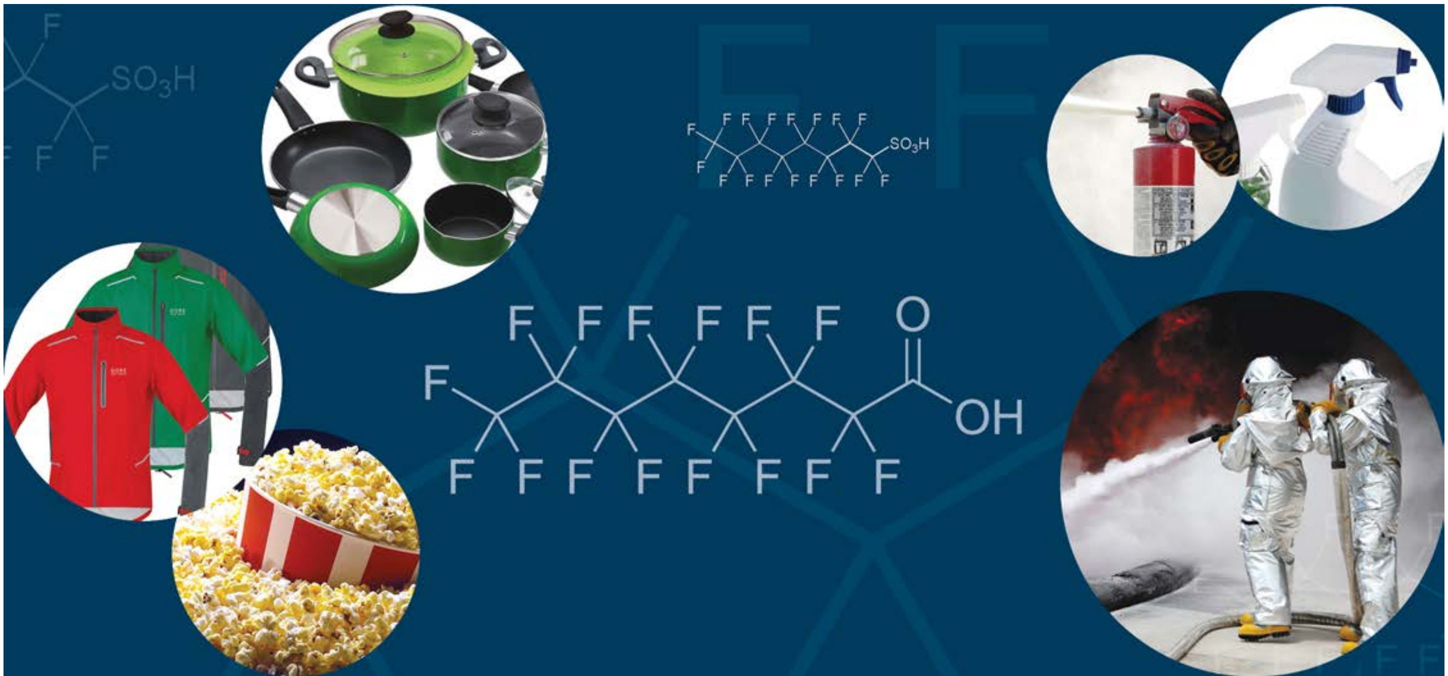
STATEMENT OF QUALIFICATIONS



Per- and Poly-fluoroalkyl Substances (PFAS) and 1,4-Dioxane

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A Summary of the Emerging Contaminants

Per- and Poly-fluoroalkyl Substances (PFAS) - What are they?

PFAS are a family of synthetic chemicals.

- Per-fluoroalkyl substances contain one or more carbon atoms on which all of the hydrogen has been replaced by fluorine atoms.
- Poly-fluoroalkyl substances are partially fluorinated, whereby one or more carbon atoms are bonded with a non-fluorine atom (e.g., hydrogen or oxygen).
- PFAS are environmental emerging contaminants with widespread applications in industry due to their resistance to heat, water and oil.
- PFAS have been widely utilized in aerospace, automotive, building/construction, chemical processing, semiconductor, and textile industries since the 1950s.
- PFAS have been commercially produced for a variety of industrial uses such as carpeting, apparels, upholstery, food paper wrappings, fire-fighting foams, and metal plating.
- Two common PFAS are Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). 3M, the primary American producer of PFOS, began the phase-out of PFOS, PFOA, and PFOS-related products in 2000. These have been replaced with other PFAS compounds that can degrade in the environment to PFOS and PFOA.

PFAS Use in Aqueous Film-forming Foams (AFFF)

- PFAS-based surfactants have been used in AFFFs that have been used for fire training and at crash sites since the 1970s.
- Historically, run-off from AFFF fire-fighting activities was neither collected nor pre-treated prior to discharge to water treatment systems or to the environment.
- Many major industries, including Department of Defense (DoD) and commercial airports routinely trained with and used AFFF in fire-training activities, throughout the US.
- Release of AFFF into the environment may be the largest release, on a per mass basis, of PFAS.

Why are PFAS important?

- PFAS are a persistent class of chemicals able to resist degradation.
- PFAS have been found at very low levels both in the environment and in the blood samples of the general US population.
- PFAS do not have federal cleanup standards.
- Some PFAS are environmentally persistent, bioaccumulate in living organisms, and have demonstrated toxicity in laboratory animals. Thus, it may be prudent to assess and potentially mitigate human and/or environmental exposures.
- The identification of PFAS can significantly impact site objectives, schedule, cost and ongoing remedial activities, particularly without clear regulatory criteria. PFAS present unique challenges including identifying potential sources related to PFAS release, and characterizing PFAS-contaminated groundwater and/or soil.

Why are PFAS considered Environmental Emerging Contaminants?

Regulatory Status and History

- Regulations in place for these chemicals are currently limited, yet likely to increase.
- In May 2012, USEPA promulgated the Unregulated Contaminant Monitoring Rule (UCMR 3) requiring public drinking water suppliers to test for six perfluoroalkyl acids, including PFOS and PFOA. The results of this testing have revealed significant presence in drinking water systems.
- At this time, PFAS are not currently regulated by Safe Drinking Water Act (SDWA), Clean Air Act (CAA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), etc.; however the regulatory interest is increasing and future regulations are likely.
- EPA's Office of Water reanalyzed the PFAS toxicity information and in May 2016, released a lifetime drinking water health advisory (HA) for PFOS and PFOA which reduced the provisional HA from 0.2 µg/L (PFOS) and 0.4 µg/L (PFOA) to 0.07 µg/L, individually and combined total for both compounds.
- Numerous states have either adopted EPA's HA or have non-enforceable guidance values; Iowa, Minnesota and New Jersey have promulgated water standards for certain PFAS.

HAs are non-enforceable and non-regulatory guidelines which provide technical information to state agencies and other public health officials on health effects, analytical methodologies, and treatment technologies associated with drinking water contamination. These HAs may or may not be utilized within state-led regulatory environmental cleanup decisions, leading to inconsistent national application.

Based on Toxicology

- At high concentrations, certain PFAS have been linked to adverse health effects in people, such as pregnancy-induced hypertension and preeclampsia, low birth weight, delayed puberty onset, elevated cholesterol levels, liver function changes, and reduced immunologic responses to vaccination.
- USEPA has determined that there is "suggestive evidence of carcinogenic potential" for PFOA.
- Because PFAS are persistent and resist degradation, they bioaccumulate in wildlife and are in the food chain.
- Human exposure to PFAS is primarily through the ingestion of contaminated foodstuffs, either directly contaminated (e.g., as a result of bioaccumulation in fish) or through indirect contamination by food wrappings, as well as through the ingestion of contaminated drinking water.

PFAS Challenges

Scope of the Problem

- PFAS are not typically analyzed during environmental site characterization; therefore, little sampling data exist.
- Exposures to humans and wildlife are not well documented.
- Effects of exposures are not well characterized.
- It is unclear if environmental site closure can be achieved for sites with potential or verified PFAS contamination in soil or groundwater.
- PFAS may re-open sites or delay site closure.
- Analytical methods are highly specialized and not performed by the majority of analytical laboratories.

Site Characterization Challenges

- Limited investigation data for PFAS.
- Complicated fate and transport.
- Large dilute plumes may form and a "source area" may not exist.
- Potential co-mingled plumes (e.g., petroleum hydrocarbons and chlorinated volatile organic compounds (VOCs), ethylene glycol).
- An increasing number of studies indicate PFAS are widespread globally. Their persistence and ability to transport are becoming an increasing area of concern.
- Resistance to natural attenuation processes in groundwater is a cause for concern for long-distance migration in plumes.

Regulatory Challenges

- How to progress through the CERCLA process, with a lack of regulatory requirements.
- Few regulatory drivers creates an air of uncertainty.

Chemical Property and Treatment Challenges

- PFAS' surfactant properties cause it to partition at the air-water interface and also to self-associate in solution, forming micelles and micro-emulsions. This creates sampling challenges for remediation monitoring, and challenges in measuring properties such as solubility and organic carbon-water partition coefficient.
- Granular activated carbon (GAC) preferentially adsorbs naturally-occurring organic carbon and organic contaminants, which often need to be pre-treated prior to GAC PFAS treatment.
- Destruction of PFAS, once adsorbed, is by incineration at high temperatures (>1,100°C); toxic products of incomplete combustion can form at lower temperatures.
- The long-term success of in-situ soil stabilization can be affected by changes in geochemical conditions.

- In-situ redox approaches have not yet been shown to be effective on PFOA and PFOS, and may transform certain other PFAS into PFOA/PFOS, exacerbating the contamination.
- Surface foam fractionation may be an effective approach under certain conditions.

Although typically associated with TCA, a recent study of Air Force installations found 1,4-dioxane also associated with trichloroethene (TCE), indicating that 1,4-dioxane is a relatively common groundwater contaminant for both TCA and TCE.

1,4-Dioxane – What is it?

- 1,4-Dioxane is a volatile, flammable, colorless liquid at room temperature.
- It is used as:
  - a stabilizer and corrosion inhibitor for chlorinated solvents such as 1,1,1-trichloroethane (TCA);
  - a solvent for impregnating cellulose acetate membrane filters;
  - a wetting and dispersing agent in textile processes; and
  - a laboratory cryoscopic solvent for molecular mass determinations.
- 1,4-Dioxane is used in many products, including paint strippers, dyes, greases, varnishes and waxes, and is also found as an impurity in antifreeze and aircraft deicing fluids and in some consumer products (deodorants, shampoos and cosmetics).
- 1,4-Dioxane is used as a purifying agent in the manufacture of pharmaceuticals and is a byproduct in the manufacture of polyethylene terephthalate plastic. 1,4-Dioxane residues may be present in manufactured food additives, 1,4-dioxane-containing food packaging materials, or on crops treated with pesticides that contain 1,4-dioxane (such as vine-ripened tomatoes).

Why is 1,4-Dioxane important?

- It is highly soluble in water, does not bind to soils, and readily leaches to groundwater.
- It is relatively resistant to biodegradation in water and soil and does not bioconcentrate in the food chain.
- The identification of 1,4-dioxane can significantly impact site objectives, schedule, cost and ongoing remedial activities, particularly without clear regulatory criteria. 1,4-Dioxane presents unique challenges including identifying potential sources related to 1,4-dioxane releases, and characterizing 1,4-dioxane contaminated groundwater and/or soil.

Similar to HAs, the screening levels are non-enforceable and are used to determine the need for further evaluation of a chemical's overall contribution to potential adverse health impacts.

Regulatory Information

- No federal maximum contaminant level (MCL) for drinking water has been established. EPA has established a lifetime HA of 0.2 mg/L for 1,4-dioxane in drinking water; the HA is 0.35 µg/L at a 10^{-6} cancer risk level.
- EPA has calculated risk-based site remediation screening levels for tapwater (0.46 µg/L), residential soils (5.3 mg/kg), industrial soils (24 mg/kg) and migration to groundwater from soils (0.000094 mg/kg).
- Several states have established notification or guidance levels.

Why is 1,4-Dioxane considered an Environmental Emerging Contaminant?

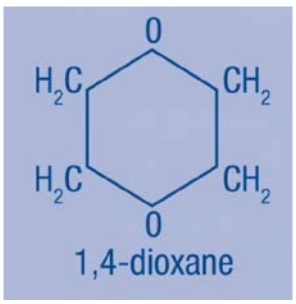
Regulatory Status and History

- 1,4-Dioxane is not regulated under the SDWA.
- The 1996 SDWA amendments require that once every five years EPA issue a new list of no more than 30 unregulated contaminants to be monitored by public water systems. The UCMR 3 promulgated in May 2012 included 1,4-dioxane. Based on results obtained through April 2016, of the 4,849 public water systems monitored, 1,062 had detections of 1,4-dioxane.
- 1,4-Dioxane is regulated under the CAA, CERCLA, RCRA, and Superfund Amendments and Reauthorization Act (SARA).

- The Food and Drug Administration (FDA) regulates 1,4-dioxane under the Federal Food, Drug, and Cosmetics Act as an indirect food additive when it is used as an adhesive component in packaging materials. FDA is surveying raw materials and products contaminated with 1,4-dioxane.
- 1,4-Dioxane is exempted from tolerances for pesticide chemicals in or on raw agricultural commodities, and it has been classified as a toxic inert ingredient of pesticide products.

Based on Toxicology

- 1, 4-Dioxane has been labeled an "emerging contaminant" by the EPA due to the potential impact of the chemical on human health and environmental quality and the current limitations of the available research.
- The EPA has classified 1,4-dioxane as a likely human carcinogen, with the potential to cause nasal and liver tumors.
- Noncarcinogenic effects include effects on the nervous system, liver and kidney.
- For cases of environmental contamination, the most important route of exposure with respect to dose and risk is ingestion of contaminated water. However, exposure can also occur via inhalation.



1,4-Dioxane Challenges

Scope of the Problem

- 1,4-Dioxane reporting limits have been significantly higher than current federal or state guidelines using standard analytical methods; therefore, there is a potential for 1,4-dioxane to be present at levels of concern at sites previously thought to be free of this contaminant.
- Exposures to humans are not well documented.
- Effects of exposures are not well characterized.
- Current concerns over 1,4-dioxane may re-open sites or delay site closure.

Site Characterization Challenges

- Limited data on 1,4-dioxane due to elevated analytical reporting limits.
- Modifications to existing sample preparation and analytical procedures may be required to achieve the increased sensitivity needed for detection of 1,4-dioxane.
- Large dilute plumes may form and a "source area" may not exist.
- Potential co-mingled plumes (e.g., TCA or TCE).
- Found at many facilities because of its widespread use as a stabilizer in certain chlorinated solvents, paint strippers, greases and waxes.
- Found in detergents used as leak detection solutions during the construction of monitoring wells and is also present in surfactants used to decontaminate environmental sampling equipment.

Chemical Property and Treatment Challenges

- 1,4-Dioxane is highly soluble and preferentially partitions into the water phase rather than the gas phase, making conventional treatments such as aeration and soil vapor extraction ineffective.
- Other conventional water treatment practices (e.g., coagulation, sedimentation, and filtration), granular activated carbon (GAC) adsorption, ultraviolet (UV), and biofiltration have proven to be ineffective at removing 1,4-dioxane from water.
- Advanced oxidation processes including a combination of hydrogen peroxide and ferrous iron, ozone and hydrogen peroxide, and UV and hydrogen peroxide have been shown to be effective for oxidizing 1,4-dioxane. Ozone (without other oxidants) has also shown to be effective.

Why TRC?

Project Experience

TRC provides characterization, sampling, analysis, compliance, risk assessment, and remediation consulting services for 1,4-dioxane and PFAS, including the most common ones, PFOA and PFOS, as well as other branched and linear PFAS isomers. Examples of TRC's specific project experience with PFAS and 1,4-dioxane are provided below.

<u>PFAS:</u>

- **Former Chromium Plating Site, New England**: TRC performed sampling of groundwater and drinking water for PFAS at a federal-lead Superfund Site as part of a Remedial Investigation/Feasibility Study. PFAS were detected in these media, and we are currently planning for additional groundwater, drinking water, and packer well sampling to define the nature and extent of PFAS. We are working with EPA Headquarters and the local EPA Region to establish protocols for PFAS on federal lead sites. TRC assisted in the development of analytical specifications for PFAS in aqueous and solid matrices in accordance with current Department of Defense Quality Systems Manual 5.1 requirements. We also perform data validation of the resulting PFAS data.
- **Airport, New York**: TRC designed a sampling plan and collected PFAS data in water/storm water for investigative purposes and as part of an Information Request received from the New York State Department of Environmental Conservation (NYSDEC) under the Environmental Benefit Permit Strategy (EBPS). PFOA and PFOS have been detected in water above the EPA health advisory (70 ng/L) and we are currently evaluating potential sources and background sources, and working on identifying and isolating potential inflow to the storm water drainage system. We have delineated a number of sources at the site by fingerprinting various PFAS mixtures associated with PFOS-rich AFFF and fluorotelomer-based AFFF, including segregating sources that may be associated with our client's site from a nearby source that has impacted a drinking water reservoir. PFAS fingerprinting and mass flow calculations were also utilized to prioritize the design of targeted remedial actions to aggressively minimize off-site migration. Following the investigation phase, TRC will recommend remedial option(s) to swiftly address the potential discharge of PFAS to the environment.

- **Petrochemical – Plastics Precursors Facility, Decatur, Alabama**: TRC collected groundwater samples for PFAS because our client had installed a large production well to supply water to its on-site environmental education center (a "lab" that included a large pond used by local schools for environmental/ecological awareness) and learned that a neighboring facility's groundwater was contaminated with PFAS. As a result of the testing, we found that PFAS had migrated from the neighboring facility's property into the supply well and the lab's pond. In the end, the neighboring facility paid to close our client's well and subsequently drained and excavated the pond, placing a cap over the area.
- **Manufacturing Facility, Gloucester County, New Jersey**: TRC is providing consulting services and investigating the PFAS for a manufacturing facility being sued by two public water supply systems, supplying replacement water to one local town while a treatment plant is constructed, and voluntarily operating over 80 point of entry treatment systems.
- **CERCLA Site, Delaware**: As part of the 5-year review at a CERCLA site in Delaware (Region III), TRC was required to sample for PFAS in groundwater, even though the historic chrome plating operation probably preceded the use of PFOS as a mist suppressant over chromic acid bath tanks, and the information on its use in the manufacture of electronics manufacture was nebulous. Only two PFAS were of regulatory concern and carried concentrations of concern: PFOA and PFOS.
- **NYSDEC Standby Engineering Services, Statewide**: TRC has been working directly for NYSDEC since 2011 in support of their efforts to investigate and clean up contaminated sites under the

State Superfund (SSF) Program. During this time, TRC has provided engineering services at 23 Inactive Hazardous Waste Disposal Sites (IHWDS), including various landfills; waste treatment, storage and disposal facilities; dry cleaners; illegal dump sites; airports; and, commercial and industrial facilities.

In January 2016, New York became the first state in the nation to regulate PFOA as a hazardous substance followed by the regulation of PFOS in April 2016. The regulation requires the proper storage of the substances and limited releases to the environment, and enabled the state to use its legal authority and resources of the SSF Program to advance investigations and cleanups of impacted sites.

Given the above, TRC has completed sampling of drinking water, groundwater and other environmental media for PFOA, PFOS and other associated PFAS, collectively referred to as PFAS, at many of its SSF Program sites, as required under the regulations. Similar to the screening process for Target Compound List/Target Analyte List (TCL/TAL) parameters during a Site Characterization, a representative number of environmental samples are also collected and analyzed at SSF Program sites for PFAS to determine if these chemicals are contaminants of concern for the sites. Sample collection and analysis methods developed specifically for the assessment of PFAS are used to investigate the sites for potential contamination. Most recently, TRC completed PFAS groundwater sampling activities at the following IHWDS on behalf of NYSDEC: Hoosick Falls Landfill, Solvent Finishers, Brillo Landfill, Fortino Tire, Fashion Care Cleaners, and Katzman Recycling.

In addition to the above activities, TRC has also performed full validation of all analytical data generated under this program. Ultimately, the information generated is reviewed by the NYSDEC and the New York State Department of Health to determine if site contamination presents public health exposure concerns, and also to determine if mitigation of any potential health exposure is required.

- **Former Manufacturing Site, Maine**: TRC has performed groundwater sampling for PFOA and PFOS as part of a USEPA Brownfields Program Phase II Environmental Site Assessment. The site is located adjacent to and partially within a watershed area for municipal water supply. Previous, non-TRC investigations resulted in detections of PFAS in groundwater in the aforementioned offsite water supply wells. To delineate potential impacts to site media, three wells along the site perimeter were sampled for PFAS to assess potential for PFOS and PFOA to be migrating onto the site.
- **Municipal Landfill, New York**: TRC was responsible for characterization of a closed municipal landfill with one area of nearby residences and several nearby surface water bodies. This landfill is believed to have accepted industrial waste, including PFOA. The landfill is strongly suspected to be releasing PFAS from local industry sources over its operational life. TRC performed sampling of groundwater monitoring wells and surface water and sediment from a nearby pond and small drainage ditches for various constituents including PFAS. TRC also performed full validation of all analytical data generated during this program. Information generated is being reviewed by the NYSDOH to determine if site contamination presents public health exposure concerns and to also determine if the landfill leachate is contaminating the nearby pond.
- **Former Microelectronics Manufacturing Facility Site, New England**: TRC has performed sampling of soil, groundwater, surface water, and sediment for PFAS at a former RCRA site (state lead). The sampling was part of a State-requested PFAS investigation at a site with a pre-existing groundwater remedial system to recover and treat volatile organic compounds (VOCs). TRC prepared a Site Investigation Workplan (SIWP) that received State approval and included detailed protocols for sampling several media for PFAS while preventing cross-contamination. The SIWP calls for collection of four quarterly rounds of groundwater sampling, and a report that includes an evaluation of PFAS fate and transport. The state approved the completed SI Report and incorporation of PFAS groundwater sampling into long-term environmental monitoring. Sampling of the ageing former groundwater treatment system demonstrated that enhanced liquid phase GAC effectively removed PFAS. TRC completed the design and

construction of replacement groundwater treatment systems, including a shallow tray air stripper, virgin coconut GAC, and styrene divinylbenzene resin absorption components for sequential treatment of VOCs and PFAS. The completed groundwater treatment system operates at flow rates of up to 150 gallons-per minute containing up to 2,500 parts per billion VOCs and up to 250 part per trillion PFAS. The treatment system effectively treats groundwater removing 99% of VOCs with the air stripper, 90% PFAS and all remaining VOCs with the GAC, and all remaining PFAS with the resin.

- **East Coast International Airport**: TRC has collected PFAS data in soil, surface water and groundwater for investigative purposes with the EPA and a state regulatory agency as the driving forces. Data were collected for 10 of the linear and branched PFAS. Currently, PFAS are not being actively remediated but several of the Superfund Areas of Concern (AOCs) exhibiting elevated PFAS are undergoing groundwater remediation for other chemicals (e.g., VOCs) via granular activated carbon technology and therefore the PFAS are also being removed.

  TRC has also recently completed extensive groundwater modeling at the site which concluded that the known PFAS contamination is not migrating offsite. The modeling results were later confirmed by the state regulatory agency who conducted offsite sampling the results of which were non-detect for PFAS.

  TRC is currently performing a site-wide Preliminary Assessment/Site Inspection (PA/SI) under CERCLA guidance to determine the location of potential PFAS areas of concern. Specific focus is being placed on past and current Fire Training Areas (FTAs) and other known and suspected PFAS or aqueous film-forming foam (AFFF) usage or storage areas.

  Several streams/waterbodies are located in close proximity and downgradient of FTAs. In order to assist in the identification of PFAS AOCs and facilitate the evaluation of human health and ecological risks, TRC will be collecting fish tissue samples within these aquatic habitats for analyses of 10 or more of the linear and branched PFAS.

1,4-Dioxane:

- **Former Pharmaceutical Manufacturing and R&D Facility, New Jersey**: TRC has successfully delineated the vertical and horizontal extent of groundwater contamination at this site. The most prevalent constituents are VOCs, which were detected throughout the shallow and deep groundwater zones under the Site. One of the specific compounds of concern at the site is 1,4-dioxane, and TRC researched and utilized analytical methods capable of achieving detection limits to meet New Jersey's recently promulgated stringent criterion. To expedite groundwater remediation, TRC evaluated remedial alternatives and has designed and implemented interim remedial measures (IRMs) to address groundwater contaminated with VOCs and 1,4-dioxane. Groundwater IRMs have varied from enhanced in-situ bioremediation (EISB), in-situ chemical oxidation (ISCO), in-well air stripping (IWAS), excavation, biosparging, and in-situ thermal remediation using electrical resistive heating.
- **Former Automotive Supplier, Marion, Indiana**: TRC investigated 1,4-dioxane in groundwater at this site. Concentrations of 1,4-dioxane (over 1 ppm) were detected above risk-based screening levels at the property line. Groundwater modeling and monitoring are currently being performed to determine fate and transport of off-site contaminants of concern. There are no groundwater receptors using groundwater in the vicinity of the site. Demonstration that no receptors are affected is likely to be favorable. Remedy will likely be monitored natural attenuation (MNA) monitoring.

- **Alloy Metal Supplier/Foundry, Kokomo Indiana**: TRC investigated 1,4-dioxane in groundwater at this site. Concentrations of 1,4-dioxane were detected at 100 μg/L levels and above the Indiana Department of Environmental Management (IDEM) risk-based screening levels at the property line. Groundwater treatment was performed using persulfate injections. Successful treatment resulted in concentrations below screening levels at the property line. Groundwater monitoring is currently being performed to determine if additional injection is appropriate to address rebound. Approximately three years of monitoring show that treatment was successful.

- **Various Sites with 1,4-Dioxane Monitoring Experience**: 1,4-Dioxane has been monitored by TRC at a vacant metal products site and an active fuzing site in Ohio under their Voluntary Action Program; results either required no further action or further groundwater evaluation is pending. TRC has also monitored for the presence of 1,4-dioxane at a vacant former DoD subcontractor in Virginia under the RCRA Corrective Action program and a vacant metal products site in Florida under the state's Waste Cleanup Program; monitoring at these sites is ongoing.
- **Superfund Site, Durham, Connecticut**: Two source areas at the site (a small manufacturing facility that used solvents to clean machinery, etc. and an automobile painting shop that used organic solvents to clean up the paint booths, etc.) created a groundwater plume with chlorinated VOCs and 1,4-dioxane in fractured bedrock in a residential area where private well usage was common. 1,4-Dioxane was not found in other media at the site. The Human Health Risk Assessment performed by TRC identified that the chlorinated VOCs and 1,4-dioxane posed an unacceptable risk to private well users. The remedy was a Technical Impracticability (TI) waiver, supported by the Connecticut Department of Energy and Environmental Protection (CTDEEP), due to the impracticability of removing solvents from the bedrock.
- **Superfund Site, Attleboro, Massachusetts**: The Human Health Risk Assessment performed by TRC's risk assessors is currently in review with EPA. This metals plating facility used organic solvents, primarily TCE. There is a TCE plume migrating from the property underneath a residential area and discharging into a brook and wetland. The TCE plume is comingled with 1,4-dioxane, both of which would pose an unacceptable risk to human health in the future, if groundwater were to be used as drinking water (no unacceptable risk was associated with 1,4-dioxane in surface water and 1,4-dioxane was not detected in soil or sediment). The area currently has public water, and the few residents with private wells were forced to decommission them.
- **Former Manufacturing Facility Site, New Jersey**: TRC developed and is implementing groundwater monitoring programs for chlorinated VOCs and 1,4-dioxane associated with a former manufacturing facility in New Jersey (state lead). Multiple investigations have been performed to delineate chlorinated VOCs and 1,4-dioxane in a multi-unit aquifer system, to evaluate potential impacts to municipal water supply wells in the area, and assess the efficacy of the existing pump and treat groundwater remediation system. TRC also designed and implemented field-scale pilot tests, feasibility studies, and groundwater models to evaluate alternative remedial technologies to address both VOCs and 1,4-dioxane, and assess risk to potentially sensitive receptors, such as wetlands and potable wells.

TRC's Center of Research and Expertise (CORE)

TRC's CORE is national team of multidisciplinary experts dedicated to advancing and disseminating technical, regulatory, and strategic knowledge, and enhancing and sustaining TRC's leadership position. The CORE team stays at the forefront of technology by conducting research, working on complex projects, teaming with leading universities on research and development, and participating in professional organizations and conferences.

Our CORE experts share knowledge through presentations and courses to our colleagues, clients, attorneys, public institutions, professional organizations, universities, and regulatory agencies. We support TRC projects nationally to streamline access to experts and creative solutions that help our clients meet their goals and manage risk.

We have a CORE Focus Team dedicated to Emerging Contaminants.

Our CORE Focus Teams include:
- Emerging Contaminants
- Risk Assessment
- Sediment Characterization & Remediation
- Advanced Characterization & Forensic Analysis
- Numerical & Visual Modeling
- Data Management & Assessment
- NAPL Assessment & Management
- In-Situ Remediation
- Sustainable Remediation
- Vapor Intrusion Assessment & Mitigation
- System Designs & Specifications
- Environmental Management Systems

We understand the unique sampling challenges.

PFAS: TRC has experience with the special precautions needed when sampling soil and groundwater for PFAS and have established standard operating procedures for the common field activities associated with sampling for PFAS. We ensure no Teflon materials are used in our sampling process (e.g., equipment, sample bottles, etc.). We refrain from the use of certain cosmetics on the day of sample collection and even ensure food products packaged in wrappers are not brought on site. These are just a few of the many safeguards we have in place. TRC is keenly aware that PFAS are now ubiquitous, which presents both a sampling challenge, and an important consideration in source attribution by regulators.

1,4-Dioxane: In general, 1,4-dioxane can be sampled using normal field procedures without any special modifications. We have experience with EPA Method 522, which does require special preservatives when sampling drinking water.

Regulatory Experience

TRC was contracted by the Massachusetts Department of Environmental Protection (MassDEP) to assist the agency in the development of fact sheets for the sampling and analysis of 1,4-dioxane and PFAS at sites within Massachusetts. The fact sheets covered background information on 1,4-dioxane and PFAS, potential sources of 1,4-dioxane and PFAS, risk-based standards for 1,4-dioxane, and special and unique sampling and analytical issues associated with these chemicals.

Analytical and Data Assessment Expertise

TRC employs a quality assurance team dedicated to the evaluation, assessment, and validation of analytical data.

- TRC has relationships with analytical laboratories capable of performing the specialized analyses associated with 1,4-dioxane and PFAS.
- TRC has experience with the validation of analytical data generated using the specialized analytical methodology (LC/MS/MS) for many different PFAS isomers. We discovered a systematic error with the integration and quantification of PFAS during review of raw data from one of the larger national laboratories. The issue was corrected and corrective action was put into place within the laboratory to prevent its reoccurrence.
- TRC assisted the MassDEP with the development of analytical protocol requirements for the analyses of 1,4-dioxane in soil, sediment, groundwater, and surface water matrices using SW-846 method 8260 with selective ion monitoring (SIM) and SW-846 method 8270 and EPA Method 522 with SIM and isotope dilution. TRC has extensive experience with the review and validation of data generated using these methodologies. We understand the importance of selecting the appropriate methodology to achieve the low risk-based criteria.
- TRC staff were lead authors on the ITRC PFAS Team on the subject of data evaluation.

Professional Organization and Presentations

TRC's professionals are recognized experts in remediation, participating in nationwide technical leadership committees, including:

- American Council of Engineering Companies
- American Society of Testing and Materials (ASTM) Sediment Work Group
- National Ground Water Association (NGWA): contributed to 2017 *Groundwater and PFAS: State of Knowledge and Practice*
- American Chemistry Council 1,4-Dioxane Panel
- Interstate Technology and Regulatory Council (ITRC). TRC experts are active in the following ITRC committees: PFAS (recipient of 2017 ITRC Industry Affiliates Program Award), Remediation Management of Complex Sites, In-situ Remediation Performance & Injection Strategies, Implementing the Use of Advanced Site Characterization Tools, Optimizing

Characterization and Remediation in Fractured Rock, LNAPL Update, and TPH Risk Evaluation at Petroleum-Contaminated Sites.

Presented below are select examples of TRC's recent dedication to assisting with the emerging issues associated with PFAS via training and presentations to a broad range of organizations.

- Denly, E., Eberle, M., Phillips, J.,Trozzolo, L., "Popcorn, Fire-fighting Foam, Adhesives, and Shaving Cream: PFAS - Potentially Fatal Anionic Stuff", Poster, **Brownfields 2017**, December 5-7, 2017, Pittsburgh, PA.
- Denly, E., Eberle, M., Phillips, J., "PFAS Overview", "Aqueous Film Forming Foams (AFFF): Solving Complex Issues", "Risk Assessment Challenges Related to PFAS", Per- and Polyfluoroalkyl Substances (PFAS): Latest Information Course, MA **Licensed Site Professional Association (LSPA) Continuing Education Course**, November 29, 2017, Taunton, MA.
- Eberle, M., "PFAS Water Treatment and Total Organic Carbon (TOC) Issues", Presented at **2017 NH Drinking Water Exposition & Trade Show**, October 26, 2017, Concord, NH.
- Denly, E., Eberle, M., "PFOA & PFOS: What Are They and What to Do If They Are Discovered in Your Source Water", **Massachusetts Water Works Association (MWWA) Education Seminar**, October 24, 2017, Westford, MA.
- Denly, E., Occhialini, J., "Potential for PFAS Cross-Contamination from Sampling Equipment, Clothing, and Personal Care Products", Presented at **AEHS 33rd Annual International Conference on Soils, Sediments, Water, and Energy**, October 18, 2017, Amherst MA.
- Krowitz, L., "PFAS Analytical Data: Potential Data Quality Issues", Poster, **AEHS 33rd Annual International Conference on Soils, Sediments, Water, and Energy**, October 2017, Amherst MA.
- Denly, E., Eberle, M., "PFAS Overview", Presented at **NYC Watershed Science and Technical Conference**, Saugerties, NY, September 13, 2017.
- Eberle, M., Denly, E., Edelman, M., "Fingerprint Evaluation of PFAS Source, Identification of Surface Partitioning, and Associated Remedial Implications", Presented at **NYC Watershed Science and Technical Conference**, Saugerties, NY, September 13, 2017.
- Denly, E., Quinn, K., "Out of Sight but not Out of Mind or Body; the Never Ending Life Cycle of PFAS", Presented at **Dioxin 2017 Conference**, Vancouver, Canada, August 22, 2017.
- Eberle, M., Edelman, M., "Fingerprint Evaluation of PFAS Source, Identification of Surface Partitioning, and Associated Remedial Implications", Presented at **Fourth International Symposium of Bioremediation and Sustainable Environmental Technologies, Battelle**, Miami, FL, May 18 – 21, 2017.

About TRC

A pioneer in groundbreaking scientific and engineering developments since the 1960s, TRC is a national engineering consulting and construction management firm that provides integrated services to the energy, environmental, infrastructure, and pipeline services markets. TRC serves a broad range of clients in government and industry, implementing complex projects from initial concept to delivery and operation. TRC delivers results that enable clients to achieve success in a complex and changing world.

This SOQ provides some general background information about two emerging contaminants, 1,4-dioxane and PFAS along with TRC's experience with characterization, sampling, analysis, compliance, risk assessment, and remediation consulting services related to these two contaminants.

TRC's Guiding Principles

Our Mission

We understand our clients' goals and embrace them as our own, applying creativity, experience, integrity and dedication to deliver superior solutions to the world's energy, environment and infrastructure challenges.

Our Vision

We will solve the challenges of making the Earth a better place to live – community by community and project by project.

Our Values

We commit to these values to guide our decisions and our behaviors:

Safety: We create a working environment that promotes safe performance.

Quality: We always strive for excellence in the services we provide and in the results we produce for our clients.

Integrity: We are committed to the highest ethical standards.

Creativity: We believe in looking at challenges and opportunities from new angles and in exercising our curiosity.

Accountability: We take responsibility for all of our decisions and actions.

Teamwork: We work together to succeed.

Passion: We deliver superior results because we care deeply about what we do.

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