ELECTRONIC SUPPORTING INFORMATION

Environmental and Private Property Contamination Following the Norfolk Southern Chemical Spill and Chemical Fires in Ohio

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NOTE: This Electronic Supporting Information file was compiled to provide the reader access to detailed descriptions of methods, more detailed observations and results that were invoked in the manuscript, and a referenced timeline that assists in the interpretation of results in context. The detail provided was determined to be necessary due to the lack of prior information available about the incident and complexity of the incident and response.

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ESI-1.1. Atmospheric pathways and dispersion modeling. The extent and likelihood of the spread of the smoke from the burn event were calculated using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model developed by the National Oceanic and Atmospheric Administration.[1] The model was initialized with archived Global Data Assimilation System (1° x 1° resolution) meteorological data to obtain 10 hr long forward trajectories of air starting at an altitude of 500 m above ground level (AGL), at 3 hr intervals from approximately the time of the prescribed burn (2200 UTC) on February 6 until 0500 UTC February 8, 2023 at the derailment site (40.8360°N 80.5227°W). The spatial distribution of the frequency of these trajectories passing through each grid is calculated by the model as,

$$Frequency = \frac{Number\ \ of\ trajectories\ passing\ through\ a\ grid}{Total\ number\ of\ trajectories}$$

Archived weather balloon soundings over Pittsburgh, Pennsylvania, a location close to the derailment site, were reviewed and showed a shallow mixed boundary layer of about 1,000 m AGL in this region at the time of derailment and open burn. Hence, in the present study, the HYSPLIT model was run for a two-day period starting at an altitude of 500 m AGL, mid-point in the mixed boundary layer, at the derailment site using the GDAS reanalysis meteorological data, same as the EPA model in the U.S. Federal Emergency Management Agency (FEMA) report.[2]

ESI-1.2. Sampling equipment, methods, reagents, supplies, and chemicals. Water samples for organics analysis (total petroleum hydrocarbons – TPH, total organic carbon – TOC, volatile organic compounds – VOC, semi-volatile organic compounds – SVOC, per- and polyfluoroalkyl substances – PFAS) were collected using amber glass bottles headspace free with polytetrafluoroethylene (PTFE)-lined caps precleaned with HNO_3. Plastic bottles were used for inorganic sample collection. Sediment samples were collected in glass jars with PTFE-lined caps precleaned with HNO_3. All samples were stored at 4°C until analysis. A variety of supplies were obtained from Thermo Fisher Scientific: dichloromethane (DCM, for HPLC with purity percent of ≥99.9%), methanol (for HPLC with purity percent of ≥99.9%), and acetone (for HPLC with purity percent of ≥99.5%). Reagent grade water (18.2 MΩ-cm) was obtained from a Thermo Scientific Barnstead Nanopure™ water purification system. Standards of butyl acrylate (BA), 2-butoxyethanol (2-BE), 2-ethyl hexanol (2-EHL), 2-ethylhexyl acrylate (2-EHA), and naphthalene (NAP), benzene were purchased from purchased from Sigma Aldrich, Thermo Fisher Scientific, Spex CertiPrep). A USEPA Method 8270 mixed standard was purchased from Restek. A ppbRAE3000 handheld photoionization detector (PID) [fs = 1/60 s–1, RAE Systems, 10.6 eV lamp] was used to screen air quality. The PID sensor reported the total volatile organic compound (VOC) signal and was calibrated with a 10-ppm isobutylene standard. The 17 homes included in this study had previously contacted the group United for East Palestine seeking assistance. The authors selected homes that were closest to either the derailment site or the Sulphur Run or Leslie Run creeks. In addition, the selection of households was limited geographically, and socioeconomic status was not considered in this study.

ESI-1.3. VOC and SVOC analysis of creek and well water samples. Surface water samples were collected from Sulphur Run, Leslie Run, and waterways upstream and adjacent to the area. All surface water sampling locations were within the Upper Ohio watershed, except for one in the Maohing watershed. Creek sediment was collected in East Palestine and background areas. Private well water was collected from properties around the derailment site in Columbiana County, Ohio and Beaver County, Pennsylvania. Trip blanks and field blanks were prepared for all analyses. To characterize VOC and SVOC concentrations in water samples, a liquid-liquid extraction method, followed by extract analysis using a gas chromatograph-mass spectrometer (GC/MS), was applied. A gas chromatograph-mass spectrometer (GC/MS) Shimadzu GC-2010 Plus GC coupled with a Shimadzu TQ8030 triple quadrupole mass spectrometry was used. Separation was carried out using an Agilent HP-5MSUI column (30 m x 0.25 mm x 0.25 µm) with helium as the carrier gas with a flow rate of 1.2 mL/min. A temperature gradient was first held at 40 °C for 4 min. then jumped to 320 °C for 5 min at a rate of 9.6 °C/min. An initial scan with a range of 50-350 *m/z* was conducted to narrow down the selected compounds that were focused on. Selective ion monitoring (SIM) was used with m/z of 55, 55, 57, and 57 for quantification of BA, 2-EHA, 2-BE, and 2-EHL. The Shimadzu operated in splitless mode. Chlorobenzene-d5 was used as the internal standard while naphthalene-d8 was the surrogate standard. The samples were prepared by filtering (0.22 um PTFE filter purchased from

Thermo scientific) the raw samples into 40 mL vials as well as filtering a x5 dilution in a 40 mL vial. The USEPA method 3511 for liquid-liquid extraction (LLE) was used, with dichloromethane (DCM) as the solvent. We added 2 mL of DCM, 6 g of anhydrous sodium chloride, and 5 uL of NAP-d8 to each 40 mL sample. After mixing the samples, we collected 1 mL of the DCM layer from each vial using a gas-tight syringe and added 5 uL of Chlorobenzene-d5. The extracts were later analyzed using the GC/MS instrument. The method of detection limits (MDLs) was done for the following four compounds with a spiked known concentration of 50 ppb for BA, 2-ethyl 1-hexanol, 2-EHA and 150 ppb for 2-BE and then were extracted. The 50 ppb compounds had a T-test score with 99% confidence of 3.5 for eight samples and the 150 ppb compound had a T-test score with 99% confidence of 3.7 for seven samples. The MDL was equal to the t-test score multiplied by the standard deviation per compound. Percent recovery was also conducted with three samples for the compounds with a known spiked concentration of 50 ppb. The minimum reported limits (MRLs) were defined based on the accuracy and precision of the instrument used, as well as the calibration curve and area for each analyzed compound. The percentage recovery, MRL, MDL are shown in **Table ESI-1. Liquid-liquid extraction efficiency as well as the MRLs and MDLs determined for the GC/MS method for SVOC.**

Table ESI-1. Liquid-liquid extraction efficiency as well as the MRLs and MDLs determined for the GC/MS method for SVOC.

Name	RT, min	% Recovery	MRL (ppb)	r^2	MDL (ppb)
Chlorobenzene-d5	6.325	-	0.53	0.618	14156.7 (based on area)
Butyl acrylate (BA)	7.630	64.5	1.42	0.990	0.571
2-Butoxyethanol	7.796	49.5	1.42	0.989	1.04
Phenol	9.465	52.5	2.63	0.982	0.49
2-Chlorophenol	9.590	92.3	2.63	0.993	0.64
2-Ethylhexanol	10.350	103.5	1.63	0.992	0.60
o-Cresol	10.860	75.4	0.53	0.992	0.39
Hexachloroethane	11.209	88.9	0.53	0.990	0.29
p-Cresol	11.229	67.6	2.63	0.989	0.33
Isophorone	12.059	88.6	0.53	0.992	0.28
2,4-Dimethylphenol	12.484	76.2	2.63	0.996	0.37
Bis(2-chloromethoxy)methane	12.717	79.8	2.63	0.991	0.71
Naphthalene-d8 (NAP-d8)	13.100	84.2	0.53	ISTD	-
Naphthalene (NAP)	13.145	91.8	0.53	0.994	0.28
2-Ethylhexyl acrylate (EHA)	13.770	70.4	0.58	0.996	0.54
4-Chloro-3-methylphenol	14.709	81.1	39.47	0.988	0.36
2-Methylnaphthalene	14.874	91.0	0.53	0.992	0.33
1-Methylnaphthalene	15.133	86.7	0.53	0.991	0.27
2-Chloronaphthalene	16.060	88.5	13.16	0.988	0.28
Acenaphthylene	17.088	81.1	2.63	0.993	0.30
Acenaphthene	17.559	82.3	2.63	0.996	0.28
Dibenzofuran	17.964	83.8	2.63	0.995	0.28

2,4-Dinitrotoluene	18.817	81.7	2.63	0.996	2.29
Fluorene	18.817	81.7	13.16	0.992	0.43
Phenanthrene	21.169	79.8	5.26	0.991	0.44
Anthracene	21.282	74.3	5.26	0.980	0.49
Carbazole	21.767	94.6	5.26	0.982	0.44
Fluoranthene	24.130	64.0	2.63	0.992	0.44
Pyrene	24.663	76.2	2.63	0.996	0.47
Benz(*a*)anthracene	27.682	53.2	2.63	0.989	0.44
Chrysene	27.779	64.4	2.63	0.989	0.52
Benzo(*b*)fluoranthene	30.150	50.8	13.16	0.986	0.42
Benzo(*k*)fluoranthene	30.255	62.5	2.63	0.991	0.48
Benzo(*a*)pyrene	30.883	56.1	2.63	0.987	0.41
Indo(*1,2,3-c,d*)pyrene	33.070	55.9	2.63	0.975	0.45
Dibenzo(*a,h*)anthracene	33.122	76.4	2.63	0.975	0.50
Benzo(*g,h,i*)perlyene	33.523	64.7	2.63	0.981	0.46

RT= Retention time

ESI-1.4. Total petroleum hydrocarbon concentration for creek water analysis. Total petroleum hydrocarbon (TPH) diesel range organics (DRO-C10 to C28) analysis was conducted because it was initially used by the Ohio EPA during the early weeks of the response. The HACH Immunoassay Reagent Set was used along with the DR 3900 Laboratory VIS Spectrophotometer. The Reagent Set contained antibody cuvettes, TPH enzyme conjugate, color developing solution, stop solution and calibrators. The factory issued calibration standards used were 2, 5, 10 and 20 ppm. An additional calibrator was created by mixing equal parts water and the 2 ppm calibrator to create a 1 ppm sample. Prior to analysis, the creek samples were filtered with a 0.22 um PTFE filter. Approximately, 0.5 mL of each water sample and 50 uL of each calibrator was added to the antibody cuvettes. Next, 0.5 uL of methanol was added to only the samples. Then, 0.5 mL of the TPH Enzyme Conjugate was added to all the cuvettes. After the addition, the samples rest for 10 min with 30 seconds of mixing at 0 and 5 min. After 10 min, the cuvettes were gently rinsed and dried. Color Developing Solution (0.5 mL) was added to all cuvettes and the samples sat for 10 min with 30 seconds of mixing at 0 and 5 min. After 10 min, Stop Solution (0.5 mL) was added to the cuvettes. After mixing the samples for 20 s, the sample absorbance was quantified with the DR 3900 at a wavelength of 450 nm.

ESI-1.5. Inorganics analysis for creek and well water samples. Creek water and well water samples were analyzed for ions and metals by ion chromatography (IC) and inductively coupled plasma – optical emission spectrometer (ICP-OES). For IC analysis, samples were rapidly analyzed as is (no pH adjustment

or preservative) while for total metals determination samples were first acidified with nitric acid. An aliquot of sample was added to a 15 mL metal free centrifuge tube with 70% HNO_3 to pH < 2 and Yttrium as an internal standard. Prior to analysis samples were filtered through a 0.45 µm surfactant free cellulose acetate membrane filter to remove suspended particulates. Field blanks were prepared and analyzed using the same procedure used in sample acidification.

Prior to analysis, samples were filtered with 0.45 µm surfactant free cellulose acetate membrane filters. The anion eluent (3.2 mM sodium carbonate (Na_2CO_3) with 1 mM sodium bicarbonate ($NaHCO_3$) for ion chromatography was prepared from 99.8+ % purity salts from Sigma Aldrich, USA. A standard mix of seven anions that included: F^-, Cl^-, NO^-, Br^-, NO_3^-, PO_4^{3-}, and SO_4^{2-} was purchased from Metrohm, Inc. The determination of anions concentrations was performed on a 940 Professional IC Vario TWO/SeS Ion Chromatograph (Type 1.940.2400, Metrohm, FL, USA), equipped with a Metrosep A Supp 5-150/4.0 chromatographic column. The eluent pressure during the determinations was around 10.4 MPa, with a flowrate of 0.7 mL/min at ambient temperature, with a run time of 20 min. The system is operated by MagIC Net software (Metrohm). The samples were diluted 7.5 to10 times for all unknown concentrations to be within the standard curve calibration range (0.2 to 100 mg/L) of each anion.

For element determination an inductively coupled plasma - optical emission spectrometer iCAP 7400 Duo (Thermo Scientific, Inc.) was used. The instrument settings were the same for radial and axial plasma views. Method parameters including the list of elements, acquisition wavelengths, limits of detection (LOD) and quantitation (LOQ) can be found in **Table ESI-2**. Prior to analysis by ICP-OES, the samples were diluted 7.5 to 200 times with 2% HNO_3. The standards for ICP-OES analysis were acquired from Inorganic Ventures, Inc. Multi-element ICP standards were created from three separate multi-element standards, such that the final standards contained a total of 44 elements. Yttrium (Y) in 2% nitric acid was used as an internal standard. Calibration range for total elements was 0.01 to 50 ppm. The instrument requires Argon (99.997%) and ultra-high purity liquid nitrogen. The data was acquired with Qtegra software (Thermo) and post-processed in Microsoft® Excel.

Table ESI-2. LODs and LOQs for ICP-OES analyses, ppb.

Element	LOD	LOQ	Element	LOD	LOQ
Ag	2.04	6.81	Mn	0.08	0.27
Al	0.75	2.51	Mo	0.66	2.19
As	43.7	145.66	Na	1.38	4.59
B	0.55	1.85	Nb	0.84	2.80
Ba	0.03	0.09	Ni	0.73	2.43
Be	0.12	0.41	P	6.91	23.0
Ca	2.16	7.20	Pb	1.73	5.76
Cd	0.16	0.53	S	3.98	13.3
Co	0.23	0.76	Sb	1.86	6.18
Cr	0.17	60.8	Se	53.2	177
Cu	0.54	1.80	Si	3.31	11.1

Fe	0.66	2.19	Sn	1.25	4.17
Ga	6.40	21.35	Sr	0.03	0.09
Ge	6.33	21.12	Ta	6.83	22.8
Hf	3.69	12.31	Ti	0.63	2.09
Hg	1.40	4.65	V	0.94	3.12
K	61.1	203.58	W	9.71	32.4
Li	2.34	7.79	Zn	0.18	0.61
Mg	0.05	0.18	Zr	0.33	1.10

ESI-1.6 Gauze surface wipe and creek water soak samples. Exterior building wipe samples were collected from East Palestine buildings. New 12-ply 2x2 gauze pads were used for surface wipe and creek water surface soak sampling. The pads were “Rayon-polyester blend and not made with natural rubber latex” (CVS Health, Inc.). On March 17, we collected wipe samples from exterior buildings in East Palestine (**Table ESI-3**). Wipes were dosed with acetone (HPLC Grade) in the field. Each wipe sample was collected at a different location, even when on the same property. At the laboratory, each sample was inserted into a 40 mL amber glass bottle with polytetrafluoroethylene (PTFE)-lined caps that had been precleaned with HNO_3. DCM (20 mL) was then added to each vial to facilitate extraction. The vials were then sonicated using a Branson 1510 Ultrasonic sonicator for 30 min, followed by syringe filtration with a 0.22 um PTFE filter into a 1 mL clear bottle, adding internal and surrogate standards to each sample before GC/MS analysis.

Table ESI-3. Wipe samples for buildings collected on March 17, 2023.

Name	Distance from Derailment Site, mi	Distance from Contaminated Creek, mi	Description
WP1	0.07	0.06	North from site
WP2	0.13	0.12	North from site
WP3	0.83	0.07	West from site
WP4	1.48	0.60	West from site
WP5	-	-	Lab control

ESI-1.7. Sulphur Run sorbent pads: New and used. Sorbent pads were observed floating in local creeks and sometimes used pads were left on private property. The sorbent pads were brought to the laboratory for physical, thermal, and chemical analysis from the first trip, on February 25. The first was an unused pad and the second had been floating on one of the dams installed on Sulphur Creek. These pads were located at the closest access point the authors could reach to the derailment site, within 0.3 miles west. The purpose of this examination was to determine the type of sorbent material being used and its potential for removing contaminants associated with the spill from the water surface.

ESI-1.8. LC/HRMS for water and soil analysis. Liquid chromatography high-resolution mass spectrometry (LC/HRMS) was applied to examine creek water samples. Water samples were prepared directly in 1:1 water/methanol composition. Data acquisition for the prepared samples was conducted using HR/MS. PFAS analytical standard stocks were prepared in different solvents and pH conditions depending on the physicochemical properties of the specific PFAS. Stocks were prepared in methanol/isopropanol as a final master mixture for standard solution preparation or as stock to spike for matrix spike or lab processing spike sample preparation. PFAS analytical standards and mass-labeled chemicals were purchased from Wellington Laboratories (Guelph, Canada). Methanol, ammonium acetate, and isopropanol were purchased from Thermo Fisher Scientific (Hampton, NH) at HPLC optima or higher grade and nanopure water (Thermo Scientific MicroPure Ultrapure Water System) was used for mobile phase and Quality Assurance Quality Control sample preparation.

Target analysis for quantification, suspect screening, and non-target analysis were performed on an Ultra High-performance Liquid Chromatograph Mass Spectrometer system (Shimadzu, Nexera 40) coupled with Sciex 7600 Zeno Quadruple time of flight (LC–QToF). Data was acquired using SWATH® Data-Independent Acquisition mode supported in both positive and negative electrospray ionization (ESI) mode for TOFMS and MS/MS analysis. A delay column (Phenomenex, Luna 3 µm C18(2) 100 Å, LC Column 30 x 4.6 mm) was installed for the removal of potential contamination from the LC system. The analytical column was Kinetex® 5 µm EVO C18 (Phenomenex, 100 Å, LC Column 100 x 2.1 mm) with a guard filter (Phenomenex, KrudKatcher ULTRA HPLC In-Line Filter, 2.0 µm Depth Filter x 0.004in ID), and the column temperature was maintained at 40ºC. The injection volume was 10 µL. A combined flow rate of 0.3 mL/min was used for mobile phases A (0.15% acetic acid in water) and B (2 mM ammonium acetate in methanol). The gradient started at 5% B for first 4 min, increased to 65% in 10 min, 100 % at 29 min and maintained for 9 min, decreased back to 5% in 0.5 min, and maintained for 11.5 min.

Acquired data was processed using Sciex OS software (ver 3.1) for quantifying analysis of selected compounds that are available in their standard chemicals. For suspect analysis, the initial screening was performed in Sciex-OS and R script based on acceptable criteria which included minimum peak area (> 3000), reasonable retention time, signal/noise ratio (>10), mass error (< 5 ppm is acceptable), library hit (PFAS MSMS spectra library, Fluorous 2.0), and isotopic pattern with a list of suspected compounds (>2100

chemicals). Final screening was performed manually in Sciex-OS for peak confirmation. For nontarget analysis (NTA), peak peaking was conducted using Sciex Os. Field blank was selected as nontarget control for water samples while lab processing blanks were used for NTA blank of soil samples. The selected peaks obtained from the peak picking process using SciexOS and their MS/MS results were compared with the database in Sciex and NIST MS/MS library. Then the suggested chemical formula and structure from the library were compared to the nominal isotopic pattern for final chemical confirmation. For peaks without the library matching required chemical formula finding from the chemical isotopic pattern and mass accuracy, and then the tentative chemical structure was finalized using MS/MS result for fragment confirmation. The final NTA screening result was confirmed with open-access NTA online databases & libraries including PubChem, CompTox Chemicals Dashboard, MassBank, mzCloud, etc.

ESI-1.9. LC/MS/MS for water analysis. Samples were processed and analyzed at the University of Notre Dame using an adapted EPA Draft Method 1633 Version 2, as follows. Samples were homogenized by inverting 3-4 times in sample container. 25 mL of sample was transferred to another 50 mL tube. An ultrapure water method blank and two controls were also prepared. The controls were: one at mid-range concentration and one at concentration expected to be 2x the LoQ. The pH of each sample was checked to be within 0.5 of pH=6.5 for all samples. Samples were then spiked with extraction internal standards per EPA Draft Method 1633 Version 2. The WAX solid phase extraction (SPE) cartridge was conditioned with 15 mL of 1% NH4OH in methanol and then 5 mL of 0.3 M formic acid in water. The sample was loaded and extracted at 5 mL/min. The sample was then rinsed with 5 mL of ultrapure water followed by 5 mL of 1:1 formic acid:methanol. The SPE was dried for 15 s and then eluted into a 15-mL polypropylene vial using 5 mL of 1% NH_4OH/MeOH. After SPE, the sample was processed using a clean-up step to remove residual organics before LC-MS/MS analysis. Briefly, 25 µL of glacial acetic acid and 10 mg of carbon was added to the sample vial. The sample was gently mixed on a shaker for 5 min and then vortexed for 30 s, and then centrifuged at 3,300 × g for 10 min. Injection internal standards were spiked, and the sample was then filtered through a 0.2-µm nylon filter. An aliquot was added to an LC/MS/MS vial for analysis.

LC/MS/MS analysis was performed on an Agilent Infinity II UHLPC coupled to an Agilent 6470BA using specifications detailed in EPA Draft Method 1633 Version 2. Data was acquired using dynamic multiple reaction monitoring acquisition mode in negative electrospray ionization (ESI) mode. A delay column (Agilent PFC Delay Column, 4.6x30mm) was installed for the removal of potential contamination from the LC system. The analytical column Agilent ZORBAX Eclipse Plus C18 (2.1x100mm, 1.8 uM) (P/N 959758-902) was used and the column temperature was maintained at 55 ºC. The injection volume was 10 µL. A combined flow rate of 0.4 mL/min was used for mobile phases A (90/10 H2O/MeOH + 2 mM ammonium acetate) and B (100% MeOH). The gradient started at 5 % B for the first minute, increased to 55% B in 0.5 min, to 70% over 5 min, 80% over 1.5 min, then to 100% over 5 minutes and maintained at 100% for 2 min, then decreased back to 5 % in 0.5 min, and maintained for 2.5 minutes.

Linearity was performed with 7 concentrations between 0.02- 50 ng/mL that were injected to generate a calibration curve and the response between concentration and measured peak area for all analytes was best described by a linear curve fit with no weighting with R^2 >0.975 for all analytes. Seven replicate injections of a mid-range calibration concentration (1 ng/mL) were used to measure precision & accuracy. Precision was measured by determining the relative standard deviation (RSD) of the average measured peak area across these replicate injections. For all analytes the RSD values ranged from 1.5-17.7% (median 8.3%). The same 7 replicate injections were used to determine accuracy through the percent difference of this measured concentration from the true concentration. The absolute percent difference values ranged from 0.8-42.7% (median 15.5%). Finally, the limit of detection (LoD) and the limit of quantification (LoQ) were determined. These values were determined using a previously described approach that measures the average analyte signal present in a set of blank replicates and incorporates the variability of replicate injections at a low concentration of analyte to estimate the LoD. The LoD for all analytes ranged from 0.06-4.41 ng/mL. The LoQ for each analyte was set equal to either the value found by LoQ=3.3*LoD or to 0.02 ng/mL, whichever was greater. Seven replicate injections of 0.02 ng/mL were performed to ensure the estimated LoQs gave low variability, with all analytes having a measured standard deviation of these replicate injections within ±30%. The calculated limits of detection and limits of quantification are given in **Table ESI-4**.

Table ESI-4. Limits of detection and quantification of LC/MS/MS analysis.

Analyte	LOD (ng/mL)	LOQ (ng/mL)*
PFBA	1.1432	3.77
PFMPA	0.2784	0.92
PFPeA	0.2993	0.99
3-3 FTCA	0.5818	1.92
PFBS	2.4341	8.03
PFMBA	0.3244	1.07
PFEESA	0.3227	1.06
NFDHA	0.2514	0.83
4-2 FTSA	0.8321	2.75
PFHxA	0.1496	0.49
PFPeS	0.0831	0.27
HFPO-DA	0.0631	0.21
PFHpA	0.1402	0.46
PFHxS	0.1069	0.35
DONA	0.2131	0.70
5-3 FTCA	3.6653	12.10
6-2 FTSA	0.8490	2.80
PFOA	0.0958	0.32
PFHpS	0.1144	0.38
PFOS	0.1407	0.46
PFNA	0.1465	0.48
7-3 FTCA	4.4123	14.56
9Cl-PF3ONS	0.1686	0.56
PFNS	0.0605	0.20
8-2 FTSA	0.8149	2.69
PFDA	0.0713	0.24
N-MeFOSAA	0.1500	0.50
PFDS	0.1595	0.53
PFOSA	0.1597	0.53
PFUnDA	0.1201	0.40
N-EtFOSAA	0.1879	0.62
11Cl-PF3OUdS	0.1310	0.43
PFDoDA	0.2753	0.91
PFDoS	0.1185	0.39
PFTrDA	0.1878	0.62
N-MeFOSA	0.0987	0.33
MeFOSE	1.0094	3.33

PFTDA	0.1541	0.51
EtFOSE	0.9912	3.27
N-EtFOSA	0.1555	0.51

***Method LoQ is ~ 5 times lower than instrument LoQ**

ESI-1.10. Bench-scale sorbent pad experiments. In addition to the sorbent pads from East Palestine, new sorbent pads were purchased to perform additional tests to determine the absorbance capacity to remove chemical contaminants of concern from the water. Pads from three different brands were purchased: Sellars Oil Only Light Weight Sorbent Pads (Pad A), Meltblown Technologies Standard White Lightweight Pads (Pad B), and Texas Boom Company's P-200 Oil Only Pads (Pad C). All pads (5.08 cm x 6.36 cm) averaged 0.578, 0.471, and 0.524 g in mass for Pads A, B, C, respectively. The average mass of the new pad from East Palestine was 0.757 g. All were chosen due to their similar components to those being used in the contaminated creeks.

Derivative Thermogravimetry - Thermogravimetric Analysis (DT-TGA) was employed to analyze the new and used sorbent pads (dried for 12 hr at 28 °C to remove water), aiming to gain insight into their composition. A TA instrument Q50 thermogravimetric analyzer was utilized to conduct DT-TGA. Samples weighing between 20-30 mg were placed in an alumina pan, and the analysis involved heating the materials from the atmospheric ambient temperature to 800 °C at a rate of 10 °C per min, in air atmosphere with a gas flow rate of 60 ml/min. In addition, Infrared (IR) spectroscopy was utilized to verify the material of the sorbent pad, detect any contaminant peaks in the contaminated sorbent pad (dried for 12 hr at 28 °C to remove water). Specifically, Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) spectroscopy was employed for the IR studies. ATR-FTIR spectroscopy was conducted using a Perkin Elmer Spectrum 100 spectrometer. The spectroscopy involved performing 20 scans in transmission mode, ranging from 4000 cm^{-1} to 600-500 cm^{-1}. A resolution of 2 cm^{-1} was used for the analysis and a Diamond/ZnSe crystal was utilized. Furthermore, extraction studies were performed to understand the absorption of chemicals in the stream by the sorbent pad. Extraction studies were performed with dichloromethane (anhydrous grade, with purity of ≥99.8%), chloroform (ACS reagent grade, with purity of ≥99.8%), and hexane (laboratory reagent grade, with purity ≥95%) as the solvent and 4 g of each new and used pads were used with 20 ml of solvent in scintillation vials and the stirring for extraction was performed in an orbital shaker for 36 hr. Vacuum distillation was performed on the contaminated pad to collect the volatile materials from the pad and perform chromatography on the distillate. Experiments were done both without solvent and with chloroform as the solvent at 150 °C, vacuum of 0.8 bar, and the collected distillate was cooled down cryogenically with liquid nitrogen to prevent the escape of vapors of distillate, the extracts and distillate were sent for analysis with GC/MS.

To replicate the composition of contaminated water in East Palestine, the authors prepared a mixed solution containing butyl acrylates (BA), 2-butoxyethanol (2-BE), 2-ethylhexanol (2-EHL), 2-ethylhexyl acrylate (2-EHA), and naphthalene (NAP) (**Table ESI-5**). Concentrations selected were lower than the maximum concentrations RESP found in the creeks, with the exception of NAP. NAP concentration in the present study was chosen to be higher so that NAP-sorbent pad sorption differences could be detected, if present. Contaminated water was poured into 40 mL amber vials with no headspace with PTFE replacement septa caps: 24 hr controls, 48 hr controls, and the three different pads. A 250 mL jar with a PTFE cap of remaining solution was also kept as extra and filled to the top with no headspace. Additionally, 40 mL blanks with reagent grade water were also tested. After 24 hours, the sorbent pads were inserted into the 40 mL vials and filled up to the top with no headspace using the extra solution. After allowing the sorbent pads to remain for 24 hours, they underwent a dilution process, being reduced by a factor of two in preparation for subsequent testing.

Using EPA's liquid-liquid extraction method 3511, the samples were extracted and put into 2 mL vials for Shimadzu GC-2010 Plus gas chromatography coupled to a Shimadzu TQ8030 triple quadrupole mass spectrometry. Separation was carried out using an Agilent HP-5MSUI column (30 m x 0.25 mm x 0.25 µm) with helium as the carrier gas with a flow rate of 1.2 mL/min. A temperature gradient was first held at 40°C for 4 min and then jumped to 320°C for 5 min at a rate of 9.6°C/min. Selective ion monitoring (SIM) was used with m/z of 55, 55, 57, 57, and 128 for quantification of BA, 2-EHA, 2-BE, 2-EHL, and NAP. The

Shimadzu operated in splitless mode. Chlorobenzene-d5 was used as an internal standard while NAP d-8 was used as the surrogate standard; both in methanol solution.

Table ESI-5. Compounds tested and analyzed: BA, 2-BE, 2-EHL, 2-EHA, and NAP.

Parameter	Compound				
	BA	**2-BE**	**2-EHL**	**2-EHA**	**NAP**
C_{max} in Ohio creek water, ppm	180	848	Detected	122	0.01
C_w, mg/L, 25 °C	2,000	N/A	880	est. 100	31
Log K_{ow}	2.36	0.83	2.73	4.09	3.3
VP, mmHg, 25 °C	5.45	0.88	0.136	0.178	0.085
HLC, atm-m^3/mol, 25 °C	$4.6x10^{-4}$	$1.6x10^{-6}$	$2.6x10^{-5}$	$4.32x10^{-4}$	$4.4x10^{-4}$
MW, g/mol	128.17	118.17	130.23	184.27	128.17

ESI-1.11. Bench-scale experiment – Aeration. To better understand the impacts of contaminated water on air quality, air was sampled with a ppbRAE3000 PID (photoionization detector) above laboratory prepared contaminated water containing BA, 2-BE, and 2-EHA. These measurements were conducted directly above a 20 mL contaminated solution inside a 40 mL vial under a fume hood (2.83 m^3/s face velocity). Both static and aeration conditions were evaluated to simulate field operations. The device was calibrated using a 10-ppm isobutylene standard and air. Control air sampling was conducted above reagent grade water (no chemicals added) to ascertain device response variability for both conditions applied. The manufacturer reported the device had a minimum detection limit of 1 ppb and a maximum detection limit of 10,000 ppm. Correction factors of 1.6, 1.2, and 1.1 for BA, 2-BE, and 2-EHA respectively were recommended by the manufacturer. An 18-gauge stainless steel needed was used to inject ultra-pure nitrogen at 1 psi under aeration conditions into sampling vials. To limit the potential for cross contamination, the PID signal was allowed to return to zero between each sampling event. If the device did not reach absolute zero, the device was recalibrated using air and 10 ppm isobutylene. If calibration was not successful, the device was dismantled and cleaned using ultra-pure nitrogen. Calibration was then completed again before testing continued. For the aeration condition, the needle was cleaned using dichloromethane and rinsed with reagent grade water between samplings.

Aqueous concentrations selected were based on surface water quality monitoring results from the Ohio EPA. Amber glass vials, 40 mL, with PTFE lined septa were filled with 20 mL of selection solution (contaminated water). Contaminated water solutions were created by dosing neat chemical into water for dissolution. Acetone, methanol, and dichloromethane (insert purity for each solvent) were not used to dissolve neat chemicals as the solvents would confound the PID signal. Samples were allowed to sit for 2 hr at room temperature (20°C). Next, the cap was removed and the PID was inserted into neck of vial and held for 5 min to sample the headspace. Air sampling frequency was conducted at 15 s intervals with average, minimum, and maximum gas signal recorded. Aqueous concentrations of contaminants were determined using the GC/MS method.

ESI-1.12. Silicone products and honey analysis. Silicone retail products were collected from a commercial building located directly above Sulphur Run less than 0.5 mi from the derailment site and from a building 5 mi North of East Palestine. Silicone products were cut in half, weighed, and subjected to two different extraction procedures: immersed in 20 mL of methylene chloride in a 40 mL vial, or were wiped using an acetone dampened gauze and the gauze was immersed into 20 mL of methylene chloride in a 40 mL vial. All samples were capped and sonicated for 30 min. After sonication, extracts were analyzed using the GC/MS method.

Honey from four colonies in Columbiana and Beaver Counties, Ohio was collected with the help of the owners and beekeepers. According to the beekeepers in Ohio, more than 28 bee colonies died at their hives during the days following the fire, and smoke was observed on three of the four properties. All were located within 5 mi East, South, and West of the derailment site. Honey was collected in glass bottles with PTFE caps directly from honey and nectar frames in the colony. For the analysis, 1 g to 2 g of honey was mixed with 5 mL Type I water, agitated, and left to stand for 30 min. The mixture was then diluted in a 1:4 ratio to prevent MS detector saturation. Samples were analyzed using an Agilent 7890B gas chromatograph coupled with an Agilent triple quadrupole mass spectrometer using headspace analysis. Separation was carried out using an Agilent HP-5MSUI column (30 m x 0.25 mm x 0.25 µm) with helium as the carrier gas with a flow rate of 1.2 mL/min. 500 uL headspace samples were injected using a 10:1 split ratio. The injection temperature was held at 230°C. The oven program was held at 40°C for 4 min, then 90°C at 12 C/min, then to 240°C at 10 C/min. Selective ion monitoring (SIM) was used with *m/z* of 78, 91, 91, and 106 for quantification of benzene, toluene, xylene, and ethylbenzene while the *m/z* of 55, 55, 57, and 57 for quantification of BA, 2-EHA, 2-BE, and 2-EHL. Results revealed MRLs of 0.4 ppb. Chlorobenzene-d5 was used as the internal standard.

ESI-1.13. Chemical fate modeling with the USEPA's EPI Suite. Chemical transport using USEPA's EPI Suite program was modeled for vinyl chloride, BA, 2-BE, 2-EHL, 2-EHA, NAP, and benzene. To model chemical transport, the Sulphur Run and Leslie Run water depth, wind velocity, and current velocity values were considered before and after February 3, 2023. Average wind velocity was determined from local weather records. Creek water depths and current velocities were obtained through field measurements and estimations, and these agreed with resident observations during the study period (**Table ESI-6**). EPI Suite software also applied chemical volatilization and fugacity models so the authors could estimate (a) chemical half-life in air, (b) the degree of chemical removal from a conventional wastewater treatment facility (a crude estimate of best-case aerobic conditions in a creek in the present study), as well as (c) estimating the mass percentage of each chemical when they were transported into four media: air, water, soil, and sediment. Since the EPI Suite software modeled soil and sediment separately, to account for the transport of chemicals into the sediment as the major contributor over soil, the emission values into soil were modified from the default 1,000 kg/hr to 0 kg/hr underneath the fugacity model tab in the software. The same approach was applied for each chemical. Separately, the CompTox chemicals dashboard was used to check that the EPI Suite calculations were reasonable. Since the CompTox system did not require any factors to be specified, each chemical was searched in the dashboard to determine their (a) biodegradation half-life values, (b) bioaccumulation factors, and (c) soil adsorption coefficients (K_{oc}).

Table ESI-6. Input values used in each EPI Suite calculation based on field observations and a historical data record review.

Location and Period	Water Depth, m	Wind Velocity m/s	Current Velocity, m/s
Sulphur Run (Feb 6-8)	0.096	4.42	0.41
Sulphur Run (Feb 8-May 31)	0.096	3.68	0.41
Leslie Run (Feb 6-8)	0.077	4.42	0.05
Leslie Run (Feb 8-May 31)	0.077	3.68	0.05

ESI-RESULTS AND DISCUSSION

ESI-2. Chemical Plume Pathway Reports

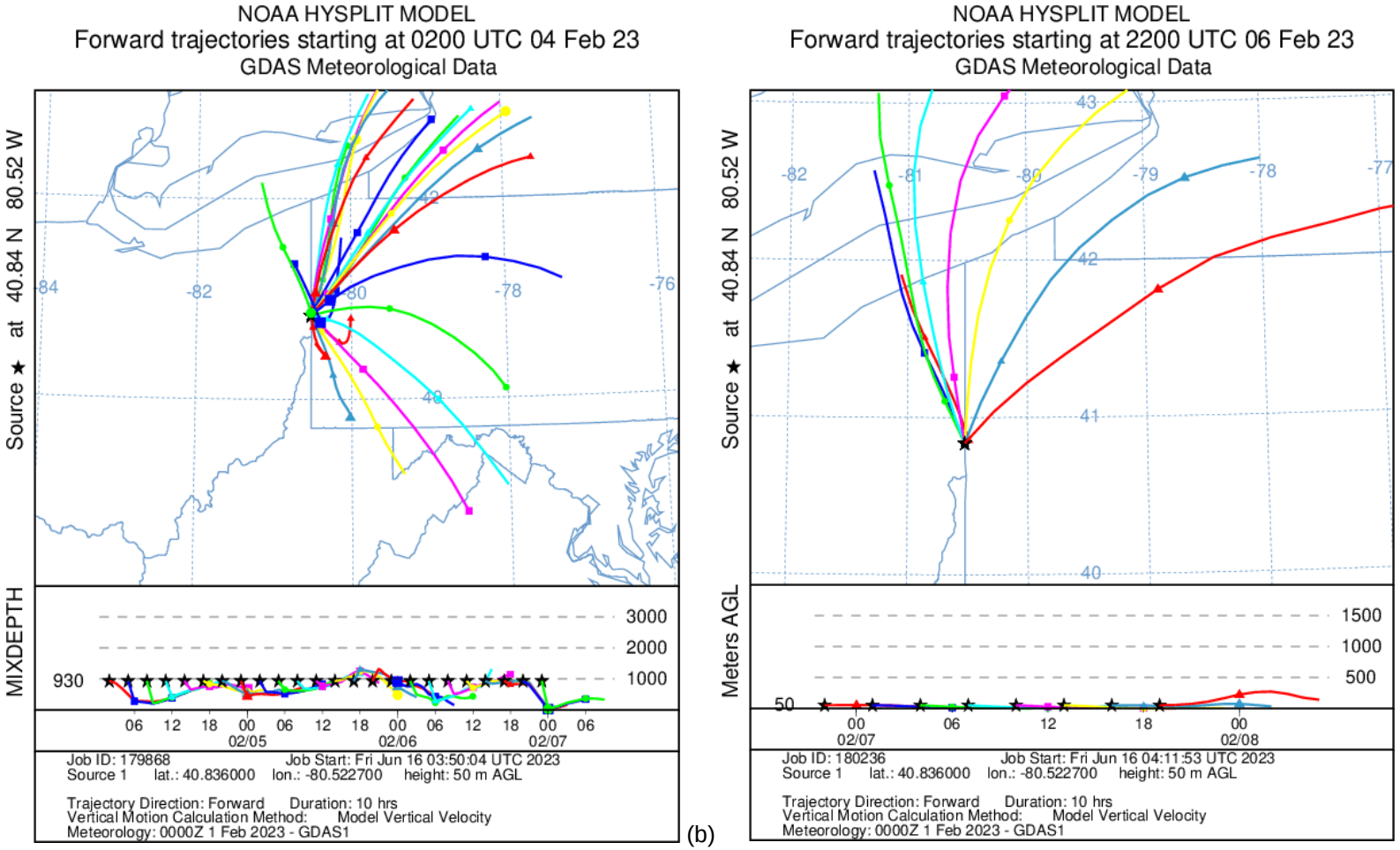


Figure ESI-1. (a) A map of some of the forward trajectories starting at 50m AGL of the spill site at the time of the train derailment. This map clearly shows the air from this location moved towards east, southeast, and north of the spill site (b) A map of the forward trajectories starting at 50m AGL of the spill site at the time of the controlled burn. This map clearly shows the air from this location moved mostly towards north of the spill site.

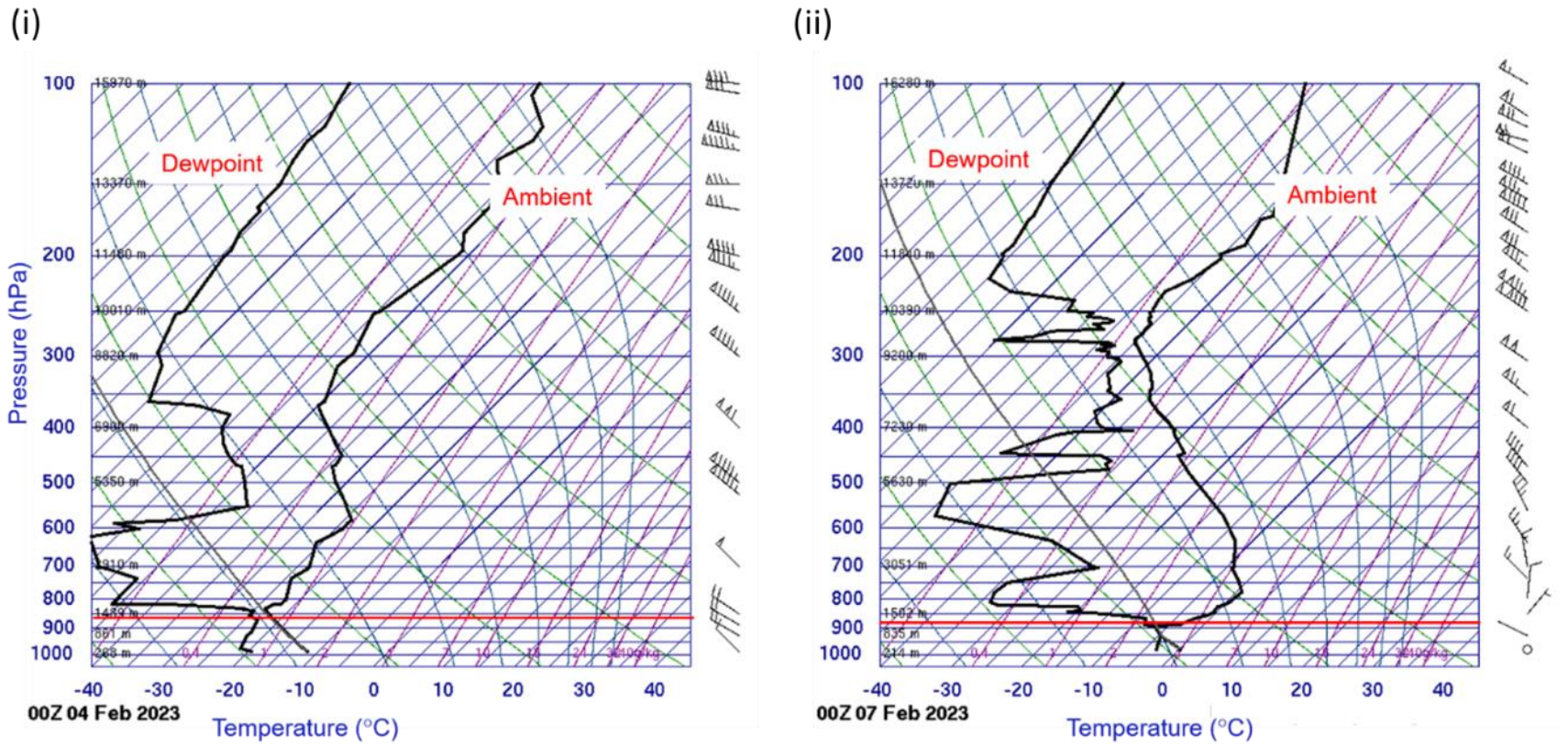
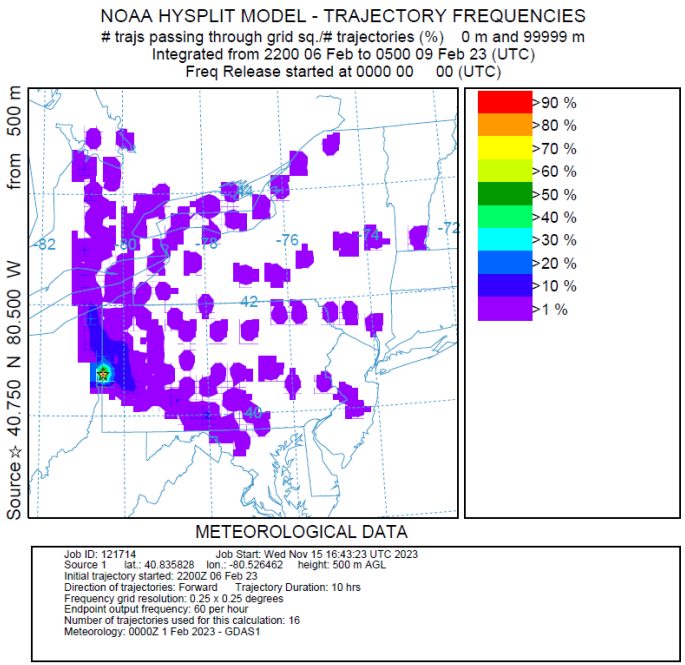


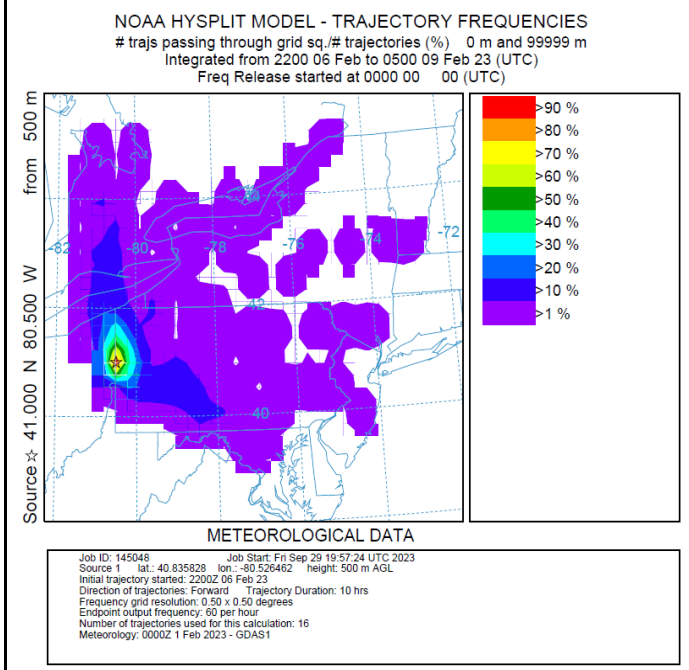
Figure ESI-2. Shew-T plots showing the vertical structure of the atmosphere over Pittsburg, Pennsylvania at 7:00 PM on (i) February 3, and (ii) February 6, 2023.[3]

The two black curves represent the dew point temperature and ambient air temperature as recorded by the weather sounding balloon. The red horizontal lines in both figures indicate the mixed boundary layer heights on these days. The height at which the two curves intersect indicates cloud height. These plots have been retrieved from the University of Wyoming website for atmospheric observations.[3] Archived weather balloon soundings over Pittsburgh, Pennsylvania, a location close to the derailment site, were reviewed due to a lack of data at the derailment site. The sounding data showed a shallow mixed boundary layer of about 1,000 m AGL in this region at the time of derailment and open burn. Hence, the model simulation was set at a starting altitude of 500 m AGL, mid-point in the mixed boundary layer.

a)


NOAA HYSPLIT MODEL - TRAJECTORY FREQUENCIES
trajs passing through grid sq./# trajectories (%) 0 m and 99999 m
Integrated from 2200 06 Feb to 0500 09 Feb 23 (UTC)
Freq Release started at 0000 00 00 (UTC)
Source ☆ 40.750 N 80.500 W from 500 m
>90 %
>80 %
>70 %
>60 %
>50 %
>40 %
>30 %
>20 %
>10 %
>1 %
METEOROLOGICAL DATA
Job ID: 121714 Job Start: Wed Nov 15 16:43:23 UTC 2023
Source 1 lat.: 40.835828 lon.: -80.526462 height: 500 m AGL
Initial trajectory started: 2200Z 06 Feb 23
Direction of trajectories: Forward Trajectory Duration: 10 hrs
Frequency grid resolution: 0.25 x 0.25 degrees
Endpoint output frequency: 60 per hour
Number of trajectories used for this calculation: 16
Meteorology: 0000Z 1 Feb 2023 - GDAS1

b)


NOAA HYSPLIT MODEL - TRAJECTORY FREQUENCIES
trajs passing through grid sq./# trajectories (%) 0 m and 99999 m
Integrated from 2200 06 Feb to 0500 09 Feb 23 (UTC)
Freq Release started at 0000 00 00 (UTC)
Source ☆ 41.000 N 80.500 W from 500 m
>90 %
>80 %
>70 %
>60 %
>50 %
>40 %
>30 %
>20 %
>10 %
>1 %
METEOROLOGICAL DATA
Job ID: 145048 Job Start: Fri Sep 29 19:57:24 UTC 2023
Source 1 lat.: 40.835828 lon.: -80.526462 height: 500 m AGL
Initial trajectory started: 2200Z 06 Feb 23
Direction of trajectories: Forward Trajectory Duration: 10 hrs
Frequency grid resolution: 0.50 x 0.50 degrees
Endpoint output frequency: 60 per hour
Number of trajectories used for this calculation: 16
Meteorology: 0000Z 1 Feb 2023 - GDAS1

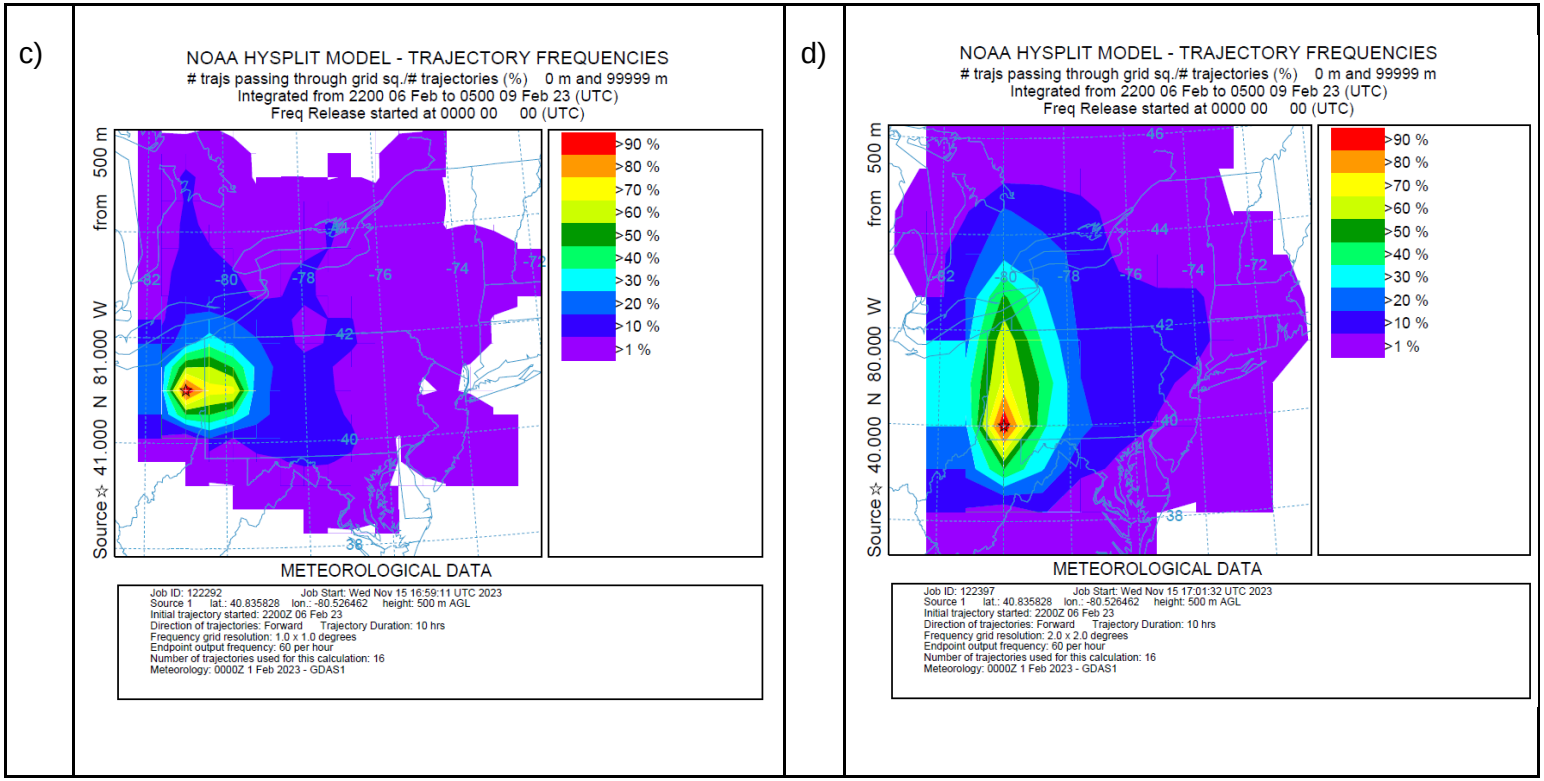


Figure ESI-3. The grids in the model are fixed based on the selected spatial resolution, which is used to calculate the trajectory of an air parcel.

After the model calculates the trajectories, it likely assigns colors to each grid based on the fraction of trajectories passing through it, using a specified color scale. Consequently, the center of the frequency plot can be spatially offset from the actual starting location (the derailment site). This discrepancy becomes evident when the model is run at different spatial resolutions, represented by trajectory frequency plots at 0.25, 0.5, 1, and 2 (labeled as a, b, c, and d, respectively). Since the only difference among these plots is the model resolution, it is evident that these variations are artifacts resulting from the grid resolution in the HYSPLIT model.

Table ESI-7. A comparison of the different model specifications.

Model	Spatial resolution	Product	Pollutant dispersion
HYSPLIT	1° x 1° (~43km x 34km at 40°N)	Air trajectories at 3 hr intervals	No
HR-NAM	12 km	Dispersion of soot	Yes (soot only)
Modified HRRR	3 km	Dispersion of pollutant	Yes

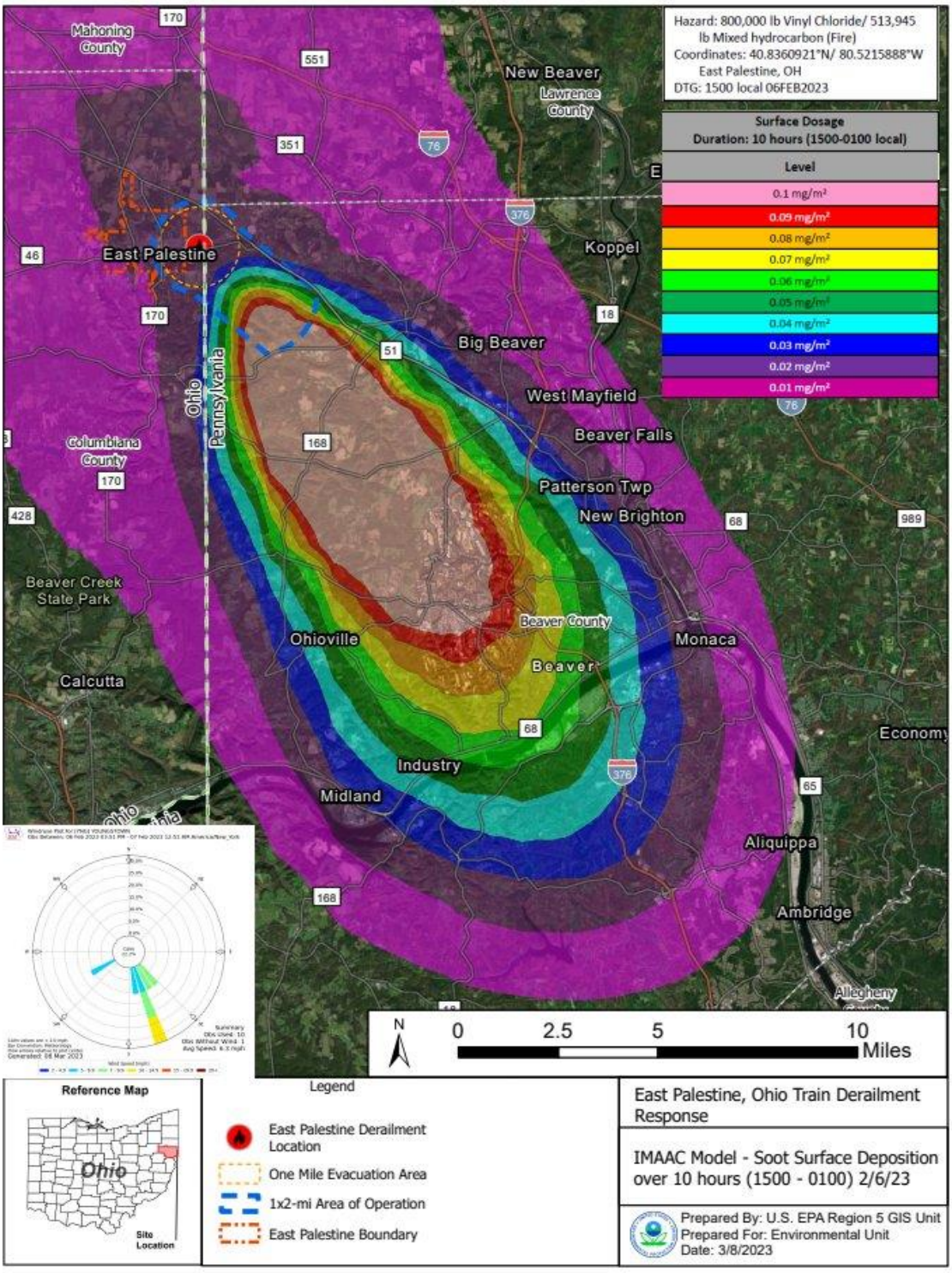


Figure SI-4. Map of Soot Surface Deposition over 10 hours on February 6, 2023 from 1500-0100 created by USEPA Region 5 on March 8, 2023.[4]

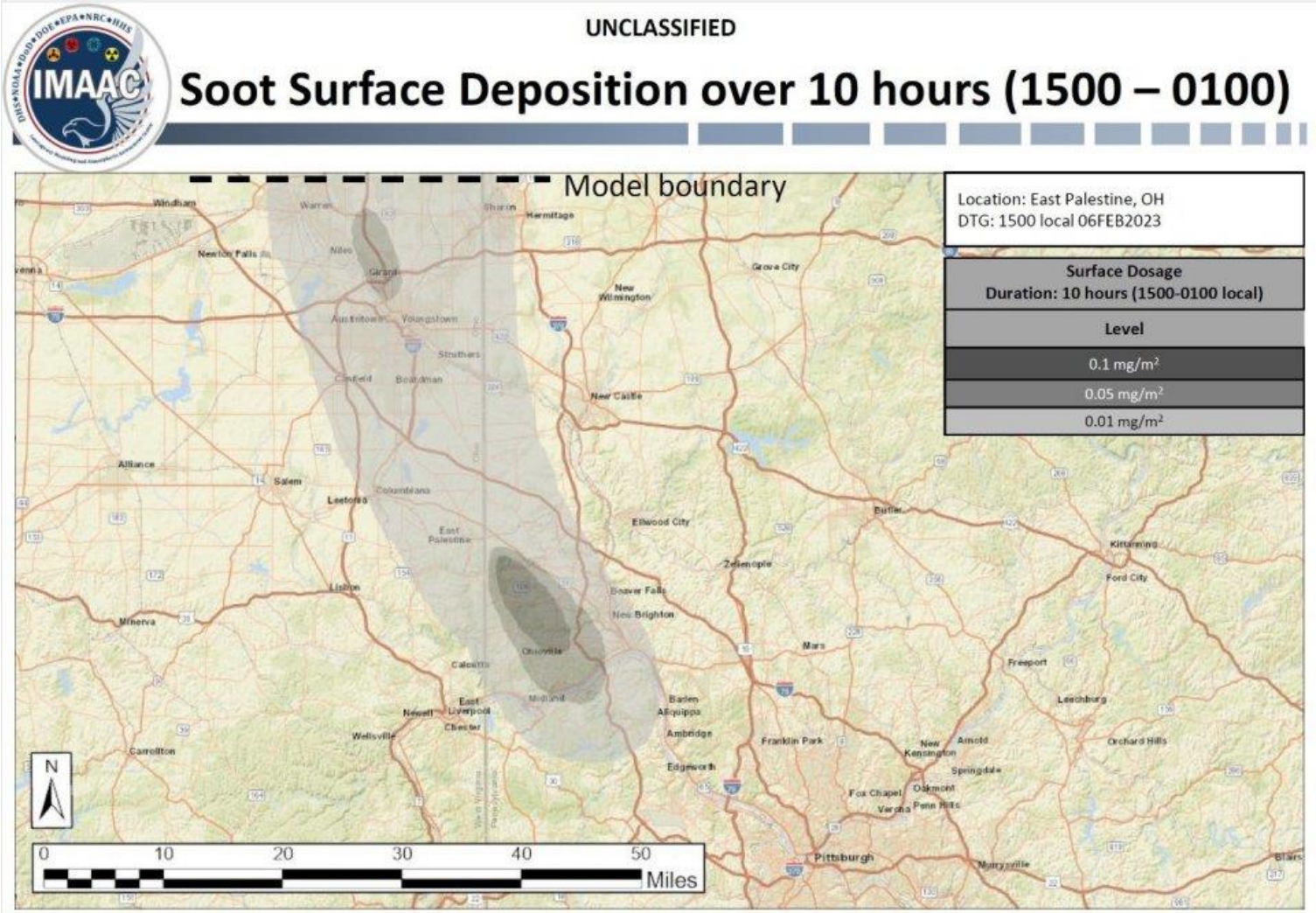
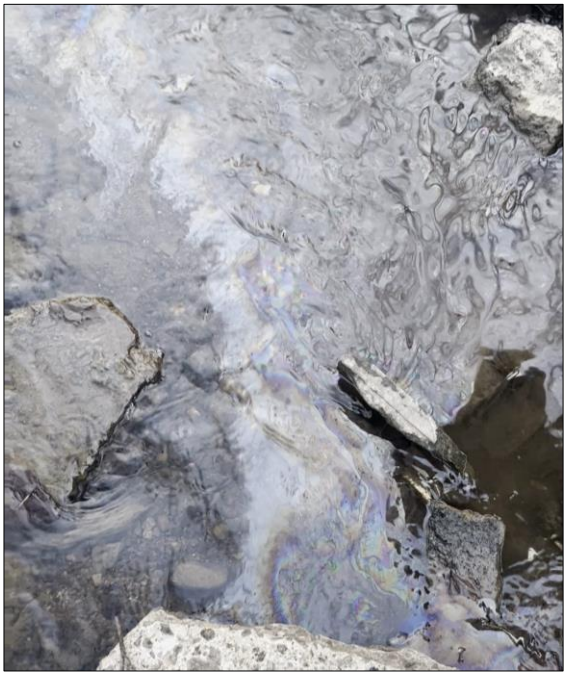


Figure ESI-5. US Federal Emergency Management Agency Interagency Modeling and Atmospheric Assessment Center (IMAAC) East Palestine Train Derailment Soot Surface Deposition Map released by the USEPA May 31, 2023.[2]

(a)



(b)

(c)

(d)

Figure ESI-6. Sheen was observed freely flowing in (a) Sulfur Run and (b) Leslie Run creeks during the first field investigation, including outside the USEPA's "containment area", (c) Sulphur Run 500 feet downstream from the derailment site, and (d) Foam was also observed on the surface of the creeks.

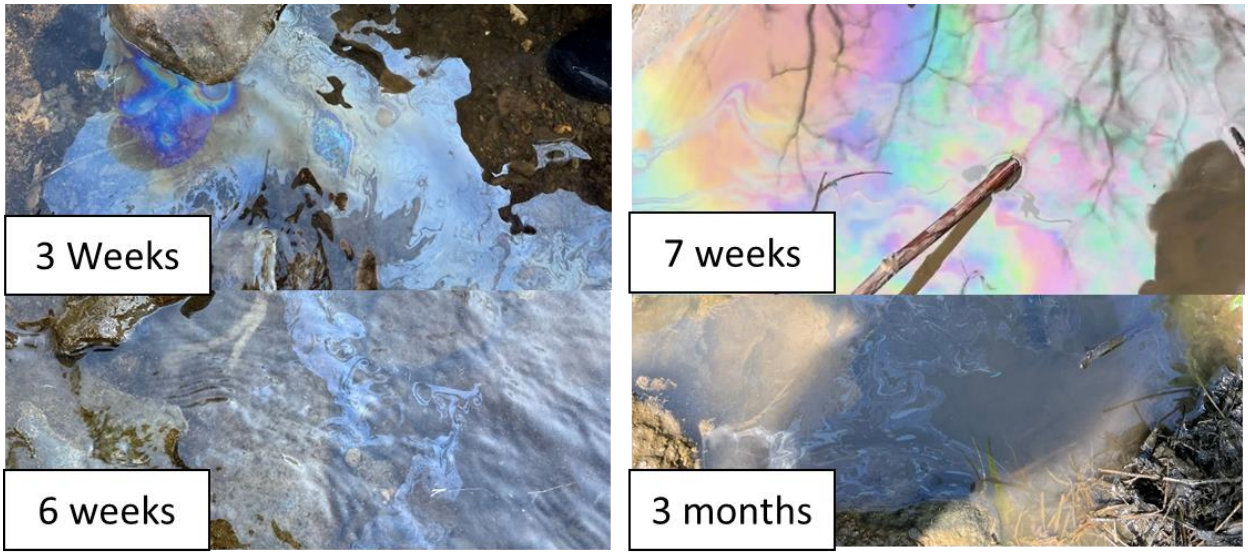


Figure ESI-7. Sheen was present, but exact chemical composition was unclear.

Responders used TPH analysis early on and found maximum of TPH-DRO at 20 ppm and TPH-GRO at 14 ppm in Leslie and Sulphur Runs. Levels decreased with time. Three weeks after the incident, we found both TPH-DRO and TPH-GRO at <1 ppm, while GC/MS analysis did not reveal the contaminants present in the sheen. Three months later, sheen was still eluting from creek banks, but not openly flowing like we saw during the first field trip, three week following the disaster. RESP aerated creeks, pressure washed creeks and rocks in some locations and numerous events occurred between each other field investigations by the authors.

ESI-3. Chemical Found at Ohio Exterior Buildings Surface

Table ESI-8. Chemicals detected on East Palestine, Ohio exterior building surfaces compared to new gauze and vinyl siding.

Chemical	New Gauze (unused)		New Vinyl Siding			Building Exterior in East Palestine (distance from derailment site, miles)											
						FW1 – 0.07 miles			FW2 – 0.13 miles		FW3 – 0.83 miles		FW4 – 1.5 miles		FW5 – lab control		
	G1	G2	A	B	C	1-Siding	2-Siding	3-Door	4-Siding	5-Window sill	6	7	8	9	10	11	12
Chemicals Unique to East Palestine NOT found on New Vinyl Siding or Gauze																	
2-BE						1.42	1.49	2.85			2.05		1,81	2.52	1.64	1.62	2.28
NAP						D	0.60	0.53	2.69	D	0.57		D	D			
Phenanthrene									D								
Fluoranthene								D			D						
Benzo(g,h,i)perlyene						D	D	D	D		D						
Chemicals Found on New Vinyl Siding or Gauze																	
BA		D	2.68	D	1.49						2.53			6.78		1.86	
Phenol	3.15	2.72	3.94	D	D			D	D		D			D			
2-EHL		D		1.64	6.74												
2-EHA	D	D		0.69													
Pyrene			D					D			D						
Chrysene			D			D		D	D		D						
Benzo(k)fluoranthene						D					D						
Indo[1,2,3-c,d]pyrene			D														
Dibenzo(a,h)anthracene			D			D											

Objects wiped included vinyl siding, metal artwork, and windowsills on the front of buildings next to the front door. D = Detection greater than the MDL, but less than the minimum reporting limit for quantification. Blank cells indicate the chemical was not detected.

ESI-4. Chemicals Detected in the Silicon Wristbands Extractions

Table ESI-9. Silicone retail products from the contaminated building contained several chemicals previously confirmed by the authors and others associated with the derailment as well as other chemicals identified here for the first time.

Chemical	Control 1	Control 2	Control 3	Batch 1 – Rep. 1	Batch 1 – Rep. 2	Batch 1 – Rep. 3	Batch 2 – Rep. 1	Batch 2 – Rep. 2	Batch 2 – Rep 3
BA				101.85					
2-BE				37.68	37.02	38.47	26.95	28.23	28.10
2-EHL				27.15	22.82	22.43	16.54	18.94	17.98
2-EHA				89.19	50.46	57.62			
NAP				18.10				4.56	
Isophorone				30.54	17.00	16.86	15.99	15.83	15.73
p-Cresol				98.31	92.26				
Phenol				240.70	226.97	222.46	82.91	86.51	81.85
2-Chlorophenol				49.65					
Acenapthene				31.08					
Fluorene				42.55					
2,4-DMP	226.52	252.49	273.79		98.15	98.32	186.61	188.03	183.90
Phenanthrene				73.05					
Anthracene				66.19				70.31	70.30
Fluoranthene		63.96	64.08	86.25			63.34	63.24	
Pyrenne	72.75	72.89		95.64			71.75	71.64	71.89
Benzanthracene				189.73					
Chrysene				79.26					
Benzo(b)fluoranthene				93.24					100.85
Benzo(*k*)fluotanthene				166.80				143.67	
Benzo(*a*)pyrene		79.29	81.01	86.48	81.15				97.80
Benzo(*g,h,i*)perlyene				114.29					

Table SI-10. Concentrations of some airborne chemicals associated with this disaster at which health effects may occur according to the U.S. EPA and NIOSH.[5–10]

Chemical Name	U.S. EPA AEGL #1, ppm	NIOSH REL, ppm
Butyl acrylate	8.3	10
2-Butoxyethanol	none	5
Isophorone	none	4
Cresols	none	2.3
Phenol	6.3	5

ESI-5. Characterization of Plumbing Inspect During Field Investigation

Table ESI-11. Plumbing characteristics for homes visited with private drinking water wells.

House	Dist. from Derailment Site, mi	Dist. from Contaminated Creek, mi	Plumbing Pipes for cold and hot water	Indoor Water Treatment
1	2.04	0.02	HDPE, PVC, PEX, Cu	Sediment filter, softener
2	2.08	0.06	HDPE, PEX, Cu	Sediment filter, no softener
3	2.12	0.02	PEX	Sediment filter, no softener
4	2.14	0.02	No information	None
5	2.91	0.02	CPVC	Sediment filter, softener
6	0.44	0.43	HDPE, PEX, CPVC, Cu	Softener
7	0.88	0.88	HDPE	No information
8	0.84	0.83	HDPE, PVC, PEX, Cu	Softener
9	0.78	0.77	HDPE, PVC, CPVC, Cu	Sediment filter, softener
10	0.94	0.93	HDPE, PVC, Cu	Softener
11	0.97	0.96	No information	No information
12	0.99	0.98	HDPE, PVC, Cu	Water softener, RO water filter
13	0.82	0.81	HDPE, PVC, Cu	Sediment filter, softener
14	3.20	0.48	HDPE, PVC, Cu	Sediment filter, softener

15	6.05	3.99	HDPE, Cu	Sediment filter, softener

HDPE = High-density polyethylene; PVC = Polyvinylchloride; CPVC = Chlorinated PVC; PEX; Crosslinked polyethylene; Cu = Copper; RO = Reverse osmosis

ESI-6. LC/MS/MS for water analysis

Table ESI-12. Sample concentrations (ng/L) analyzed by LC/MS/MS. Limits of detection and quantification are shown in Table ESI-13. *C1 was not considered because the non-extraction isotopic standard recovery was poor for this one (see Table ESI-13).

Concentration in sample (ng/mL)	Controls		Samples						
	FB	LB	H1	C1*	C2	C6	C9	C10	C13
PFBA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFMPA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFPeA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
3-3 FTCA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFBS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFMBA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFEESA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
NFDHA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
4-2 FTSA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFHxA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFPeS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
HFPO-DA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFHpA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFHxS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
DONA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
5-3 FTCA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
6-2 FTSA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFOA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFHpS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFOS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFNA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
7-3 FTCA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
9Cl-PF3ONS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFNS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
8-2 FTSA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFDA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
N-MeFOSAA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFDS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFOSA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFUnDA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
N-EtFOSAA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
11Cl-PF3OUdS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFDoDA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFDoS	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFTrDA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD

N-MeFOSA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
MeFOSE	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
PFTDA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
EtFOSE	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
N-EtFOSA	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD
ΣPFAS (ng/mL)	<LOD	<LOD	<LOD	N/A	<LOD	<LOD	<LOD	<LOD	<LOD

LOD = Limit of detection; FB = Field blank; LB = Nanopure lab water. Concentrations were blank subtracted.

Table ESI-13. Limits of Detection and Quantification for PFAS.

Analyte	Limit of Detection (ng/L)	Limit of Quantification (ng/L)
PFBA	1143	3773
PFMPA	278	919
PFPeA	299	988
3-3 FTCA	582	1920
PFBS	2434	8033
PFMBA	324	1070
PFEESA	323	1065
NFDHA	251	830
4-2 FTSA	832	2746
PFHxA	150	494
PFPeS	83	274
HFPO-DA	63	208
PFHpA	140	463
PFHxS	107	353
DONA	213	703
5-3 FTCA	3665	12095
6-2 FTSA	849	2802
PFOA	96	316
PFHpS	114	378
PFOS	141	464
PFNA	147	484
7-3 FTCA	4412	14561
9Cl-PF3ONS	169	556
PFNS	60	200
8-2 FTSA	815	2689
PFDA	71	235
N-MeFOSAA	150	495
PFDS	159	526
PFOSA	160	527
PFUnDA	120	396
N-EtFOSAA	188	620

11Cl-PF3OUdS	131	432
PFDoDA	275	908
PFDoS	118	391
PFTrDA	188	620
N-MeFOSA	99	326
MeFOSE	1009	3331
PFTDA	154	508
EtFOSE	991	3271
N-EtFOSA	155	513

Table ESI-14. Non-extracted isotopic standard recoveries.

Percent Recoveries (%)	Controls		Samples						
	FB	LB	H1	C1	C2	C6	C9	C10	C13
13C3-PFBA	94	74	93	2	60	90	108	91	122
MPFHxA	121	88	110	1	72	97	156	106	159
MPFHxA	121	88	110	1	72	97	156	106	159
MPFHxA	121	88	110	1	72	97	156	106	159
MFPHxS	103	88	95	2	59	101	132	105	138
MPFHxA	121	88	110	1	72	97	156	106	159
MPFHxA	121	88	110	1	72	97	156	106	159
MPFHxA	121	88	110	1	72	97	156	106	159
MFPHxS	103	88	95	2	59	101	132	105	138
MPFHxA	121	88	110	1	72	97	156	106	159
MFPHxS	103	88	95	2	59	101	132	105	138
MPFHxA	121	88	110	1	72	97	156	106	159
MPFHxA	121	88	110	1	72	97	156	106	159
MFPHxS	103	88	95	2	59	101	132	105	138
MPFHxA	121	88	110	1	72	97	156	106	159
MPFHxA	121	88	110	1	72	97	156	106	159
MFPHxS	103	88	95	2	59	101	132	105	138
MPFOA	105	97	89	1	60	108	159	117	132
MFPHxS	103	88	95	2	59	101	132	105	138
13C4-PFOS	119	88	94	2	61	99	158	111	158
MPFNA	104	84	94	1	65	102	152	116	149
MPFHxA	121	88	110	1	72	97	156	106	159
MPFHxA	121	88	110	1	72	97	156	106	159
13C4-PFOS	119	88	94	2	61	99	158	111	158
MFPHxS	103	88	95	2	59	101	132	105	138
MPFDA	124	108	125	2	70	118	186	140	158
13C4-PFOS	119	88	94	2	61	99	158	111	158
13C4-PFOS	119	88	94	2	61	99	158	111	158
13C4-PFOS	119	88	94	2	61	99	158	111	158
MPFDA	124	108	125	2	70	118	186	140	158
13C4-PFOS	119	88	94	2	61	99	158	111	158
MPFHxA	121	88	110	1	72	97	156	106	159
MPFDA	124	108	125	2	70	118	186	140	158
13C4-PFOS	119	88	94	2	61	99	158	111	158

MPFDA	124	108	125	2	70	118	186	140	158
13C4-PFOS	119	88	94	2	61	99	158	111	158
13C4-PFOS	119	88	94	2	61	99	158	111	158
MPFDA	124	108	125	2	70	118	186	140	158
13C4-PFOS	119	88	94	2	61	99	158	111	158
13C4-PFOS	119	88	94	2	61	99	158	111	158

ESI-7. Chemical Air Exposure Levels Considered by the USEPA

USEPA considered chemical air screening levels during the first week of the disaster, as well as for other exposures (2 week, one-year). According to the USEPA who became Incident Commander of the disaster February 21, 2021, all screening levels were established by the ATSDR.[11] During the first week RESP chose to consider exposures for five chemicals in air for the general public (**Table ESI-15**). Short-term (2 week) and one-year exposures were only considered for two compounds, vinyl chloride and BA. While 330 ppb butyl acrylate was listed as the 1-2 week screening level below, on February 7 the ATSDR recommendation was 3,300 ppb, and that number was changed to 50 ppb on February 9.[227] The USEPA reduced the number of chemicals they considered a concern in air from five to two "based on sampling/analytical and knowledge of released materials".[12] Separately, exposure limits were considered for derailment site workers for only VC and BA.[13] Health effects of exposure to BA were found and is a known sensitizers.[14] 2-EHA reported to exhibit carcinogenicity.[15]

Table ESI-15. Chemical air screening levels used for public safety decisions per the USEPA.

Chemical USEPA Deemed an Initial Exposure Risk	Screening Level Established by the ATSDR per the USEPA, ppm			Screening level basis per the USEPA	Odor Threshold per the USEPA, ppm
	1 Wk	2 Wk	1 Yr		
VC	0.5	0.020	0.020	ATSDR Acute EMEG	3,000
Hydrogen chloride	1.4	-	-	CA EPA REL	0.26 to 10.0
BA	0.33	0.050	0.020	NIOSH REL, adjusted for 24 hr exposure, adjusted for sensitive populations with a factor of 10	0.05**
2-EHA	0.83	-	-	OSHA TWA, adjusted for 24 hr exposure, adjusted for sensitive populations with a factor of 10	-
Isobutylene	8.3	-	-	AGCIH TLV, adjusted for 24 hr exposure, adjusted for sensitive populations with a factor of 10	-
Ethylene glycol monobutyl ether acetate	-	-	-	-	-

Dash (-) indicates information was not reported. USEPA reported being concerned about exposure to ethylene glycol monobutyl ether acetate (CASN 112-07-2), but this compound was not reported to have been on the train or have been created. Ethylene glycol monobutyl ether (CASN 111-76-2), also known as 2-BE was on the train, is a different chemical, was detected in the creeks at very high concentrations, and USEPA did not include this in setting air screening levels. During the second week of the response, the USEPA reduced their compounds of interest from six to two "based on sampling/analytical and knowledge of released materials".[12] The 1-year screening level was the ATSDR residential MRL, which "is an estimate

*of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified route and duration of exposure. ** Information was obtained from the Norfolk Southern Company safety plan.*[13]

ESI-8. Geological Characterization for Groundwater Quality in East Palestine

The Village of East Palestine municipal wellfield consists of five wells installed from 50 to 100 ft depth in unconsolidated glacial sediment.[16] An inner management zone (IMZ) and a drinking water source protection area (WSPA) exist for the municipal wellfield. The boundaries of these two were established based on the time it would take for contaminants to reach the wellfield based on 1-year (IMZ) and 5-years (WSPA) of constant groundwater pumping.[16] The WSPA is larger than the IMZ and extends approximately 3.6 km to the northwest of the Village. These protection zones are based on a prior assessment showing that the unconsolidated aquifer system near East Palestine was highly susceptible to contamination having one of the highest susceptibility scores in Columbiana County.[17] The high susceptibility is based on the following factors: lack of a surficial clay layer to slow infiltration and presence of contaminant sources in the protection zones.

Some private wells were installed in either unconsolidated glacial sediment or in bedrock.[17] The bedrock is comprised of Pennsylvanian sedimentary rocks including shale, siltstone, and sandstone.[17–20] Mines were also found to exist in the area, including a coal mine along Leslie Run.[21] Onsite observations suggest that many of the private wells sampled in the present study were installed in shale having low yields. Angle[17] reports yields of around 3 gpm for wells installed in shale and ranges up to 25 gpm in sandstone. Sand and gravel water-bearing units in unconsolidated glacial sediment typically have higher yields,[17] especially the unconsolidated aquifer near the municipal wellfield. In addition, aquifers in buried channels tend to be more productive with an aquifer thickness ranging up to 10 to 12 m and yields ranging up to 400 gpm.[16,17] Concerns also exist for the village of East Palestine, since it obtains groundwater from 5 wells installed from 50 to 100 ft in unconsolidated glacial sediment.[16] No contamination was reported by RESP at the time this study was completed.

ESI-9. Sorbent Pads Characterization

FTIR analysis confirmed the peaks at 2950.20 cm^{-1}, 2917.88 cm^{-1} confirm the presence of -CH group,[22–25] peaks at 1452.36 cm-1 and 1376.12 cm^{-1} indicate the presence of CH_2 and CH_3 groups respectively.[22–25] IR performed on the contaminated pad (dried) exhibited one weak peak at 1638.5 cm^{-1} which indicated either conjugated alkene or alkene, monosubstituted (fatty acids or phospholipids in the river stream)[22] or a deformation mode of molecular water that remained in the contaminated pad after drying[26–28] and rest all other peaks matched with polypropylene spectra.[22–25]

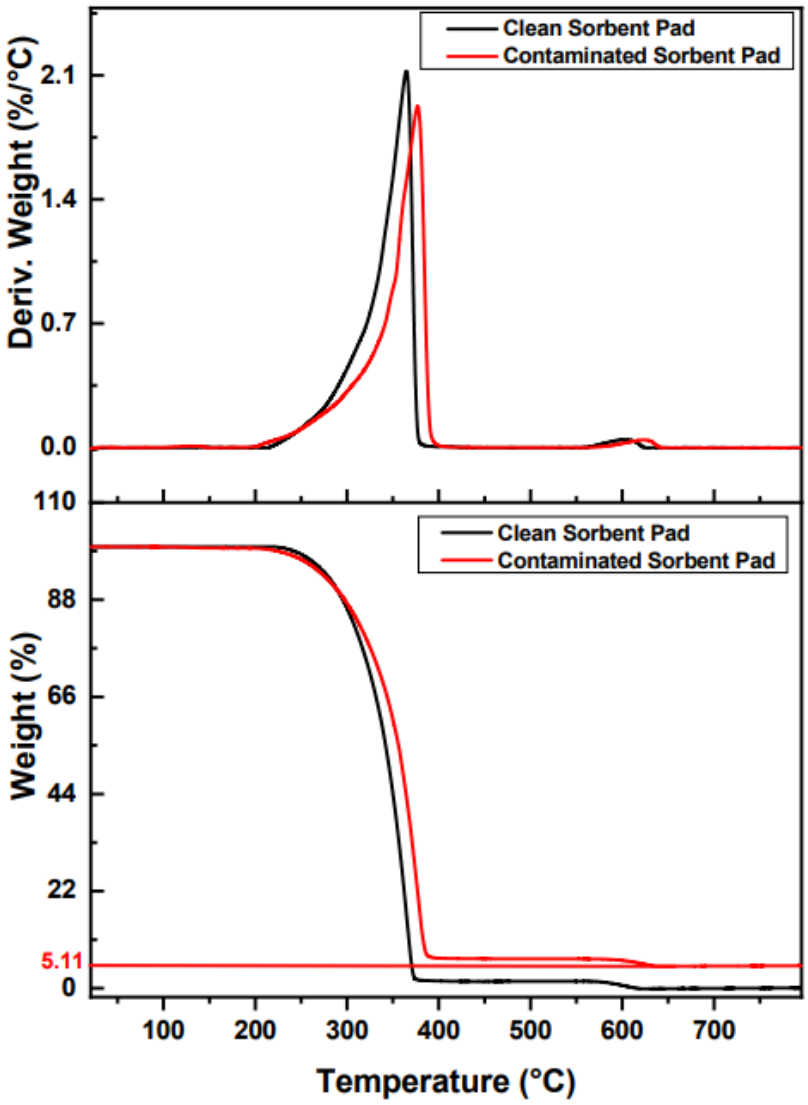


Figure ESI-8. DT-TGA of clean and contaminated sorbent pad.

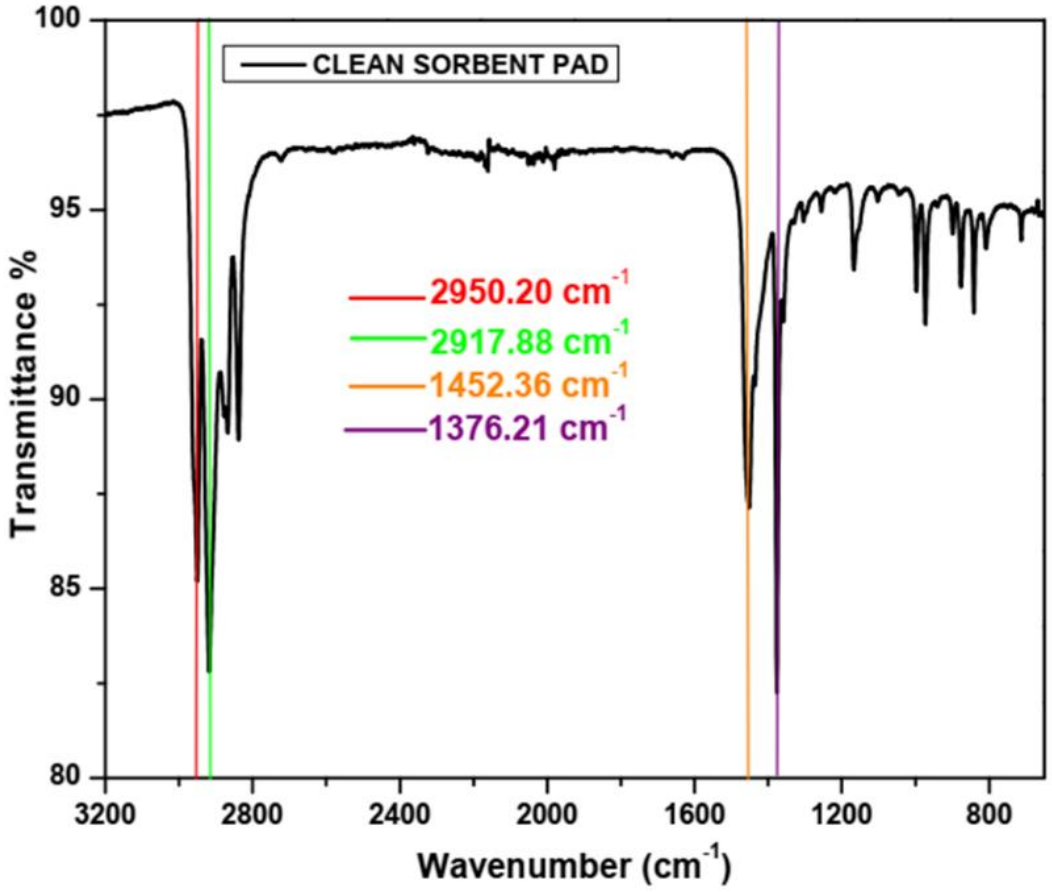
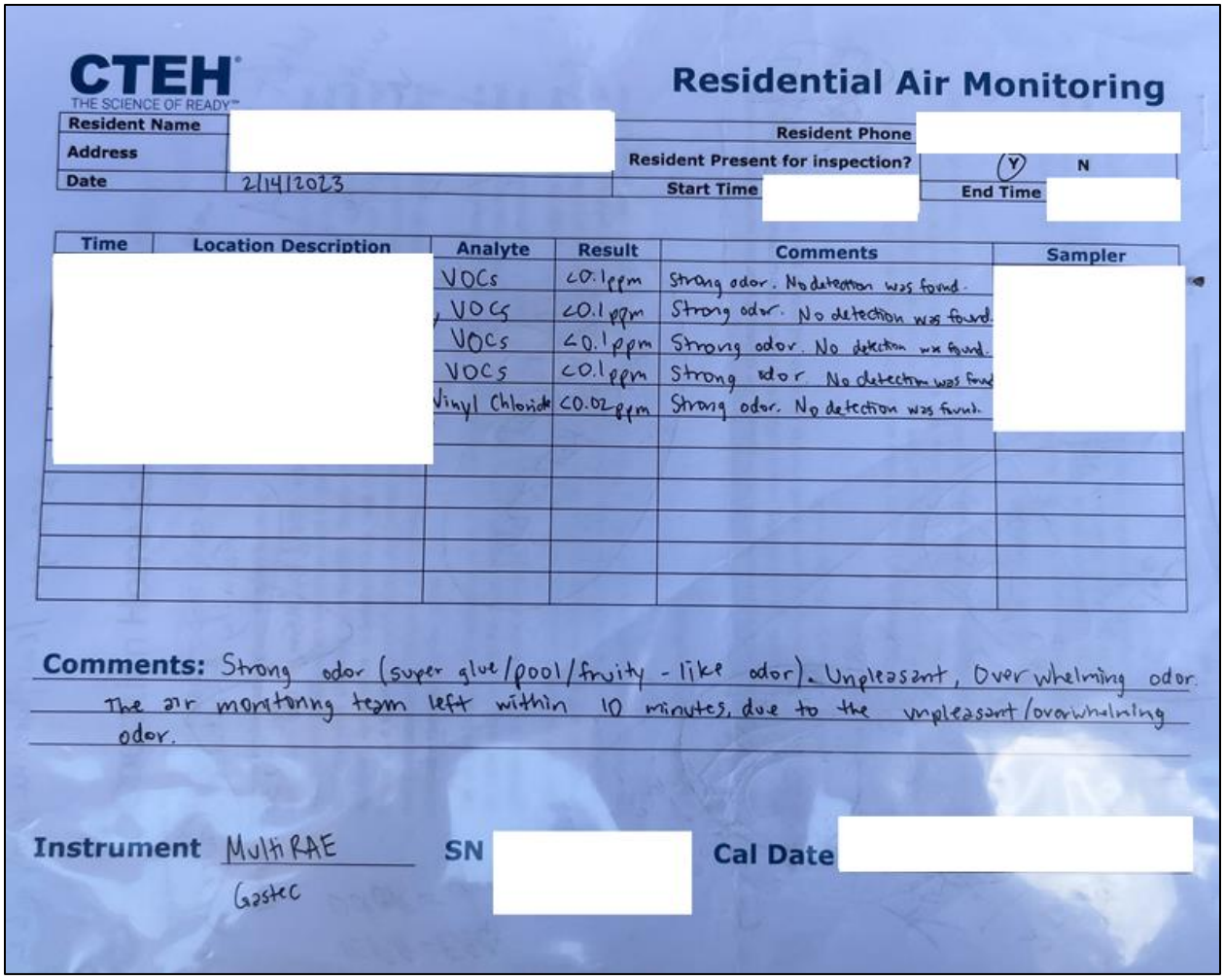


Figure ESI-9. ATR-FTIR spectra for a clean sorbent pad indicating that the product was polypropylene.

ESI-10. Watersheds and Surface Water Testing

Sampling for VOC and SVOC analysis was initiated around February 9 for some contaminants and was expanded for additional contaminants that were also on the train on February 28. According to the Potable Water Testing Plan,[29] Norfolk Southern used USEPA Methods 524.2 for VOCs, and USEPA Method 525.2 for SVOCs. Contamination was also found East of the derailment location indicating that materials traveled in air to the East and then deposited and reached Sulphur Run, which traveled West.



CTEH
THE SCIENCE OF READY™

Residential Air Monitoring

Resident Name		Resident Phone	
Address		Resident Present for inspection?	(Y) N
Date	2/14/2023	Start Time	End Time

Time	Location Description	Analyte	Result	Comments	Sampler
		VOCs	<0.1 ppm	Strong odor. No detection was found.	
		VOCs	<0.1 ppm	Strong odor. No detection was found.	
		VOCs	<0.1 ppm	Strong odor. No detection was found.	
		VOCs	<0.1 ppm	Strong odor No detection was found	
		Vinyl Chloride	<0.02 ppm	Strong odor. No detection was found.	

Comments: Strong odor (super glue/pool/fruity-like odor). Unpleasant, Over whelming odor. The air monitoring team left within 10 minutes, due to the unpleasant/overwhelming odor.

Instrument MultiRAE Gastec **SN** **Cal Date**

Figure ESI-10. Norfolk Southern/CTEH indoor air testing report dated February 14, 2023 (11 days after the derailment) showing a "strong odor" was noticed but their handheld PID did not detect any chemicals.

The comment section for this air testing report indicated that the CTEH team (hired by Norfolk Southern Company) left the site within 10 min due to the overwhelming and unpleasant odor.

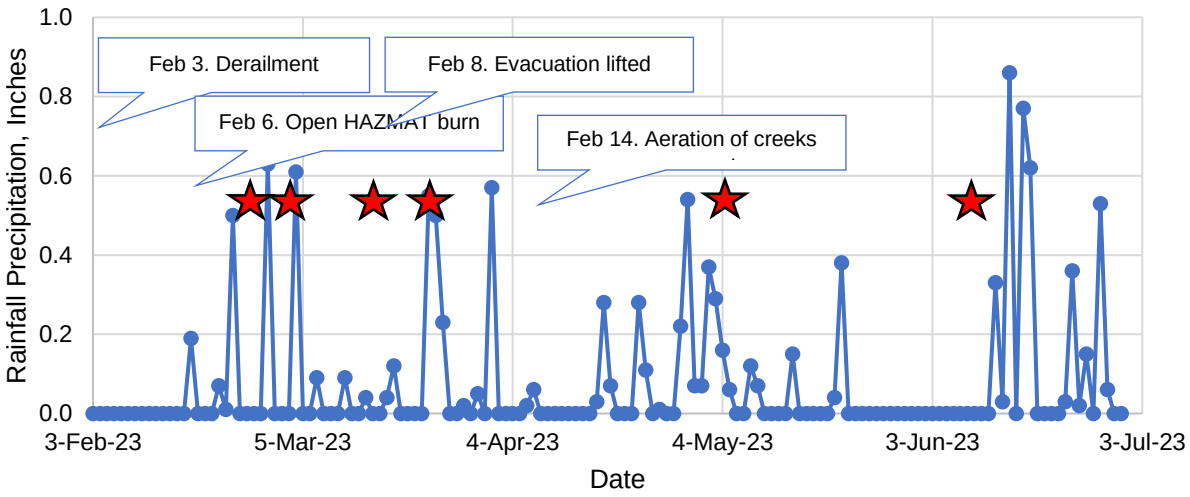


Figure ESI-11. Timeline of field investigations compared to measured precipitation events.

Stars indicate the date of the author's field investigations (February 25-27, March 3-4, March 17-19, March 23-25, May 4-5, June 8-10). Other key activities are shown.

ESI-11. Soil Testing

Following the train derailment and the environmental crisis that it caused, residents in East Palestine raised concerns about the soil contamination, and how it could affect gardening activities, associating it to health problems from the exposure.[30] Derailment site soil TPH testing was conducted from February 8 to 10 by the USEPA, and sometimes revealed gross hydrocarbon soil contamination. Specific compound testing also revealed a variety of VOCs (benzene, 4-chloroaniline, toluene, xylenes, methylcyclohexane, 1-methylnaphthalene, 2-methylnaphthalene, naphthalene, vinyl chloride) and SVOCs (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluorene, fluoranthene, hexachlorocyclopentadiene, indeno(1,2,3-cd)pyrene, pentachlorophenol, phenanthrene, pyrene).[31]

Table ESI-16. Summary of the USEPA SVOC soil sampling results for 146 locations, including residential, commercial, and agricultural properties available online as of May 21, 2023.[32]

Chemical Name and Classification as Reported by the USEPA	Summary Statistic		
	Minimum	Mean	Maximum
Semivolatile Organics			
2,4,5-Trichlorophenol	0.019	0.07892	0.330
2,4,6-Trichlorophenol	0.019	0.07889	0.330
2,4-Dichlorophenol	0.023	0.09387	0.390
2-Chlorophenol	0.019	0.07889	0.330
2-Methylnaphthalene	0.006	0.31157	8.600
4-Chloro-3-Methylphenol	0.023	0.09906	0.420
4-Chlorophenyl-phenylether	0.019	0.07889	0.330
Acenaphthene	0.004	0.03306	0.650
Acenaphthylene	0.005	0.04717	0.740
Anthracene	0.004	0.08996	3.400
Benzo(a)anthracene	0.004	0.3469	9.700
Benzo(a)pyrene	0.004	0.38348	10.000
Benzo(b)fluoranthene	0.004	0.47339	12.000
Benzo(g,h,i)perylene	0.004	0.28179	7.700
Benzo(k)fluoranthene	0.004	0.1771	4.800
Chrysene	0.004	0.40133	10.000
Dibenzo(a,h)anthracene	0.008	0.08187	1.800
Fluoranthene	0.004	0.7707	25.000
Fluorene	0.004	0.03658	0.840
Hexachlorobenzene	0.008	0.03313	0.140
Indeno(1,2,3-cd)pyrene	0.005	0.25379	7.000
Naphthalene	0.008	0.20201	5.700
Pentachlorophenol	0.076	0.33095	1.400
Phenanthrene	0.005	0.47738	13.000
Phenol	0.019	0.07935	0.330
Pyrene	0.004	0.59209	19.000
PCDD/PCDFs			
1,2,3,4,6,7,8-HpCDD	0.000	0.00019	0.015

1,2,3,4,6,7,8-HpCDF	0.000	5.0E-05	0.002
1,2,3,4,7,8,9-HpCDF	0.000	5.5E-06	0.000
1,2,3,4,7,8-HxCDD	0.000	6.2E-06	0.000
1,2,3,4,7,8-HxCDF	0.000	6.6E-06	0.000
1,2,3,6,7,8-HxCDD	0.000	1.1E-05	0.001
1,2,3,6,7,8-HxCDF	0.000	6.8E-06	0.000
1,2,3,7,8,9-HxCDD	0.000	1.0E-05	0.001
1,2,3,7,8,9-HxCDF	0.000	4.7E-06	0.000
1,2,3,7,8-PeCDD	0.000	5.2E-06	0.000
1,2,3,7,8-PeCDF	0.000	4.8E-06	0.000
2,3,4,6,7,8-HxCDF	0.000	7.1E-06	0.000
2,3,4,7,8-PeCDF	0.000	6.5E-06	0.000
2,3,7,8-TCDD	0.000	6.2E-06	0.001
2,3,7,8-TCDF	0.000	1.6E-06	0.000
Octachlorodibenzofuran	0.000	0.0001	0.004
Octachlorodibenzo-p-dioxin	0.000	0.00193	0.110
Total dioxins and furans	0.000	1.7E-05	0.001

All results are reported as mg/kg

ESI-12. Chemical Volatilization from Flowing Creeks and Mechanical Aeration

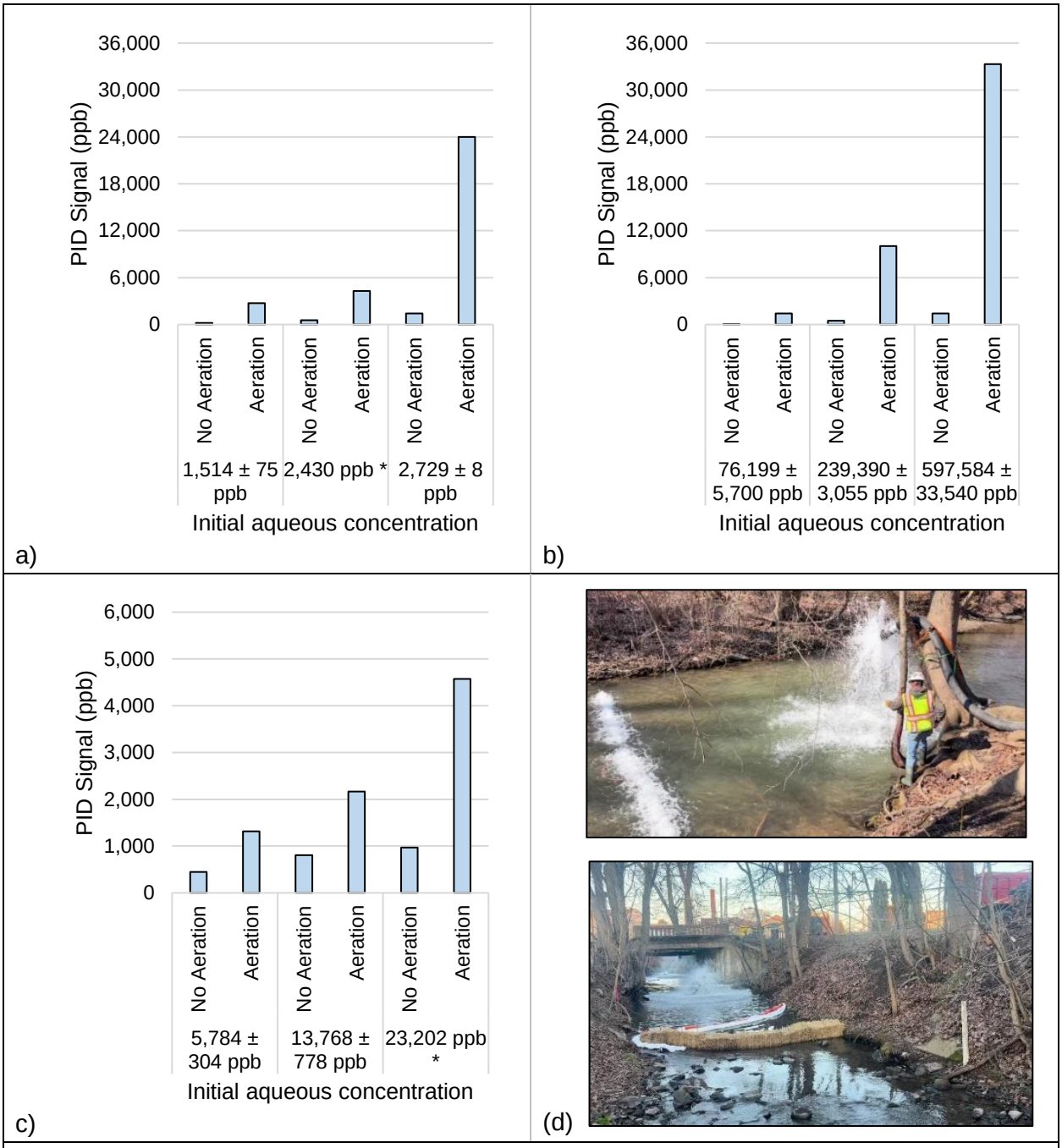


Figure ESI-12. Aeration increased PID signal due to the volatilization of (a) BA, (b) 2-BE, and (c) 2-EHA into the air, and (d) RESP sprayed contaminated water it into the air along Sulphur Run and Leslie Run Creeks, which caused contamination to travel away from the creek banks into nearby areas and buildings.

15 min average PID signals shown. Mean and standard deviation values for three replicates shown. Standard deviation ranged from < 0.5% to 7.2% depending on the chemical, concentration, and aeration condition. Bubble creek bottom diffusers were also present and volatilized chemicals into the air.

ESI-13. Remediation Actions

To interpret environmental sampling results and observations, it is important to understand response and remediation actions. As Norfolk Southern resumed train travel through the contaminated site on railroad tracks over the contaminated soil, vapors and particulates may have been suspended and transported offsite. Initially contaminated soil and mud was tracked onto East Palestine roadways by Norfolk Southern contractors.[33] To limit contamination spread, check dams were established in Sulphur Run and sorbent pads and socks were added to Sulphur Run, Leslie Run, and other downstream waterways. Information about what chemicals these materials collected (or their magnitudes) was not publicly found. In late February, heavy rainfall prompted damage to containment, collection, and stream treatment systems, leading to the discharge of polluted water from Sulphur Run into Leslie Run.[34] In the February 28 update, the rainfall and contaminated water collected and stored onsite in storage bins was 90% full.[34] To address wastewater generation and storage challenges, two 1 MG tanks were constructed at derailment site to store contaminated storm water.[35] A temporary wastewater treatment plant was constructed.[36]

To remove chemical contamination from both Sulphur Run and Leslie Run, sediment cleaning was counducted.[37,38] A second phase of "sediment washing" was initiated February 27, which was reported to visibly decrease the presence of floating contaminants in the water.[39,40] The USEPA described the process as involving aeration or the disturbance of sediments to bring contaminants to the surface, thus enabling the collection of theses contaminants.[41] This was done by drawing in water from the creek and discharged it into the air. Also at these points, bubble diffusers were utilized at these locations too. Aerators were sometimes positioned immediately outside homes (<20 ft away) and other times grouped together (i.e., East Palestine Park). Aeration was halted before Easter and Ohio claimed "the oxygenation was successful in significantly decreasing the contamination levels in the water."[42] Ohio stated that the purpose of aeration was to "promote the natural breakdown of dissolved contaminants".[40] The USEPA also stated that the purpose of aeration was to "enhance the natural biological activity and bring contaminants to the surface to the sorbent booms on the water" and that some material would volatilize.[43] However, the process of inducing the chemicals to volatilize from creeks into the air posed a risk of chemical exposure to people, since RESP did not collected or analyze air samples from the surrounding areas where the aeration. Air knifing was used for creeks.[44]

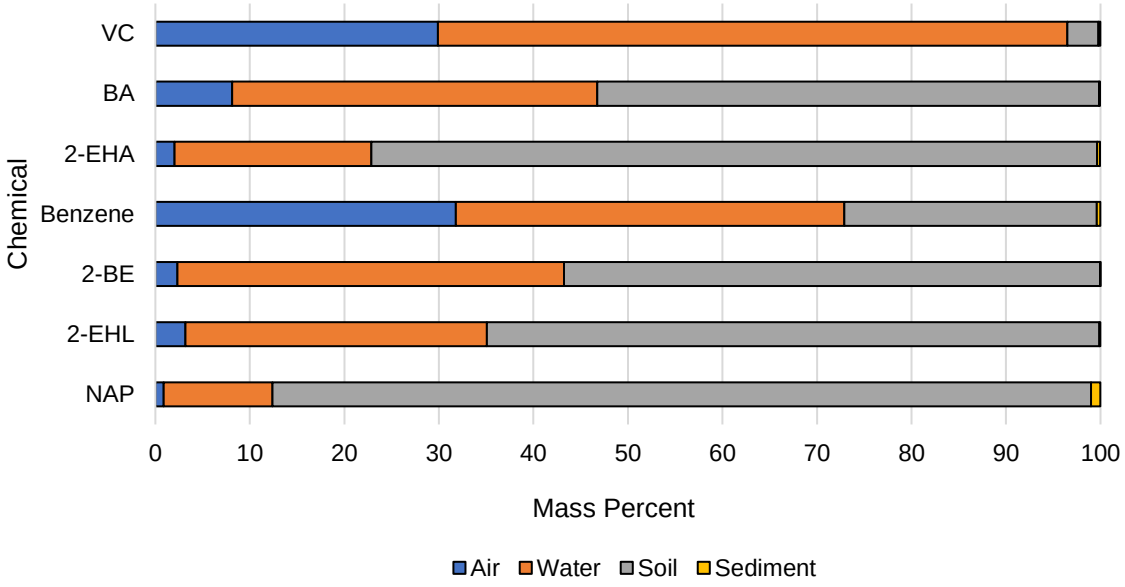
Excavated soil was stored onsite in piles and ultimately hauled to incinerators and secured landfills. A high-density polyethylene liner was installed at the derailment sites for storing soil one month after the disaster. Plastic sheeting was applied to cover the top of contaminated debris piles to limit rainfall entry. Industrial fans were used at the derailment site to "circulate the air".[45]

ESI-14. Chemical Fate and Exposure Pathways

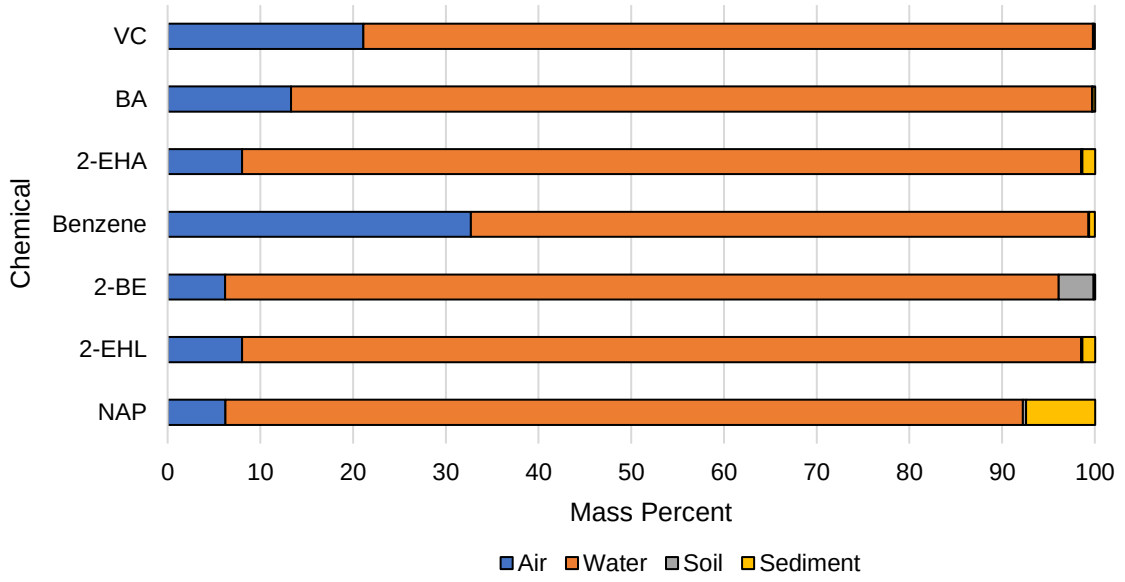
Chemicals traveled through East Palestine and reached residents through several different pathways. First, chemicals were released from the train derailment immediately by leaking railcars as well as railcars with product on fire (i.e., PVC resin). This prompted release into the atmosphere, nearby soil, and Sulphur Run creek that was less than 10 ft from the derailment. The open burn released large quantities of particulate matter as well as vapors into the air. High amounts of liquid chemical flowed into Sulphur Run, which flowed directly through downtown East Palestine, Ohio through open and enclosed concrete and corrugated metal culverts. Residential, commercial, and government buildings lined Sulphur Run banks where chemicals flowed. During containment and cleanup operations, contractors utilized sorbent booms and pads on the Sulphur Run water surface as well as aeration and bubble diffuser units. Contractors also pressure washed some buildings, and no apparent capture of that rinse water was conducted. Materials on streets were washed off which then entered storm drains and Sulphur Run. Street sweepers were periodically used to remove dust from roadways near the derailment site.

Discussions with owners of residential and commercial buildings indicated that chemicals likely entered their properties through open windows, doors, window A/C units, foundations, sump pump pits, foundation cracks, chimneys, and drains. Information from contaminated dust literature and a warning from the Pennsylvania Department of Health (after the evacuation order was lifted) indicated HVAC turning on and off as well as vacuuming may cause dust resuspension. The authors found that in East Palestine, residents and workers were also likely exposed to chemicals due to the aeration activities in the Sulphur Run conducted by Norfolk Southern. Emission from chemicals sorbed to exterior buildings may also have

prompted exposures. Sulphur Run also had periods of high and low flows, and high flows would emit greater amounts of VOCs into the air. Additional work is ongoing to confirm these pathways.



(a)



(b)

Figure ESI-13. The mass percent of each chemical transported into each natural resource estimated using the USEPA EPI Suite software (a) when soil was considered as a pathway, and (b) when soil was not considered as a pathway.

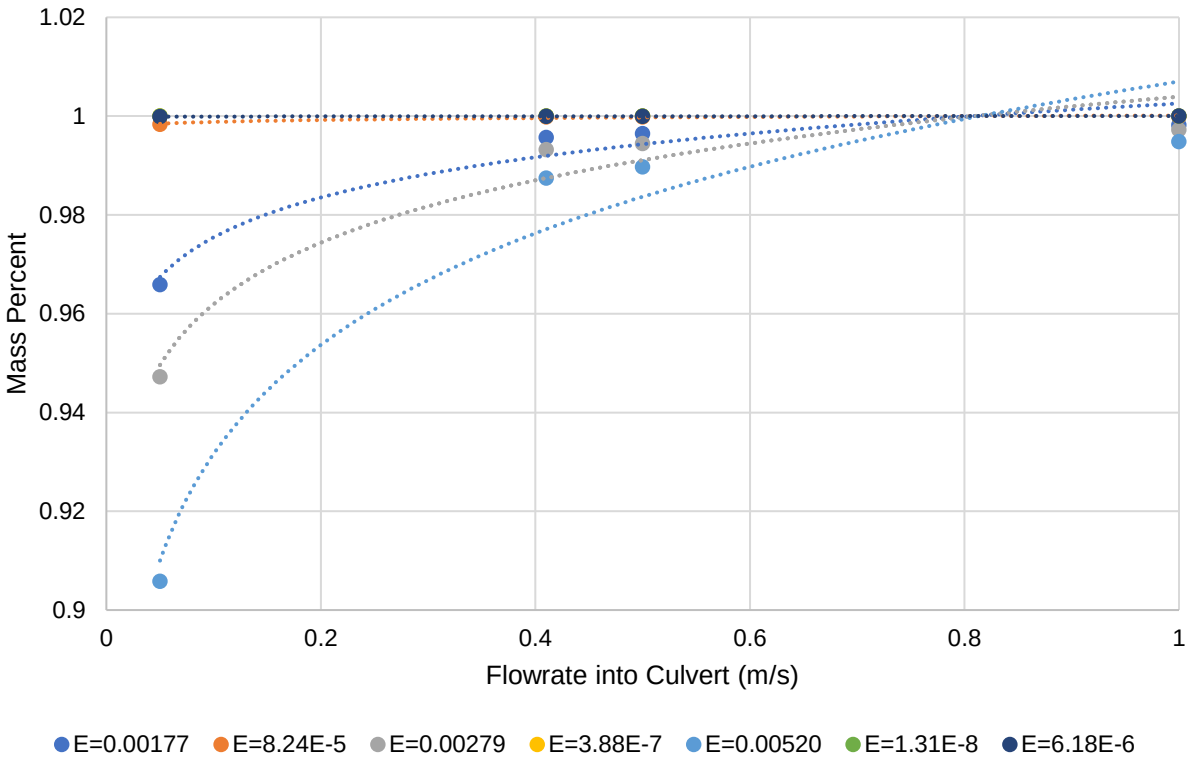


Figure ESI-14. Results obtained with the USEPA EPI Suite indicated that as the creek flowrates increased, the mass percent of chemical in air in the culvert would increase as well. Several emission rates (E) were evaluated.

(a)

(b)

Figure ESI-15. Mechanical aerators and creek bottom diffuser equipment were operated along Sulphur Run and Leslie Run. This equipment discharged contaminated water and contaminants into the air.

(a)

(b)

Figure ESI-16. Sometimes the chemically contaminated creeks were filled with water and other times they were dry, with contaminated sediment directly exposed to the air. Sulphur Run was visited (a) June 10 after three weeks of little rainfall and (b) on June 12, after rainfall.

(a)  (b) 

(c)  (d) 

(e)  (f) 

(g)  (h) 

Figure ESI-17. Concrete and metal culverts transport Sulphur Run water underneath and adjacent to East Palestine roadways, properties, as well as commercial, residential, and municipal buildings.

(a)

(b)

(c)

Figure ESI-18. In East Palestine, Ohio (a) Particulates were seen suspended into the air during recovery along a roadway near the derailment site, (b) street sweepers were deployed near East Clark Street, and (c) contractors were seen pressure washing East Taggart Street near the derailment site. Image (a) was taken by Jake Cozza, other images from author AW.

ESI-15. Reported Occupational and Public Exposures and Symptoms

A variety of workers reported adverse health impacts while working in the area after the evacuation order was lifted. Nearby manufacturing facility workers experienced coughing, headaches, nose bleeds, and were diagnosed with chemical bronchitis after the evacuation order was lifted.[46] Railway workers who responded to the site reported experiencing nausea and headaches.[47] Two USEPA contractors working near the derailment site reported symptoms associated with strong odors and were recommended to leave

the area.[48] An elected official from Pennsylvania and his staff also visited the creeks in February for 5 to 6 hours and reported experiencing headaches, rashes, and respiratory issues.[49] In February, 7 of 15 federal government public health employees experienced sore throats, headaches, coughing and nausea, and because of this, were removed from the field.[48]

Table ESI-17. Resident and First Responder After Chemical Exposure (ACE) Survey: Top five symptoms reported to the Ohio Department of Health as of the closing March 31, 2023 which was designed to collect information about initial impacts from chemical exposure in the community.[50]

First Responders Surveyed (212)	Residents Surveyed (534)
Stuffy nose/sinus congestion – 26.4%	Headache – 74.5%
Runny nose – 25.0%	Anxiety – 61.4%
Increased congestion/phlegm – 21.7%	Fatigue/tiredness – 53.2%
Burning nose or throat – 20.3%	Coughing – 53.0%
Hoarseness – 15.1%	Irritation/Pain/Burning eyes – 49.8%

ESI-15.1 Public

During the evacuation and after the evacuation order was lifted[51] people publicly reported illnesses.[52] Symptoms included sore throats, rashes, and headaches. Some people sought medical attention at emergency rooms.[53]

Concerns about the Health of Animals

In the aftermath of the disaster, it was reported that more than 43,000 fish, 5,500 other aquatic species, like small fish, crayfish, amphibians, and macroinvertebrates, died in Ohio,[54–56] Pennsylvania veterinarians treated horses exposed to the smoke,[57] and pets were reported to be sick and dying in Ohio.[58–60] Humane society reported that pets are sick and dying.[60,61]

Various necropsies were conducted by the State of Ohio on other animals, but some animals received were too decomposed for analysis.[62] Animals examined were dogs, cats, chickens, racoons, muskrats, beef calves, birds, an opossum, turtle, and Ohio reported no evidence of chemical toxicity as a cause of death was found. The location of the animals to the derailment site as well as testing results and methods for these determinations were not reported.

On March 17, Ohio discovered two hellbenders in Little Beaver Creek downstream of the derailment.[63] Several other actions were taken by Ohio to include necropsies of animals (dogs,[42,64] chicken,[65] cats,[66] beef calf, birds, opossum,[54,67] raccoons, muskrat,[63] and snapping turtle.[68] Additional testing was ongoing at the time the study was completed to include a tissue investigation of fish from impacted creeks.[42]

For food products, hay and wheat tissue sampling was initiated,[69] as well as testing for other plant material, egg, and milk.[70]

ESI-CONTEXT

ESI-16. Organizations Involved

During the first three months of the response, the authors observed a variety of local, county, state, and federal organizations responding to the disaster (**Figure ESI-19**). Numerous nonprofit organizations and universities also contributed. Contaminated water, air, or both impacted Ohio, Pennsylvania, Kentucky, Indiana, and West Virginia. Communication to residents was done through updates in Ohio EMA website (OH EMA, 2023).

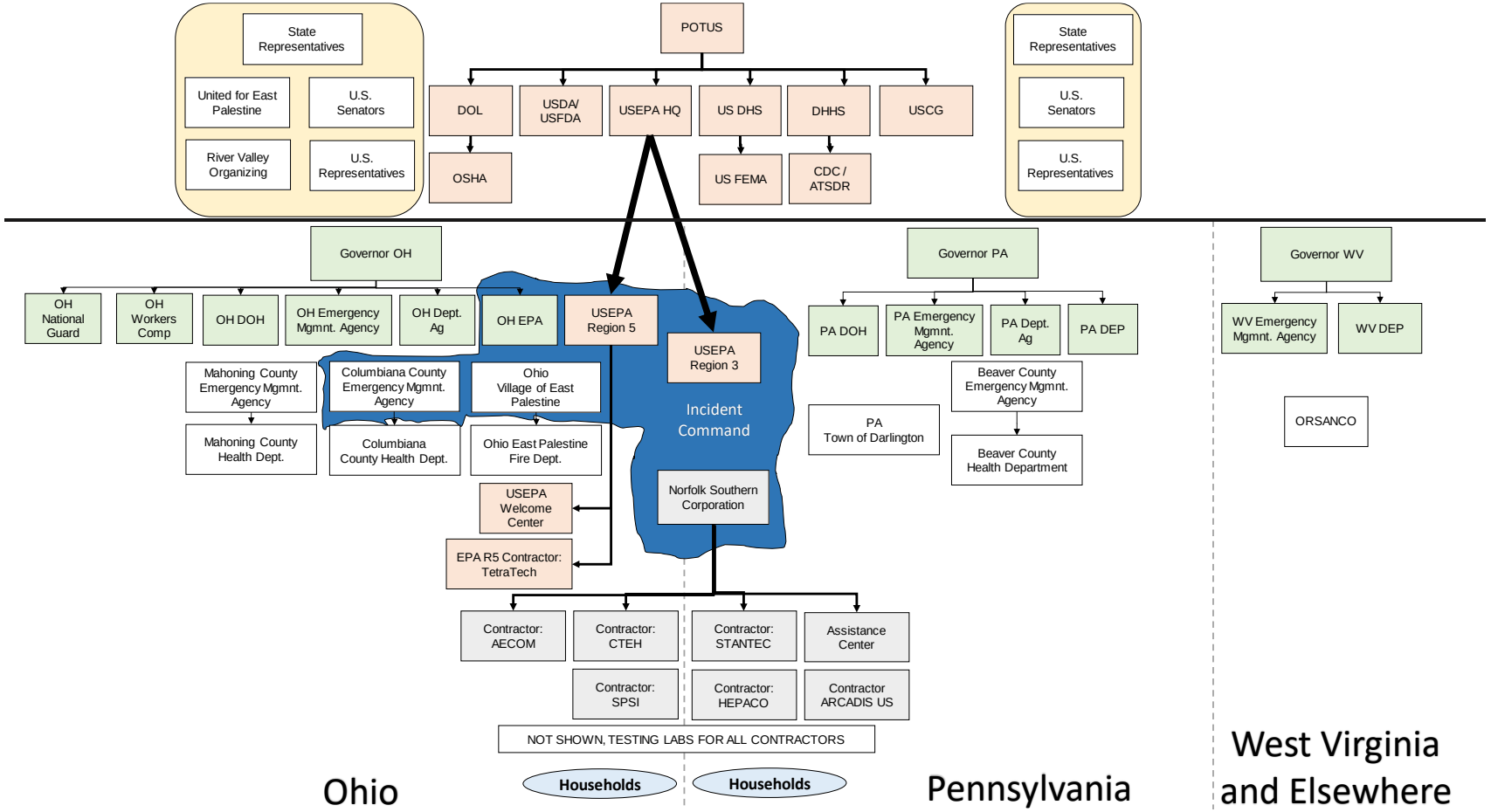


Figure ESI-19. Organizational chart created by the authors in late February to understand chemical spill response and recovery decisions and actions in Ohio, Pennsylvania, and West Virginia.

The USEPA was the Incident Commander due to their Administrative Order against Norfolk Southern February 21, 2023.[71] Though, the area impacted was overseen by two different USEPA Regional Offices, USEPA Region 5 in Chicago, Illinois (Ohio, Indiana) and USEPA Region 3 in Philadelphia, Pennsylvania (Pennsylvania, West Virginia). In addition to USEPA Regions 5 and 3, other agencies involved in the incident command included the Ohio EPA, Norfolk Southern, the Columbiana County Emergency Management Agency, and the Village of East Palestine.

ESI-17. Publicly Reported Chemicals Released

A variety of chemical products were released from the train derailment, and the list of chemicals evolved over three months. During the first week of the response, Norfolk Southern declared 24 chemical products were present in the railcars and some materials had been released or burned.[72] For days after the derailment, the chemicals being released to the environment were unclear to emergency responders as reported by the USEPA and Mayor of East Palestine.[73] In March, the State of Ohio Attorney General identified specific chemicals were released into the environment.[74] Separately, the USEPA published an aerial image showing that many more railcars were damaged than initially reported by Norfolk Southern.[75] In a legal filing, the US Department of Justice also reported naphthalene and "petroleum" were released by the train and these compounds were not mentioned by any other organization.[76] VC was a contaminant that received much public discussion and was reportedly released in excess of 877,000 pounds.[74]

Table ESI-18. Comparison of chemicals and chemical products that were declared released or damaged by Norfolk Southern, the State of Ohio, and USEPA.

Product mentioned by Norfolk Southern to USEPA and Rail Car Condition Assessment Given to USEPA		OH ATG (2023)	USEPA (2023a)	USEPA (2023b)	USEPA (2023c)
Polypropylene	Unclear				
Polyethylene	Unclear				
Residue lube oil	Unknown				
Vinyl chloride (VC)	Released and burned	Yes	Yes	Yes	Yes
Dipropylene glycol	Released				
Propylene glycol	Released				
Ethylene glycol monobutyl ether (2-butoxyethanol)	Unknown	Yes	Yes	Yes	
Polyvinyl	Released and burned				
Petroleum lube oil	Released	Yes			
Diethylene glycol	Released				
Polypropyl glycol	Released				
Isobutylene	Damaged	Yes	Yes	Yes	Yes
Butyl acrylates, stabilized (BA)	Released	Yes	Yes	Yes	Yes
Petrol oil NEC	Released				
Fuel additives	Damaged			Yes	
Medical balls container	Burned				
Sheet steel	Burned				
Frozen vegetables	Burned				
Benzene	Damaged		Yes	Yes	
Paraffin wax	Damaged				
Powder flakes	Burned				

Hydraulic cement	No declaration				
Autos passenger	No declaration				
Malt liquors	No declaration				
Chemicals mentioned by others and not listed by Norfolk Southern Company					
2-Ethylhexyl acrylate (EHA)		Yes	Yes		Yes
Petroleum			Yes	Yes	
Naphthalene (NAP)				Yes	
Ethylene glycol					Yes

The following references were used to create the table: USEPA 2023a. US Environmental Protection Agency. Letter: General Notice of Potential Liability East Palestine Derailment Site. February 10, 2023. Norfolk Southern Railway Company, Atlanta, Georgia USA; USEPA 2023b. US Environmental Protection Agency. Complaint: United States of America v. Norfolk Southern Railway Company and Norfolk Southern Corporation. Case: 4:23-cv-00675. March 30, 2023. US District Court for the N. District of Ohio Eastern Division; State of Ohio, Attorney General. Complaint: State of Ohio v. Norfolk Southern Railway Company and Norfolk Southern Corporation. Case: 4:23-cv-00517. March 14, 2023. US District Court for the N. District of Ohio Eastern Division; USEPA 2023. East Palestine, Ohio Train Derailment. Background. Accessed May 15, 2023. Washington, D.C. USA. https://www.epa.gov/east-palestine-oh-train-derailment/background

Government officials suspected that additional chemicals were created during the initial fires and were released into the environment and posed a health risk. For example, based on aerial images reported by the US NTSB, polyvinylchloride (PVC) resin in hopper cars was on fire,[77] and PVC combustion is known to generate dioxins.[78] The VC combustion process was suspected to have created phosgene gas, hydrogen chloride, and dioxins,[74] but also carbon dioxide, and carbon monoxide.[79] No studies were found that documented the combustion of VC creating dioxins, but USEPA believed that it was possible.[80,81] Additional compounds suspected to have been created during the fires included VOCs, as well as SVOCs such as polycyclic aromatic hydrocarbons.

ESI-18. Economic Impacts and Concerns about Business and Product Safety

There were numerous questions raised about the impact of the disaster on surrounding businesses and products. In the aftermath of the disaster, questions were raised about the chemical exposure of livestock and produce.[82,83] Apiaries were also concerned about honey product contamination.[84] The State of Ohio formally commissioned plant tissue chemical testing for grasses, wheat, barley, and forage covers within five miles of the derailment.[85] A grocery chain even withdrew bottled water created 25 miles from the train derailment site out of an abundance of caution.[86] Activists recommended against planting any vegetables for 1 year,[87] which raised concerns by locals to USEPA representative.[30,88]

WYG Refractories manufacturing facility closed.[46] Business at a small engine repair company dropped off.[89] Private home contracts fell through out of buyer concern about environmental safety.[90] Airbnb bookings canceled.[89] Concerns expressed by business owners of plants, housewares, restaurants, and other items.[91] At the time this study was published, an economic analysis of the disaster on Ohio communities was ongoing.[92]

ESI-19. Vapor and dust suppression

A variety of chemical products were used by Norfolk Southern to suppress vapors and dust during response and recovery operations at the derailment site.[93] The vapor suppressant product was Acronel SS-30, which had 8% diethanolamine and 92% undisclosed ingredients.[94] Dust suppression product sprayed on gravel areas was called Envirotac-II which contained acrylic polymer, ammonia, and water according to the material safety data sheet.[95] Water was reportedly used for dust suppression on roads.

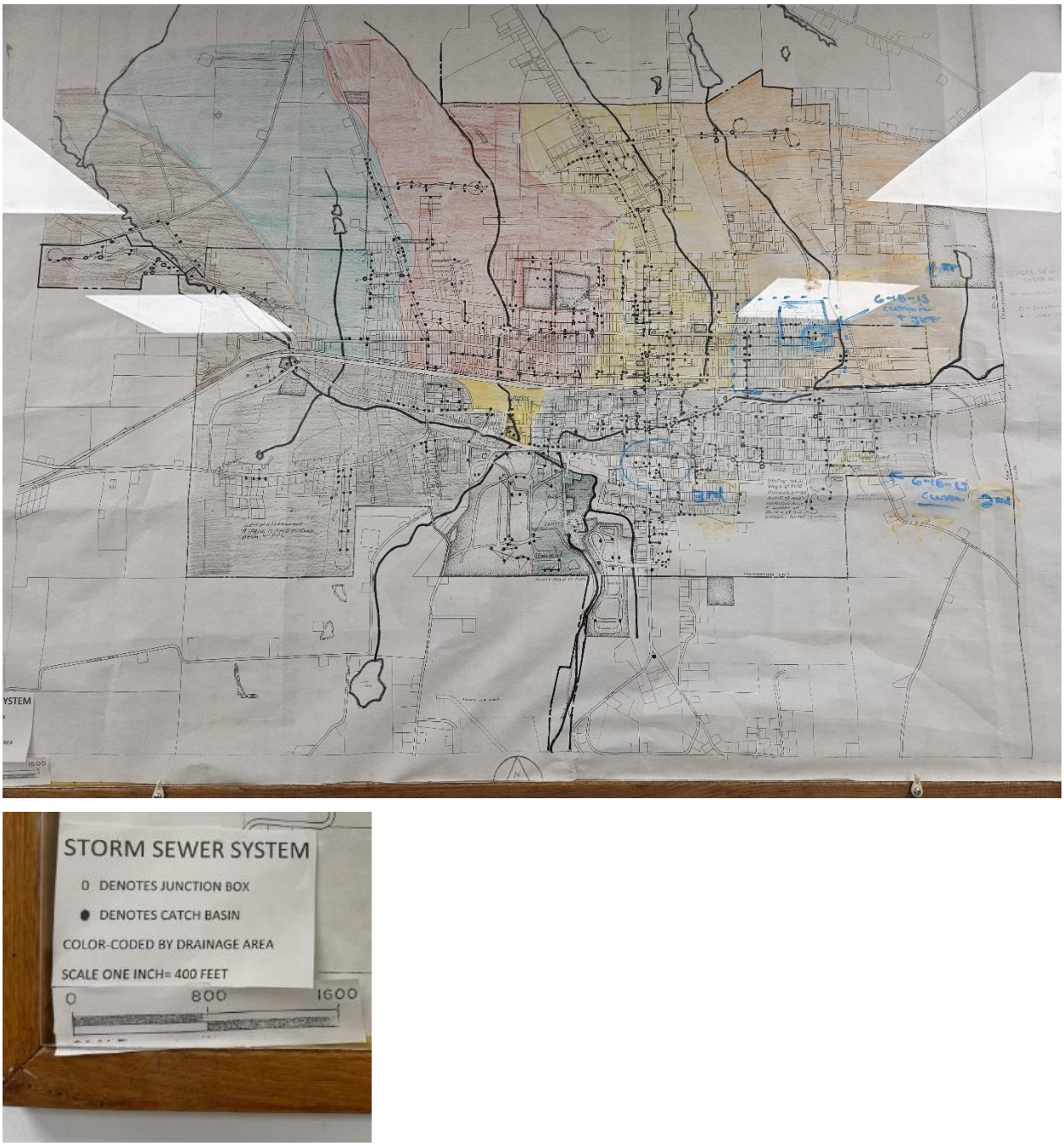


Figure ESI-20. Image of hand-drawn storm sewer map for East Palestine, Ohio hanging in East Palestine Municipal Building, March 2023.

Image courtesy of Jami Wallace.

Table ESI-19. US Census results (2020) for some areas impacted by the disaster.

Characteristic	Communities Impacted				State and National Statistics		
	East Palestine, OH	Columbiana Co., OH	Mahoning Co., OH	Beaver Co., PA	OH	PA	US
Population	4,761	101,877	225,636	165,677	11 million	12 million	333 million
Household income, median, $	44,498	51,664	50,750	62,152	61,938	50,750	69,021
%, Households below poverty	9.1	12.9	19.3	11.1	13.4	12.1	11.6
%, Bachelor's degree or higher	11.5	15.7	24.9	25.9	29.7	33.1	33.7
%, Without healthcare coverage under 65 years old	5.6	9.6	8.5	6.5	7.8	6.6	9.8
Total households	1,929	41,313	97,293	71,717	4.7 million	5.1 million	124 million
%, 65 years and older	20.8	21.4	21.8	22.3	17.8	19.0	16.8

The Village of East Palestine is located in Columbiana County, Ohio. Information obtained from the US Census Bureau and represents the year 2020;[96] Need Economic / US Census info for East Palestine, OH.[97] Based on 2020 US Census data, East Palestine, OH has a higher percentage of elderly residents (20.8%) compared to state and national averages. This, combined with lower median household income and educational attainment, highlights potential vulnerabilities. The slightly lower uninsured rate for those under age 65 (5.6%) compared to the state average (7.8%) indicates some level of access to health care but is still a concern. These factors suggest that the population of East Palestine may face significant challenges in addressing the effects of the disaster, including health issues and recovery efforts.

ESI-20. Firefighting

An estimated 50 fire departments responded to the disaster with approximately 300 firefighters.[98] According to the USEPA, about 20 gallons of firefighting foam brought onsite contained PFAS compounds.[93] According to the author's interviews with households bordering the derailment site, water was sprayed on railcars and a whitish foam-looking material was reported in the trees. Per a property owner directly bordering north of the derailment site, grass on their private property was "shiny" for days following the derailment, but the shiny nature disappeared.

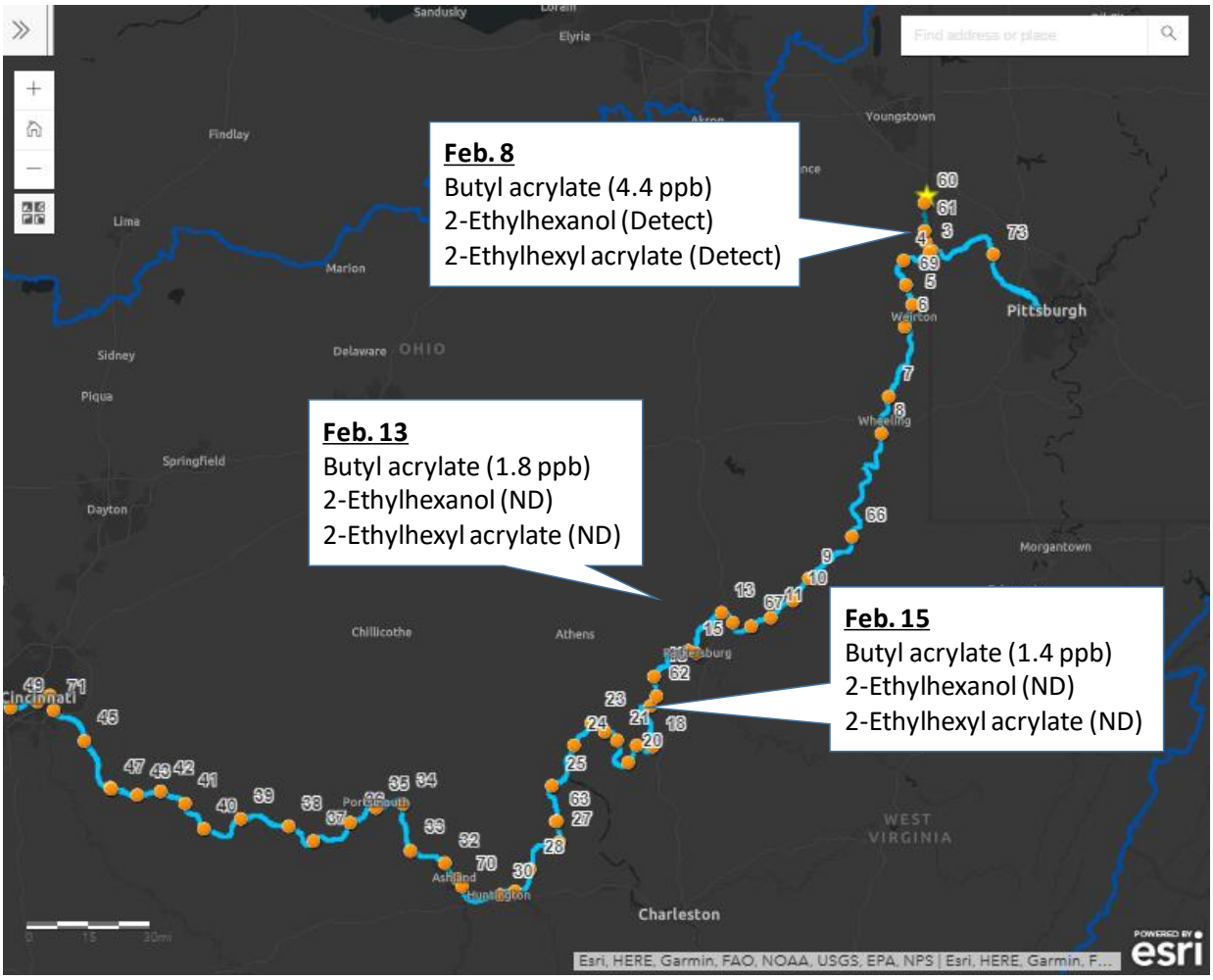


Figure ESI-21. Chemicals released in East Palestine, Ohio on February 3, 2023 (represented by the yellow star on the map) were detected 270 miles down the Ohio River, according to water quality monitoring results released by the Ohio River Valley Sanitation Commission (ORSANCO).[99]

The Ohio River is a source of drinking water for more than five million people in multiple states. The US Agency for Toxic Substances and Disease Registry (ATSDR) created three drinking water screening levels: BA (560 ppb), 2-EHA (500 ppb), and 2-EHL (200 ppb). Maximum concentrations found in the Ohio River were BA 12.5 ppb, 2-EHA 17.1 ppb, and 2-EHL 27.6 ppb. Vinyl chloride (<0.5 ppb) and other select VOCs screened by ORSANCO (<0.5 ppb) were not detected. A challenge with interpreting the water testing results however was that the following information was not reported by the ATSDR or USEPA about the screening levels created: exposure duration (1 day vs 7 day vs. 30 day), exposure routes (inhalation, ingestion, dermal), or population (bottle-fed infant vs 10 kg child vs adult). The authors requested this information from the USEPA and ATSDR in March and April, and neither provided the information.

ESI-21. Incident Overview February 2023 to August 2024

The timeline in this study provides a baseline by detailing key decisions made by incident command and other authorities in response to the East Palestine disaster and related chemical exposures. It also includes meetings with the RESP community, instances of misinformation, testing activities, and communications with authorities. While the timeline is intended to be comprehensive, the authors acknowledge potential gaps and recognize that important updates may have occurred since the study was completed.

February 3, 2023 – A 149 railcar Norfolk Southern train derailed in East Palestine, Ohio around 8:54 pm EST. Of the 38 railcars that derailed, 11 carried hazardous materials. Fires were observed when emergency responders arrived and these fires damaged an additional 12 non-derailed railcars.[77] Initially, at 10:00 pm EST a 1-mile evacuation zone was implemented affecting about 2,000 residents.[77] The Ohio National Guard Civil Support Team and West Virginia were involved in decision making activities.[100] At 10:53 pm EST Norfolk Southern officially reported the incident to the US National Response Center.

February 4 – At 2:00 am EST, USEPA representatives arrived onsite. At 12:00 pm EST, the US National Transportation Safety Board (NTSB) held a press conference.

February 5 – The State of Ohio National Guard was activated.

February 5 – At 7:30 pm, Ohio Governor Michael DeWine was notified that the temperature of one of the rail cars was increasing and concerning.[101] The concern was that shrapnel would be thrown into the air if the car exploded. An evacuation area of 1 mile was determined. This was determined based on the Emergency Response Guidebook according to the Fire Chief.[102]

February 5 – At 8:30 pm, the Ohio Governor encouraged 500 persons who had not evacuated to evacuate immediately due to concern that these railcars could explode causing death and serious injuries.[103,104]

February 5 – At 9:00 pm, the Columbiana County Ohio Sheriff's Office issued a warning and said "people who refuse to evacuate could be arrested for misconduct in an emergency, a fourth-degree misdemeanor if only adults are in the home and a first-degree misdemeanor if children are in the home. A charge of endangering children also is possible".[105,106]

February 6 – Ohio and Pennsylvania authorities ordered a 1-mile evacuation area and shelter in place order for those persons between the 1 to 2 miles.

February 6 – Nearby residents saw the train wreck fire from East Taggart Street looking towards the CERAMFAB building.

Figure ESI-22. Nearby residents saw the train wreck fire from East Taggart Street in East Palestine, Ohio looking towards the CERAMFAB building on February 3, 2023, before the open burn was conducted February 6, 2023. Image taken by Lonnie Miller.

February 6 – Some responding organizations decided that vinyl chloride should be drained from five railcars and ignited or burned. They referred to this as a "controlled burn." The USEPA subsequently stated that they did not provide input to a five railcar burn, and that it was their knowledge that only one railcar was to be burned.[43,73]

At 4:15-4:20 pm, the “controlled” release occurred. Air monitoring was conducted. According to the Governor of Ohio, the US Department of Defense and Ohio National Guard completed modeling to estimate likelihood of population death and danger should the rail car explode. The Governors of Ohio and Pennsylvania reportedly examined the risks associated with shrapnel thrown and “controlled” release options with other agencies.

February 6 – At 1:56 pm EST, the Governor of Ohio released a map depicting a proposed chemical plume footprint associated with burning vinyl chloride (**Figure ESI-23. Map depicting a chemical plume footprint from the derailment site estimating the locations where death and injury could occur.**[107]).[107] They proposed the chemical plume would travel Southeast and cross into Pennsylvania from the derailment site.[107,108] The plume’s impacts were not predicted to cross South Pleasant Drive (to the South) or North Pleasant Drive (to the West). According to the USEPA, the chemical fire footprint was generated by the Ohio National Guard Weapons of Mass Destruction (WMD) Civil Support Team (CST) and was estimated for five railcars. It was unclear what this figure exactly represents as there was discussion of a single rail car burn, then five rail cars, and multiple other fires occurred during the incident response. According to the map, the red shading indicated a zone where death was possible, and the orange shading indicated a zone where injury was possible.

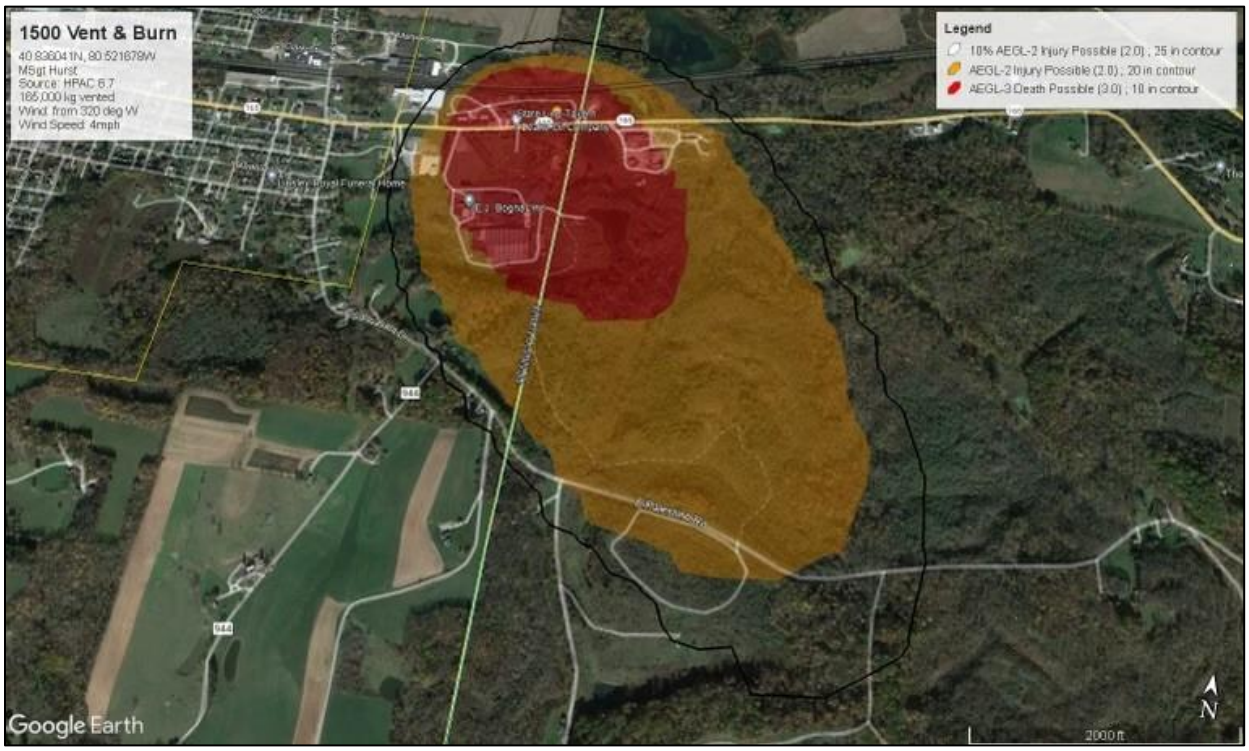


Figure ESI-23. Map depicting a chemical plume footprint from the derailment site estimating the locations where death and injury could occur.[107]

February 6 – At 4:30 pm, open burning of vinyl chloride was initiated after the vinyl chloride tanks were breached by Norfolk Southern, drained into a ditch and that product was then set on fire.[109] The resulting fire extended anywhere from a quarter to half a mile along the railway tracks and was visible from a distance of at least 10 miles.[33]

A NOAA satellite captured the chemical plume in East Palestine, Ohio from space on February 6 at 4:30 pm EST.[110,111]

Figure ESI-24. The US National Oceanic and Atmospheric Administration (@NOAASatellites) recorded the chemical plume emitted from East Palestine, Ohio.[111]

Radar models of local news stations indicated that material released from the derailment into the air did move Southeast as expected, but the plume also spread West, North and South (**Figure ESI-25**).[112] This footprint extended beyond the evacuation and shelter in place areas.

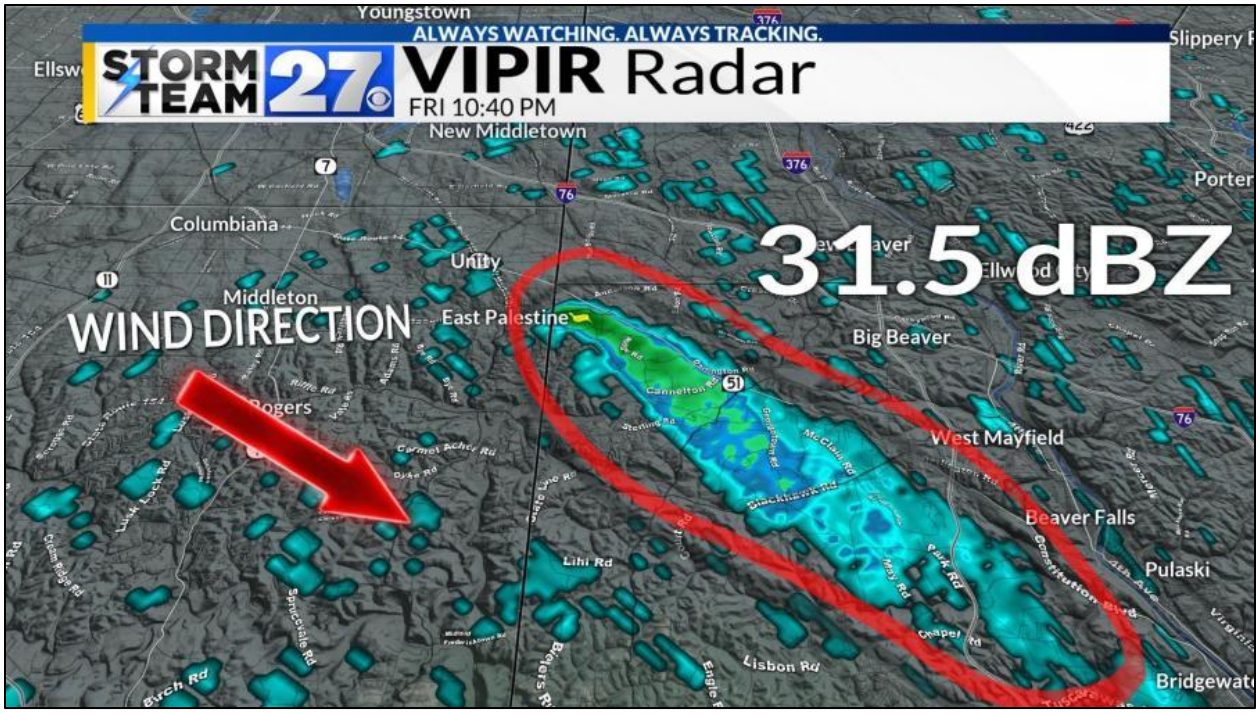


Figure ESI-25. VIPIR radar image shown by WKBN at 10:40 pm after the open burn was initiated. The radar indicated signals in the Southeast direction, but also North, South, and West of the derailment site.[112]

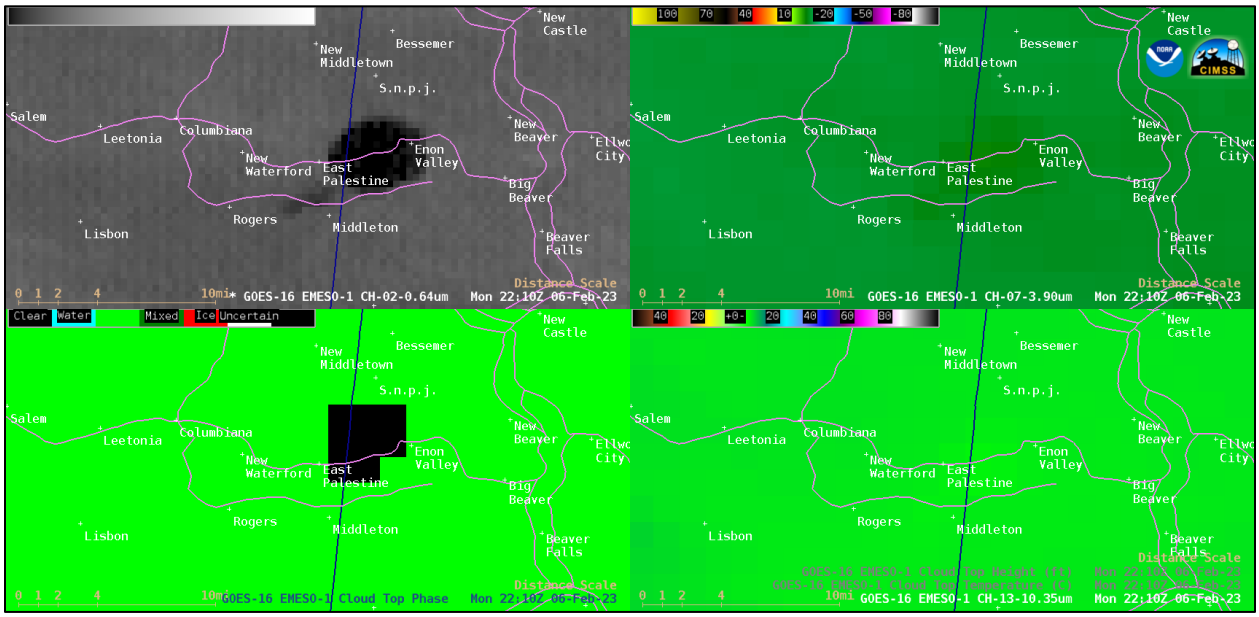


Figure ESI-26. Satellite image analysis for 10:10 pm on February 6, after the burn was initiated in East Palestine, which indicates that materials moved to the East and North.[113]

Image posted by the University of Wisconsin. On February 6th, toxic chemicals from five rail cars were "control burned". Satellite imagery from GOES-16 showed a black smoke plume penetrating a supercooled water droplet stratus cloud layer. The plume emerged at 2139 UTC, casting a shadow to the northeast at 2140 UTC.[113]

February 7 – The USEPA Aspect Response Team conducted air testing from a plane over East Palestine. Analysis revealed peroxyacetyl nitrate (PAN) less than 1 ppm. Thermal energy also indicated discrete location where temperature exceeded 60 °C. Another flight the same day, was detected ozone immediately in and around the derailment site. "Smoke was seen being emitted from the railcar pile, and within agreement with the ozone detections".[114]

The Commonwealth of Pennsylvania measures results for hydrogen chloride (HCL) at 12:39 am and 12:48 am indicated levels below the 1.8 ppm.[115]

February 8 – After initial air testing by RESP, the evacuation order was lifted.[116,117] Pertaining to air quality the USEPA stated "that **all the readings we have been recording in the community have been at normal concentrations normal background in what you would find in any community operating outside**." The Ohio EPA stated "the unfortunate side, there's were it was immediately toxic to fish but all the information and **data to date is it has still been protective to drinking water**".[118,119] Minutes after the evacuation order was lifted Norfolk Southern trains resumed travel through East Palestine on the new railroad tracks installed over the contaminated soil and along the contaminated Sulphur Run waterway.[33]

The Ohio Department of Health Director reported that the "air was basically what is was prior to the crash." The Ohio Natural Guard was dispatched to measure air quality.

February 11 – Contractors reportedly hired by Norfolk Southern were going door to door letting households know their drinking water may be contaminated. The fire department said their safety gear was ruined and were purchasing new gear. Local businesses reported losing business and some had hired companies to professionally clean their buildings due to a smell detected after the derailment.[120]

February 13 – The USDOT Secretary Pete Buttigeig stated that the USEPA had screened 291 homes for "VOCs" and "other chemicals of concern" and "no detections were identified."[121]

February 14 – Media reported that members of the public were becoming ill when they were in their homes, but also illnesses for pets and wildlife in the impacted area. Reports of animals dying 10 miles away (i.e., chickens) surfaced. Households just across the railroad tracks in East Palestine complained of headaches and odor.[122]

February 14 – The USEPA stated they have been leading with "robust air quality testing…in and around East Palestine" and "assisted with the screening of 396 homes under a voluntary screening program offered to residents, and no detections of vinyl chloride or hydrogen chloride were identified".[123]

February 14 – An author, AW, from Purdue University and a community group that formed after the disaster, United for East Palestine, connect.

February 14 – The State of Ohio held a press conference.[101]

- Governor DeWine **tells people they should drink bottled water** if he lived in the area.
- The Ohio Department of Health director is asked if residents should use water filters. The director recommends people "consider using bottled water", and they are waiting on testing results of the municipal water sources. The radius of people who should use bottled water is listed on maps of the impacted zone and residents should call the telephone number he provided.
- The Ohio Department of Health director said most of the chemicals worried about and talking about are called volatile organic compounds (VOC). He first invoked routine VOC exposures such as pumping gas in your car, burning wood, smoking and secondhand smoke. By the time they decided to bring people into the impacted area, they had air testing [data] that told them the air looked similar to before the event happened. The director says that private well owners should call a telephone number 330-849-3919 for free well testing. They also strongly recommend "use bottled water", especially for pregnant, breastfeeding, and infant formula. The compounds they were talking about, they made sure the atmosphere was clean. Now they are working on assuring clean water. In response to a journalist, the director said that odor detection is at a level well below where the exposure could be unsafe. "The air sampling in that area is really not pointing to an air source, and secondly, in terms of water, we encourage people to use bottled water, particularly with a private water source." In response to a journalist asking about the safety of air inside homes, and

he said “they have very good data as it relates to air quality and there continues to be air monitoring.”

- **The Ohio EPA Chief of Surface Water said Norfolk Southern has containment within 1.3 miles of Sulphur Run**. Sulphur Run remains contaminated, but February 4 data on Lesley Run and North Fork Beaver Creek show very low detection levels of contaminants mostly from fire residual chemicals. February 10 data shows low levels of only two contaminants, butyl acrylate and ethylhexyl acrylate in Lesley Run. Butyl acrylate dissipates to not detected levels to the North Folk of Beaver Creek. The other dissipates once we get to Little Beaver Creek. Have not detected any vinyl chloride in downgradient waterways. Ohio EPA working with ORSANCO to track the contaminant plume in real time, moving about 1 mile per hour. In response to a journalist, the Chief reported that the plume contains “100s” of fire combustion chemical detections in data that they have, and they have not yet tested for the PFOS compounds. Haze and odor were noticeable in the area after the fires were out.
- Mr. Kurt Kollar at Ohio EPA stated that during the initial spill emergency, after they could get close, in-situ treatment of contamination in Sulphur Run and containment was the approach applied at 3 sites. **They used booms to try to stop floating products. He reported that aeration and sparging units were breaking down the dissolved phase of the contaminants and stated that there was residual material in Lesley Run, and they have aeration in Leslie Run**. They have excavated contaminated soil (north ditch and south ditch). Water is being pumped around. In response to a journalist, he reported that haze and odor was in the area after the fires.
- The Ohio DNR director reported that after the spill they looked into aquatic life impacts of Sulphur Run, Lesley Run, and Beaver Creek. They discovered through testing and sampling, early on, about 3,500 dead fish across those waterways. 12 different species, none were threatened or endangered. They have not investigated fatalities of hellbenders, federally protected species. She declared that there was no apparent increase in the number of fish killed since the derailment.

February 15 – The State of Ohio reported that the return home was based on “air quality samples taken from 291 area homes which had no detections of vinyl chloride and hydrogen chloride”.[124] The day before, the USEPA stated that 396 homes had been tested for HCl and VC as well as using the plane and there were no detections.[123] After the order was lifted, cleaning companies began approaching homeowners directly offering to clean their homes.[33] Some claimed to be working for Norfolk Southern and stated that the exposures were not hazardous. In late February, USEPA established a hotline for residents to request cleaning of homes.

February 15 – Governor DeWine announced that the “Ohio EPA is confident that the municipal water is safe to drink”. He also recommended private drinking water well owners have testing.[125]

February 15 – The Ohio Emergency Management Agency encouraged residents to return home after the disaster based on USEPA and Ohio Department of Health air testing results. The announcement stated “Is the smell in the area normal? A: Yes. Residents may still smell odors from the site of the derailment. Even though you may smell the chemicals in the air, it does not mean they exist at unsafe levels. Air quality levels are still being monitored by the USEPA 24 hours a day which has not detected any levels of concern. People who are sensitive to smells may experience headaches or nausea”.[124]

February 17 – Public reports of illnesses in households continue for those persons who returned to the area. Illness symptoms include rashes, sore throats, nausea and headaches.[51]

February 17 – The State of Ohio and US FEMA announce that FEMA will be sending representatives to the disaster impact zone.[126]

February 17 – The US ATSDR began an Assessment of Chemical Exposures (ACE) survey to document health impacts for residents in Ohio and Pennsylvania.[127]

February 17 – Governor DeWine announced his intent to file for an extension to request the incident be declared a federal disaster by the President of the United States.

February 18 – US Ohio Senators Sherrod Brown and JD Vance asked USEPA to explain how they were testing for dioxins and the results.[80]

February 20 – Norfolk Southern created a drinking water testing plan and then provided it to Incident Command.[29] For three weeks county health departments and Norfolk Southern conducted East Palestine municipal well water testing (weekly) and private drinking water well testing (>1 month). Municipal water and private well drinking water test results began to be publicly shared three weeks after the disaster. When results were posted online, the author's discovered that not all chemicals known to be released by the train into the environment were being screened for (i.e., 2-BE, 2-EHA, diethylene glycol, and ethylene glycol monobutyl ether). One unit within the Ohio EPA was conducting well water testing, but another division in Ohio EPA was overseeing surface water testing by Norfolk Southern. For surface water testing, these contaminants were being screened for and had been found at high levels. A review of the private well water testing plan developed by Norfolk Southern in February 2023 revealed that officials did not designate all chemicals known to be released by the train into the environment in their plan.[29]

February 21 – A journalist reported that the municipal drinking water test results the Governor of Ohio relied upon to declare drinking water safe were from Norfolk Southern contractor AECOM, not Ohio EPA. The Ohio EPA declares it began its own testing of municipal drinking water.[128]

February 21 – The USEPA assumed oversight control of the multi-state disaster footprint through an Administrative Order to Norfolk Southern.[129] Prior to this Administrative Order, multiple local, state, and federal agencies were conducting different activities. At the same time, claims by government agencies that the air and water were safe were not paired with publicly available chemical testing information.

February 22 – The Pennsylvania Department of Health (PADOH) issued guidance to their citizens about how people can be protected from chemical exposure. The PADOH warned that "running a vacuum may cause chemicals that have settled on floors and surfaces to become airborne, which could cause inhalation concerns. Out of an abundance of caution, if you decide to vacuum, you should vacuum while following the above steps of airing out your home, and vacuum small amounts at a time and take frequent breaks by walking outdoors".[79] The PADOH recommended that residents wipe down "any surfaces that could have been exposed to chemicals, which would include anything used for the preparation or eating of food, any children's or infant's toys, anything touched frequently, such as light switches, remotes, etc. These surfaces can be wiped down with a diluted bleach cleaner using one cup of bleach for five gallons of water".[79]

February 22 – The US NTSB released a preliminary investigation report for the causes of the derailment.[130]

February 22 – Ohio Governor DeWine and USEPA Administrator Michael Reagan visit an East Palestine resident's home and drink tap water for a media photo opportunity.[131]

February 23 – Ohio begins to test municipal drinking water for the first time.

February 23 – The State of Ohio Department of Natural Resources disclosed that they had revised the overall number of animals found dead from 3,500 to more than 43,500.

February 24 – The USEPA formally rents and opens a building in East Palestine, which they call a welcome center.[132]

February 24 – Ohio reported that air testing had been conducted in 569 homes and claimed no contaminants associated with the derailment were detected.[133]

February 24 – Ohio declared that no contamination was detected upstream of the derailment site.[133]

February 24 – Michigan officials were surprised that waste from East Palestine, Ohio was delivered to hazardous material facilities in their state and were then reportedly told by the USEPA that no additional waste would be delivered.[134,135]

February 24 – Michigan US Congresswoman Debbie Dingell issued statement that "that contaminated soil from the site of the Norfolk Southern derailment in East Palestine, Ohio will be moved by truck to US Ecology Wayne Disposal in Belleville, and she was not given a heads up on this reported action. She declared she was making inquiries of EPA, DOT, Norfolk Southern, US Ecology, the state of Ohio, and all others involved to understand what is being shipped, whether these are approved storage facilities, the implications of this decision, and how we ensure the safety of all Michigan residents.[136]

February 24 – An activist held a meeting in the impact area. The activist recommended that residents not to plant vegetable gardens this year due to the potential for soil contamination from the derailment. No post-disaster soil testing data was available for the impacted area when this statement was made.[87]

February 25 – Ohio reported that air testing had been conducted in 574 homes and claimed no contaminants associated with the derailment were detected.[137]

February 25 – The Columbiana County Health Department publicly releases the first private well water testing results.[137]

February 25 – The US ATSDR begins its onsite public health investigation.

February 25 – The USEPA publicly states a pause on waste shipments by Norfolk Southern to waste disposal facilities outside Ohio.[138]

February 25-27 – A Purdue University team conducted its first site visit to East Palestine Ohio area and visits the creeks and homes to collect samples. During their visit they observed children, adults, and pets near the creeks and no site access controls. The team also observed cleanup workers wading through the creeks without proper PPE, among other discoveries. The team found unaddressed acute health risks were present in and near the creeks. Discussions with households indicate that many were unaware of the health risk posed by the exposure. The team saw, 2 miles downstream, sheens flowing on contaminated creeks and the spill had not been "contained", which was stated at a recent government press conference. Private drinking water well owners explained to the team that they had called the telephone numbers given to them by agencies for free private well testing four times and no one had called them back. The team advised the public to avoid the waterways. A Purdue University researcher contacted USEPA Region 5 but received no response. A Purdue University researcher contacted the White House and asked that a statement be issued to warn the public.

February 26 – Ohio reported that air testing had been conducted in 578 homes and claimed no contaminants associated with the derailment were detected.[139]

February 26 – The USEPA ordered a pause in shipping waste to deep well injection and incineration facilities after Texas and Michigan officials expressed safety concerns.[140]

February 27 – Some waste from East Palestine is announced to go to Grafton, Ohio.[141]

February 27 – The USEPA publicly declared they will not test for dioxins.[142]

February 28 – Indiana Governor Holcomb issued a statement about objecting to the delivery of hazardous waste from the East Palestine train derailment to Indiana and that his administration had encouraged waste to be disposed closer to the derailment site, not Indiana.[143]

February 28 – The USEPA announced deployment of the Trace Atmospheric Gas Analyzer mobile laboratory (TAGA bus) to conduct ambient air sampling".[34]

March 1 – USEPA Administrator Michael Regan publicly warned that adults and children do not play in the creeks and streams.[144,145]

March 1 – Railroad union associations send a letter to US Department of Transportation Secretary Pete Buttigieg asking him to investigate illnesses to cleanup workers send in after the chemical spill and fires.[146]

March 2 – USEPA announces they are directing Norfolk Southern to test for dioxins.[81]

March 2 – A Purdue University researcher sent a letter to the US Occupational Safety and Health Administration (OSHA) asking for a worker safety investigation based on acute health hazards associated with chemical exposures observed during the February onsite trip.[147,148]

March 2 – Researchers from Texas A&M University/Carnegie Mellon University report that they detected some pollutants in air near the spill and fire site during their February air sampling campaign in East Palestine, Ohio.[149]

March 2 – The US Department of Labor and OSHA reached out to a Purdue University researcher to obtain additional information about worksite safety risks observed during the February 2023 visit to the disaster site.

March 2 – Governor DeWine requests an extension on the ability to request a federal disaster declaration to FEMA, which is approved until July 3, 2023.[150]

March 3-4 – A Purdue University team returns to the area to conduct a second visit. During the visit to the USEPA Welcome Center they see a factsheet being provided to visitors, authored by the ATSDR, that stated "In general, most substances that cause odors in the outdoor air (environmental odors) are not at levels that can harm your health".[151]

March 3 – For the first time, signage is posted to residents and visitors to East Palestine keep out of local contaminated waterways.[62]

March 3 – Residents express concern about the safety of their gardens. USEPA mentions they are working on a soil testing plan, but have not finalized it yet.[30]

March 3 – The early results from the ATSDR ACE public health survey with the Ohio Department of Health indicate that acute public health impacts did occur because of the incident. The Ohio Department of Health reports that for the 168 surveys completed, the most common symptoms reported (Symptom, Number reporting, Percentage of total respondents) were Headache (n=125, 74%), anxiety (n=108, 64%), coughing (n=103, 61%), fatigue/tiredness (n=97, 58%), irritation, pain or burning of skin (n=88, 52%). The median age of respondents is 57 and most participants are over the age of 18 (94%).[152]

March 3 – The community group United for East Palestine released results of their informal survey of 100 residents and describe many respondents claimed to have experienced illness and smells in the air after the derailment.[153]

March 4 – During temporary dam modification activities, water from Sulphur Run was allowed to overflow into the floodplain at the confluence of Sulphur Run and Leslie Run and contained some contamination.[154]

March 6 – Seven members of the US ATSDR acute chemical exposure (ACE) team operating in East Palestine, Ohio experienced chemical exposure symptoms (etc., nausea, headaches) and returned to their hotel 30 miles away. The CDC notifies the USEPA, who is the Incident Commander. [This information is not publicly disclosed until late March].[48]

March 6 – Texas A&M University/CMU researchers report to confirm USEPA's findings on ambient air quality in East Palestine and encourage additional testing.[155]

March 7 – A Purdue University researcher submits a letter to the *US Senate Committee on the Environment and Public Works* requesting that officials begin to test for all chemicals released into the environment and the need for access controls using contractor fencing to prevent unauthorized entry into the contaminated waterways and warning signs.[156]

March 8 – Indiana Governor Holcomb concluded that waste delivered to Indiana from East Palestine, Ohio did not contain harmful levels of dioxins.[157–159]

March 9 – The USEPA initiated soil semi-volatile organic compound (SVOC) sampling of residential, commercial, and agricultural properties in and around East Palestine, Ohio.[32] Samples were collected at the surface and then another sample 1 to 6 inches in depth. Furans and dioxin contaminant loadings were investigated. USEPA stated that they looked for 19 chlorinated compounds as "indicator" chemicals for dioxins.[80]

March 9 – Sulphur Run culvert cleaning was conducted to remove indoor air odors that were being detected in homes and businesses. The thought was that contaminated sediment in the culverts was contributing.[160]

March 9 – Texas A&M University /CMU researchers publicly release their own outdoor chemical air testing results, where acrolein was detected above background levels in East Palestine, Ohio.[161]

March 9 – Ohio EPA Director Anne Vogel testified at the hearing by the US Senate Committee on Environment and Public Works in Washington, D.C. She mentioned hearing questions such as "How long

will we test the water? How long until the fish come back? Can I play in the yard and eat out of my garden? How or when will we know if the damage to our village is worse than we thought, or even irreparable?".[162]

March 10 – An activist publicly claimed that residents were being told by the state their private drinking water wells were contaminated, and released a statement about what residents should do to hold Norfolk Southern accountable and get compensation for the accident.[163]

March 12 – Oklahoma Governor publicly announced that he stopped waste from East Palestine, Ohio from being disposed of in his state.[164,165]

March 14 – The Ohio Attorney General files suit against Norfolk Southern.[74]

March 14 – Ohio announced that the culvert for Sulphur Run contributed to indoor air odors (chemical exposures) in homes and businesses and was cleaned with high-pressure washing.[64]

March 15 – Ohio announced that culverts under James Street and Taggart Street contributed to indoor air odors (chemical exposures) in homes and businesses.[70]

March 17-19 – A Purdue University team conducts a third visit.

March 17 – The first soil sampling results from the USEPA begin to be publicly shared.[63]

March 20 – A hearing was held by the Commonwealth of Pennsylvania Senate Committee on Veterans Affairs and Emergency Preparedness. A Purdue University researcher described that chemicals known to be released from the derailment were not tested for by federal and state agencies, and there were inconsistent agency testing approaches.[166] Senator Doug Mastriano disclosed that he and his chief of staff visited East Palestine in February and became ill with headaches.[49]

March 21 – A Purdue University researcher submits testimony to the US House of Representatives Subcommittee on Environment, Manufacturing, and Critical Materials with several recent field observations and recommendations.[167]

> "Government agencies should test for the chemicals we identified. Further, officials should notify the Ohio and Pennsylvania communities in and around East Palestine that their analysis to date has not been sufficiently representative of possible exposure risks. Some of these compounds could be present in deposited particulate matter observed in homes and properties. It is unclear why government agencies have not conducted indoor surface analysis to mitigate acute exposures and provide necessary guidance on safe cleaning.
>
> Assess the past worker and public exposures near creeks and aeration units has been conducted. This should be conducted. To understand worker and public exposures, thorough chemical analysis of the creek water should be conducted. Existing testing data are not adequate for understanding the complexity of inhalation and dermal exposures.
>
> Conduct environmental sampling and analysis for PFAS to determine the full extent of the contamination and ongoing health risks to residents and businesses.
>
> Request that Norfolk Southern immediately order their contract testing laboratories to provide unrestricted access to all private well water testing results in their entirety to the public health response agencies. This could enable government agencies to see if other chemicals present, which they did not screen for, were found by Norfolk Southern.
>
> Professionally clean East Palestine High School to remove residual contaminants on surfaces and in the HVAC system. Conduct testing including wipe samples to validate the environment is safe for children and adults. Determine which other buildings, where susceptible populations reside, were officially decontaminated by the USEPA and which were not."

March 21 – A USEPA Newsletter is released and responds to a few public questions:[168]

> Can I plant my vegetable garden and/or farm field? **There is no reason to believe that the particles in the smoke produced from the train derailment fire contain substances at levels of concern on residential, recreational, or agricultural properties.** As an extra step, EPA is directing that soil sampling be conducted in areas most impacted by smoke and particles from the fire. Results from this sampling, to date, have not shown any cause for concern.

> Do I need to do anything to ensure my pool is safe? **There is no current evidence of aerial deposition from the derailment that would impact pools,** however ongoing soil sampling and surface water sampling will assist in further verifying the status of aerial deposition. Following these activities, messaging on private pools will be updated as necessary.
>
> Can we use our football field? What about cross country running? In addition to our overall guidance about soil use and safety, part of the soil sampling plan has been targeted toward recreational sites. If any results indicate a concern, the public will be informed. **At this point, there are no concerns with outdoor activities or sports, except for inside Sulfur and Leslie Run.**

March 22 – Health departments engaged school superintendents "assuring that it is safe to hold usual activities. A Ohio Department of Health and Columbiana County Health Department letter mentioned continued air monitoring that has shown no harmful levels of contaminants and emphasized that school officials would be notified immediately if any harmful readings occurred."[169]

March 23-24 – A Purdue University team conducts site visit.

March 23 – Governor DeWine delivers testimony at the hearing by the *US Senate Committee On Commerce, Science, And Transportation*, East Palestine, Ohio.[170] He describes that residents ask if it's safe for children play in their yards, residents said they developed bloody noses, rashes, and others want to know what will happen to their health in 15 years. Others want to know if it is safe to plant a garden this Spring, and if they do, will the vegetables be safe to eat, and what will happen to their property values, and if they will ever be able to sell their homes. **"While all the tests of the air and the soil and the water have thus far shown repeatedly that things are safe, fear remains".**[171]

March 27 – A USEPA Administrative Order for Removal Actions – First Amendment issued to Norfolk Southern.[71]

March 27 – A teacher from a local East Palestine school contacted the Purdue University team and explained she and her colleagues were still experiencing health impacts and were concerned about children's health. A Purdue University researcher asked East Palestine School Superintendents to accept the USEPA's offer to chemically decontaminate their buildings, which were not thoroughly cleaned.[172] The USEPA had told the researcher that the USEPA offered and the school had not yet chosen to accept the offer.

March 27 – The Officer of Inspector General at the USEPA initiated an inquiry of the EPA's response to the train derailment, by contacting USEPA Region 5 and other EPA program offices.[173]

March 28 – The Mayor of Baltimore, Maryland announced shipments of East Palestine wastewater would not go to the local Clean Harbor business locations.[174]

March 28 – A town hall meeting is held in East Palestine, Ohio and filmed by River Valley Organizing.[43] The Mayor of East Palestine, USEPA, and community residents were on a panel.

> An audience member said someone was sampling the contaminated creek, went onto private property, and then put contaminated water on the private property. USEPA said they knew who was down near Sulphur Run and will address it.
>
> An audience member asked about soil sampling and whether it's being tested for every byproduct or chemical. The USEPA encouraged residents to view their website and mentioned they are including testing for dioxins and furans.
>
> An audience member said they completed a vinyl chloride urine test about 2 weeks ago and it came back positive. But primary physician initially refused to order the test, and the resident stated they lived 2.9 miles from the hot zone and work in Pennsylvania.
>
> The East Palestine Mayor said the village hired their own independent consultants to review data.

March 28 – A USEPA newsletter stated that **"creek agitation and aeration is nearing completion and creek soil washing will continue", "there's a lot of rain in the forecast this week. When it's raining, our crews will not be working in the creeks. We advise residents to stay out of the water until the creeks are fully restored,**" and "According to the Ohio EPA, the East Palestine water utility draws water from wells 52 to 98 feet below the ground".[175] The newsletter responded to a few public questions:

Is our East Palestine City Park safe for activities? Yes. Results show that levels of dioxin and semi-volatile organic compounds are well below any levels that we would consider restricting activities, and all are either at or below typical background levels for soil in the United States. In addition, the village has cleaned all recreational equipment, including the pool, as part of its annual maintenance program. Other improvements included installing new landscape fabric, playground mulch and sod.

Are the trucks leaving the derailment site spreading contamination? Each truck leaving the derailment site that is carrying contaminated waste is checked to ensure all material is safely secured. Also, all trucks go through a washing process before departing the site. The washing process ensures the vehicles' wheels and undercarriage are free of dirt and mud. Street sweepers then run along Taggart Street to clean remaining dust or dirt.

What are the large blue tanks at the derailment site? As EPA continues overseeing cleanup work at the derailment site, two large blue lake tanks will reduce EPA's on-site frac tank footprint. Frac tanks, for smaller quantities of liquid storage, have been used since the derailment to stage liquid before it is removed for off-site disposal.

March 29 – Ground water monitoring wells were installed between derailment site and municipal well field.[66]

March 29 – East Palestine announced that it will install activated carbon treatment for its municipal drinking water wells.[66]

March 29 – The **USEPA mentioned that after the evacuation order was lifted the indoor cleaning program by Norfolk Southern was not overseen by USEPA**, around time stamp 57:51 min.[43]

March 30 – The US Department of Justice files suit against Norfolk Southern.[76]

April 2 – At a River Valley Organizing/United for East Palestine community group meeting, Purdue University researchers shared new results from chemical water quality analysis of samples collected Feb 25-27 from Sulphur Run and Leslie Run, the heavily contaminated creeks.[176]

April 3 – The State of Ohio passed a new law requiring increased railroad safety requirements.[177]

April 3 – An East Palestine resident living adjacent to derailment site reported that her urine tested positive for vinyl chloride and benzene exposure.[178]

April 4 – A USEPA Newsletter stated that "stream contaminant mitigation and water quality improvement efforts in Sulphur run and Leslie run are nearing completion.[179] **Air sparging involves putting air into the water so that oxygen and microbes break down chemicals, like acrylates and glycols, in sediment.** Ohio EPA's website has an interactive map with sampling results that shows the effectiveness of this technique and surface water quality continues to improve. Along with containment and vacuuming/removing water from the stream, this is a standard technique for emergency response to eliminate contaminants from water." The USEPA also responds to a few public questions:

Is the air monitoring equipment detecting chemicals of concern? Yes, the air monitoring and sampling equipment are capable of detecting many chemicals of concern in the community and currently detections are below levels of concern. Some of the monitoring equipment may not detect a portion of the chemicals at lower levels–specifically n-butyl acrylate. However, there are independent tools used at the same time to measure air quality. These tools can detect this and other chemicals at low concentrations, which are below levels anticipated to be harmful to health. This monitoring and sampling will continue to ensure the health and safety of the community.

Are odors from the derailment site dangerous? As site work continues and waste is shipped off-site for disposal, there may be times where odors can be smelled. In general, many substances can cause odors in the outdoor air but not be at levels that can harm your health, but they can still affect your quality of life. For example, n-butyl acrylate has a distinct odor even at very low concentrations. This odor threshold is much lower than the exposure concentrations associated with potential health effects. Part of EPA's air monitoring network includes sampling devices and driving the Trace Atmospheric Gas Analyzer, or TAGA, mobile laboratory around the derailment site and nearby neighborhoods during active work hours to monitor the air for levels of potential health concern.

What's the difference between short-term and long-term chemical exposure levels? Acute or short-term exposure assumes that a person has been exposed to a chemical for a short period of time. Long term, also known as chronic, exposure assumes a person has been constantly exposed to a chemical for a lifetime, or approximately 70 years.

April 9 – An Easter Egg hunt for area children was held in East Palestine Park, which was in the chemical plume impact zone. Soil testing commissioned by the Village of East Palestine indicated that the park was "free from harmful substances".[180]

April 10 – An underground storage tank (UST) was found to have contaminated a ground water monitoring well that was installed to monitor contamination movement from the derailment site.[69]

April 10 – An East Palestine resident declared they tested positive for traces of vinyl chloride in their urinalysis.[181]

April 11 – A USEPA Newsletter stated that "air sparging was completed at the city park.[182] **Air sparging was completed within Leslie Run and Sulphur Run at the East Palestine City Park. Air sparging is a common cleanup technique which involves putting air into the water so that oxygen and microbes break down chemicals.** Next steps will include continued cleaning of the sediment in both streams." Also reported was that "EPA Region 3, PA Department of Environmental Protection and the PA Department of Agriculture completed soil sampling of 15 priority farms within two to eight miles of the derailment site. The sampling was conducted in coordination with the Lawrence and Beaver County extension offices. The preliminary results from this round of sampling do not show impacts from the derailment."

April 11 – The USEPA estimated that the cost of complying with the Administrative Order issued to Norfolk Southern was $688 million.[12] Communities impacted were similar in economic status according to the US Census (**Table ESI-19**).

April 12 – A truck containing 40,000 pounds of contaminated soil from the derailment site overturned in Ohio dumping 20,000 pounds onto the road and nearby area.[42] Details about the chemical composition of the waste were not found.

April 12 – A Purdue University researcher asked USEPA Administrator Regan to exert oversight for the private drinking water well testing program as households are confused by the information being provided to them by Norfolk Southern. In particular, laboratory water test records indicated the labs used by Norfolk Southern were unable to detect 29 chemicals at levels that pose a health risk to households, but testing reports were being provided to households anyways claiming there is no contamination.[183]

April 18 – A USEPA newsletter stated that "Teams are checking nearby streams daily, including Sulphur Run, Leslie Run, and Little Beaver Creek.[44] **The assessment work includes documenting the absence or presence of sheen, odors, and wildlife.** Dissolved oxygen meters are also used to take water quality readings in the waterways. These measures look at the level of dissolved oxygen, which provides a snapshot of water quality conditions at that moment to see if the waterway is suitable for fish and other animals." Also stated are that "**air knifing teams are making progress along Sulphur Run. This process involves poking a pressurized wand into the stream bank to see if there are any pockets of contamination. If any contaminants are released, they are then taken up by a vacuum truck immediately downstream.** This process will continue all the way down Sulphur Run until all contamination is released and removed and the stream is cleaned." Also reported were that "Portable High-throughput Integrated Laboratory Identification System (PHILIS) is one of EPA's mobile laboratories being used for on-site analysis of samples. PHILIS involves three mobile units using state-of-the-art analytical equipment and is sometimes deployed after accidental chemical releases or natural disasters. The labs can analyze soil, water, and air samples for volatile and semi-volatile organic compounds, including vinyl chloride that were released during the derailment. PHILIS can process and analyze these samples within 24 hours."

April 20 – The USEPA held an "Information Session: Soil Sampling".[184] Recording here: https://youtu.be/YIDIDl8lvC8

According to the USEPA, no levels of concern for dioxins were found on residential/recreational/agricultural properties.[185] USEPA also reported they found outliers on the sides of roads (public right-of-way), but nothing elevated on property compared to typical background.

April 25 – The USEPA posted on their webpage that residential soil sampling results demonstrated the soil being safe for gardening.[88]

April 26 – The **USEPA announced that they determined private wells now only need to be tested for 29 contaminants per the Norfolk Southern potable water sampling plan**, which they approved.[186]

April 27 – The USEPA held an "Information Session: Air Monitoring and Sampling".[187] Recording here: https://youtu.be/Qmmzf3__TXI

April 28 – East Palestine residents report testing positive for vinyl chloride exposure two months after the train derailment and asks formal testing to be conducted for the community. A chiropractor says that he has encouraged patients to seek help from their physicians. Some patients had gone to their physicians who said they did not understand what to do for their patients for the chemical exposure.[188]

April 29 – A chiropractor records a video under the concrete culverts, revealing contamination in Sulphur Run, pipes connecting people's homes to the contaminated creek, and cracks in the walls and ceiling of the concrete, with water dripping from the roof.[189] Recording here: https://youtu.be/XJmTzNQ3sGk?si=cIc0dSp-tUSzr3PB

May 2 – A USEPA Newsletter stated "Cleanup under the south track is complete and the track is now active.[190] The north track has been removed and excavation is now underway. Crews are excavating areas near North Pleasant Drive moving east. The remaining soil will be sampled to ensure contaminated material is removed. Once excavated, soil is staged for removal and sent off-site for disposal." Also, pertaining to storage of waste onsite "Staging areas for soil waste are lined with thick plastic and concrete barriers. Last week, Waste Pile 5 was fully cleared with all soil waste sent off-site for disposal. Workers then re-lined the area to prepare for additional waste staging from the north track excavation. To prepare the staging area, workers laid new, thicker plastic liners and constructed concrete berms. Plastic liners protect underlying soil and groundwater, and concrete berms prevent runoff. When soil piles are not actively managed, thick plastic is placed on top for safety." Also reported where various ways chemical air sampling can be conducted: "You may have noticed stainless steel canisters around town. They are called Summa canisters. The canisters capture "a whole air sample" because they do not require a pump due to having a vacuum inside. The pressure difference between the inside and outside of the container allows air to naturally flow into the empty space. They allow a whole bulk air sample to be analyzed for a variety of contaminants. Air sampling equipment include Summa canisters: stainless steel containers that capture whole air samples; Trace Atmospheric Gas Analyzer (TAGA): a vehicle and mobile laboratory that measures real-time contaminant levels in air as it moves from one location to another; Passive samplers: small devices that slowly absorb chemicals from the air; Portable monitors: handheld devices that detect contaminant levels at the point of use; Sorbent tubes: sealed glass tubes that are used with a pump to pull in air and absorb contaminants on the special material; Sampling bags: plastic bags that collect whole air samples."

May 4-5 – A Purdue University team conducts a site visit.

May 4 – The USEPA held an "Information Session: Private Well Water Sampling Program".[191] Recording here: https://youtu.be/AhGNLB-x6BU

> At the meeting in East Palestine Ohio, the USEPA and Columbiana County Health Department report to have tested 398 private drinking water wells. But a USEPA newsletter issued to East Palestine Ohio residents before the meeting claimed 459 wells had been tested.

May 9 – A USEPA newsletter included several announcements.[192] "Sediment Cleaning in Leslie Run is planned for Leslie Run. "This week Norfolk Southern will be conducting cleanup activities in Leslie Run, with part of the effort being testing the restoration methods. These restoration efforts have been designed to further stream cleanup with specific sensitivity to protecting the existing ecological community within the stream. Under expert regulatory guidance and direction from USEPA and OEPA, the activities will focus on addressing the remaining residual impacts to the sediments in the waterway to facilitate the stream and associated wildlife's return to conditions prior to the incident." Also, "Ohio EPA and Norfolk Southern stopped treating water in Sulphur Run in April after receiving favorable water sampling data. **Crews recently removed the water treatment equipment, like water pumps, air compressors, and diffusers, from the creek."**

May 11 – The USEPA held an “Information Session: Surface Water Sampling Program” Recording here: https://youtu.be/lHXrxoP6G1o.[193] During the meeting, the audience was told a “full, complete fish kill” from the derailment site to Little Bull Creek occurred. [37]

May 11 – The Ohio Department of Health Director stated that urine tests for vinyl chloride exposure are unreliable.[194]

May 12 – 110 tons of asbestos contaminated soil (5% was transite) was discovered at the derailment site and was then hauled offsite for disposal.[195]

May 16 – A USEPA Newsletter explains why **the area of concern for nearby private drinking water wells was extended** and describes dust concerns.[196] **“Why was the well water priority zone boundary extended?** The priority zones are extended to reflect additional testing done by Columbiana County Health District and Norfolk Southern. The purpose of this extension is to ensure that drinking water supplies downstream to the Ohio River are monitored. The extension is not due to any additional environmental or health concerns. As more information regarding groundwater flow is gathered, we will continue to assess our priority zones.” USEPA also stated that they are working to control dust: “What is being done to control dust? Norfolk Southern contractors use engineering controls to reduce dust generated from cleanup activities and disturbed soil surfaces. All contaminated material leaving the derailment site is secured and tarped, and all contaminated material on site is tarped nightly. Trucks are decontaminated before they leave the site, and large water trucks are used to clean roadways. EPA monitors for particulate matter using DustTraks. Air monitoring data table summaries can be found on EPA’s East Palestine website.”

May 18 – The USEPA held an “Information Session: Track Operations”.[197] Recording here: https://youtu.be/OQl6CJZY4Lg

May 19 – A Purdue University researcher testifies at a meeting of the Democratic Policy Committee Commonwealth of Pennsylvania in Harrisburg, PA.[198]

May 23 – A CTEH report dated on May 23, 2023 on the air knifing operations revealed that **cleanup workers reported a strong odor in Sulphur Run creek that caused workers to become ill** with "nausea, headache, and upper respiratory irritation periodically during air knifing operations."[199] According to the report, after the workers became ill, the operation was suspended on April 15, 2023. This information was not made public until August 14, 2024.[200]

May 23 – A USEPA Newsletter reported that odors being detected are not associated with the derailment and asbestos was found at the derailment site.[201] Specifically, regarding nighttime air monitoring, “Unified Command has 24/7 air monitoring in place. Recently, community members brought to EPA’s attention odors at night in two residential areas. The odors have been thoroughly investigated and are unrelated to the derailment site.”

“EPA has received questions from residents about information that we shared back in April regarding discovered asbestos containing material (ACM). During site cleanup activities, ACM was discovered near one of the work areas. The ACM was unrelated to the incident. The material was not included with either the train or the materials being transported. To protect the workers in the area and facilitate the remediation of the incident, Norfolk Southern utilized Ohio licensed asbestos abatement contractors to remove the material for offsite management and disposal in accordance with associated regulations.”

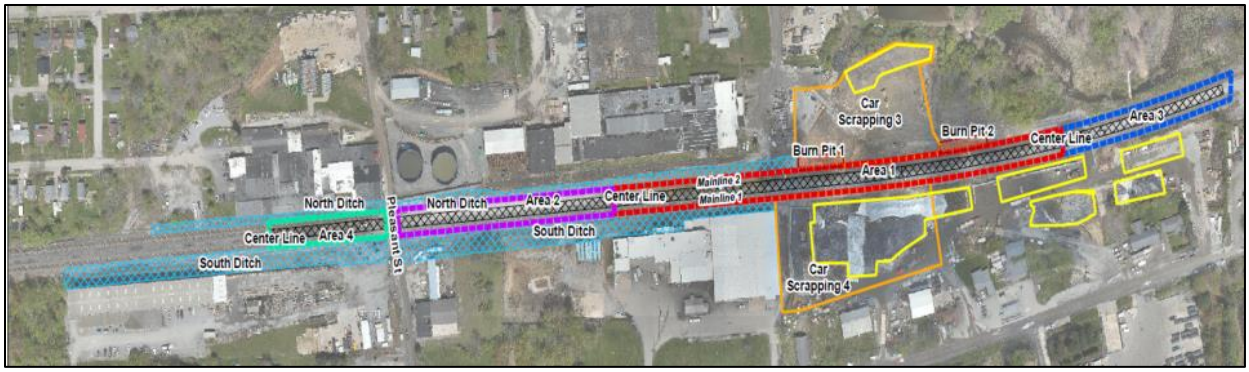


Figure ESI-27. A USEPA map describing the derailment site.[201]

The USEPA also described why mats are being placed over stormwater drains. "Dust mats are used over the inlets on the roadways around the derailment site to keep particles, such as dust and dirt, out of the stormwater sewer system. The system, which collects water from sources, such as rainfall, water trucks, and snowmelt, discharges directly to the local creeks and tributaries. Excessive particles, such as dust, in the storm sewer catch basin can clog the catch basin and block water flow, so it is important to keep them from entering the system. If you see these mats around town, please do not remove them as they are helping to protect water bodies and aquatic habitats. The storm sewers do not connect to the pipes in your house. You can watch our latest in the moment video about storm sewers in East Palestine on the EPA webpage to learn more."

The USEPA also reported: What are the health agencies doing? The Centers for Disease Control and Prevention and Agency for Toxic Substances and Disease Registry (ATSDR) are analyzing their Assessment of Chemical Exposure (ACE) survey results to assess the health impacts of the train derailment. CDC and ATSDR continue to support the Ohio and Pennsylvania health departments and will be back in the community in June to discuss public health. EPA is collecting questions from residents ahead of time (r5_eastpalestine@epa.gov or drop a question off at the Welcome Center). Additionally, the National Institute for Health (NIH) will be coordinating a series of workshops to evaluate public health research needs in East Palestine and surrounding areas.

May 30 – A USEPA Newsletter reported "Truck traffic has increased near the derailment site.[202] **Up to 100 truckloads of soil and water leave the site every day.** Weekends have less truck traffic." USEPA also describes different type of trucks being used in East Palestine including trucks spraying water on roadways. USEPA stated "Some community members have expressed concern about water wash trucks that appear to be spilling water. **These trucks are spreading clean water to help reduce the spread of dust from the cleanup site.** At the cleanup, most of the dust generated comes from gravel which was brought in as a surface for heavy construction materials used onsite. ….. The gravel is being replaced by paving which will reduce the amount of dust. Hazardous water waste vehicles securely transport wastewater from the site for treatment."

May 31 – The USEPA posts a website statement about vinyl chloride urine testing in response to resident concerns.[203,204]

June 1 – A journalist investigation revealed that the devices USEPA approved Norfolk's Southern to use to assess building indoor air safety were not capable of detecting butyl acrylate at less than 160 ppb. Draft government documents reviewed stated "at the time when these assessments were conducted, no data was available to determine if residents returning to their homes near the site were exposed to n-butyl acrylate above the intermediate exposure threshold of 20 ppb." "There is now uncertainty as to whether the results provided by the PIDs were representative of any potential chemical exposure to homes or in the community".[205]

June 6 – The USEPA held an "Information Session: Public Health Update with CDC and State Partners".[206] Recording here: https://www.youtube.com/watch?v=ICWHTEFU7yg.

ATSDR Captain Shugart reported that their investigation is meant to learn how release of chemicals impacted the health of people impacted. She confirmed several employees became ill while they were conducting their survey in East Palestine by going door to door in March. This happened "in the area closest to the accident" and the exact locations were not disclosed. Staff that had symptoms were similar to symptoms of those impacted by the train derailment such as headaches. **"We don't know for certain if there will or won't be long-term health effects from these exposures"**, stated. "The levels of exposures were in general much lower than those studied for people who have been exposed through their work".

A resident reported they called the ATSDR and CDC who never gotten a call back and called the "toxic hotline" and doesn't get answers.

CDC recommends residents see their physician with concerns. **CDC says "One thing that we can agree on is the exposure happened. It happened. We have symptoms. It's documented…. The problem is that for us to fix exposure we have to go back in time and we can't do that….If you develop any of the really scary health effects in the future, like cancer, for example, angel sarcoma of the liver, that's a cancer for vinyl chloride. We want to detect that early.** So that's why we're saying go to your doctor so that you can get examined and can get the proper test. We know how to treat Angel sarcoma. We may not know how to get rid of vinyl chloride from the body, but we know how to treat those cancers."

June 6 – A USEPA Newsletter stated that vapor suppressants are used to control odors.[207] "When soil waste is loaded or staged there may be increased vapors. Continuous air monitoring is done to ensure the air remains safe. Also, **a vapor suppressant foam is used on active piles to reduce odors.** Some chemicals of concern, such as butyl acrylate, have a low odor threshold and can be smelled below levels of concern."

June 6 – The USEPA held an "Information Session: Public Health with NIH and the University of Kentucky".[208] Recording here: https://www.youtube.com/watch?v=vnwJIt-hT0g&t=4s

June 10-11 – Purdue University team conducts final site visit.

Some other notable dates after the end of the author's field investigation

June 13 – A USEPA Newsletter describes their position about vinyl chloride contamination of a nearby American Legion drinking water source.[209] "Did drinking water samples from the American Legion in East Palestine have detections of vinyl chloride? No. The drinking water supplied to the American Legion from the Village municipal water system has been tested weekly since the incident and vinyl chloride has not been detected in the drinking water, nor any of the water supply wells. A filter company collected water at the American Legion, and had it spiked with vinyl chloride at a lab to determine if the tools used by the lab could accurately measure vinyl chloride and to evaluate filters sold by the company. Some of the company's messaging around this testing incorrectly stated that the vinyl chloride came from the drinking water. The company has been made aware of the confusion and is working to correct the messaging."

June 26 – **The USEPA releases, for the first time, a soot deposition map representing particulate matter fate from the derailment representing for the February 6, 1500 to 0100**. The map corresponds to the open burn and indicates particulate matter deposited outside the Ohio evacuation zone and into Pennsylvania as well. **The map does not consider air pollution release when chemical fires were taking place before 1500 February 6, 2023**.[2]

July 3 – Governor DeWine requested a federal disaster declaration from the President of the United States.[210] According to the letter, this support was not necessary to the date, since "no unmet needs have been reported to the State", and the letter was a way to ensure resources to be available for the community assistance in the future, if necessary.

August 2 – The US OSHA fined Norfolk Southern for five explicit unsafe work practices and environments.[211] The investigation was opened one day after a Railroad Union sent a letter to OSHA warning of workers becoming ill while at the derailment site and not being provided safety protection. The following day a Purdue University professor sent OSHA a letter warning of unsafe work practices in East Palestine observed during the Purdue team's first visit in February.

August 6 – An East Palestine resident states that Wayne State University researchers found 2-ethylhexylacrylate (a chemical released from the incident) in her home and vinyl chloride in an outdoor burn pit.[212]

August 8 – The USEPA issued a map that described the eligibility boundary for buildings where indoor cleaning will be offered. Residents are given until September 5 to express interest and will then meet with both Norfolk Southern and USEPA to discuss the details.[213]

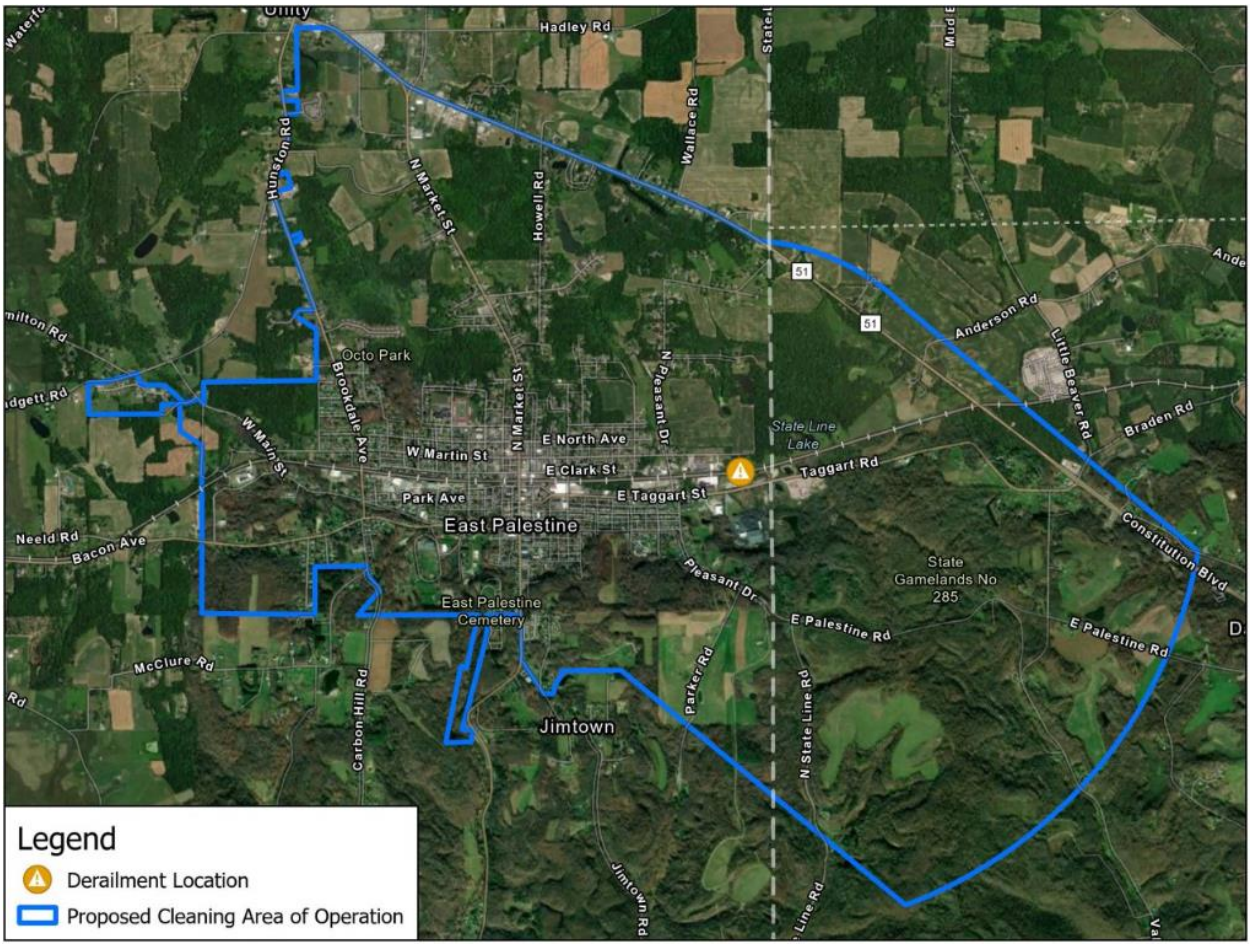


Figure ESI-28. Map of indoor cleaning eligibility boundary per the USEPA.[213]

Residents were provided mailers that described what the USEPA cleaning activity with Norfolk Southern will and will not include (**Figure ESI-29**). During Summer and Fall 2023, the USEPA started to offer to indoor home and place of business cleaning in East Palestine or within 2-mile Ohio and Pennsylvania evacuation.[214] No chemical tests are included for the cleaning activity to confirm the existence of contamination or removal of contamination.

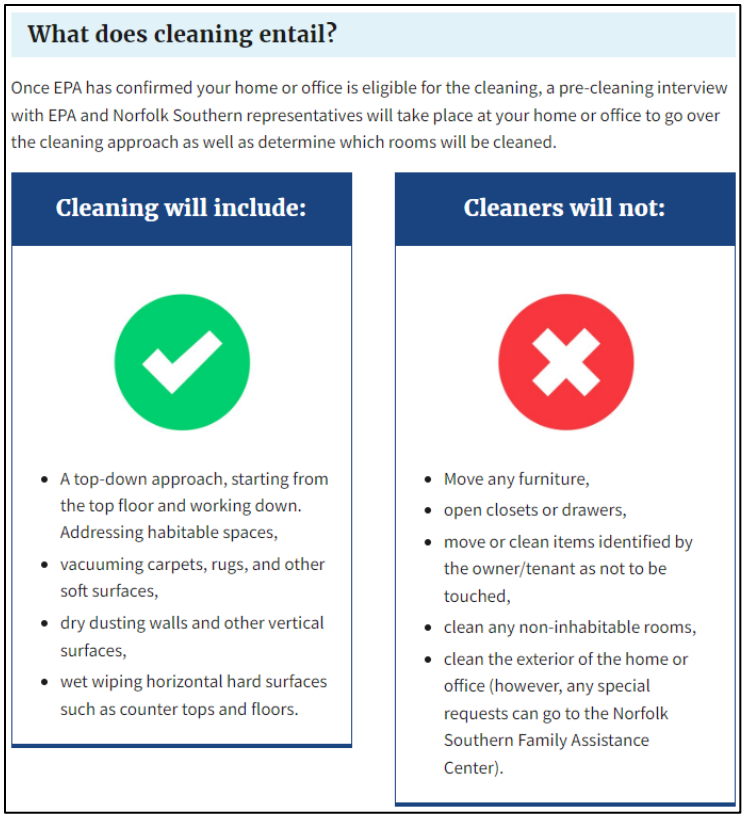


Figure ESI-29. Information about the USEPA indoor cleaning program issued by a newsletter.[214]

August 11 – A fish kill was discovered in Leslie Run around the time Ohio Department of Transportation bridge construction activities were taking place at East Palestine Park. This location is near where contaminated Sulphur Run emptied into contaminated Leslie Run. Residents claimed the fish kill was due to contamination remaining in Leslie Run. The Ohio EPA responded onsite and chose not to collect any water samples for testing.[215]

August 25 – The USEPA held an "Information Session: Operational Updates & Interior Structure Cleaning Overview".[216] Recording here: https://www.youtube.com/watch?v=gkW6j2xy0q8&feature=youtu.be

September 20 – The President of the United States issued an executive order that "the Secretary of Homeland Security, through the Administrator of FEMA, shall designate a Federal Disaster Recovery Coordinator (Coordinator) to oversee long-term recovery efforts in the affected communities and conduct a comprehensive assessment of unmet needs of the affected communities in recovering from the derailment beyond the cleanup work directed by EPA".[217]

October 17 – The Center for Health, Environment, and Justice released their analysis of USEPA's dioxin samples results from East Palestine, Ohio and called for additional testing.[218]

October 18 – The USEPA ordered Norfolk Southern to clean up oil contamination under the *Clean Water Act*. In addition, the company should conduct investigations specifically targeting the presence of oily sheens and sediments in Sulphur Run and Leslie Run creeks, and surrounding areas, within 5 miles from the impacted area.[219]

November 6, 7 – The US National Academies of Sciences, Engineering, and Medicine held a "Public Health Research and Surveillance Priorities from the East Palestine, Ohio Train Derailment: A Workshop".[220] This two-day virtual workshop brought together experts from government, non-governmental organizations, the private sector, and affected communities to discuss the potential health impacts arising from the train derailment in East Palestine, Ohio. A video recording of the workshop can be found here: https://www.nationalacademies.org/event/40970_11-2023_public-health-research-and-surveillance-priorities-from-the-east-palestine-ohio-train-derailment-a-workshop.

November 10 – In response to a September 20 executive order, the USEPA submitted a report to the White House detailing their response to date on air, soil, surface water, groundwater, and drinking water sampling.[221]

November 15 – USEPA members presented at the SETAC annual meeting the tools used during the communication with residents and businesses in East Palestine following the disaster.[222]

January 26 – Norfolk Southern estimated that the total costs related to the train derailment are $1.1 billion, including environmental-related costs, as well as legal costs and community assistance.[223]

March 6 – NTSB Chair Jennifer Homendy testified in a Senate Commerce Committee hearing that Norfolk Southern had been informed prior to the railcar burn that "polymerization was not occurring, and there was no justification to do a vent and burn. There was another option: let it cool down."[224]

March 9 – The PID instrument was initially used to screen indoor building contamination, but later in the disaster response it was found not to be sensitive enough to detect harmful levels of BA.[225] Despite knowing the limitations of their equipment, RESP failed to inform residents whose homes had already been tested and did not offer retesting. This has led to mistrust in the community and concerns about long-term health effects. While ongoing testing shows no current exposure, past exposure remains uncertain.

May 23 – In a proposed settlement, the United States Department of Justice (DOJ) reached an agreement with Norfolk Southern for more than $310 million to address the consequences of the East Palestine train derailment.[226] The agreement encompasses the costs of environmental remediation, health monitoring, and rail safety improvements, as well as a civil penalty. The date chosen for all public comments to be due is August 2, 2024.

July 3 – Some residents from East Palestine filed an objection to federal class-action lawsuit settlement of $600 million dollars, requesting an extension of the time to decide whether to opt in or out.[227] In addition, the residents highlight in the objection the decision-making process that requires them to opt in before knowing how much they would receive from the settlement.

June 19 – A study conducted by the University of Wisconsin-Madison found that the contamination from the train derailment was more widespread than claimed by RESP, including federal agencies. The study revealed that contamination affected 16 states in the U.S. and Canada, covering an area of 1.4 million km^2.[228]

July 19 – The US Federal Railroad Administration (FRA) concluded that the derailment was caused by an overheated wheel bearing. Inadequate procedures and staffing may also have contributed. The severity of the accident was increased by the use of a general-purpose tank car for butyl acrylate, which was unsuitable for hazardous chemicals. In addition, the FRA reported 24 inhalation injuries involving both civilians and contractors.[229,230]

June 7 – Results of a post disaster exposure of 18 adults indicated no difference between a toxic equivalence (TEQ) value compared against national data.[231] Study results are important, and further testing with a more representative population is recommended.

June 14 – USEPA posted on its website that "three small areas on-site where significant hazardous substance management operations occurred showed low levels of vinyl chloride present just above site screening levels. In accordance with the approved plans, soil was removed for off-site disposal. More details about this process will be included in the next site newsletter, including a description of how low-level exceedances of other volatile organic compounds will be managed."[232] The area size and amounts of vinyl chloride were not reported.

August 2 – In response to the U.S. Department of Justice settlement proposal, the Governor of Pennsylvania submitted a letter of concern outlining deficiencies.[4] These included inadequate health care funding for present and future health impacts related to the toxic plumes of contaminants that filled our air following the derailment; Inadequate range of applicability for health and environmental monitoring provisions; Failure to incorporate recommendations made by the National Transportation Safety Board in its final report of the incident.

August 20 – East Palestine residents objected to the U.S. Department of Justice's $310 million settlement with Norfolk Southern, claiming it inadequately addressed public health funding, medical treatment,

groundwater safety, and lacked provisions for comprehensive medical monitoring and data management.[233]

August 29 – Pennsylvania Department of Environmental Protection announces a 10-year water monitoring program for drinking water wells for PA residents living within one mile of the train derailment.[234]

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