# Groundwater Sampling for 1,4-Dioxane, PFAS, and Appendix I Constituents using the Dual-Membrane Passive Diffusion Bag Sampler

Andy Alexander – BLE
Brad Varhol – EON

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# “Testing for Emerging Contaminants”

Andrew Alexander – BLE
Brad Varhol – EON

# Why Diffusion Technology?

- No Purge Water Disposal
- Reduced Manpower
- Reduced PPE
- Reduced Cross Contamination
- Reduced Turbidity Issues
- Comparable (valid) Data
- Reduce Sampling Cost > 50%

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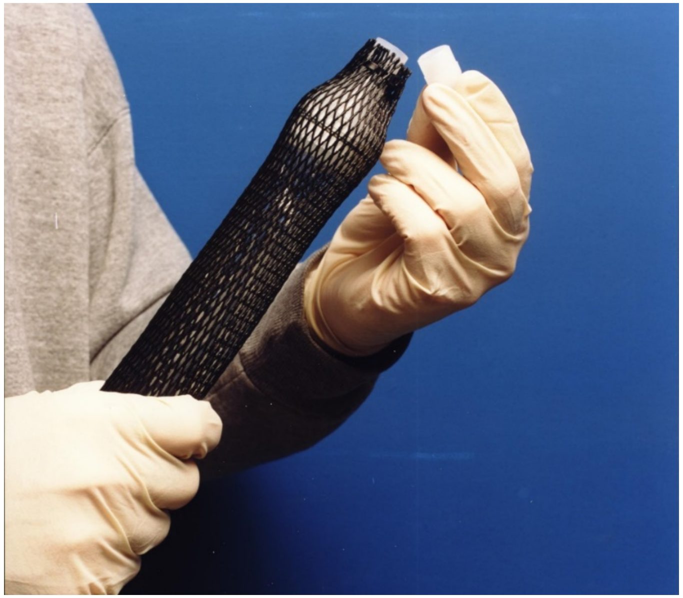
# What is Diffusion Sampling?

- Developed by the USGS and GE
- Polyethylene Membrane “Baggie” Sampler Filled with Clean Water
- Sampler is Submerged in Contaminated Water
- Contaminants Diffuse Across Membrane
- Sampler Retrieved and Water Analyzed



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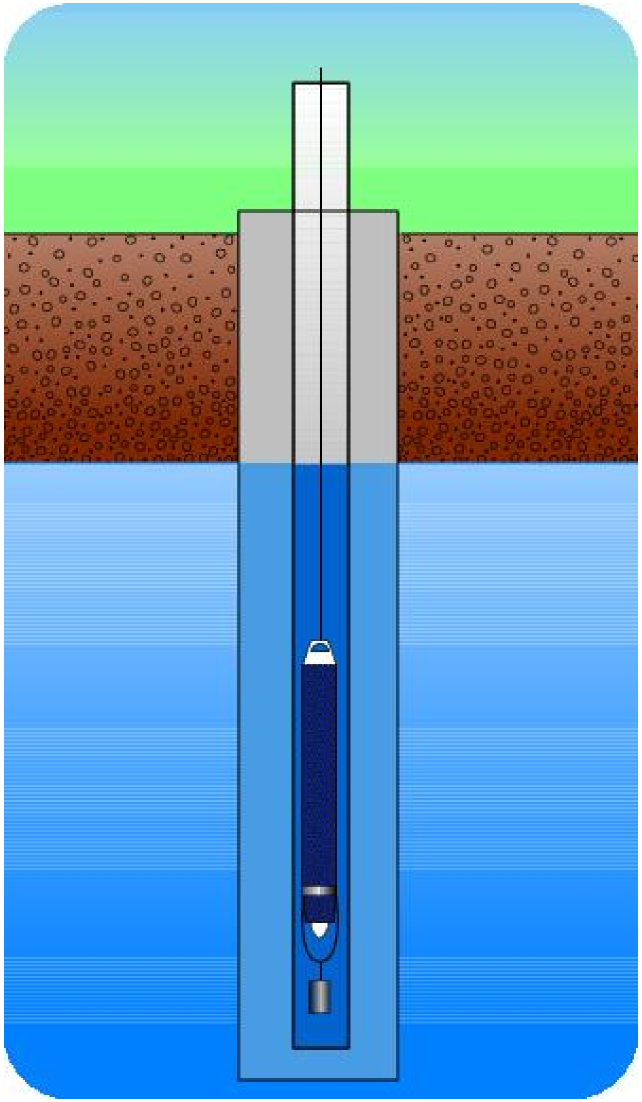

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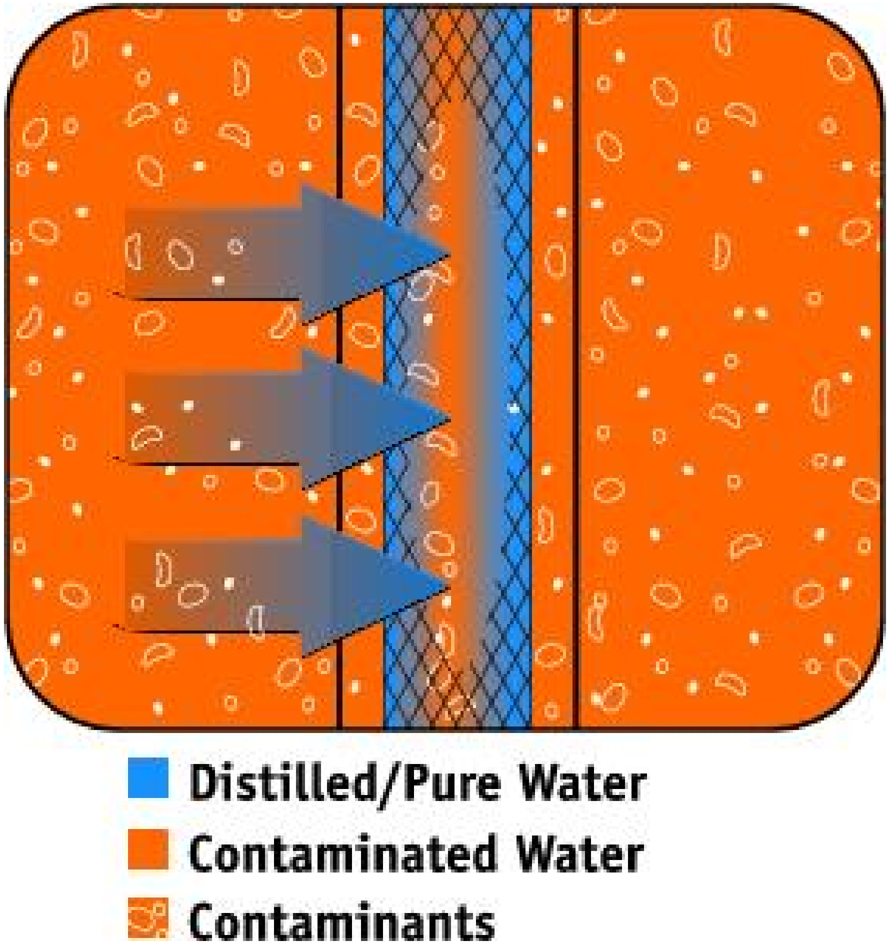


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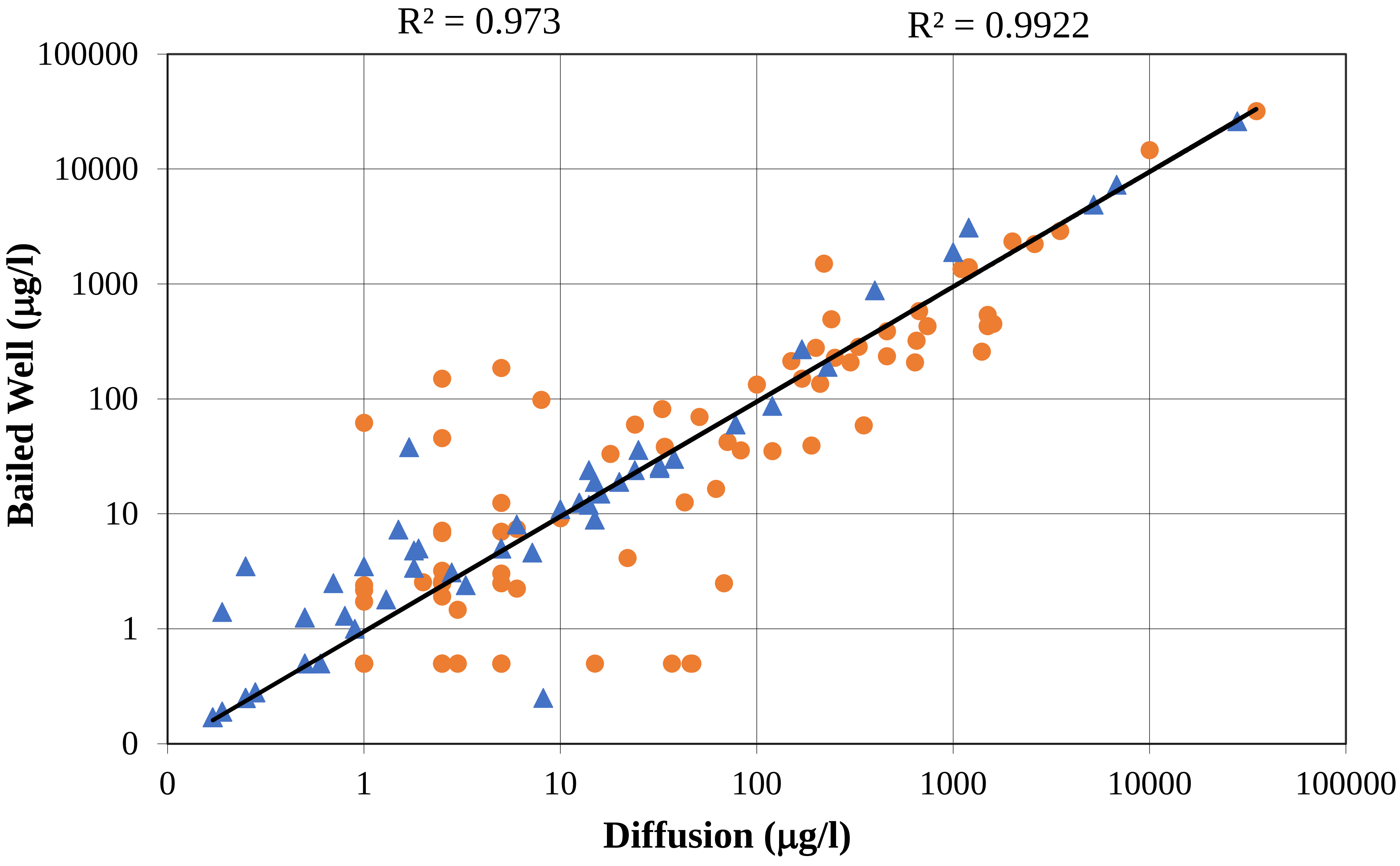
# BLE 1997 to 1999 Results

## Petroleum Hydrocarbons and Chlorinated Solvents

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# Limitations of Single Membrane & Development of Dual Membrane

- Works Well for Most VOCs
- Not for Metals, SVOCs, 1,4-DX, PFAS
- Pores in Diffusion Membrane Too Small
- Dual Membrane Sampler Developed
- Small Pores & Large Pores

# Dual Membrane Sampler Procedures

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# Barium Field-Scale Test
# Why Barium?

- Pervasive
- Naturally Occurring
- Devoid of Trends
- Wide Range of Concentrations
- Significant Detection History

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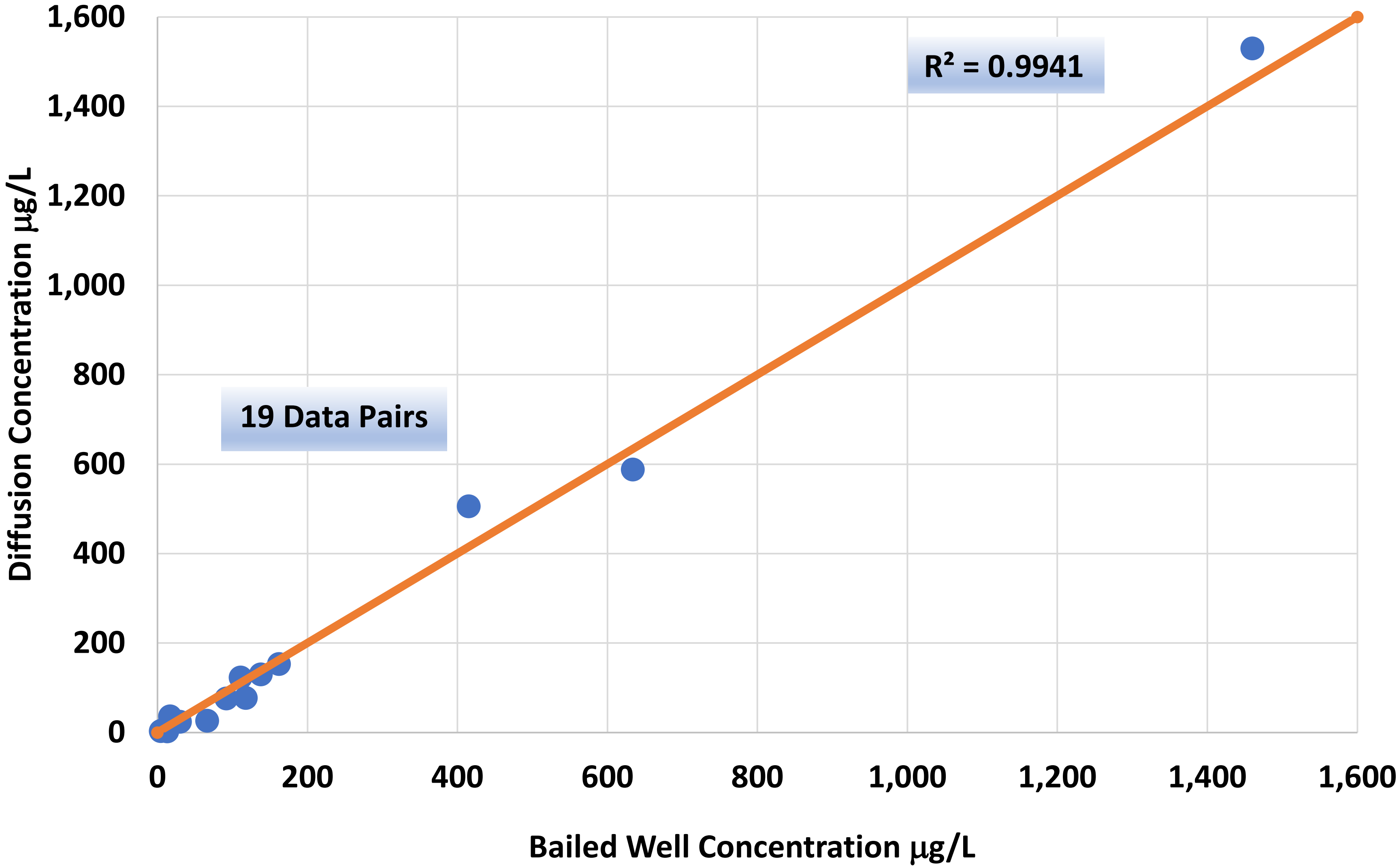
# Contemporaneous Sampling

- Landfills, DoD, Industrial, Mines
- USGS, US EPA, DoD, Consultants (BLE)
- Bailing vs. Dual Membrane Diffusion
- Low Flow vs. Dual Membrane Diffusion
- Cross-Plots to Compare Methods

# Barium – Bailed Well

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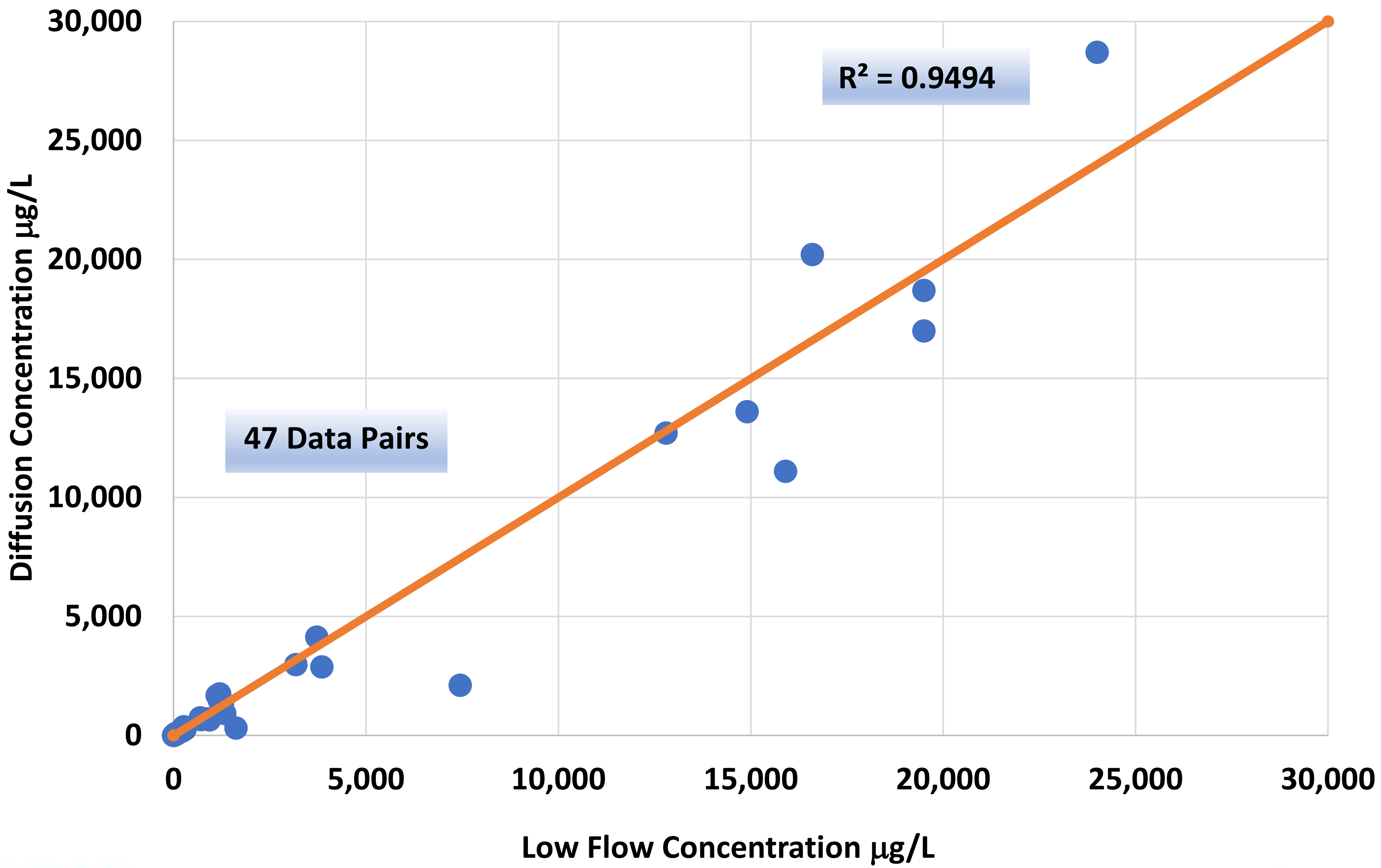
# Barium – Low Flow



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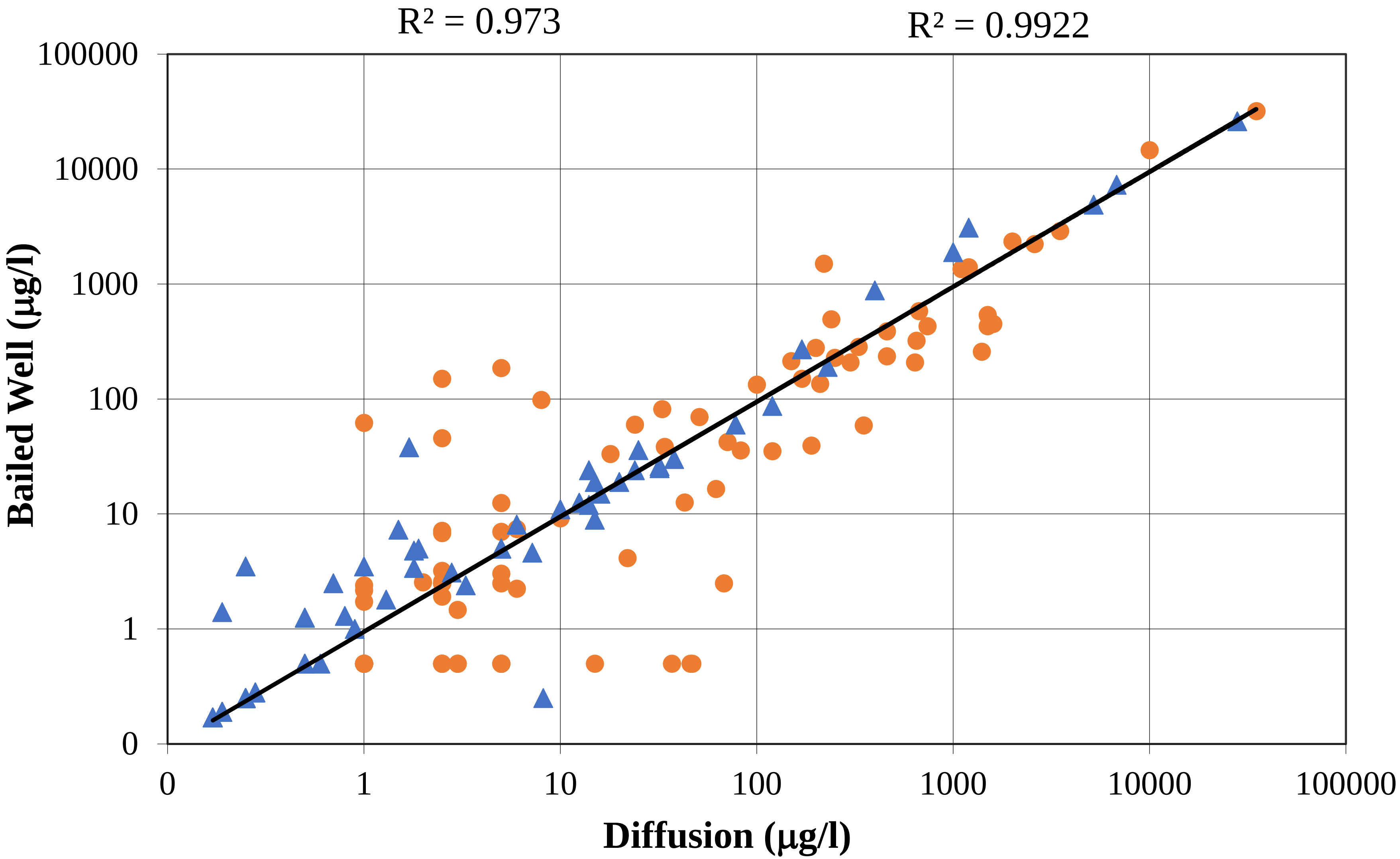
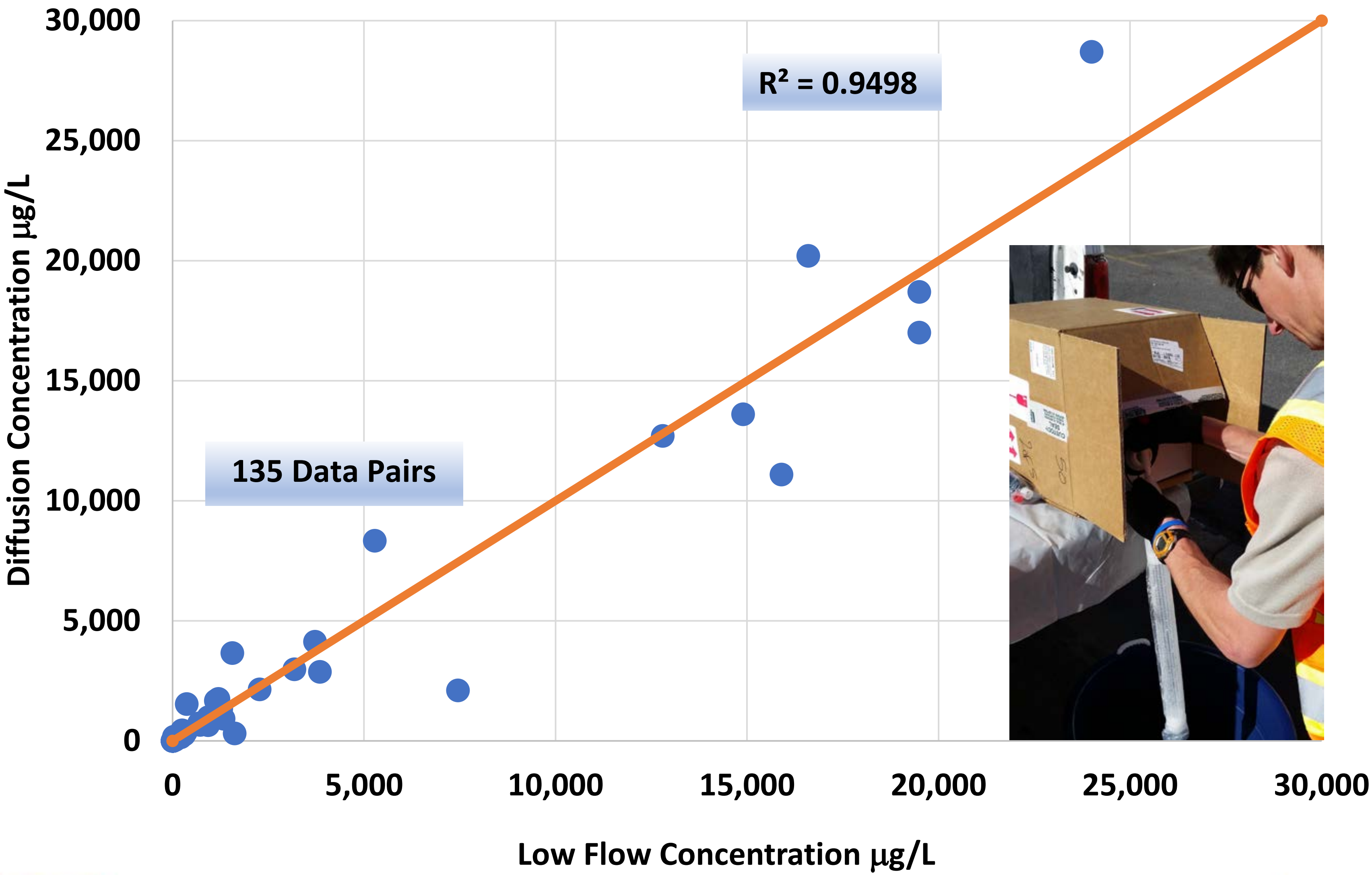


# Brad Varhol – EON Products

- Field Results - Appendix I Metals, TAL Metals, Inorganics, & PFAS
- Bench Testing Program
- Bench Test Results PFAS & 1,4-Dioxane
- Diffusion Publications/Protocol
- Diffusion Use and Conclusions

# Appendix I Metals

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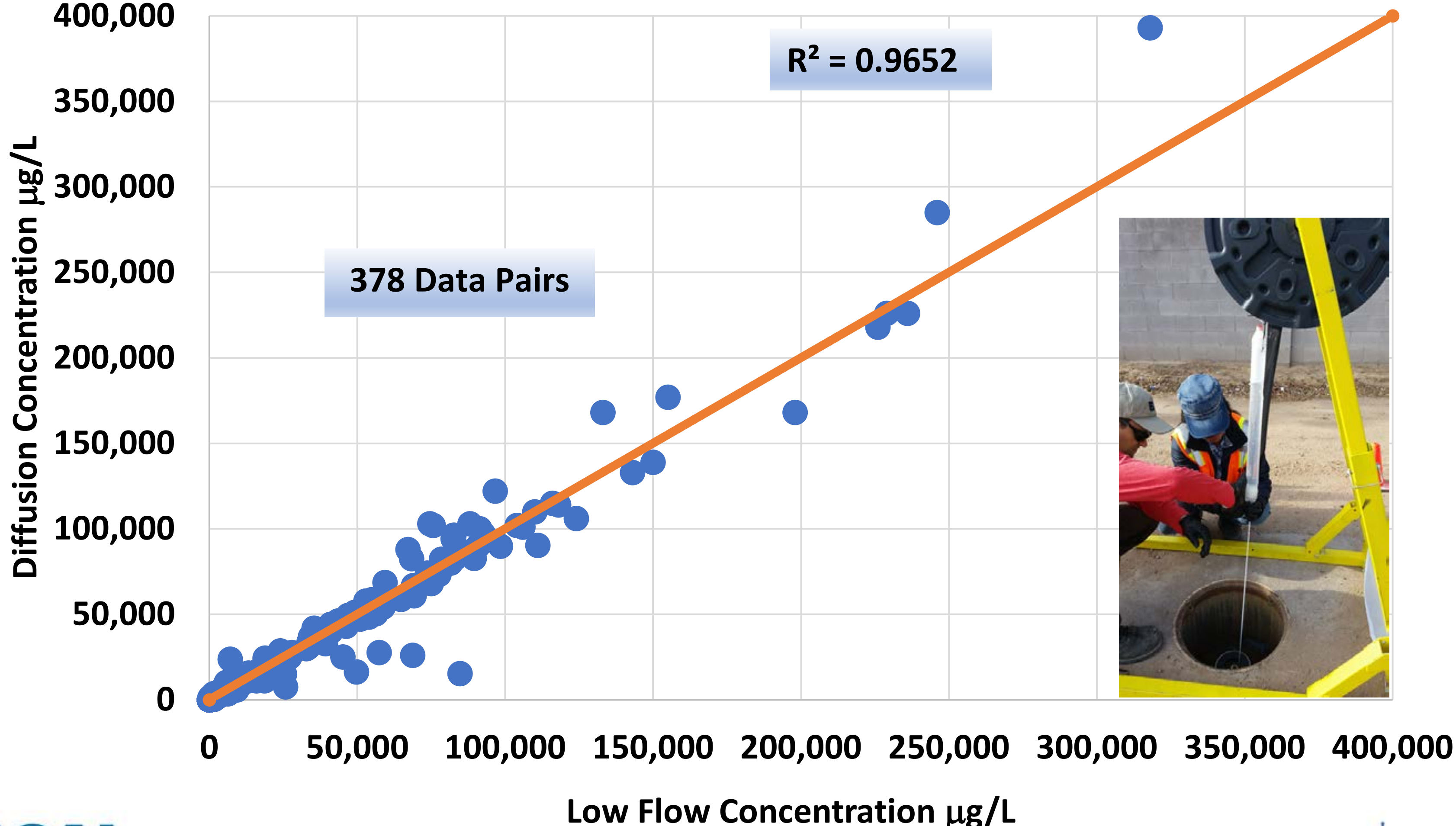
# US EPA Superfund
# TAL Metals &
# Sulfate, Sulfide, & Nitrate

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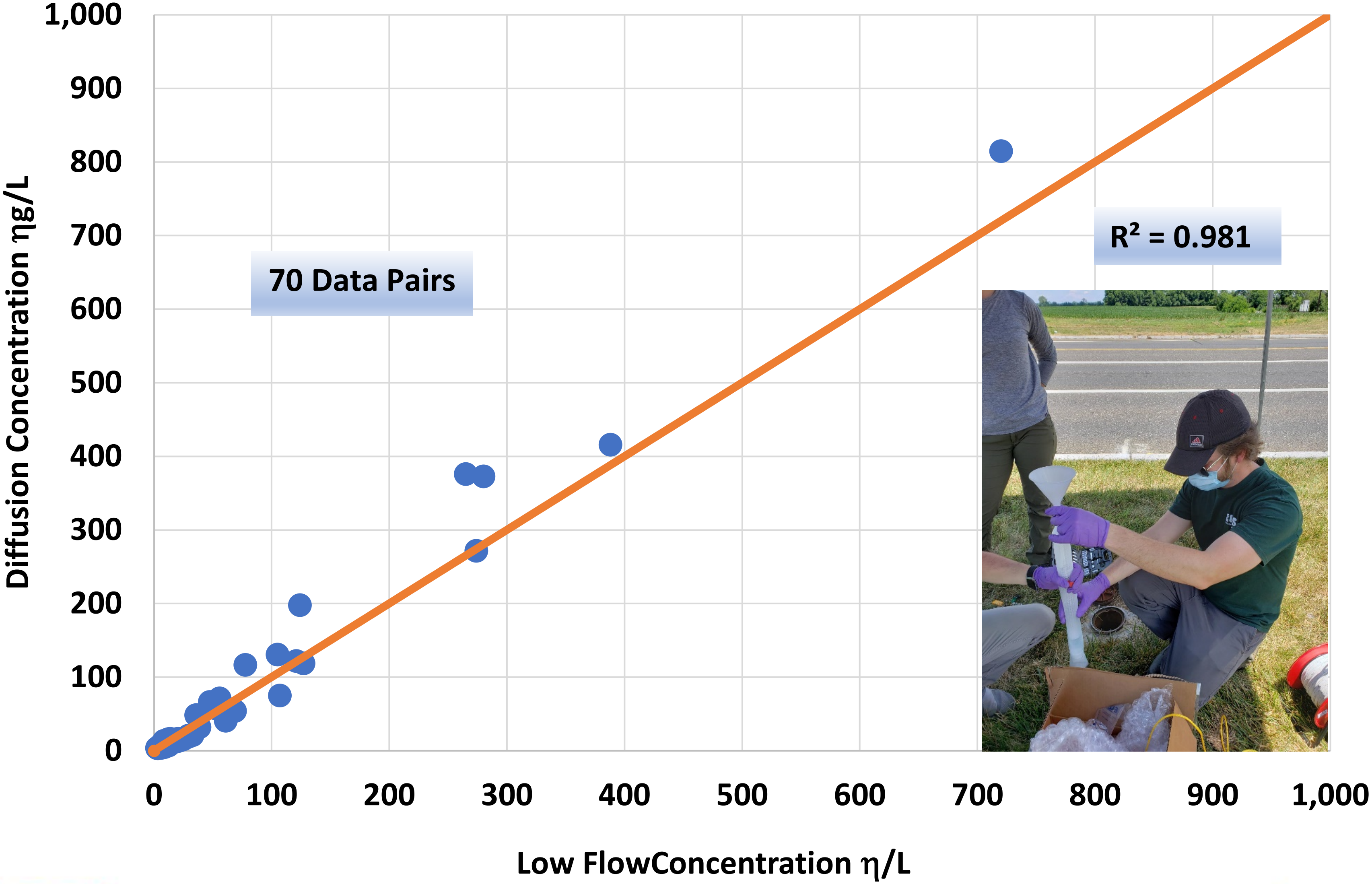
# USGS PFAS Study

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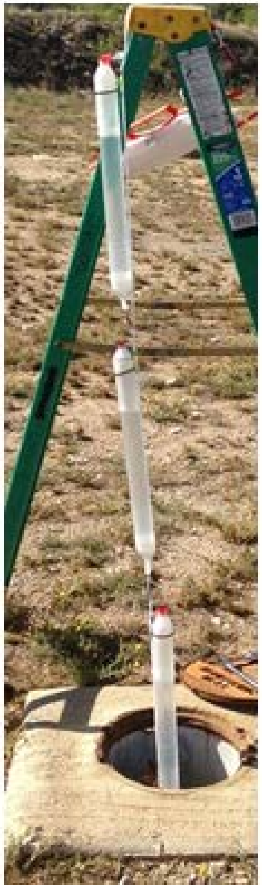
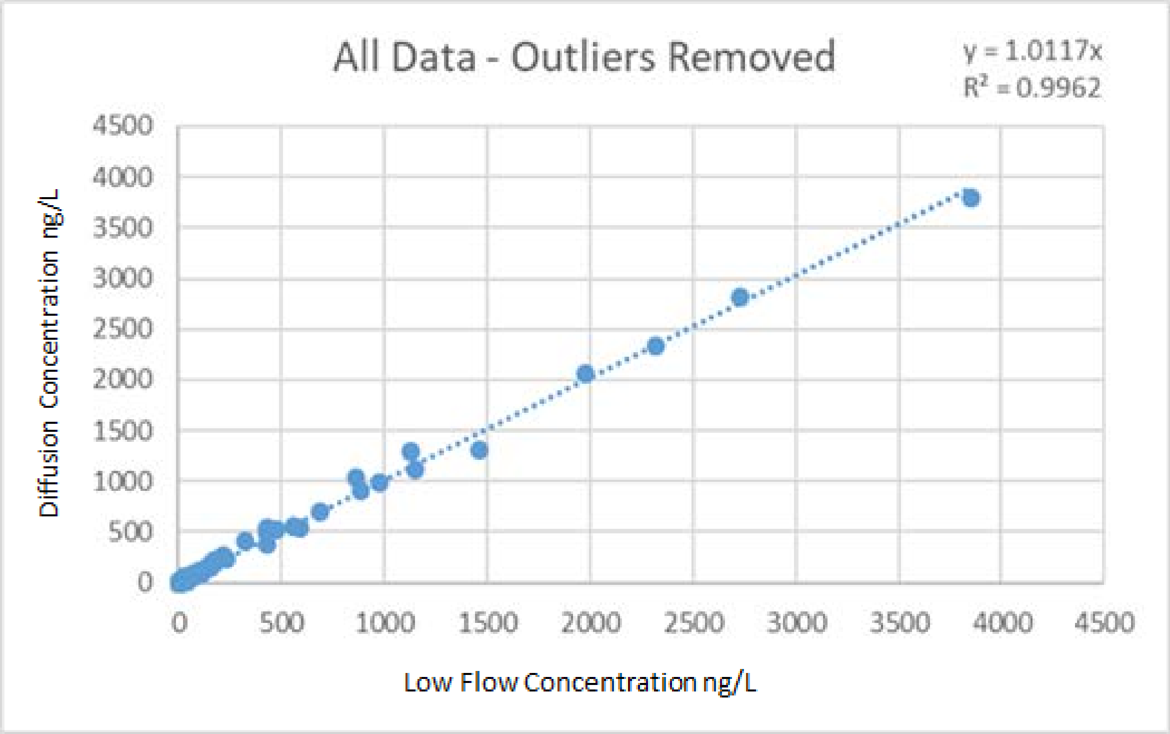
# US DoD PFAS Study



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# Bench Test Chamber

- 8in Diameter x 8ft Tall PVC Pipe
- Filled with ~71 Liters of Water
- Spiked with Contaminants of Interest
- 3 to 9 Dual Diffusion Samplers are Installed & Left In-Place for the Test Period

# Control Samples

- Collect Samples of the Chamber Water as Control Samples to Represent the Well Water Around the Sampler

- Send the Control Samples to the Lab for Analysis

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# Diffusion Samples

- Remove the Diffusion Samplers After Controls are Collected
- Obtain Samples from each Diffusion Sampler
- Send the Diffusion Samples to the Lab for Analysis

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# Compare Control to Diffusion

1. Sample the Chamber Water

2. Sample the Diffusion Water

3. Compare the Lab Results

| | Control | Diffusion |
|---|---|---|
| Ba | 23.00 ug/L | 22.50 ug/L |
| Cr | 10.50 ug/L | 10.35 ug/L |

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1,4 Dioxane

| Residence Time: 21 days (ug/L) | | | |
|---|---|---|---|
| Bench Test Results | 2 Control Samples | 6 Diffusion Samplers | |
| Analyte | Average | Range | Average |
| 1,4 Dioxane | 0.58 | 0.55-0.63 | 0.57 |
| 1,4 Dioxane | 4.20 | 3.60-4.20 | 3.90 |

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# PFAS: High Concentration

| Residence Time 21 Days (ng/L) | | | |
|---|---|---|---|
| | 2 Control Samples | 3 Diffusion Samples | |
| Bench Test Results | Mean | Range | Mean |
| 6:2 FTS | 29 | 28 - 30 | 29 |
| PFOS | 19 | 19 - 21 | 20 |
| PFBS | 36 | 33 - 34 | 34 |
| PFHpA | 27 | 26 - 30 | 28 |
| PFHxS | 28 | 24 - 27 | 26 |
| PFHxA | 30 | 30 - 31 | 31 |
| PFOA | 36 | 33 - 36 | 35 |
| PFPeA | 30 | 29 - 30 | 29 |

PFAS: Low Concentration

| Residence Time: 21 Days (ng/L) | | | |
|---|---|---|---|
| Bench Test Results | 2 Control Samples | 9 Diffusion Samples | |
| Analyte | Mean | Range | Mean |
| 6:2 FTS | 6.9 | 6.1 - 7.3 | 6.7 |
| PFBS | 8.8 | 8.2 - 10.0 | 9.0 |
| PFHpA | 7.2 | 6.6 - 7.4 | 7.0 |
| PFHxS | 7.4 | 7.0 - 7.5 | 7.3 |
| PFHxA | 8.4 | 8.4 - 9.2 | 8.8 |
| PFOS | 6.2 | 5.8 - 14.0 | 7.0 |
| PFOA | 10.0 | 9.7 - 11.0 | 10.1 |
| PFPeA | 7.4 | 6.7 - 8.1 | 7.3 |

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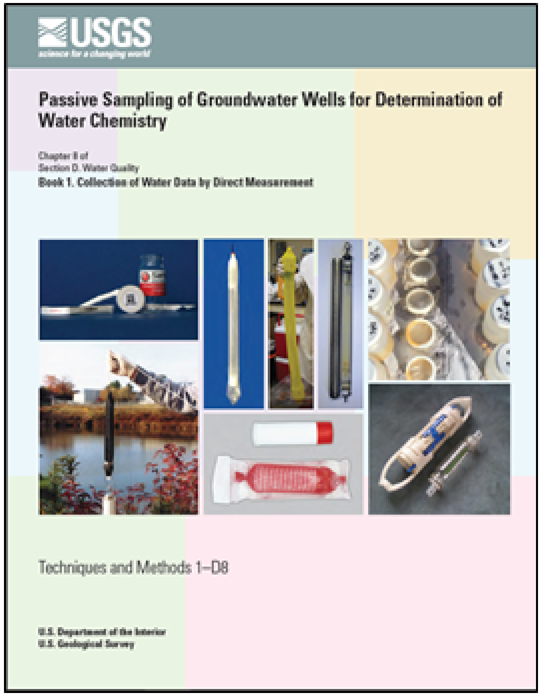
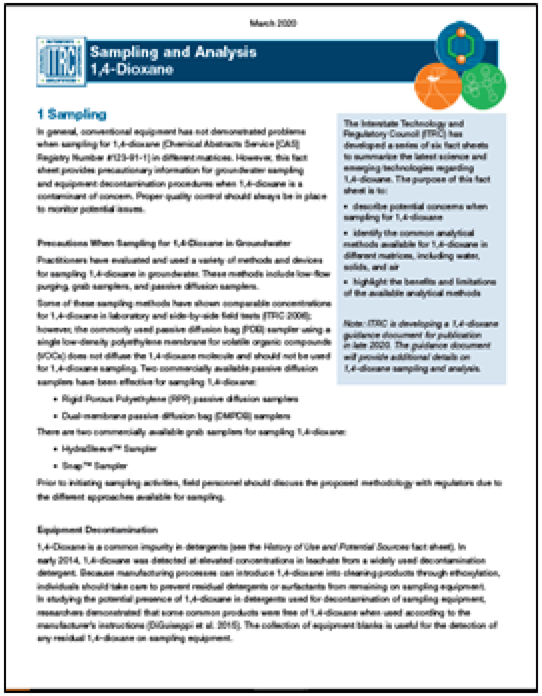
# Technical Review & Publications

March 2020

**Sampling and Analysis**
**1,4-Dioxane**

## 1 Sampling

In general, conventional equipment has not demonstrated problems when sampling for 1,4-dioxane (Chemical Abstracts Service [CAS] Registry Number #123-91-1) in different matrices. However, this fact sheet provides precautionary information for groundwater sampling and equipment decontamination procedures when 1,4-dioxane is a contaminant of concern. Proper quality control should always be in place to monitor potential issues.

The Interstate Technology and Regulatory Council (ITRC) has developed a series of six fact sheets to summarize the latest science and emerging technologies regarding 1,4-dioxane. The purpose of this fact sheet is to:

- describe potential concerns when sampling for 1,4-dioxane
- identify the common analytical methods available for 1,4-dioxane in different matrices, including water, solids, and air
- highlight the benefits and limitations of the available analytical methods

*Note: ITRC is developing a 1,4-dioxane guidance document for publication in late 2020. The guidance document will provide additional details on 1,4-dioxane sampling and analysis.*

**Precautions When Sampling for 1,4-Dioxane in Groundwater**

Practitioners have evaluated and used a variety of methods and devices for sampling 1,4-dioxane in groundwater. These methods include low-flow purging, grab samplers, and passive diffusion samplers.

Some of these sampling methods have shown comparable concentrations for 1,4-dioxane in laboratory and side-by-side field tests (ITRC 2006); however, the commonly used passive diffusion bag (PDB) sampler using a single low-density polyethylene membrane for volatile organic compounds (VOCs) does not diffuse the 1,4-dioxane molecule and should not be used for 1,4-dioxane sampling. Two commercially available passive diffusion samplers have been effective for sampling 1,4-dioxane:

- Rigid Porous Polyethylene (RPP) passive diffusion samplers
- Dual-membrane passive diffusion bag (DMPDB) samplers

There are two commercially available grab samplers for sampling 1,4-dioxane:

- HydraSleeve™ Sampler
- Snap™ Sampler

Prior to initiating sampling activities, field personnel should discuss the proposed methodology with regulators due to the different approaches available for sampling.

**Equipment Decontamination**

1,4-Dioxane is a common impurity in detergents (see the *History of Use and Potential Sources* fact sheet). In early 2014, 1,4-dioxane was detected at elevated concentrations in leachate from a widely used decontamination detergent. Because manufacturing processes can introduce 1,4-dioxane into cleaning products through ethoxylation, individuals should take care to prevent residual detergents or surfactants from remaining on sampling equipment. In studying the potential presence of 1,4-dioxane in detergents used for decontamination of sampling equipment, researchers demonstrated that some common products were free of 1,4-dioxane when used according to the manufacturer's instructions (DiGuiseppi et al. 2015). The collection of equipment blanks is useful for the detection of any residual 1,4-dioxane on sampling equipment.

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# August 2021 Publication



SPECIAL REPORT: NEXT-GEN TECHNOLOGIES

## Collecting Groundwater Samples for PFAS ANALYSIS

Bench and field scale studies indicate that dual membrane passive diffusion bags may be a viable and readily available technology for the collection of groundwater samples of per- and polyfluoroalkyl substances.

CURRENT ALTERNATIVES

FUTURE RESEARCH EFFORTS

TECHNOLOGY DESCRIPTION

BENCH SCALE TESTING

FIELD STUDY METHODS

DATA AND RESULTS

REAL-WORLD APPLICATION

It has been well documented that the collection of groundwater samples using passive samplers results in both significant cost and time savings relative to other common sampling techniques, due to lower equipment and labor costs. Passive samplers also lower the chance of cross-contamination, allow for depth-specific profiling, and generate less investigation-derived waste. This is of particular concern at PFAS sites where treatment and disposal techniques are still evolving.

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# Coming Soon….


New Jersey Department of Environmental Protection
Field Sampling Procedures Manual
Sampling Plan
Collection
QA
HASP
Site Entry
DATA
Field Analysis
Equipment
PPE
Shipment
2022
JUNE

# Diffusion Sampling is Widely Used

- Over 1 Million PDBs In Use Since 1998
- Over 12,000 Dual Diffusion Since 2014
- Diffusion Sampling is Used In All 50 U.S. States & Territories and in 20+ Countries
- Used for Wide Ranging Contaminants
  - Used on Solid Waste Facilities
  - Superfund Sites
  - DoD Sites
  - Private Sites

# Conclusions

- Strong Correlation Between Dual Diffusion and other Sampling Technologies
- Monthly, Quarterly, Semi-Annually, Annually
- Accurate Results for a Wide Range of Compounds & Concentrations Including; VOCs, Metals, 1,4-Dioxane, and PFAS
- Used by the USGS, US EPA, US Army Corps of Engineers, & Many Consultants

# From "Why Use Diffusion…"

- No Purge Water Disposal
- Reduced Manpower
- Reduced PPE
- Reduced Cross Contamination
- Reduced Turbidity Issues
- **Reduce Sampling Costs > 50%**

# Cost Comparison

**FINAL**

**Results Report for the Demonstration of No-Purge Groundwater Sampling Devices at Former McClellan Air Force Base, California**

Prepared For

U.S. Army Corps of Engineers
Omaha District

and

Air Force Center for Environmental Excellence

and

Air Force Real Property Agency

U.S. AIR FORCE

Contract F44650-99-D-0005
Delivery Order DK01

October 2005

| Sampling Method | Per Well, Per Event Cost |
|---|---|
| 3-Volume Purge | $310 |
| Low-Flow Purge | $280 |
| Snap Sampler | $155 |
| RPPS | $104 |
| PsMS* | $91 |
| RCS* | $80 |
| PDBs | $68 |
| HydraSleeve | $63 |

* Not Commercially Available

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# Questions for Andy or Brad?

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