to show the locations of nearby monitoring wells, including the 11 wells installed in 2016 by CT Male at and near the facility.*

> **Response:** Figure 3.1 (Investigation Locations: Shallow) has been revised in the Final CSM SI Report to include deep and bedrock investigation locations (previously shown on Figure 3.2). The revised Figure 3.1 does not include an inset for the Water Street facility, because the intent of the figure is to show investigation locations from the CSM SI, and Water Street was not investigated as part of this investigation. Water Street investigation locations are provided in Appendix I of the Final CSM SI Report.

Comment 11: *Section 3.0-A brief discussion is needed on the modified analytical methods used to collect PFAS samples in soil and groundwater, including assumptions and uncertainties associated with the modified method. Suggest including in the Section 3.5 (QA/QC section).*

> **Response:** A discussion of analytical method modifications has been added to Section 3.5.1.1 of the Final CSM SI Report.

Comment 12: *Section 3.1-Unconsolidated Soil Characterization-The SI report did not include shallow soil sampling results from previous sampling efforts by Saint-Gobain's consultant, particularly the shallow soil sample results included in CT Male Final Draft Shallow Soil Sampling Report, dated July 20, 2016, and the shallow soil samples collected as part of the initial site characterization at the Water Street facility in 2016. The SI report must incorporate these results into the narrative, tables, and figures. Also, ANR is not in receipt of the validated data for the shallow soil sampling effort. The SI report must include the validated results of soil samples collected by CT Male in 2016 and a figure showing the shallow soil sampling results from CT Male 2016 shallow soil sampling effort.*

> **Response:** Soil and groundwater analytical data from the 2016 former Chemfab Water Street facility site investigation were incorporated into the Final CSM SI Report. Water Street PFAS data are provided in tables and figures in Appendix I and are discussed in Section 4.4.2 of the Final CSM SI Report.

Comment 13: *Section 3.1-Unconsolidated Soil Characterization-To better understand trends in total PFAS concentrations relative to PFOA in soils with distance from the Water Street facility, include figure or figure(s) similar to Chart 2 in the CT Male shallow soil report dated July 20, 2017.*

> **Response:** PFAS data from the former Chemfab Water Street facility are presented in tables and figures in Appendix I of the Final CSM SI Report.

Comment 14: *Section 3.1.1-Background Soil Borings-This section summarizes the number of samples with detections relative to the number of samples collected, but this does not give the reader the spatial distribution of detections. Revise this narrative in the final SI Report to identify the number of borings where specific PFAS compounds were detected and non-detected.*

> **Response:** The locations of the background sample locations relative to the study area and the detected concentration of PFOA, perfluorooctanesulfonic acid (PFOS), and TOC in these samples are

shown on Figures 3.2, 3.3, and 3.4, and the frequency of specific PFAS detections in soil is shown on Figure 3.5 of the Final CSM SI Report. The text was updated to provide additional discussion of specific PFAS compounds that were detected and not detected in background samples.

Comment 15: *Section 3.1.1-Background Soil Borings-The color-coded ranges in Figures 3.3 and 3.4 appear too broad to provide insight into the spatial distribution in soils of PFOA and PFOS concentrations, respectively. Based on the distribution of PFOA concentrations in Figure 4.6, suggest the following color-coded ranges for the PFOA and PFOS ranges for Background, shallow borings, and deep borings:*

- *Less than 0.2 ng/g (or non-detect)*
- *Non-detect to 0.75 ng/g*
- *0.751 ng/g to 1.5 ng/g*
- *1.51 ng/g to 5.0 ng/g*
- *5.01 ng/g/ to 10.0 ng/g*
- *Greater than 10.0 ng/g*

Response: The color-coded ranges on these figures (Figures 3.2 and 3.3 of the Final CSM SI Report) were updated to reflect the concentration ranges above.

Comment 16: *Section 3.1.1-Background Soil Borings- There is a color for non-detects (ND) but it is not clear what that value is. Please clarify. If ND varies with a given sample, then clarify this is a note within the respective Figures.*

Response: A note was added to the figures to clarify the non-detect value(s).

Comment 17: *Section 3.1.2-Shallow Soil Borings-The same comments as Comments #14, #15, and #16 but for the shallow boring results.*

Response: Figures were revised in the Final CSM SI Report as requested.

Comment 18: *Section 3.1.3- Deep Soil Borings-The report does not include deep soil sample results from the Water Street SI completed in 2016. The report must incorporate these results into the narrative, tables, and figures.*

Response: The soil sampling results from previous investigations at and around the former Chemfab Water Street facility were incorporated into the Final CSM SI report. Validated Water Street PFAS data are provided in tables and figures in Appendix I and discussed in Section 4.4.2 of the Final CSM SI Report.

Comment 19: *Section 3.1.3-Deep Soil Borings-PFOS concentrations (16 ng/g) in deep soils greater than PFOA (7.2 ng/g) yet groundwater has much higher PFOA levels. Explain this?*

Response: These concentrations of PFOS and PFOA were detected in shallow soils from the deep soil borings. During this investigation, PFOS and PFOA were detected in soil at concentrations of up to 17 and 130 ng/g, respectively. While PFOA concentrations generally exceed PFOS concentrations in soil, there are exceptions such as that noted in this review comment. Given that PFOA and PFOS have similar soil adsorption properties (Zareitalabad et al., 2013), the greater variability and generally lower soil concentrations for PFOS result in generally lower and more variable groundwater concentrations of PFOS compared to PFOA.

Comment 20: *Section 3.1.3-Deep Soil Borings- The same comments as Comments #14, #15, and #16, but for the deep boring results.*

Response: Figures were revised as requested.

Comment 21: *Section 3.1.4-Comparision of Landfill and Non-Landfill Results-This section must be re-named and revised to compare soil sampling results for non-landfill areas to soil samples collected at or near the Water Street facility in 2016. Because of the number of soil samples collected at or around the Water Street facility, provide an inset around the Water Street facility (Figures 3.8 and 3.9) and a separate figure showing the soil sampling results at and in the immediate vicinity of the Water Street facility and how these results compare with the results from the rest of the sampling results from the area-wide SI investigation.*

Response: Consistent with responses to Comments 12, 13 and 18, figures and tables of the validated Water Street analytical data for soil and groundwater are included in Appendix I of the Final CSM SI Report. This data was not included in Section 3, Work Plan Implementation Activities and Results, since, as its name suggests, it is intended to show results for the CSM SI. Comparisons of Water Street data to data from other investigations are provided in Section 4.4.2 of the Final CSM SI Report.

Comment 22: *Figures 3.13 and 3.14 (Frequency of PFAS detections in soil samples)- Include separate figures for Water Street Area, Landfill and non-landfills/Water Streets area. Also, it would be helpful in reviewing the figure if the compounds on this and similar figures were ordered clockwise from the smallest to the largest. Lastly, provide a way to compare the frequency of occurrence with the sample concentration. This could shed light on the importance not only of occurrence but also on the significance of concentration.*

Response: Figures 3.12 through 3.15 in the Final CSM SI Report have been updated to show PFAS detection frequency for the landfill and non-landfill areas. Detection frequency figures incorporating the Water Street data are provided in Appendix I of the final report. All of the detection frequency figures have been revised to show the compounds in increasing frequency of detection. The range of measured concentrations per compound has been added to each figure within the table that defines the PFAS acronyms.

Comment 23: *Figures 3.14-Clarify whether this figure includes shallow soil data collected from the deep borings or only includes deep samples from these boring. Include all shallow results in one figure and note whether it is from a shallow or deep boring.*

Response: Figure 3.14 of the December Draft CSM SI Report included shallow and deep samples from deep borings. Figures 3.13 and 3.14 of the December report were combined into a single figure (3.13) in the February Draft CSM SI Report. For the Final Draft CSM SI Report, the figures have been revised in response to Comments 21 and 22 to compare detection frequency across sampling depths for all locations and the landfill and non-landfill areas (Figures 3.12 through 3.15). As noted in the response to Comment 22, Water Street detection frequency figures are provided in Appendix I of the Final CSM SI Report.

__Comment 24:__ *Section 3.3- Groundwater Characterization-CT Male indicated that the validated groundwater and soil sample result collected at the Water Street Facility in 2016 would be included in this report. Include validated analytical results and all applicable figures and tables to present these results.*

Response: The validated groundwater and soil PFAS analytical results from the former Chemfab Water Street facility are provided in Appendix I of the Final CSM SI Report.

Section 4 - Analysis

Section 4.2 - Hydrogeologic Conditions

Slug Tests

__Comment 25:__ *Saturated thicknesses are set to the difference between the water table to the bottom of screen rather than the actual aquifer thickness. For overburden, the difference between the water table and the top of rock may be more appropriate.*

Response: The bottom of the well is located at the top of rock for wells SG3-MW17-01, SG3-MW17-04, SG3-MW17-05, and SG3-MW17-07. The stress to the aquifer from a slug test typically does not extend very far away from the well, and therefore approximating the aquifer thickness as the distance from the water table to the bottom of the well is considered appropriate for an unconfined aquifer. To test this assumption, the SG3-MW17-03 analysis was re-run using an aquifer thickness of 123 feet (based on depth to water of approximately 7 feet bgs at SG3-MW17-03 and top of altered bedrock at 130 feet bgs at adjacent SG3-MW17-BR1) instead of 13.46 feet. The differences between the original estimated hydraulic conductivity (K) values (0.76 and 0.53 ft/day) and the estimated K values using the larger aquifer thickness (0.65 and 0.47 ft/day) were negligible.

__Comment 26:__ *Double straight line (rapid sand pack drainage for situations where the water table lies within the screened interval) invokes need to input sand pack porosity. For SG3-MW17-03 porosity was set to zero.*

Response: Following the AQTESOLV guidance for a well screened across the water table in an unconfined aquifer, equation 6.11b from Butler (1998) was used to compute the effective casing radius. This equation is a function only of the casing radius, expected initial displacement, and apparent initial displacement. Therefore, the gravel pack porosity value, which is automatically listed on the AQTESOLV report, does not factor into the analysis.

__Comment 27:__ *Compare results for SG3-MW17-04 using double straight line (sand pack drainage) option.*

Response: Well SG3-MW17-04 is not screened across the water table. The static water level at the time of the slug testing was approximately 28 feet above the top of the sandpack. It would be inappropriate to assume sandpack drainage in the analysis when the sandpack remained fully saturated during the slug testing.

__Comment 28:__ *For SG3-MW17-02, the K is high enough to suspect or expect inertial effects. The data may not be dense enough to show damped oscillations. Please provide the AQTESOLVE files.*

Response: The slug tests conducted at SG3-MW17-02 stretched the limits of the equipment used (solid slugs, transducers with a minimum recording interval of 2 Hertz); pneumatic slug tests were not possible at this well because it is screened across the water table. The discussion in Appendix G.2 acknowledges that the slug test K values for this well should be considered approximate because of the rapid response and limited available data. Given the lack of data points and the lack of any observed oscillations, it would be inappropriate to manipulate the Springer-Gelhar (1991) solution to fit an oscillatory response to the few available data points from SG3-MW17-02.

Grain Size K estimates

Comment 29: *Provide equations used for three methods (Barr, Kozeny-Carmen, Hazen) in the final SI Report.*

Response: Appendix G.3 has been updated in the Final CSM SI Report to include the Barr, Kozeny-Carmen, and Hazen equations.

Comment 30: *Hazen was designed to be used with uniform, coarser materials, not soils with high proportions of clays and silts which seem to be the dominant soil types here. Hazen is usually better for low coefficient of uniformity as well (some references suggest CU < 5). For the samples subjected to grain size analysis, the CU is generally much greater than 10 and often > 100. Include narrative in the report that discusses these limitations and how the Hazen method was used in determining the K values selected in the SI report.*

Response: The goal of the analysis of grain size distributions was to estimate an approximate K range. Multiple methods were used because assumptions vary between methods. We acknowledge that the Hazen method may not be applicable for fine-grained samples but this method is commonly used to estimate K for all soil types. For consistency, a Hazen K was calculated and reported for all samples. Discussion of the limitations of the Hazen equation was added to Appendix G.3 of the Final CSM SI Report.

Comment 31: *An assumption of porosity of 0.3 for the Barr and Kozeny-Carmen methods may not be appropriate (i.e., too low) for the range of soil types sampled and analyzed. Substantiate why this assumption was used for porosity.*

Response: The porosity in the Barr (2001) equation (which is based on the Kozeny-Carmen equation) is the effective porosity. The effective porosity is less than the total porosity because it includes only the pore volume through which water flows. The assumed effective porosity of 0.3 is within literature ranges for effective porosity of sands, silts, and clays (e.g., Rawls, Brakensiek, and Miller, 1983). Appendix G.3 of the Final CSM SI Report was revised to include this discussion of effective porosity.

Comment 32: *No comment 32*

Response: (Not applicable)

Section 4.3 – Relationships and Trends in PFAS Concentration

Comment 33: *Section 4.3-The SI report lacks analysis of PFOA data in relation to the releases from the former Chemfab Northside Drive facility. The Northside Drive facility is located towards the southeast corner of CAA II. The failure to include an assessment of soils from the Chemfab facility to other soil sample results is a serious flaw in the CSM given that one of the primary wind directions is from the south. Barr's air* *modeled annual deposition results in CAA II are similar to those of CAA I, and soil and private wells north of the plant have elevated concentrations of PFOA. Compare soil results from around the Water Street facility with other soil results around Bennington as a part of the revised CSM report.*

> **Response:** Investigation activities at the former Chemfab Water Street and Northside Drive facilities were not scoped as part of the approved Revised Work Plan – CSM Site Investigation: Bennington, Vermont (Work Plan; Barr, 2017a, 2017b) and site-specific data was not collected as part of the CSM SI. However, the Final CSM SI Report was updated with 2016 Water Street data collected by C.T. Male as an additional location category in the evaluation (Appendix I and Section 4.4.2 of the Final CSM SI Report).
>
> As discussed in other comment responses (e.g., Comment 2c), the CSM SI soil data indicate that PFOA deposited by historical air emissions at both facilities is no longer present at detectable levels in the soil. This is especially true for the Northside Drive facility, given that the investigation was performed nearly forty years after air emissions from the facility ceased (1978). A discussion of the investigation data in relation to the former Chemfab facilities at Water Street and Northside Drive was added to Section 4.4.2 of the Final CSM SI Report.

<u>Comment 34:</u> *Section 4.3-The SI report states the chemical signature from air emissions from Chemfab is no longer distinguishable in soil data. What is the chemical signature that represents the Chemfab release? What has changed such that it is no longer apparent in soils?*

> **Response:** The chemical signature of air emissions mentioned in this section was a reference to concentrations elevated above background and with a spatial distribution consistent with an air emissions source from the former Chemfab facilities. This statement was revised in the February Draft CSM SI Report (Section 4.3.1.2, Spatial Trends in Soil PFAS and Section 4.5.3, Comparison to the Conceptual Model). As discussed in other comment responses, the soil concentrations of PFOA associated with air emissions are no longer present in soil due to the leaching of PFOA out of the soils since the emissions from the former Chemfab Water Street facility ceased in 2002.

<u>Comment 35:</u> *Section 4.3- The SI report states a preliminary multivariate analysis (MVA) did not yield results from which distinct signatures of other potential sources could be readily identified. This statement seems to contradict Barr's assertion that other sources are a possible cause of contamination. Discuss this discrepancy in the final SI Report.*

> **Response:** The statement was revised in Section 4.3.1.2 of the February Draft CSM SI Report to more clearly state that the lack of distinct signatures identified in preliminary multivariate analyses was because soil concentration data are most closely tied to background sources.

<u>Comment 36:</u> *Section 4.3-The box-and-whisker plots on Figure 4.7 must include a separate plot for the Water Street Facility and immediate vicinity, using CT Male 2016 data (soil and groundwater data) so that a more meaningful examination can be made between results at and near the Water Street facility to other results.*

> **Response:** A box-and-whisker plot for Water Street data was added to each plot of the Final CSM SI Report (Figure 4.9 in the Final CSM SI Report).

Comment 37: *Section 4.3-Although addressed in Appendix D, please include in this section what data was used for the statistical analysis. Was the soil data from the Water Street initial SI (2016) used in the statistical analysis? It was not clear from the narrative in Appendix D. If not, include this soil data in the analysis.*

Response: The analysis has been updated to include the 2016 Water Street soil data. A description of the data sources for the statistical evaluation has been added to Section 4.3.1 and revised in Appendix D.1a of the Final CSM SI Report.

Comment 38: *Section 4.4.1-Background PFOA Soil Concentration-The report states PFOA concentrations are not significantly different between the background soils and non-landfill soils. Barr's derivation of background has serious shortcomings as described in Comment 2 and in comments below.*

Response: Section 4.3.1.2 of the Final CSM SI report states that the soil PFOA concentrations in the four background locations are not significantly different from the non-landfill sampling locations.

See Comment 2c and comments provided below for responses regarding the development of a background soil PFOA concentration for the CSM.

Comment 39: *Section 4.4.1-Background PFOA Soil Concentration-VT ANR disagrees with Barr's premise suggested in this section that the two Bennington Chemfab facilities plants did not contribute to PFAS found in the background samples. As stated in Comment 2c, their premise ignores the fact that these facilities emitted many tons of PFOA and are located between 8 and 22 miles from the background locations and are in the prevailing downwind direction of the two facilities. This premise also implies that all PFAS at these background locations came from potential sources that are much further away that the two former Chemfab facilities. The VT ANR air modeling indicates that 65 percent of the PFOA emitted from the Water Street facility left the model domain. It seems more plausible to believe that at least some of the PFOA found in the "background" samples have come from the 65% of the PFOA emissions from the Water Street facility that have left the model domain than from "ubiquitous" sources.*

Response: As discussed in the response to Comment 2c, residual impacts of the historical Chemfab air emissions are not apparent in the present-day soil PFOA concentrations at the four background locations.

Comment 40: *Synthetic Precipitation Leaching Procedure (SPLP) results from soil samples collected as part of the split samples that ANR's contractors collected, showed that soils with non-detect for PFOA had detectable levels of PFOA in the SPLP leachate. This could explain why some areas of Bennington that have low levels of PFOA or non-detect levels of PFOA in soils have detectable levels of PFOA in groundwater.*

Response: The potential for leaching of PFOA from soils suggested by the leachability testing results is consistent with the conceptual model of PFOA fate and transport. The test results alone do not definitively show the potential for soils with non-detect levels of PFOA in soil to be associated with detectable levels of PFOA in groundwater, due to limitations of the testing methodology (discussed below) and the need to account for the other factors affecting groundwater concentrations at a given location, e.g., groundwater flow rate/direction, upgradient groundwater concentration, infiltration rate, depth of mixing, etc.

The results of SPLP cannot be directly compared to the results from the soils analysis or the groundwater analysis. The SPLP method for this analysis involves several concentration steps when compared to a standard soils analysis. The first is the use of 20X the solids volume, and the second is the concentration of the resulting leachate, which effectively reduces reporting limits by a factor of 20. Additionally, the sample undergoes an extended period of agitation (i.e., tumbling) and pH adjustment to acidic levels (pH 4.2). The SPLP extraction is not designed to be compared against analytical results not undergoing the SPLP extraction, but is typically used to simulate the leachate generation from acid rain. SPLP procedures were originally designed to estimate the leachability of substances present in liquids soils and wastes, and PFAS compounds have already been established to be highly leachable under most conditions.

<u>Comment 41:</u> *Section 4.3.1.3 Presence of Sulfonated PFAS Compounds- The report states that presence of sulfonated PFAS are not a result of the emissions for the Chemfab Plants and are indicative of other PFAS sources. Barr has not presented evidence that Chemfab emissions only produced PFOA or that other potential sources of sulfonated PFAS also released PFOA. In addition, the sporadic presence of PFOS at very low concentrations in soils and groundwater does not mean that the PFOA in CAA II is not from the former Chemfab facilities. In addition, the Taconic Plastics 2016 stack tests results also strongly suggest that many different PFAS are emitted from a similar process, including sulfonated PFAS.*

Response: No information has been identified to suggest that PFOS was in the dispersions used at either the Water Street Facility or the Northside Drive Facility. Stack testing from Taconic Plastics in 2016 is not representative of PFAS use and operations at the former Chemfab facilities in part because operations at the Chemfab facilities ceased before 3M and DuPont phased out production of PFOA between 2002 and 2006 and turned to replacement chemistries. If PFOS was a significant component in the emissions from the former Chemfab facilities, PFOS detections in soil and groundwater would be expected to be similar in pattern to PFOA in areas where modeling indicates measurable deposition may have taken place; however, this is decidedly not the case.

<u>Comment 42:</u> *Section 4.3.2.1 Multivariate Analysis (MVA) of Groundwater Data- The report states that a groundwater MVA cluster analysis was conducted and suggests that it demonstrates a variety of other PFAS sources within the investigation area. While there may be other sources of PFASs in the area, no link of combined PFOA and sulfonated PFAS sources has been provided in the report. This section references Figure 4.10 to support it claims. Review of Figure 4.10 indicates the majority of wells in CAA II have a PFAS profile similar to those in CAA I, including those closest to the Chemfab plants (PFOA/PFHpA with no or low sulfonated PFAS).*

Response: PFOA, along with PFOS and other PFAS compounds, is a common PFAS constituent in many industrial, commercial, and consumer products. Unlike the dispersions used by Chemfab (which inventory data indicate contained only PFOA), commercial, industrial, and consumer goods are expected to be sources of a wide variety of PFAS compounds. Depending on the mixtures of materials and uses, many different combinations of PFAS compounds would expect to be attributed to various sources and co-mingled waste.

<u>Comment 43:</u> *Section 4.3.2.1 Multivariate Analysis of Groundwater Data-Figure 4.10 color-codes of three statistical groups:*

- *Groundwater with PFOA or PFOA/PFHpA low or no sulfonated PFAS compounds;*

- *Groundwater with widespread sulfonated compounds; and*
- *Groundwater with high proportions of sulfonated compounds.*

Please define your groups. What is considered low or no sulfonated PFAS compounds; what is considered widespread sulfonated compounds; and what is considered high proportions of sulfonated compounds?

> **Response:** The legend for Figure 4.12, Cluster Analysis of PFAS in Groundwater, and the associated report text, have been modified in the Final CSM SI Report to better describe the different groupings of samples.

<u>Comment 44:</u> *Section 4.3.2.2 Groundwater Type Classification. The ANR does not agree that the use of major elements (ions) alone can be used to reliably discriminate groundwater chemical groups (or sources) in the unconsolidated aquifer. Given the heterogeneity of surficial deposits and the underlying bedrock formations from which these deposits were derived, accurate discrimination of groundwater chemical groups (or sources) in the unconsolidated aquifer needs to be more robust and include trace elements and stable (H and O) isotopes.*

> **Response:** While inclusion of trace elements and stable isotopes of water would provide additional information to distinguish groundwater groups/sources, major ion composition alone was proposed in the Work Plan (Barr, 2017a) approved by VT ANR as it provides a reliable and efficient way of approximating groupings of water samples. In this investigation, the major element chemistry of the waters generally shows no distinctions among groups (e.g., Bennington Landfill, bedrock wells, Water Street) that would suggest a differentiation of sources that would necessitate refinement of the CSM through the proposed additional data collection.

Section 4.4 - Evaluation of PFAS Sources

<u>Comment 45:</u> *Barr has introduced the possibility of a regional background presence of PFOA as a reason why the modeling performed to date has resulted in consistent under-prediction of observed PFOA concentrations at monitoring locations. Barr details this approach in a Technical Memorandum contained in Appendix D.2. Barr has used the data from four selected background locations identified for the SI investigation in conjunction with inferences from the 2016 Rankin, et al., study to posit what it terms 'a representative background perfluorooctanoic acid (PFOA) soil concentration'. While in the introduction's first paragraph Barr acknowledges that "A regionally constant background PFOA soil concentration should not be expected," Barr appears to do exactly that. This exercise is flawed on several counts. First, the use of a global survey to establish probable background PFOA to total organic carbon ratios; second, the treatment of these data; third, the use and analysis of the background data set for the SI report, and lastly the omission of other SI data that suggest alternate possible background PFOA concentrations or impacts.*

> **Response:** Comment 45 suggests that the use of a constant background PFOA soil concentration in the CSM and that the development of this single background PFOA soil concentration is flawed. The evaluation of incorporating a background source in the numerical models of the CSM required a constant single background PFOA soil concentration, to be consistent with the simulation of uniform transport properties in the vadose zone across the entire modeled domain. This meant that the TOC content was set to a single value and hence the background PFOA concentration was set to a single value. Thus, the development of a single background PFOA concentration was by design to meet the requirements of the model. Because actual vadose-zone transport properties are not uniform across

the site or region, background PFOA soil concentrations will vary even when exposed to the same PFOA deposition rate (see response to Comment 2c). Thus, the associated comments in the CSM SI Report are correct.

For the CSM SI Report, the background PFOA soil concentration was obtained from the soil PFOA concentrations and TOC contents for four background sampling locations located between 8 and 22 miles from the former Chemfab facility. The resulting PFOA concentrations and PFOA/TOC ratios were compared to the cumulative probability distribution for a log-normal characterization of the Rankin *et al*. (2016) dataset for soil samples from thirty-three North American locations. The PFOA concentrations and PFOA/TOC ratios for the four background locations corresponded to the upper range of values reported by Rankin et al. (2016). While VT ANR comments mention potential improvements in the statistical characterization of the Rankin *et al*. (2016) dataset, samples from the four background locations would still correspond to the upper range of values provided Rankin *et al*. (2016).

As discussed in the response to Comment 2c, the soil data from the background sampling locations are consistent with a regional background source.

a) *Use of the Global Survey- Barr uses as a guide, data from a 2016 study (Rankin, et al.; A North American and global survey of perfluoroalkyl substances in surface soils: Distribution patterns and mode of occurrence). Barr cites that Rankin, et al sampled 33 locations in North America for background PFOA concentrations in surficial soils. However, the Rankin et al. study does not claim to be more than a survey of distributions for the perfluoroalkyl compounds (PFOA included). The Rankin et al. study, while attempting to obtain samples from perceived undisturbed locations noted that "The PFCA and PFSA congener profiles were similar amongst most locations, with a few principal-component statistical anomalies suggesting impact from nearby urban and point sources." In the Rankin, et al. study, a single surficial soil sample was taken which was then analyzed in triplicate. Multiple samples were not taken at each location to provide a true assessment of background concentrations at these selected locations. Field sampling and analytical error were assessed by the use of field and process blanks. The study reported data corrected for process blanks, but was unclear if the data were adjusted for the field blank results. When considering the data as presented on Tables S2, S13 and S14 in the supporting information to the Rankin, et al paper, two additional features of the North American (NA) data set should be noted: 1) it includes a wide band of environmental conditions (an aim of the study) from Puerto Rico to Canada to Mexico to Alaska, which would not be similar to the Bennington setting; and 2) the supporting study information notes that these data are influenced by "Several factors such as the proximity to emission sources, precipitate and other soil properties that differ significantly amongst sampling locations, which may preclude any direct comparison with TOC."; and "Lastly, there are inherent differences in soil properties, such as pH and cation exchange capacity (CEC) because of the geographical differences between sampling locations, which could suppress the sorption of PFCAs and PFSAs to TOC."*

Response: In the December Draft CSM SI Report, the potential background soil PFOA concentrations for specific soils samples were approximated using the 95th percentile value of the PFOA/TOC (0.1172 ng/mg) observed by Rankin et al. (2016) for thirty-three North American surficial soil samples. The Final CSM SI Report uses a PFOA/TOC value of 0.109 ng/mg to calculate the potential background soil PFOA concentrations for specific soil samples. This revised PFOA/TOC value was obtained directly from the data for the superficial soils at the four background sampling locations. See response to

Comment 2c. Any potential limitations regarding the Rankin et al (2016) data are not significant to prevent the use of the data (for comparison and perspective) in the Final CSM SI Report.

b) *Treatment of Data-Barr's treatment of the Rankin et al. study data is to accept them as truly representative of a range of regional background concentrations or, and more importantly ratios of PFOA to TOC, despite the above warnings and the more general Rankin, et al study goal (as a survey for world-wide distribution of PFAS) and uses all 33 North American (NA) sample results in justifying a site-specific PFOA/TOC ratio from SI background samples. Boxplots were prepared that show the Rankin et al. NA data set contains several outliers. In deleting these outliers in three successive steps, the resulting data (27 remaining samples) are still skewed (not normally distributed), but more likely log-normally distributed, and the mean and median PFOA/TOC values have decreased significantly, suggesting that the Bennington site-specific PFOA/TOC value (discussed next) may be subject to outlier bias as well. In successively removing the outliers, the respective means and medians for the NA data set of PFOA/TOC ratios become: 0.03 and 0.00726 ng/g soil (contrary to a median value of 0.0113 ng PFOA/mg TOC cited by Barr on page 2 of their internal memorandum (Appendix D.2) for all 33 values; 0.01863 and 0.00581 ng/g soil for 30 values; and 0.01245 and 0.00545 ng/g soil for 27 values. The skewness and kurtosis for the three data sets are 2.10 and 4.3 for all 33 values, 1.71 and 2.43 for 30 values, and 1.48 and 0.96 for 27 values. For the ln-transformed data set (27 values), the skewness was 0.29 and the kurtosis -0.63. Thus the use of the 95 percentile on the entire NA data set as a guide for an acceptable PFOA/TOC ratio likely produces an excessively high value for the ratio. Barr also cites the PFOA/TOC ratio for the Rankin et al. study sample NA17 at Holderness, NH, as further support while still acknowledging that "There is no indication whether the NA17 site was located near a cross-country skiing area. Use of fluorinated cross- country ski wax can result in locally elevated soil PFOA concentrations along ski trails." However, there also is no indication that it is not, and as the Rankin et al. study and data show, there are numerous other factors why this PFOA/TOC ratio could be elevated, and that the study samples were not meant to be, nor should they be considered, as representative of local background.*

Response: Comment 45b suggests approaches for improving the characterization of the Rankin *et al*. (2016) dataset for the thirty-three North American superficial soil samples. Suggested approaches included identification and removal of potential outliers, and to log transform the data to reduce skewness and kurtosis. Without additional information regarding which data points were chosen to be removed and why, we cannot comment on specific values obtained in the analysis. For the Final CSM SI Report and preceding draft versions, no data points were removed from the North American dataset, and the data were log transformed to reduce skewness and kurtosis. The cumulative probability distributions of PFOA concentrations and PFOA/TOC ratios were developed using the log transformed data.

Comment 45b also suggests that the Rankin *et al*. (2016) dataset should be used with caution, because the location-specific soil transport properties (other than TOC content) and location-specific PFOA deposition rates were not quantified. However, Vedagiri *et al*. (2018) suggest that the Rankin *et al*. (2016) North American dataset represents background soil PFOA concentrations, especially on a regional basis. See the response to Comment 45a.

Finally, Comment 45b correctly indicates that the North American values from the Rankin et al. (2016) dataset were used to suggest that the four background soil samples had average PFOA concentrations and PFOA/TOC values that were within the range of previously reported background values.

c) *The site-specific regional background sampling at just four locations is a very limited basis upon which to base Barr's main conclusion that the assumed regional background deposition is enough to correct the apparent under-prediction of the modeling versus observed concentrations. If truly regional, then more recent surficial deposits might be expected to exhibit a more uniform composition, e.g., PFOA/PFOS ratios, but apparently they do not (PFOS is quite variable across the study area).*

Response: Comment 45c suggests that soil samples collected from four sites located between 8 and 22 miles from the former Chemfab provides a limited basis for assessing the magnitude of the continuing PFOA deposition occurring in the Bennington area, and suggests that the relative concentrations of PFAS in superficial soil soils should mirror the relative concentrations associated with wet and dry deposition. As described in the response to Comment 2c, the available data indicates that continuing PFOA deposition is relatively uniform across the region encompassing the four background soil sampling locations and is the only mechanism that can explain the observed linear relationship between TOC content and soil PFOA concentration, provided that infiltration rates are similar across the region. Surficial soil PFAS concentrations are influenced by three mechanisms: deposition, infiltration, and retardation. The degree of retardation is chemical specific. Even if continuing regional deposition was the only source of PFAS and the rate of regional background deposition was spatially and temporally constant, the horizontal and vertical variation in retardation across the site would cause variations in the relative concentrations of PFAS in the superficial soils. Thus, the expectation expressed in Comment 45c for a uniform distribution is unrealistic.

d) *The SI sampling plan selected four locations considered unlikely to be affected by site-related releases and ranging from 8 to 22 miles from the former Water Street Chemfab facility. Samples were obtained from 0-0.5, 0.5 to 1.0, 1.0 to 1.5 and 3 to 4 feet below ground surface from each of the four locations. Analysis of these samples included PFOA and TOC and these data were used to calculate PFOA/TOC ratios. Although the objective was to establish 'background' for individual depths (corresponding to unsaturated zone modeling layers (0-10 cm, 10-30 cm, and >30 cm), the samples for 0-1.5 ft were lumped for the analysis. This probably reflects the limited background data set. Based on comparison with the Rankin et al. study data and 95th percentile ratio, the location BG1 was eliminated from calculation of acceptable PFOA/TOC ratios. Even so, a single average PFOA/TOC ratio was calculated for each location and then the resulting three values averaged to produce a projected average 'background' ratio of 0.0586 ng PFOA/mg TOC for the site (as opposed to an average of 0.01245 and median of 0.00545 ng PFOA/mg TOC for the reduced Rankin et al. NA data set). This was then multiplied by the assumed TOC content (25,000 mg/kg) of the top 10 cm used in the unsaturated zone model, expressed as fraction organic carbon (foc of 0.025), rather than the site-specific actual determined TOC average of 16,000 mg/kg (foc of 0.016) as summarized on Table 4.1 (page 37 of the Draft SI report). The resulting computation produces a proposed 1.46 ng/g "background" concentration for the Bennington area. This result is then applied to the results of the transport modeling to potentially account for the model's general under-prediction of impacts to groundwater.*

Response: We agree with the summary of background analyses provided in Comment 45d. No response required.

e) *While the background data set of four samples was specifically selected for comparison, there is no guarantee that these locations would not provide anomalous results. Further, with the elimination of one location and the non-detect of one of the three remaining samples, the statistical analysis of such a small data set leaves considerable doubt as to its representativeness. While other shallow and deep soil borings were placed relatively randomly across the SI study domain, and some were targeted for specific suspected impacted locations (e.g., the Bennington Landfill), nonetheless many samples, despite the suggestion of a widespread "background" surficial soil concentration of 1.46 ng/g soil and a representative PFOA/TOC ratio of 0.0586 ng/mg TOC, many of the samples analyzed at these boring locations provided cleaner samples than the proposed background levels. Of the approximately 70 soil sampling locations, 9 had a surficial sample PFOA concentration less than 1.46 ng/g but greater at a deeper depth, 46 had all samples with shallow depths analyzed as less than 1.46 ng/g, and only 15 locations had surficial soil concentrations greater than the 1.46 ng/g PFOA. Further, 45 of the samples had a PFOA/TOC ratio less than the proposed value of 0.0586 ng PFOA/mg TOC with a mean of 0.021 and a median of 0.015 ng PFOA/mg TOC. The lack of widely spread proposed "background" concentrations across the study area suggests the proposed number of 1.46 ng/g is excessively high to use as a background concentration.*

Response: Comment 45e suggests that the single background soil PFOA concentration used in the Conceptual Site Model is excessively high, because about two-thirds of the shallow soil samples had PFOA/TOC values less than the 0.0586 ng PFOA/mg TOC used in developing a background superficial soil concentration for the model. While it is true that a number of the surficial soil samples had measured PFOA/TOC ratios less than the average value of 0.0586 ng PFOA/mg TOC obtained from three of the four background sampling locations, the surficial (0 – 0.5 ft) soil dataset suggests that out of 33 individual samples (locations) with measurable PFOA concentrations one-half had PFOA/TOC values greater than 0.0586 ng/mg. The 33 samples had an average value of 0.097 ng/mg and a median value of 0.058 ng/mg. The inclusion of the samples with PFOA concentrations below the MDL lowered the average and median values to 0.073 and 0.031 ng PFOA/mg TOC, respectively.

f) *In summary, the analysis misapplied the Rankin et al. data set as representative of background, does not examine the Rankin et al. data set for apparent sampling location outliers or other environmental factors differentiating them from Bennington (thereby needing adjusted guidance according to the changed statistics), considers only the four-sample background data set locations combining depths and PFOA/TOC ratios for 0-1.5 ft rather than upper 6-inches (understandable given the few data points), and applies assumed foc values rather than those resulting from the SI data.*

Response: Responses to the topics presented in this comment are addressed in responses to Comments 2c, 45a, 45b, and 45e.

Section 4.5.2 - Evaluation of Expected Distribution of PFAS Concentrations

Comment 46: *Figure 4.14 presents measured versus simulated PFOA in soil under two conditions (a) all data in previous and the current investigations and (b) measured versus simulated PFOA in soil for model layers 1, 2, and 3. Figure 4.14 (a) shows poor correlation between measured versus simulated concentrations; with measured concentrations being much higher than simulated (roughly 2 orders of magnitude). Figure 4.14(b) adds a "background" mass to the simulated results for each model layer, which improves the overall correlation, but the fit is still poor (biased high in measured concentrations). The basis for the background* *adjustment, as discussed previously, has serious shortcomings and does not explain the poor correlation between modeled and observed result.*

> **Response:** As described in Section 4.5.2, simulated soil concentrations of PFOA are consistently lower than measured values across the investigation area. The difference between simulated and measured soil concentrations shown on Figure 4.17a (Figure 4.14a in the December Draft CSM SI Report) is one of many lines of evidence that emissions from the former Chemfab facilities alone does not explain the distribution and the amount of PFOA currently observed in the soil. Inclusion of background soil concentrations significantly improves the correlation as shown on Figure 4.17b (Figure 4.14b in the December Draft CSM SI Report). As discussed in Section 4.5.3, Figure 4.17b illustrates two considerations: (1) representing more of the measured spatial variability in TOC concentrations in the model would likely improve agreement between simulated and observed PFOA soil concentrations and (2) including background contributions to soil concentrations is important in assessing the fit between model-simulated soil concentrations and measured concentrations. Further discussion regarding VT ANR's comments about background concentrations is provided in responses to other comments, including Comment 2c.

<u>Comment 47:</u> *Text describing aspects of the data evaluation indicates sampling for TOC/foc was biased by preferential selection of soil with visible organic content. The text has confusing statements such as "the method detection limit exceeded the minimum detected values", and "therefore non-detect values were not accounted for in the geometric mean calculation". Interpreted literally this means that the MDL was greater than the minimum detected values for TOC. If so, how could the minimum detected values be detected if they were below the MDL? For statistical purposes, it also common to us ½ the MDL for non-detects. There is no discussion of the data distribution, so it is not clear if the geometric mean is a better measurement than an arithmetic mean for this particular data set. It is understood that geometric mean calculations cannot contain zero values. Table 4.1 lacks units for foc but it is understood to be the decimal equivalent of percent.*

> **Response:** The text in Section 4.5.2 has been revised for clarity. Statistics in Table 4.2 (Table 4.1 in the December Draft CSM SI Report) have been updated to reflect additional data from Bennington College and the Water Street facility, as requested in Comment 49 below. The updated statistics also use values of ½ the MDL for non-detects. The data distribution for fraction organic carbon (foc) is presented on the revised Figure 4.20, foc vs. Depth in Soil, in the Final CSM SI Report. By definition, foc is unit-less. Table 4.2 in the Final CSM SI Report has been updated for clarity.

<u>Comment 48:</u> *Please add units to Table 4.1. The minimum and maximum values at each depth vary by a small factor (3 - 3.5) yet the geometric means vary by more than an order of magnitude, and the foc values selected as model inputs vary by two orders of magnitude. Use of the selected foc values for the model input is not supported by the data statistics as presented in Table 4.1. Provide the data set used to calculate Table 4.1 summary statistics and review that data against available site data.*

> **Response:** As discussed above in response to Comment 47, foc is by definition unit-less; Table 4.2 (Table 4.1 from December Draft CSM SI Report) has been updated for clarity. The investigation data used for summary statistics in Table 4.2 are presented in Tables 3.5, 3.6, 3.8, 3.9, and 3.10; other foc data represented by the summary statistics in Table 4.2 are the data from C.T. Male *Draft Shallow Soil Sampling Report, Former Chem Fab Site & Surrounding Areas* (C.T. Male, 2016b) and unpublished data provided by Bennington College for soil borings at Bennington College. The data collected for this investigation confirm the conceptual model of organic carbon decreasing with depth and confirm that

values used in the model are representative and fall within the range of expected values. The geometric mean (or other measures of central tendency) are not appropriate for direct comparison to model values and are provided for descriptive purposes only. The model input values are the result of model calibration to groundwater concentrations, and the results of the SI confirm that the values follow the observed trends and are within the observed ranges.

Comment 49: *The full soil data set had not been compiled at the time of this review and will need to be evaluated for foc, with a focus on vertical distribution in soil. Data from Bennington College, soil investigations around the former Water Street facility, and available SI data indicate considerably higher foc values at depth than were used by Barr in their model. The use of artificially low foc in the soil leaching model results in rapid leaching and loss of PFOA in soil, thereby yielding an overly optimistic timeframe for clean-up of both soil and groundwater. The applicable model(s) must be revised to reflect the results of the SI data that shows higher foc values at depth than the assumed values used in the Barr models.*

Response: Figure 4.21, foc vs. Depth in Soil, (Figure 4.15 in December Draft CSM SI Report), Table 4.2 (Table 4.1 in December draft), and the text in Section 4.5.2 of the Final CSM SI Report have been updated to include Bennington College and Water Street facility organic carbon data. As discussed in the responses to Comments 47 and 48 above, results of the CSM SI confirm that the values used in the model for foc follow the observed trends with depth and are within the ranges observed. The SI data do not indicate foc values at depth are "considerably" higher; 121 of the 524 samples from depths below 36 cm had detections lower than the value used in the model for that depth range (0.0005) or were non-detects. Values of foc in the model are not "artificially" low; the foc of the 0-10 cm depth range, shown to be the most sensitive foc value (Barr, 2017c) is 1.6 times higher than the geometric mean, though still well within the observed range, and 95 of 130 samples in that interval had foc values lower than the model value.

Section 4.5.3 - Comparison to the Conceptual Model Unsaturated zone modeling

Comment 50: *The geometric mean of 0.0032 for observed foc in the >36 cm below the ground surface zone is 6 times that used in the unsaturated zone model (Table 4.1). While Figure 4.15 suggests foc may generally be < 0.005 in the very deep zones, the model needs refinement to account for the fact that one foc value does not appear to be representative for the vadose zone below a depth of 36 cm One approach is to use a gradation of foc values over layers 3- 16 within the unsaturated zone model.*

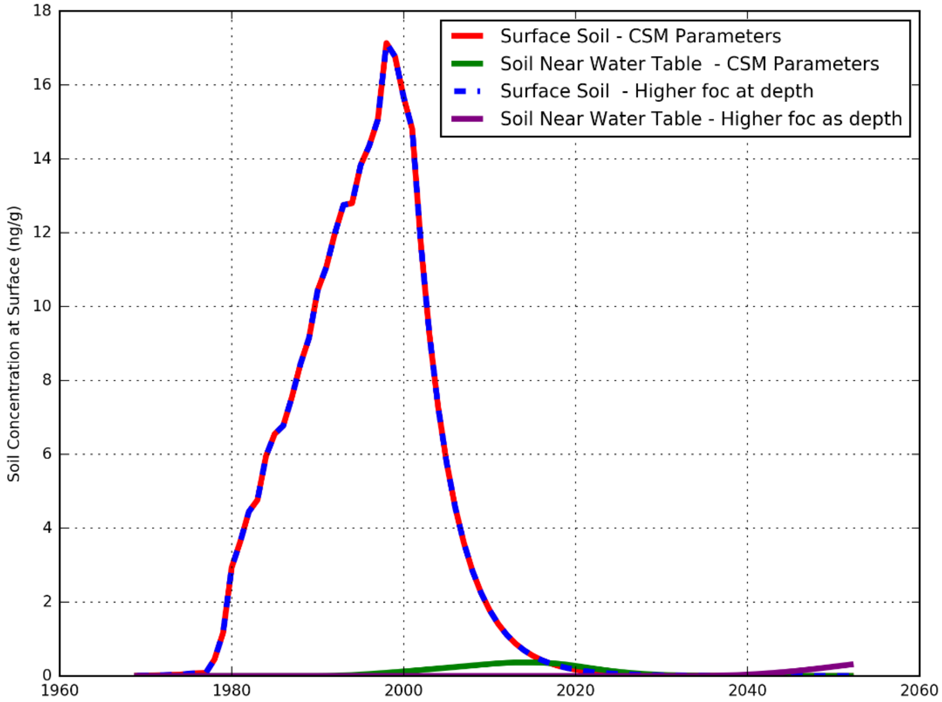
Response: As discussed in the responses to comments 47, 48, and 49, foc values used in the model are supported by the data from this study. The geometric mean (or other measures of central tendency) are not appropriate for direct comparison to model values; they are provided for descriptive purposes only. The results of the SI confirm that the foc values determined during model calibration follow the observed trends and are within the ranges observed. Models representing heterogeneous environments can always be further parameterized, such as the suggested gradation of foc in deeper layers. However, such parameterization must be done in a way that is justified by the data and does not hinder the predictive capacity of the model (Hill and Tiedman, 2007). As shown in Appendix D of the Draft CSM Report (Barr, 2017c) the foc of layers 3-16 is the least sensitive of the foc parameters and additional parameterization of this interval would likely provide little improvement and could potentially negatively affect the predictive capacity of the model.

Comment 51: *Figure 4.16 shows a typical delay curve for the rise of surface zone concentrations over the period of Chemfab operation and fall after emissions ceased, and the resultant soil concentration at the water table as they rose to a maximum and then fell, but including a delay dependent on the assumed recharge, vertical K, and retardation factor (different for the three vertical soil zones). The foc is a major factor in determining the retardation given assumptions for bulk density, porosity and organic carbon partition coefficient. If the foc in the lower soil column is greater than assumed (0.005), then there may be more PFOA mass in the unsaturated zone and delay patterns may be different than shown. For comparison, even using the unsaturated zone assumed foc values (using bulk density of 1.86 g/cc and a porosity 0.3), the retardation factors are 86.25, 18.05, and 2.705 for the 0-10, 10-36, and >36 cm depth intervals, respectively. If the > 36 cm foc value were the geometric mean of the observed values (0.0032), the retardation factor would be 11.9. However, as pointed out above, a more realistic approach would be to provide a gradation of foc over the lower unsaturated zone model layers. This refinement to the model would make the retardation factor for this unit even greater than the ones listed above.*

Response: While we agree with general observation in VT ANR's comment that retention in the soil column is a function of the hydraulic and transport properties of the soil, there are several points raised by VT ANR that require revision. As described in the Draft CSM Report (Barr, 2017c), recharge rates were not assumed, they were calculated using the SWB model. The vertical hydraulic conductivity specified in the unsaturated zone modeling is for saturated material. At the average infiltration rates calculated using SWB, the soils are not saturated, therefore the simulated vertical hydraulic conductivity is much lower than the saturated vertical hydraulic conductivity (Niswonger, et al, 2006). The retardation factor for unsaturated materials depends on the water content of material, not the porosity. The water content varies throughout the model domain in proportion to the calculated infiltration rate.

Regardless, increasing the foc in the > 36 cm depth interval would decrease the simulated mass of PFOA in groundwater at any time after breakthrough occurs. For example, the figure below shows the simulated time series presented in Figure 4.19 of the February Draft CSM SI Report (Figure 4.16 of the December Draft CSM SI Report), updated to include a time series with the foc for the >36 cm interval set to 0.0032 as suggested. With a larger foc for the deeper interval, PFOA does not reach the deepest soils (and subsequently does not reach the water table) until approximately 2035, a condition that is not observed (i.e., groundwater analytical data clearly indicate that transport through the unsaturated zone is much faster).

It is also noted that if geometric mean values of foc were used to calculate retardation factors, as described in the comment, then the retardation factor for the 0-10 cm interval would drop since the geometric mean of measured values in the 0-10 cm soils is lower than the value used in the model. As discussed elsewhere, the foc values determined from CSM SI data provide a range of expected values and confirm the conceptual understanding that TOC (foc) decreases with depth. Model values of foc were adjusted during the calibration process and evaluated during sensitivity analysis. The data collected as part of the CSM SI confirm that the model uses reasonable values for foc.



Appendix D: Statistical Analyses

Comment 52: *D1a. Soils: This section provides basic descriptive statistics and many comparisons, mainly between Bennington Landfill and non-landfill areas, but the results of this effort are relatively unsurprising given the wide variety of soils over such a large study area. This seems to weaken possible correlations or differences, especially with respect to elemental analyses. Spatial trends (distance and depth) exist for PFOA and TOC and would be more relevant to the CSM (higher near the former Chemfab facility and higher in shallower soils) then might be expected from the aerial deposition at ground surface, the mechanism of migration, and the gradation of foc decreasing with depth, coupled with the moderate Koc for the PFOA (550 cc/g). The analysis suggests and uses a relatively strong relationship between TOC and PFOA to normalize these into a PFOA/TOC ratio that generates somewhat stronger correlations. The analysis shows a correlation between PFOA and silver, but that may just be coincidental, and a negative one with pH, which Barr suggests may be due to a lower sorptive capacity for more acidic soils.*

> **Response:** We agree that the soil composition is variable across the investigation area, which is illustrated by few statistically significant relationships and weak correlations between soil geochemical parameters. The statistically significant relationships and correlations for soil PFOA and TOC and lack of similar relationships for metals achieve the primary purpose of the investigation data collection and analysis to evaluate whether such relationships exist.

<u>Comment 53:</u> *D1b. Groundwater: This evaluation uses many of the same statistical tests as for soils, but adds Piper and STIFF diagrams for looking mainly at differences between Landfill and non- landfill groundwater sample sets. Only one background groundwater sample was taken so statistical comparisons with background were not possible. The STIFF and Piper diagrams show similar general water quality composition for major anions and cations with a few exceptions, e.g., S24, S28, B-2-2, and the vault sample for the landfill, and D03, S08, and S49 for the non-landfill samples. A narrow hexagon shape seems dominant in both groups (see D1b, Figure 2). The main focus of this effort was on PFOA and PFOS concentrations between landfill and non-landfill samples. The D1b appendix concludes that distributions of PFOS and PFOA were similar between the Bennington landfill and non-landfill samples despite relatively large differences in individual PFOA concentrations. The lack of statistical distinction may be due in part to large standard deviations resulting in overlap of confidence intervals. Perform a similar comparison in the final SI report for localized Chemfab facility results and non-Chemfab facility results to show the similarities and/or differences between these two exercises.*

> **Response:** A Tarone-Ware comparison of groundwater PFOA and PFOS concentrations between Water Street former Chemfab facility locations and the rest of the Bennington area was added to Appendix D.1b of the Final CSM SI Report.

Vermont Geological Survey (VGS) Comments on Appendix E.1: Bedrock Desktop Review and Outcrop Study Report (Golder and Associates, December 14, 2017)

Section 2.2.1 OC-1

<u>Comment 54:</u> *The locations of fracture domains 6 and 7 were not transposed on the map by Kim (2017b), as suggested by Golder. The rose diagrams and equal area nets for domains 6 and 7 were not transposed either. Only the photos for domains 6 and 7 were reversed and this was remedied on the 11-21-17 version of Kim (2017b) that was uploaded to the VGS website on November 27, 2017. November 22, 2017 and December 1, 2017 emails to Jonathon Carter of Barr Engineering described these issues.*

> **Response:** The note on suspected transposition of Domains 6 and 7 on Kim (2017b) has been removed from memo.

<u>Comment 55:</u> *The location of OC-1 on Figure 1 of Golder corresponds directly with domain 7 of Kim (2017b) and not domain 6.*

> **Response:** Text has been updated to note that Golder OC-1 corresponds to Domain 7 of Kim (2017b).

<u>Comment 56:</u> *Golder states that "The stereonet plot for Domain 6 indicates the VT ANR data have slightly steeper bedding dips to the northwest……". Because the bedding planes at this outcrop strike to the northeast and dip to the southeast, VT ANR suspects that Golder meant southeast.*

> **Response:** The text has been updated to indicate that bedding dips to the southeast.

<u>Comment 57:</u> *Golder states that "These (VT ANR) joint sets do not correspond to the two predominant joint sets (J1 and J2) measured by Golder at this location". The VT ANR does not concur. The rose diagrams for domain 7 show statistical peaks at 263.3 degrees (standard deviation of +/- 14.7 degrees) and 177.4 degrees (standard deviation of +/-8.1 degrees) for full ranges, including standard deviations, of 248.6-278 degrees* *(peak 1) and 169.3 -185.5 degrees (peak 2), respectively. The Golder petals (Figure 2) that span the bins from 250-280 degrees match the 248.6-278 peak of Kim (2017b). The Golder petal with an azimuth bin of 170-180 degrees matches the second most dominant 169.3-185.5 degree peak of Kim (2017b). Although not shown on the rose plots of Kim (2017b) as a statistical peak, the equal area net for domain 7 shows a 2% contour zone in the southwest quadrant for poles to fracture planes that strike in the 150-160 range and dip moderately to the southwest, the second major Golder petal.*

> **Response:** Golder had thought that OC-3 corresponded to Domain 6, not Domain 7. After comparing OC-3 and Domain 7 stereonets and rose diagrams, Golder concurs that the orientation of VT ANR joint sets correspond with joint sets measured by Golder. The text has been updated to reflect this.

Section 2.2.2 OC-2

Comment 58: *Golder states that "The stereonet plot for Domain 8 indicates the VT ANR data have slightly steeper bedding dips to the northwest…". Because the bedding planes at this outcrop strike to the northeast and dip to the southeast, VT ANR suspects that Golder meant southeast.*

> **Response:** The text has been updated to indicate that bedding dips to the southeast.

Section 2.2.3 OC-3

Comment 59: *This outcrop corresponds directly to domain 6 of Kim (2017b). The locations of fracture domains 6 and 7 were not transposed on the map by Kim (2017b), as suggested by Golder. The rose diagrams and equal area nets for domains 6 and 7 were not transposed either. Only the photos for domains 6 and 7 were reversed and this was remedied on the 11-21-17 version of Kim (2017b) that was uploaded to the VGS website on November 27, 2017. November 22, 2017 and December 1, 2017 emails to Jonathon Carter of Barr Engineering described these issues.*

> **Response:** The note on the suspected transposition of Domains 6 and 7 on Kim (2017b) has been removed from memo.

Comment 60: *Golder states that "The stereonet plot for Domain 7 indicates the VT ANR data have similar orientations as the Golder bedding data set (both dipping gently to the northwest)…". Because the bedding planes at this outcrop strike to the northeast and dip to the southeast, VT ANR suspects that Golder meant southeast.*

> **Response:** The text has been updated to indicate bedding dips to the southeast.

Section 2.2.5 OC-5 and OC-5A

Comment 61: *These OC-6 and OC-6A outcrops correspond directly to domain 2 of Kim (2017b). Golder noted that poles to bedding planes were not plotted on the earlier version of Kim (2017b); however, these poles are included on the most updated version (11-21-17) that was uploaded to our website on 11-27-17.*

> **Response:** The note on the bedding not plotted on Kim's (2017b) stereonet has been removed. The text has been updated to compare bedding from Kim (2017b) to that measured by Golder.

Section 2.2.8 OC-9 and OC-9A and Section 2.2.9 OC-10 and OC-10A

<u>Comment 62:</u> *Because of overlapping stations and labels, it is difficult to tell exactly where these outcrops plot on Figure 1. The locations of these outcrops appear to roughly correspond to those of domain 4 on the Figure 1 map of Golder and the Kim (2017b) map. The fact that the Golder bedding dips to the west means that these outcrops are likely on the west limb/side of the south-plunging anticline hinge shown on cross section C – C' of Kim (2017a). The domain 4 outcrops are located east of the anticline hinge because of their eastward dips. Outcrops OC- 11 and OC-12 more closely match the location and structural position of domain 4.*

> **Response:** Figure 1 of Appendix E.1 has been updated in the Final CSM SI Report.

Appendix E-2: Private well logs

<u>Comment 63:</u> *Well yield tests for these seven wells suggest good yields for wells completed in bedrock. Yields ranged from 4 to 50 gpm, although the duration of the yield test was short in some installations. This data along with the presence of soft, weathered/fractured rock, suggest that a second bedrock layer in the saturated zone model is warranted. The VT ANR will provide more comments about the need to include a second bedrock layer after completing the review of updated SI report that was submitted on February 15, 2018, which provides additional bedrock data.*

> **Response:** These data do not suggest a second bedrock layer is warranted. Additional response is provided in response to VT ANR's later comments (e.g., Comment 9 on the February Draft CSM SI Report).

Appendix H-Preliminary Evaluation of Other Potential PFAS Sources

<u>Comment 64:</u> *Chemfab did not manufacture high-performance plastic products. They coated fiberglass cloth using PTFE and PFOA as a dispersant.*

> **Response:** Section 1.0 of Appendix H.1 has been updated to indicate the manufacturing of coated fiberglass cloth.

<u>Comment 65:</u> *As stated in previous comments, VT ANR disagrees with the comment that PFOA was the only PFAS compound emitted from the Chemfab facilities, given the soil data near the Water Street facility and the absence of product sampling or documentation supporting this claim.*

> **Response:** See response to Comment 4 on the December Draft CSM SI Report.

February 26, 2018 Comments on February 2018 Draft Conceptual Site Model Report

Comment 1: *Hydrogeologic conditions are similar to those used in the conceptual site model (CSM)*

VT ANR does not agree with this conclusion because the new SI data show that there are sufficient differences in the hydrogeologic conditions that warrant an update to the CSM and the applicable numerical models prepared by Barr Engineering. VT ANR provided remarks on this finding in previous comments (VT ANR comments dated February 21, 2018) on the original SI. In addition, this updated SI report lacks discussion of the influence of major structural features on the CSM, particularly groundwater flow and contaminant migration. The final report must address the influence of these major geologic features on the CMS. As stated in our comments on the original SI, the input parameters of the unsaturated zone and groundwater model also must be revised to reflect the fact that there is more organic carbon present in the subsurface than assumed in Barr's numerical models.

> **Response:** Discussion regarding revision of the models is provided in response to VTANR comments from February 21, 2018 (above). In response to the influence of structural geologic features, there is no evidence that these features appreciably affect groundwater flow or solute transport at the scale of the investigation or the models. Evidence of enhanced, or restricted, flow along or across structural features has not been observed. Borehole geophysical logging did indicate that some zones have higher permeability due to secondary porosity, which is consistent with the conceptual model of flow through fractured media. However, at the scale of the model and investigation, an equivalent porous media approximation is still appropriate. Incorporation of potential zones of high permeability or local-scale structural features recently mapped and identified with detailed geophysical logging is not practicable at the regional scale of the model. Site specific models with finer discretization would be necessary to capture these features. For the design purpose of the models developed for the CSM, which is a regional evaluation, these smaller features are not important and beyond the scope of the models design intent. Larger scale structural features are captured in the distribution of hydraulic conductivity zones as described in Appendix D of Barr 2017c.

Comment 2: *Relationships and trends in PFAS concentrations indicate that current concentrations in CAAII soils are not indicative of historical impacts from the former Chemfab facilities*

VT ANR does not agree with this finding and provided remarks on this finding in previous comments (VT ANR comments dated February 21, 2018) on the original SI, which included the following:

- *Air modeling, completed by both Barr and VT ANR, indicates PFOA deposition occurred throughout CAA II from the former Chemfab facilities; and*
- *The concern that soil sample collected predominately in disturbed areas compromise the ability to evaluate relationships and trends in PFAS distribution and to assess the measured distribution of PFAS in soils and groundwater against the predicted distribution based on modeling of air emissions from the former Chemfab facilities.*

> **Response:** Responses to these comments are included in Comments 9, 34, and 41 to the December Draft CSM SI Report.

<u>Comment 3:</u> *Statistical analysis of available groundwater data from this investigation suggest different (multiple) PFAS sources, including the Bennington Landfill, as reflected by groundwater of different PFAS composition.*

VT ANR does not agree with this finding and provided remarks on this finding in previous comments (VT ANR comments dated February 21, 2018) on the original SI. In addition, VT ANR has several other issues concerning this analysis. First, PFOS detection limits in many samples around the former Chemfab Water Street facility were elevated (many wells, including the Water Street monitoring wells, had detection limits for PFOS of 40 or 13 ng/l, higher than many of the PFOS detects near the landfill of <10 ng/l). Second, the ratio of PFHpA/PFOA in most drinking water well samples, in addition to the groundwater samples taken as part of this site investigation, have a ratio of PFHpA/PFOA of 0.02-0.05, compared to the ratio of PFHpA/PFOA (ranging from 0.22 to 0.28) in SG3-MW17-BR2, which Barr identified to be influenced by the landfill. On the other hand, the ratio in SG3-MW17-BR3, the reported downgradient bedrock monitoring well from the landfill, is 0.03, which is consistent with the area-wide ratio. Third, even using the groupings presented in the report (Figure 4.12), there is no clear spatial representation of the three independent groups. For the most part, the data points are randomly spread around the site, specifically for Group C. VT ANR does not agree with Barr's interpretation that the patterns of groupings can explain any specific source(s) for the PFAS identified in this analysis. Even if there are other possible localized sources of PFAS in select wells, the low levels of all other PFAS compounds, other than PFOA, does not clearly indicate a source for the PFOA identified in these wells.

Response:

1) PFOS detection limits

During the first round of groundwater sampling (July 2016) at the monitoring wells installed adjacent to the former Chemfab Water Street facility, the laboratory MDL for PFOS in groundwater was 40 ng/L. Subsequent (December 2016) groundwater samples were analyzed to a detection limit for PFOS of 2 ng/L. The December 2016 analytical data previously provided to VTDEC and included in Appendix I of the Final CSM SI Report, show PFOS concentrations ranging from non-detect (< 2 ng/L) to 17 ng/L; with all but two of the detections at qualified concentrations of 3 ng/L or less. The distribution of PFOS detections is sporadic at the former Water Street facility and across the investigation area, suggesting a source that is not deposition of air emissions from the former Chemfab Water Street facility. Deposition of air emissions from the former Water Street facility would result in the uniformly elevated concentrations at and near the facility.

2) PFHpA/PFOA ratio

A more detailed analysis of available groundwater data (bedrock and unconsolidated) for the investigation area (from private wells, POETs, the CSM Site Investigation, and the Water Street investigation) indicates a more distinct pattern of the ratio of PFHpA/PFOA across the investigation area than the referenced range of 0.02 to 0.05. A discussion of the pattern of the PFHpA/PFOA ratio has been included in Section 4.3.2.3 of the Final CSM SI Report and is summarized below. A map of PFHpA/PFOA ratios calculated from groundwater data across the investigation area is provided on Figure 4.14 of the Final CSM SI Report.

While the PFHpA/PFOA ratios are similar between the Water Street monitoring wells and SG3-MW17-BR3 and lower than the landfill-impacted well SG3-MW17-BR2, the overall pattern of PFHpA/PFOA ratios is not consistent with an air emissions source for the following reasons:

- Ratios in the range 0.02 to 0.05 (the area-wide average presented in the comment) are generally clustered near the Water Street facility and, to a lesser extent, downgradient of the Bennington Landfill. The relatively low PFHpA/PFOA ratio values in these areas are likely reflective of relatively high PFOA concentrations resulting from air emissions from the former Water Street facility (in the Water Street area) and from groundwater impacts from Bennington Landfill (in the Bennington Landfill area).
- In the outer regions of CAAI and across CAAII (including along Harwood Hill Road, downgradient of Bennington Landfill) the PFHpA/PFOA ratio values are similarly clustered but at higher ratio values (0.05-0.23).
- The difference in PFHpA/PFOA ratio value groupings between the areas near Bennington Landfill and the former Water Street facility is consistent with different sources of PFHpA and PFOA to groundwater in those areas.
- Wells along Harwood Hill Road between the Water Street facility and SG3-MW17-BR3 have PFHpA/PFOA ratios greater than the range in the Water Street area and approach the value at SG3-MW17-BR2.

The difference in PFHpA/PFOA ratio value groupings between the areas near Bennington Landfill and the former Water Street facility is consistent with different sources of PFHpA and PFOA to groundwater in those areas (i.e. is more consistent with multiple sources than a common air emission source at the Water Street facility).

3) Interpretation of groundwater statistical groups

While there are no hard boundaries between the statistically grouped groundwater data points, the distribution is not random across the investigation area. It is apparent on Figure 4.13, Cluster Analysis of PFAS in Groundwater that the majority of Group B and Group C points exist in the eastern portion of the investigation area near Bennington Landfill.

The VT ANR states, "Even if there are other possible localized sources of PFAS in select wells, the low levels of all other PFAS compounds, other than PFOA, does not clearly indicate a source for the PFOA identified in these wells."

The distinction between air emissions and other localized sources of PFAS at a well can be made by identifying the presence of a compound that is not associated with an air deposition source (i.e., a sulfonated PFAS compound, such as PFOS). If a sulfonated compound is present at the well, the associated PFOA cannot be definitively shown to result from air deposition alone, which would not explain the presence of PFOS. For that reason, concentrations of non-PFOA PFAS compounds, even at low levels and especially for those parameters shown to be characteristic of a source that is not air emissions (e.g., PFOS), are key groundwater quality parameters for PFAS source identification.

<u>Comment 4:</u> *Concentrations of PFAS compounds in the bedrock aquifer at Bennington Landfill are highest directly downgradient (southwest) of the landfill cap area; are at much lower concentrations upgradient of this area; are consistent with bedrock flow through fractures and zones of bedrock alteration forming* *discrete flow paths. In the Summary Section, Barr states that the bedrock analytical data indicate that the Bennington Landfill is the primary source of PFAS in groundwater south and southwest of the landfill.*

The sections of the updated report that pertain to the hydrogeology and PFAS fate & transport for the Bennington area is confusing, contradictory, and does not adequately explain how PFAS transport can occur from the landfill waste and/or soils to the groundwater under the landfill to groundwater outside the landfill. Barr must revise the updated SI report to adequately explain this and to make it less confusing. The revision must address the following:

The February 2018 CSM by Barr Engineering acknowledges that groundwater flow directions in the bedrock aquifer in the Bennington landfill area are complex, heterogeneous, and spatially variable, but they do not integrate all existing data sets at the scale of the landfill to comprehensively characterize the aquifer(s). The regional potentiometric contour map for the bedrock aquifer (Kim and Dowey, VG2017-4D) is not of suitable scale for a detailed look in this area (as noted on the map), since it does not include the static water level information from the McLaren/Hart (1997) report (or the recent work by Barr/Golder/RealTime Aquifer Services). Barr must revise the "landfill CSM" to include the following:

- *Potentiometric surface contour map of the surficial aquifer.*
- *Potentiometric surface contour map of the bedrock aquifer.*
- *Bedrock surface contour map.*
- *Overburden thickness (isopach) map.*
- *Ocher/Kaolin thickness map.*
- *Geophysical logs placed in the structural (anticline) and lithologic (formation contact) context of the bedrock geologic map.*
- *PFAS fate and transport*

Response:

1) Potentiometric surface contour map of the surficial aquifer

Potentiometric surface contours for the surficial aquifer were prepared using groundwater elevations measured in November 2017 at SG3-MW17-01, SG3-MW17-02, and SG3-MW17-06, and May 2017 groundwater levels measured at B-12, MW-07, and MW-100S along with groundwater elevation data for the surficial aquifer previously collected by McLaren/Hart (1997). The potentiometric surface contour map indicates groundwater in the surficial aquifer flows to the east-southeast from the landfill. The potentiometric surface contour map has been included in the Final CSM SI Report as Figure 3.28.

2) Potentiometric surface contour map of the bedrock aquifer

Bedrock aquifer potentiometric surface contour map: Groundwater elevations measured at bedrock monitoring wells in January 2018 combined with data from the regional potentiometric contour map previously prepared by Kim and Dowey (2017) were used to produce a potentiometric surface contour map for the bedrock aquifer in the vicinity of the landfill. The map indicates flow in the bedrock in the vicinity of the landfill is generally to the west and southwest. The potentiometric surface contour map has been included in the Final CSM SI Report as Figure 3.29.

3) Bedrock surface contour map

The depth to bedrock map included as Figure 4.7 of the report was produced by revising the dataset compiled by the Vermont Geological Survey (*Kim, J., and C. Dowey, 2017. DRAFT Preliminary Isopach Map (Overburden Thickness) of the Bennington Area, Vermont (feet, smoothed). Open File Report 2017-3B, scale 1:12,000. Montpelier, VT: Vermont Geological Survey*). A corresponding map of bedrock surface is not required for purposes of this investigation.

4) Overburden thickness (isopach) map

The overburden thickness is already presented in the report and is shown on Figure 4.7 as the analogous "depth to bedrock". As discussed in Section 4.1 of the report, the unaltered bedrock is overlain by overburden composed of unconsolidated materials and altered bedrock.

5) Ocher/Kaolin thickness

Altered bedrock was identified at four borings/wells drilled as part of the investigation. Locations where altered bedrock was encountered during the investigation are discussed in Section 4.1.2.2 of the report. The report states:

> *"Hydrothermally altered bedrock was encountered in the eastern half of the site at bedrock monitoring wells SG3-MW17-BR1 and SG3-MW17-BR4 at or near Bennington Landfill and at deep soil boring D07 along Chapel Road. Hydrothermally altered bedrock was also encountered at one location (deep soil boring D24) in the southwestern area of the site near William H. Morse State* Airport (Figure 3.2)."

The thickness and type of altered bedrock at well SG-MW17-BR1 is shown on Figure 4.6 (geologic cross section E-E′). The thickness and type of altered bedrock at well SG-MW17-BR4 is shown on Figure 4.5 (geologic cross section D-D′). Figure 4.4 (geologic cross section C-C′) shows that altered bedrock was encountered in boring D07 but the boring did not reach the bottom of the altered bedrock. Figure 4.4 has been modified in the Final CSM SI Report to show interval and type of altered bedrock encountered in boring D07. As shown on Figure 4.2 (geologic cross section A-A′), boring D24 encountered altered bedrock but did not reach the bottom of the altered bedrock. Figure 4.2 has been modified to show interval and type of altered bedrock encountered in boring D24. Intervals where altered bedrock was encountered have been more clearly identified on the boring logs for borings D07 and D24 in the Final CSM SI Report.

The inferred variable thickness of altered bedrock in the investigation area is shown on geologic cross sections A-A′ through E-E′ on Figures 4.2 through 4.6 of the Final CSM SI Report. The geologic data from McLaren/Hart (1997) are also included on these cross sections, where applicable, with the material originally interpreted to be saprolite shown as altered bedrock.

6) Geophysical logs placed in the structural (anticline) and lithologic (formation contact) context of the bedrock geologic map

A technical memorandum prepared by Golder that compares the borehole and bedrock structural data is presented in Appendix E.5 of the report. In Section 3.0 the technical memorandum states;

> *"Borings SG3-MW17-BR2 and SG3-MW17-BR3 lie about 150 feet and 1,400 feet southwest of the southwest corner of the landfill, respectively. Based on the shallow dip of the bedding to the southeast measured in the boreholes, both borings may lie on the east-southeast of the anticline's axial plane, on the south-southeast dipping limb but close to the center. Rose diagrams and stereonets of the closest outcrop locations to the borings are presented in the Golder 2017 report (OC-4, OC-5, OC-10A, OC-11 and OC-12), and in the recent VTDEC fracture map (Kim, 2017b; Domains 3 and 4). Comparison of these data sets indicates SG3-MW17-BR2 and SG3-MW17-BR3 data closely mimic Golder outcrop locations OC-11 and OC-12, and with VTDEC Domain 4, located on the north and north-northwest sides of the landfill."*

As noted in section 4.2.3.2 of the report, and elsewhere in the report, PVC well screen and riser pipe was installed in wells SG3-MW17-BR1 and SG3-MW17-BR4BR4 to prevent the wells from being rendered useless from collapse of bedrock into the borehole. Due to the presence of PVC riser and screen in these wells ABI and OBI logs could not provide any structural information for evaluating orientation of bedding, foliation, and joints in the bedrock.

7) PFAS fate and transport

A discussion of PFAS fate and transport in the landfill area is included in Section 4.4.3 of the Final CSM SI Report.

__Comment 5:__ *Measured soil concentrations across the investigation area are generally consistent with background concentrations and may also be indicative of localized sources of PFAS.*

VT ANR does not agree with this finding/conclusion and provided remarks on this finding/conclusion in our February 21, 2018 letter on the original SI. As stated, and supported, in previous comments on the original SI, VT ANR has concluded that the variability in data does not support Barr's basis for applying a background adjustment to explain why their model simulations under-predicts the measured PFOA concentrations found in area-wide groundwater. Another explanation for the under-prediction of PFOA in their model simulations is that the emission rates were greater than used in their model.

Response: Discussion of the topics addressed in this comment can be found in responses to Comments 2c and 2d on the December Draft CSM SI Report.

__Comment 6:__ *Section 2.3 Characteristics of PFOA, PFOS, and Associated Compounds (Page 8), last sentence – The updated SI report states, "Very small sources of PFOA and PFOS can result in detections in groundwater in the ppt and parts per billion (ppb) range." VT ANR agrees, SPLP testing of soils at site shows non-detect levels in soils (less than 1 ppb PFOA) can result in detectable levels of PFOA in water extract. This could be one explanation into why at some parts of CAA II PFOA is not detected in soils samples but is found in groundwater samples.*

Response: Although we agree that very small sources of PFOA and PFOS can result in detections in groundwater in the part per trillion (ppt) and ppb range, we caution against comparing the results of SPLP to the results from the soils or groundwater analysis due to limitations of the testing methodology and the need to account for other factors affecting groundwater concentration at a given location (e.g., upgradient groundwater concentration). Please see response to Comment 40 on the December Draft CSM SI Report for additional information.

<u>Comment 7:</u> *Section 3.2.3.2 Flow Logging, paragraph 2 (Page 19) – The updated SI report states, "This suggests that flow through the borehole is predominately lateral." This statement, along with others to follow pertaining to groundwater flow around the landfill, is confusing. As stated in Comment 3, VT ANR requests that Barr explains their statements about groundwater flow around the landfill.*

> **Response:** As presented in Appendix E.3 and discussed in the report, borehole flow logging for wells SG3-MW17-BR2 and SG3-MW17-BR3 did not identify upward or downward flow in the wells under ambient conditions. This suggests that there is no significant head difference between the hydraulically active zones identified in the wells. Since there is no significant head difference between the hydraulically active zones to drive upward or downward flow in the wells under ambient conditions, groundwater entering the wells would be expected to flow laterally across the open well bores.

<u>Comment 8:</u> *Section 3.2.3.3 Discrete Interval Sampling (Page 20), paragraph 3 - This paragraph appears to contradict itself. The updated SI report does not provide sufficient information that supports the claim that apparent leakage during the packer tests is from hydraulic connections around the borehole through fractures rather than inadequate packer inflation. In either case (vertical fractures or an inadequate seal), mixing of water during discrete sampling intervals is inevitably occurring.*

> **Response:** Information provided in Appendix E.3 for wells SG3-MW17-BR2 and SG3-MW17-BR3 indicates that the borehole walls generally had minor, if any, excursions in the intervals where the packers were placed for the discrete interval sampling, so the packers would be expected to seal against the borehole wall when inflated. Inspection of the borehole geophysical log montages in Appendix E.3 shows that lack of significant borehole wall excursions does not mean there are no fractures intersecting the borehole. Packer pressures monitored during the discrete interval sampling did not indicate loss of pressure in the packers. Based on the placement of the packers and no pressure loss in the packers during the sampling, changes in head above or below the sample interval are most reasonably attributed to hydraulic connections via fractures around the borehole. Some mixing would be expected during discrete interval sampling given this hydraulic connection.

<u>Comment 9:</u> *Section 3.3.5-Hydraulic Conductivity- The hydraulic conductivity values derived from specific capacity testing of the four new bedrock wells was significantly higher in 3 of the four bedrock wells (Table 3.15 and Table G.4.1) than the K used in the groundwater model (1 ft/d). Barr must revise their groundwater model and CSM to reflect this site-specific data or substantiate why incorporating site-specific data is not warranted.*

> **Response:** The geometric mean of the hydraulic conductivity values derived from specific capacity testing of the four bedrock wells is 10.2 ft/day. While the hydraulic conductivity of the quartzite and marble in much of the groundwater model domain is 1.0 ft/day, the hydraulic conductivity of Zone 18 (bedrock in the vicinity of Bennington Landfill) is 10.7 ft/day (Table D2 and Figure D4 of the Draft CSM Report; Barr, 2017c). Hydraulic conductivity values from Zone 18 are more applicable for direct comparison to investigation data as this is where the specific capacity testing was conducted. The hydraulic conductivity values derived from specific capacity testing of the four bedrock wells confirms the calibration process resulted in reasonable hydraulic conductivity values. Data do not justify additional subdivision of the bedrock within the groundwater model.

<u>Comment 10:</u> *Section 4.2.2.2 Bedrock Aquifer (Page 37), paragraph 3 – The updated SI report states, "The barometric response observed in the transducer data indicates that the bedrock aquifer is confined." This section must clarify where Barr believes that the bedrock aquifer is confined (everywhere on site, in CAA II, or just around the landfill) and explain the transport mechanism that is taking the PFAS from the landfill into this aquifer.*

> **Response:** The text in Section 4.2.2.2 of the Final CSM SI Report was revised to clarify Barr's interpretation of the observed barometric responses. The relationship between the unconsolidated and bedrock aquifers is discussed in Section 4.2.3.3 of the Final CSM SI Report.
>
> A similar response to barometric pressure fluctuations was observed in all wells equipped with transducers. As shown on Figure 3.25, Transducer Locations, these wells are all located in and around the landfill; therefore, this is another line of evidence suggesting that the surficial aquifer is perched above the bedrock aquifer in the vicinity of the landfill. As shown on Figure 3.24, Groundwater Elevation Map, hydraulic heads measured at wells completed in the unconsolidated aquifer are higher than hydraulic heads measured at nearby wells completed in the bedrock aquifer, indicating a downward gradient, and therefore, the potential for downward vertical flow from the landfill and the surficial aquifer to the bedrock aquifer. As noted in the response to VTDEC Comment 15 on the February Draft CSM SI Report, evidence for leakage through the base of the overburden saturated zone includes historical detections of VOCs in bedrock wells at the landfill (McLaren/Hart, 1997).

<u>Comment 11:</u> *Section 4.2.3 Hydrogeologic Setting of the Bennington Landfill – This section requires revisions to address the following:*

a. *As stated in Comment 4, a potentiometric surface contour map of the bedrock aquifer for the Bennington landfill area is needed using bedrock water level data from bedrock monitoring wells within and near the landfill and from drinking water wells installed with pressure transducers. The hydrogeology section on the Bennington landfill discusses the presence of discrete flow pathways and the hydrologic significance of the hydrothermally altered bedrock (previously referred to as saprolite by McLaren and Hart) and groundwater flow direction. In subsection 4.2.3.1, the report indicates it intention to evaluate the existence of "discrete flow paths" in bedrock. This section does little more than to acknowledge that the bedrock system comprises a discrete fracture network, which over an equivalent elemental volume, can be approximated or modeled as an equivalent porous media. Due to the degree of fracturing encountered, the elemental volume at which the system behaves as an equivalent porous media should not be large and it should be possible to interpret potentiometric surfaces and groundwater flow directions with the scale of the Bennington Landfill setting.*

> **Response:** A potentiometric surface contour map of the bedrock aquifer is included as Figure 3.27 in the Final CSM SI Report.

b. *Section 4.2.3.2 Hydraulic Significance of Bedrock Alteration - This section concludes that the altered bedrock (whether of Cheshire or Dunham Formation) is more transmissive than unaltered bedrock without an explanation. An explanation must be provided to support this conclusion and to address whether the altered bedrock and unaltered bedrock represent the same or different hydro-stratigraphic units.*

Response: During flow logging, well SG3-MW17-BR1 was pumped at approximately 20 gallons per minute (gpm) with drawdown of less than 1.5 feet. The well log for this well shows that the upper five feet of the screened interval intersects ocher and that the remaining 65 feet of the screened interval included zones of altered bedrock. Typically, these zones of altered bedrock were identified by washouts in the core and return water color consistent with that observed in zones of altered bedrock seen elsewhere.

During development, well SG3-MW17-BR4 was pumped at approximately 20 gpm. The well log for SG3-MW17-BR4 indicates that the upper seven feet of the screened interval likely intersects altered bedrock. As discussed in Appendix E.3, flow logging data suggest that flow in the well decreases with depth within the screened interval.

The private well report for the residential well at 175 Michaels Drive (Well Report #381, Unique GIS Name: BI381), which is approximately 1,500 feet due south of Bennington Landfill, shows the well completed in "orange ochre" and cased over 245 feet of its 252 feet of total depth. The reported yield for the well was 30 gpm. Geophysical logging of the well in 2016 (Kim and Romanowicz, unpublished data) confirmed the well was cased top to bottom because of "rotten" ochre zones and with no exposed bedrock to log. The relatively high yield from the fully cased well suggests relatively high transmissivity of the altered bedrock zone tapped by the well.

The observations in all these wells are consistent with altered bedrock being somewhat more transmissive than unaltered bedrock. Additional data would be needed to fully quantify the differences in the hydraulic characteristics of the altered and unaltered bedrock. Such a characterization was beyond the scope of this investigation.

c. *Section 4.2.3.3 Groundwater Levels and Flow Directions – This section provides no technical evaluation of the water level data collected. The introduction to the section concludes that the groundwater conditions in the discretely fractured bedrock are too heterogeneous and complicated to allow interpretation of heads and flow directions in the bedrock aquifer. The subsection goes on to concur with the interpretation of McLaren/Hart of the existence of a perched overburden groundwater system underlying the landfill that flows toward the southeast. The second paragraph of this section states that directions of groundwater inferred from this recent study and regional mapping are to the west and southwest. The section goes on to state that the water levels measured in older bedrock wells at the landfill were consistent with historical data from McLaren/Hart but fails to acknowledge that McLaren/Hart interpreted deep bedrock groundwater to have a west to east flow direction component under the landfill. The updated SI report makes no effort to compare the water levels from its own study to the very generalized regional groundwater flow map present by Kim and Downey (2017). This paragraph also places unreasonable weight on the water levels from SG3-MW-17-BR2 as being indicative of potentiometric conditions that defy interpretation due to heterogeneity. Discussion is needed that addresses the comments within this paragraph and explain why there is a large hydraulic head drop from the unaltered to the altered bedrock or articulate whether this large hydraulic head drop indicates that the unaltered Cheshire and altered Cheshire/Dunham represents two separate and distinct hydro-stratigraphic units. Also, more explanation, including supporting discussion of hydraulic head distribution and consideration of the previously discussed geology, is needed to support the conclusion in this section that the orientation of fractures has a greater control on groundwater flow direction at the local (landfill scale).*

Response: McLaren/Hart's inferred easterly component of bedrock groundwater flow was based on measurements from only three wells which were nearly collinear. The new bedrock aquifer contour map (Figure 3.29 in the Final CSM SI Report) was developed from data points covering the entire landfill and surrounding area. The new bedrock aquifer contour map is consistent with a southwesterly regional groundwater flow direction, but local flow directions in the vicinity of the landfill are variable due to mounding in this area. The new contours show an easterly component of flow through wells SG3-MW17-BR2, B-6-3, and B-2-3, consistent with McLaren/Hart, but there is also a northerly component of flow in this area due to mounding.

Comment 12: *Section 4.3.1.2 Spatial Trends in Soil PFAS - Explain how the statistical analysis of trends in PFOA would be affected by fact that the majority of soils samples being collected from previously disturbed soil horizons when the objective was collection of samples from undisturbed (since the late 1960s) locations.*

Response: Appendix D1a summarizes a statistical evaluation of PFAS and TOC concentrations by location and depth. Depth was defined as surface soils (0-1.5 feet bgs), shallow soils (1.5 – 5 feet bgs) and deep soils (greater than 5 feet bgs). Results of the analysis determined that for TOC, all three depth classifications were statistically significant from one another. For PFOA, surface and shallow soil concentrations were not significantly different from each other; however, both were statistically significant from deep soils. See response to Comment 2b on the December Draft CSM SI Report and Appendix D1a for additional information.

Comment 13: *Section 4.3.2.2 Multivariate Analysis of Available Groundwater Data – See Comment 3.*

Response: See response to Comment 3 on the February Draft CSM SI Report.

Comment 14: *Section 4.4.2 Bennington Landfill Impacts (Page 46), last paragraph – The updated SI report states, "Capping of the unlined landfill was completed in 1999, which effectively cut off the source of infiltration within the footprint of the cap." If this is true, which it may well be, then why is PFOA still present at SG3-MW17-BR2? Barr's CSM states that PFOA is not attenuated in the bedrock aquifer, and if this is the case, without an ongoing source, wouldn't all of the PFOA in the bedrock aquifer have flowed out of the groundwater system?*

Response: Ongoing sources of the PFOA detected in SG3-MW-17-BR2R may include: infiltration of leachate from the landfill that was not removed by the leachate collection system; PFOA sorbed to soils beneath the landfill or the soil stockpile area or former leachate infiltration gallery; downward leakage from the shallow aquifer layer; and water migrating from the unsaturated zone between the bedrock aquifer and the shallow aquifer into the bedrock aquifer. Section 4.4.3 of the Final CSM SI Report has been updated with this clarification.

Comment 15: *Section 4.4.2 Bennington Landfill Impacts (Page 46) – The Section states, "Since the leachate collection system was decommissioned in 2008, no leachate infiltration has occurred in the leachate infiltration gallery and little or no infiltration has occurred through the footprint of the landfill in recent years. VT ANR would again like to reiterate that the landfill leachate from the vault was treated with carbon, thereby eliminating or greatly reducing the mass of PFAS going into the leachate infiltration gallery. At the end of this paragraph it states that the PFAS would most likely be in deeper media like bedrock groundwater. As stated in previous comments, explain this transport mechanism to bedrock given the presence of confining layer(s) between the overburden saturated zone and the bedrock aquifer in the landfill area.*

> **Response:** Regarding the first two sentences, the comment is noted. Regarding the remainder of the comment, the overburden saturated zone has developed on a leaky basal layer, not an impermeable layer. Evidence for leakage through the base of the overburden saturated zone includes historical detections of volatile organic compounds (VOCs) in bedrock wells at the landfill (McLaren/Hart, 1997). The Final CSM SI Report has been updated to provide additional clarification (Section 4.4.3).

Comment 16: *Section 4.4.2.2 Groundwater (Page 47), paragraph 2 – VT ANR does not agree with the statement that radial flow outward from the landfill could explain low level detections of PFOA in well SG3-MW17-BR1 and B-4-3 as wells as low-level detections of PFOA in private wells north and west of Bennington Landfill. The groundwater flow directions show on Figures 4.15A and 4.15B must be re-evaluated based on Comment 11. VT ANR disagrees with the conclusion that detections of PFOA (14 ng/L) in the up-gradient bedrock well (BR-1) could be a result of groundwater flow from landfill. A more in-depth analysis of the local groundwater flow conditions around the landfill is required. How does the lack of other (non-PFOA) PFAS compounds (i.e., those detected in the vault and BR-2) in well SG3-MW17-BR3, approximately 1000 feet downgradient of SG3-MW17-BR2, affect the CSM relative the fate and transport of PFAS in this area.*

> **Response:** The new bedrock aquifer contour map (Figure 3.29 in the Final CSM SI Report) shows B-4-3 as downgradient of SG3-MW17-BR2.

Comment 17: *Section 4.4.2.2 Groundwater (Page 47), paragraph 3 – the updated SI report states, "PFAS concentrations in well SG3-MW17-BR2 are interpreted to be the result of leakage and downward flow from Bennington Landfill." This statement is inconsistent with the statements made on pages 19 and 46. A more clearly prepared and supported CSM of the landfill is needed. VT ANR does not concur with the conclusion in this paragraph (that the landfill is the source of the PFAS identified in wells south and southwest of the landfill). If the landfill, a point source, were the source of the PFOA identified in the wells south and southwest of the landfill, one would expect that dilution and dispersion would decrease the levels of PFOA with distance from the source (the landfill). This is not what is observed in these drinking water wells. Additionally, there are a number of shallow drinking water wells in CAA II that could not be impacted in the manner that is presented in this section. Atmospheric contamination of soils around these wells is a much more plausible explanation as to how these wells became contaminated. Lastly, the PFHpA/PFOA ratios in these wells is consistent with the levels identified in drinking water wells located near the Water Street Chemfab facility and not similar to the ratio identified in SG3-MW17-BR2.*

> **Response:** Bennington Landfill contains mixed, co-mingled municipal, commercial, and industrial waste. Many different PFAS compounds, including PFOA and PFOS, are associated with different types of wastes, and PFAS compounds are expected to vary, depending on the waste type. The fact that mixed municipal landfills generate PFAS leachate and result in groundwater with detectable levels of PFAS compounds has been determined by multiple studies throughout Europe, the United States, and Canada (Busch et al., 2009; 1469-1471; Eggen et al., 2010; 5153; Eschauzier et al., 2013; 477-481; Li et al., 2012; 3368; MPCA, 2007; 3; MPCA, 2009; N.P.). Different parts of the landfill can be expected to have different ratios of PFAS compounds, depending on the types of waste disposed of in a particular area, leachate migration through the waste, and subsurface heterogeneity in the unsaturated zone. Concentrations of PFAS compounds currently measured in wells downgradient of the Bennington Landfill reflect the reduced leachate percolation conditions that have resulted from capping of the landfill and collection/treatment of leachate. According to EPA's 2014 Five-Year Review, corrective actions performed at the Bennington Landfill over the past 20 years were deemed to be effective in "reducing or eliminating landfill leachate". Therefore, it would be expected that concentrations of

PFAS compounds would begin to reduce in the vicinity of the landfill. Concentrations in wells downgradient of the landfill are affected by dispersion and advection but they also represent a different landfill source condition, prior to corrective action and capping. Over time, the PFAS concentrations in these wells would be expected to decline as groundwater with progressively lower PFAS concentrations migrates (with dispersion and advection) toward the downgradient wells.

Variability in the PFHpA/PFOA ratio across the investigation area is consistent with different sources between CAAI and CAAII, as opposed to an air emission source explaining the similarity in ratio values between SG3-MW17-BR3 and the former Water Street facility. This is discussed in detail in the response to Comment 3 on the February Draft CSM SI Report.

__Comment 18:__ *Section 5.0 Summary – For the reasons stated in the previous comment letter and this letter, VT ANR does not concur with many of the conclusions in this section and has concluded that atmospheric deposition from the two former Chemfab facilities is the most reasonable explanation for the PFOA identified in the drinking water wells located in CAA II. VT ANR does not rule out that other potential sources of PFASs may have contributed to smaller amounts of PFAS compounds in some of the samples collected throughout the site.*

Response: The CSM modeling and investigation do not dispute that air emissions and deposition of PFOA from former Chemfab facilities occurred; however, the data demonstrate that within CAAII, air deposition from the former Chemfab facilities does not explain the distribution and type of PFAS compounds found in soil and groundwater. The data strongly suggest that Bennington Landfill is a source of PFAS measured in private wells in CAAII. Because of the ubiquity of PFAS compounds in industrial, commercial, and consumer goods, we agree with VT ANR that there are other potential sources of PFAS throughout the site.

__Comment 19:__ *Section 5.3.2 Bennington Landfill-Based on updated SI report, only SG-3MW17-BR 2 which is located at the boundary of the landfill cap, has other PFAS compounds similar to those found in the landfill vault. Provide a summary table and/or figure that supports the conclusion that private wells south and west of landfill are related to the other compounds (non PFOA) detected in leachate.*

Response: Figures were prepared interpolating site-wide concentrations for PFOA, PFOS, PFHpA, PFHxA, and PFHxS and have been included in Appendix H.3 and discussed in Section 4.4.3 of the Final CSM SI Report. The data supports the conclusion that PFAS detections in private wells south and west of the landfill are related to compounds detected in the leachate.

__Comment 20:__ *Section 5.3.2 Bennington Landfill- A CSM needs to account for all sources of contamination release. The CSM SI Report must acknowledge and evaluate the other (non - Air deposition) Chemfab contributions of PFOA to the Bennington landfill; namely the 14,000 gallons of waste from Chemfab and sludge from the WWTP disposed of at the landfill, since the WWTP received industrial process waste water from Chemfab.*

Response: An in-depth evaluation of the sources of PFAS in Bennington Landfill waste was not part of the Work Plan (Barr, 2017a) approved by the VTDEC; however, a preliminary evaluation of landfill contributors potentially using PFAS-containing compounds was completed and is provided in Appendix H-2 of the Final CSM SI Report. This evaluation includes the names of landfill contributors and volume of potentially PFAS-containing material sent to the landfill (e.g., Johnson Controls Battery Group, Inc, 576,240 gallons; Chemfab Corporation, 14,040 gallons; etc.) as reported by the EPA.

Comment 21: *Appendix A.2 – There is no information other than the cover page. Include this information in the next report.*

Response: The Environmental Services Field logs contained in Appendix A.2 were provided in the December Draft CSM SI Report and the February Draft CSM SI Report and are also included in the Final CSM SI Report. If this comment was in reference to an appendix section other than A.2, it is not clear from our review of appendix content which one that would be.

Comment 22: *Appendix H.1 – other Sources. The assessment begins with the premise that Chemfab only emitted PFOA during manufacturing and that other PFAS compounds were not part of the dispersions used or emissions discharged. As stated in comments on the original SI report, Barr must provide evidence that supports this assertion.*

Response: Dispersion inventory data indicate that only PFOA (as APFO) was the PFAS used by Chemfab. We have not seen any air emissions sampling data to suggest that other PFAS compounds were emitted from the former Chemfab facilities. The pattern of PFOS in soil and groundwater is not consistent with air emissions and deposition from the Chemfab facilities.

Comment 23: *Appendix H.2 Potential PFAS Contributions to Bennington Landfill Memorandum (dated February 8, 2018) – To avoid confusion for readers, the heading in the first row-second column must be revised to "Potential PFAS-Containing Products…" This reinforces that the list provided is not a known inventory of products used at a given facility but a suspected/potential inventory list of PFAS-containing products that a given manufacture may have used based on a literature review.*

Response: The requested edit has been made to Table 2 in Appendix H-2 of the Final CSM SI Report.

Attachment A: Acronyms and Abbreviations

Responses to Vermont Agency of Natural Resources Comments on December 2017 Draft Interim Conceptual Site Model Site Investigation Report and February 2018 Draft Conceptual Site Model Report

APFO	ammonium perfluorooctanoate
bgs	below ground surface
CEC	cation exchange capacity
CSM	conceptual site model
CAAI	Corrective Action Area I
CAAII	Corrective Action Area II
foc	fraction organic carbon
ft/d	feet per day
gpm	gallons per minute
K	hydraulic conductivity
lbs	pounds
lbs/yr	pounds per year
MDL	method detection limit
mg/kg	milligrams per kilogram
MVA	multivariate analysis
ND	non-detects
ng/g	nanograms per gram
ng/mg	nanograms per miligram
ng/L	nanograms per liter
PFHpA	perfluoroheptanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFAS	per- and polyfluoroalkyl substances
PFTeDA	perfluorotetradecanoic acid
ppb	parts per billion
ppt	parts per trillion
QAPP	Quality Assurance Project Plan
ROW	right-of-way
SI	Site Investigation
SPLP	Synthetic Precipitation Leaching Procedure
SWB	soil-water-balance
TOC	total organic carbon
VT ANR	Vermont Agency of Natural Resources
VOC	volatile organic compound
yr	year

Barr D.W., 2001, Coefficient of Permeability Determined by Measurable Parameters. Ground Water v. 39, no. 3 pg. 356-361.

Barr Engineering Co. 2017a. Revised Work Plan – CSM Site Investigation: Bennington, Vermont. Prepared for Saint-Gobain Performance Plastics. Dated August 2017. Minneapolis.

Barr Engineering Co. 2017b. Responses to Vermont Department of Environmental Conservation and Environmental Protection Agency Comments on CSM Site Investigation Work Plan: Bennington, Vermont. Dated August 2, 2017. Minneapolis

Barr Engineering Co. 2017c. DRAFT Conceptual Modeling of PFOA Fate and Transport: North Bennington, Vermont. Prepared for Saint-Gobain Performance Plastics. Dated June 2017. Minneapolis.

Barr. 2017. DRAFT Conceptual Modeling of PFOA Fate and Transport: North Bennington, Vermont. Appendix B. Prepared for Saint-Gobain Performance Plastics by Barr Engineering Co. Dated June 2017.

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