TLI Solutions

1,4-DIOXANE: CHALLENGES OF REMEDIATING A CENTURY-OLD "EMERGING CONTAMINANT"

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SAME GKC
Industry Day
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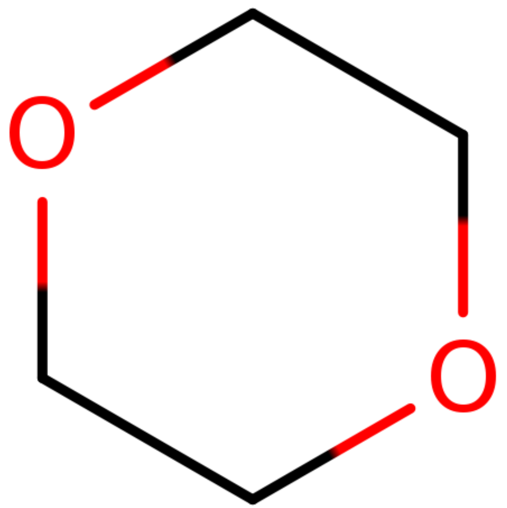
Society of SAME American Military Engineers

WHAT IS 1,4-DIOXANE?

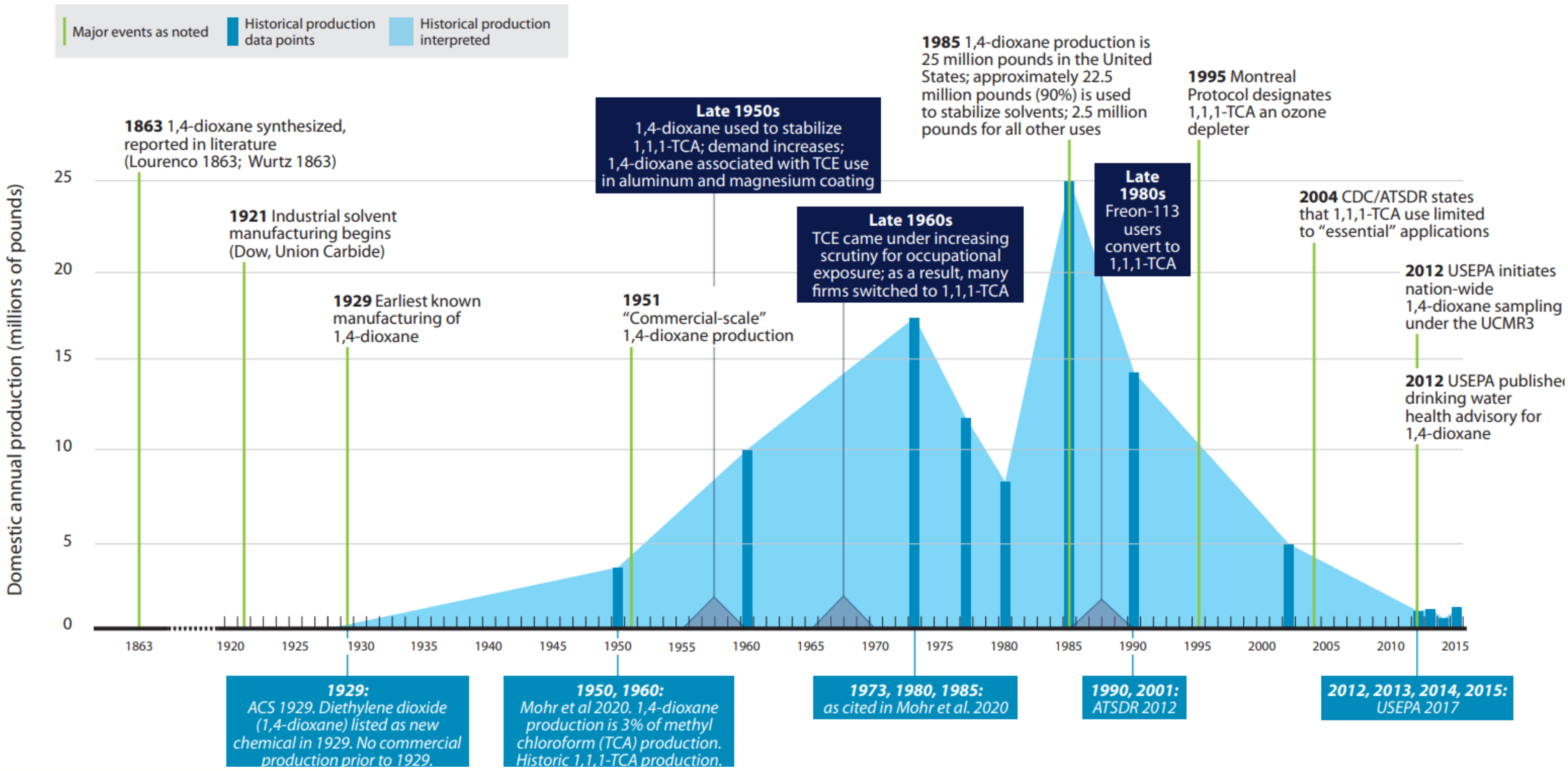
- 1,4-dioxane is a synthetic organic compound made from carbon, hydrogen, and oxygen
- Highly mobile and highly soluble in water
- Does not adhere to soil particles, so it can move from soil into groundwater
- Does not bioaccumulate or biomagnify
- Also known as dioxane, p-dioxane, diethylene oxide, 1,4-diethylene dioxide, and glycol ethylene ether



HISTORY

- First synthesized and reported in 1863
- Limited commercial use in 1929; large production began in 1951
- 90% of all 1,4-dioxane manufactured was used to stabilize 1,1,1-trichloroethane
- Also used as stabilizer in trichloroethene
- Present as a byproduct in:
  - paint strippers
  - dyes
  - greases
  - antifreeze
  - aircraft deicing fluids
  - consumer products:
  - deodorants,
  - shampoos
  - cosmetics

HISTORY



https://14d-1.itrcweb.org/history-of-use-and-potential-sources/#1_1

POTENTIAL HEALTH CONCERNS

- Cancer – EPA suspected carcinogen
- Irritant – eye, nose, throat
- Liver and kidney damage
- 2023 Draft Supplement to the Risk Evaluation for 1,4-dioxane (TSCA)

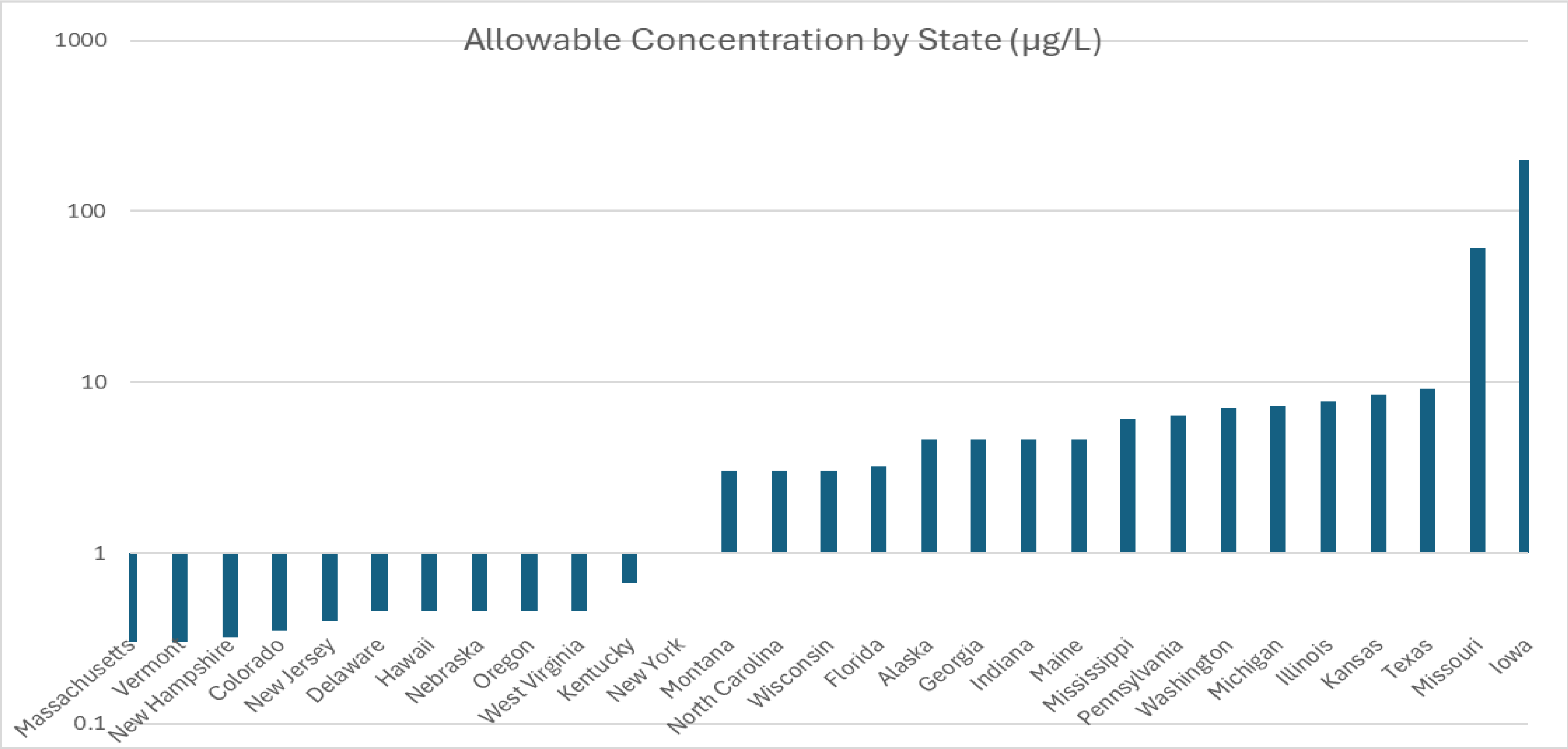
OCCURRENCE

- Detected in:
  - 45 states
  - 1,964 drinking water systems
  - Drinking water of 90 million people
  - 34 of the 1,000+ NPL sites (2016)
  - CA Study (2021): 194 of 2000+ sites (95% contained chlorinated solvents)

REGULATORY LANDSCAPE

- There is no federal drinking water standard for 1,4-dioxane
- 30 States have developed 1,4-dioxane standards
- Allowable concentration range is 0.3 µg/L (MA, VT), to 200 µg/L (IA)
- Records of Decision, ROD Amendments and ESDs issued to address 1,4-dioxane (Federal Superfund)
- Investigations at previously closed sites at which the chemical had not been initially identified as a COC (reopeners)

REGULATORY LANDSCAPE



CHALLENGES

Analysis

- PQLs below 1 PPB
- Lack of agreement on method:
  - SW846 8260
  - EPA 624
  - SW-846 8270
  - EPA 625
  - EPA 1625
  - DOE UM1B

Remediation

- Miscible in water
- Low Henry's Constant – not readily air stripped
- Low log Koc – doesn't adsorb to organic carbon
- GAC, air stripping, SVE not generally effective
- Competition with chlorinated VOCs (co-contaminants)
- Not easily oxidized
- Not amenable to anaerobic biodegradation

COMMON TREATMENT METHODS

- Ex Situ
  - Advanced Oxidation Processes (AOPs)
  - Synthetic Adsorbents (Resins)
- In Situ
  - ISCO
  - MNA

Focus of technologies above is groundwater; other considerations for drinking water and wastewater

CASE STUDY – PUEBLO CHEMICAL DEPOT, CO, SWMU 41

- 1,4-dioxane plume
- Concentrations up to 15 µg/L (PPB)
- Historical use as a stabilizer for chlorinated VOCs
- The adoption of a 0.35 µg/L limit for 1,4-dioxane in GW by CDPHE required a change to the CMWP and Permit

CASE STUDY – PCD SWMU 41

- 1,4-dioxane Plume consists of a source area and a plume extending to the boundary capture system
- Alluvial terrace aquifer 15-60 ft thick with no confining layer
- GW depths vary from 15-35 ft BGS
- K values range from 11.8 to 39.6 ft/d with a geometric mean of 17.7 ft/d

CASE STUDY – PCD SWMU 41

The treatment technologies considered for groundwater remediation include:

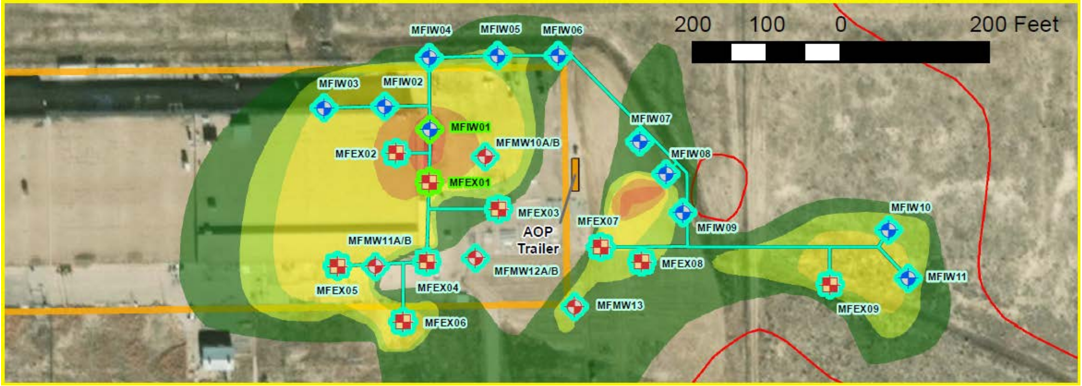
- Monitored Natural Attenuation (MNA)
- In-Situ Chemical Oxidation (ISCO)
- Ex-Situ Granular Activated Carbon (GAC)
- Ex-Situ Synthetic Resins
- Ex-Situ Advanced Oxidation Process (AOP)
- Ex-Situ Evaporation Pond
- Bioremediation

CASE STUDY – PCD SWMU 41

- Three primary criteria were used to evaluate these individual technologies: effectiveness, implementability, and relative cost.
- Two of these technologies (AOP and ISCO) were also assessed using bench-scale and pilot-scale testing. The evaluation of the above noted technologies indicated that AOP, phytoremediation, and MNA are retained for incorporation into corrective measures alternatives
- AOP+ was chosen for remedy

CASE STUDY – PCD SWMU 41

- Purifics PhotoCAT® AOP+ systems are being installed at the source and boundary areas with pump and treat remedies
- Installation is underway and startup is scheduled for July 2024
- Purifics PhotoCAT® AOP+ systems are chemical free and use a TiO2 slurry-based photo-catalytic process to achieve destruction via oxidation

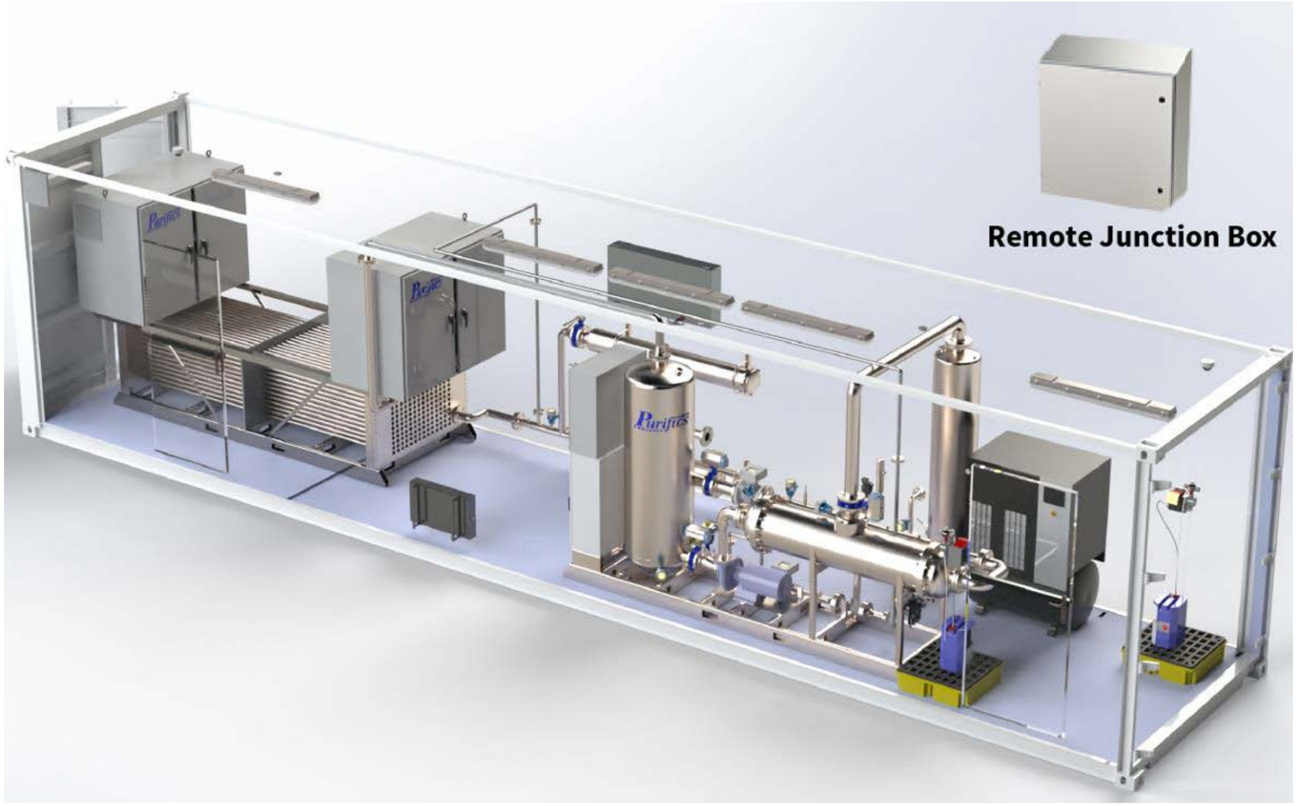


CASE STUDY – PCD SWMU 41

Factory system acceptance – 5/16/2024

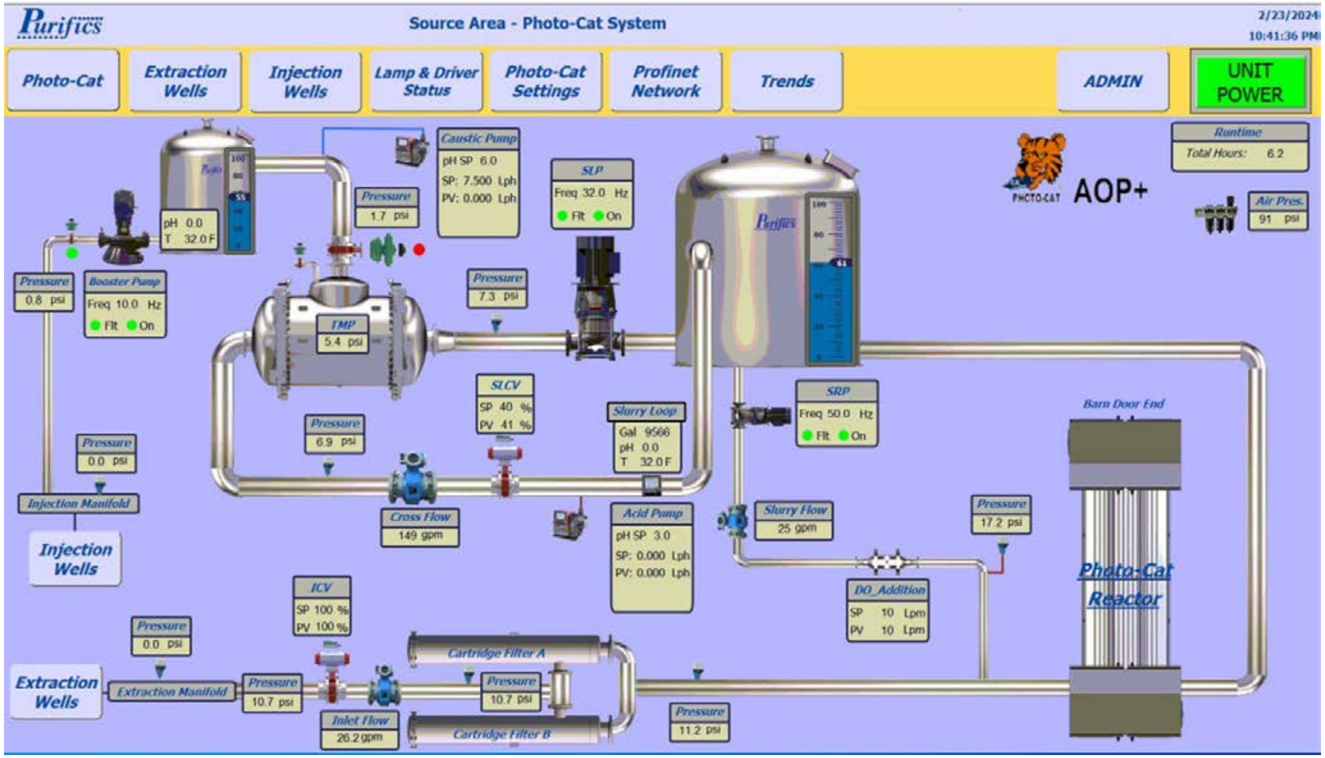
CASE STUDY – PCD SWMU 41

- The PhotoCAT systems are delivered in CONEX boxes (sea cans) as plug and play units
- Each unit has connections for influent, effluent, power, and telemetry



CASE STUDY – PCD SWMU 41

- The system's human-machine interface and SCADA is fully automated and capable of remote access via phones, tablets, and computers
- Components are integrated and automated in real-time using Siemens PROFINET®



CONCLUSIONS

- 1,4-dioxane nearly always co-exists with chlorinated VOCs
- Identified at many sites across the US, but several others may exist
- No federal drinking water standard, but state regulations/standards
- States/EPA requiring assessment and remediation at Superfund, RCRA and State-led sites
- Properties make 1,4-dioxane mobile in environmental media, so thorough site characterization critical
- Difficult to treat using conventional treatment methods