PASSIVE GROUNDWATER SAMPLING TECHNIQUES VS. LOW FLOW: *WHEN PASSIVE MAKES SENSE, AND WHEN IT DOESN'T*

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August 24, 2016

OVERVIEW

I. Introductions/What is Passive Sampling?
II. One Regulator's Experience…
III. Case Study: A Switch to Passive Sampling
IV. Questions/Thank You

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I. INTRODUCTIONS/WHAT IS PASSIVE SAMPLING?

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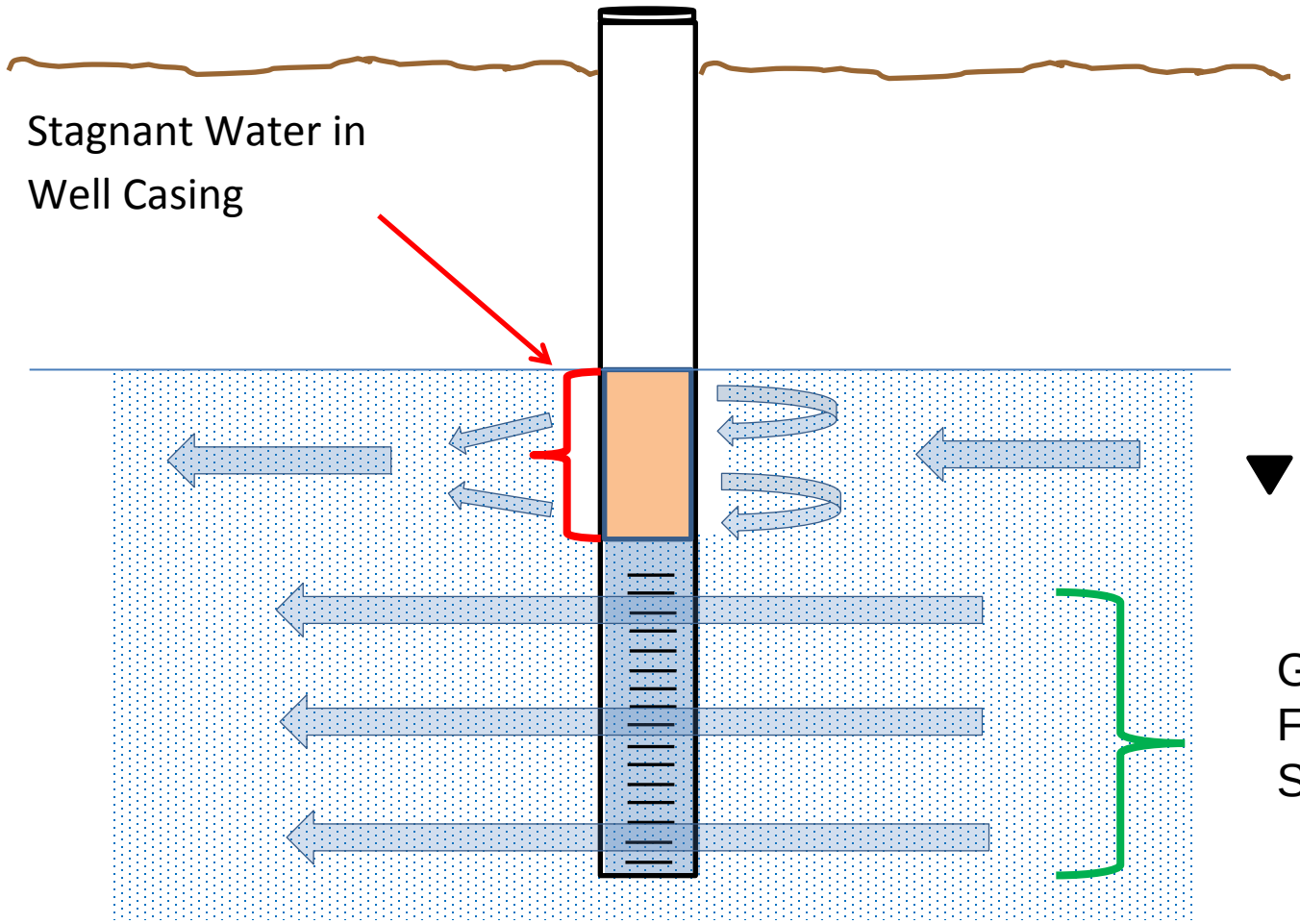
TYPICAL GROUNDWATER MONITORING WELL



Groundwater Flow through a Screened Well

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VOLUME PURGE/BAILING

1977 to Present

- Pump or Bail 3-5 Well Volumes
- Draw a Mix of Stagnant Casing Water & Aquifer Water from the Well
- Collect Sample

Affects on Sample

- Operator Influence
- Equipment Capability
- Blended Sample
- Uncertain Origin

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Low-Flow Purge

1

- Pump to Minimize Drawdown of Casing Storage
- Draw in Water from Adjacent Aquifer
- Check for Stabilized Water Chemistry

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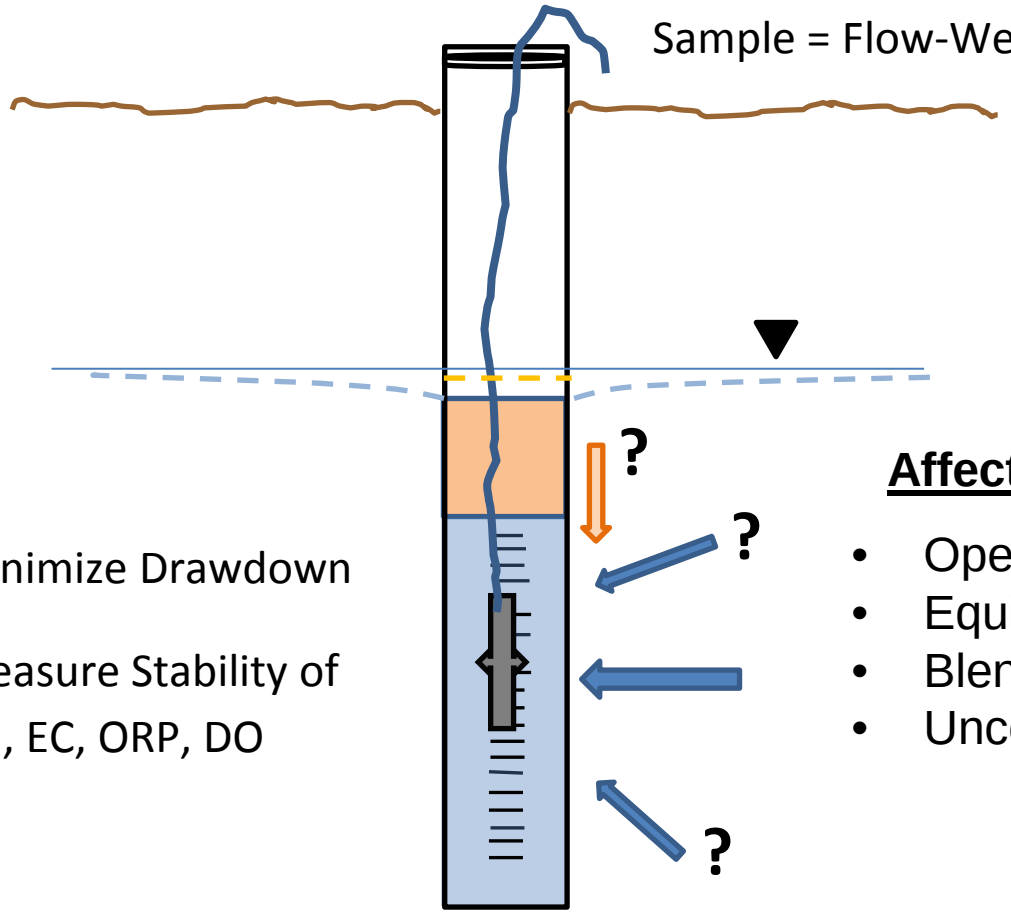
LOW-FLOW PURGE



- Minimize Drawdown
- Measure Stability of pH, EC, ORP, DO

Affects on the Sample

- Operator Influence
- Equipment Capability
- Blended Sample ?
- Uncertain Origin ?

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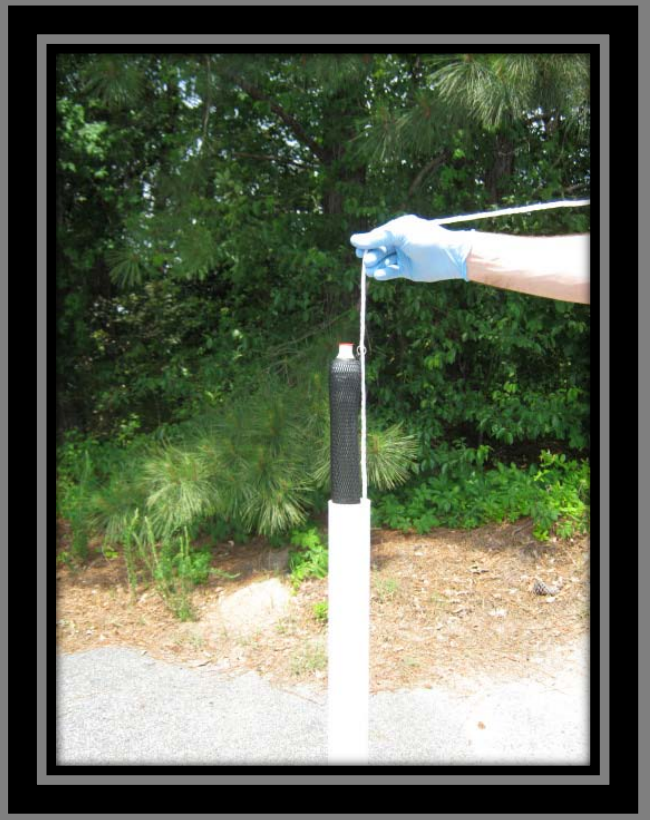
INTRODUCING PASSIVE GROUNDWATER SAMPLING

- Obtain a Representative Sample of Compounds in Groundwater
- In-Place at Discreet Zones
- Without Inducing Flow into the Well
- Reduce Cost



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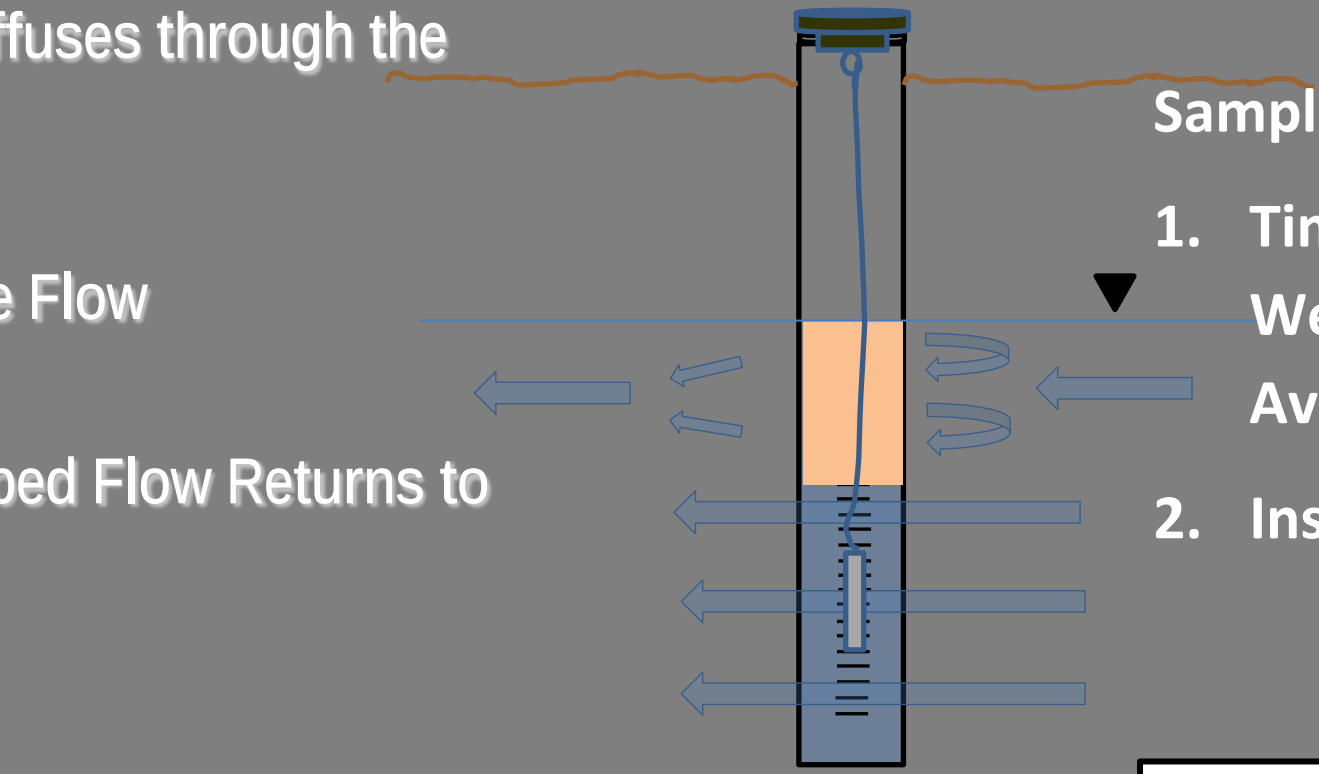
WHAT IS PASSIVE SAMPLING ?

- Groundwater Flows & Diffuses through the Well Screen
- Sampler is Located in the Flow
- Left in Place Until Disturbed Flow Returns to Normal
- Sampler is Recovered



Sample =

1. Time Weighted Average
2. Instant

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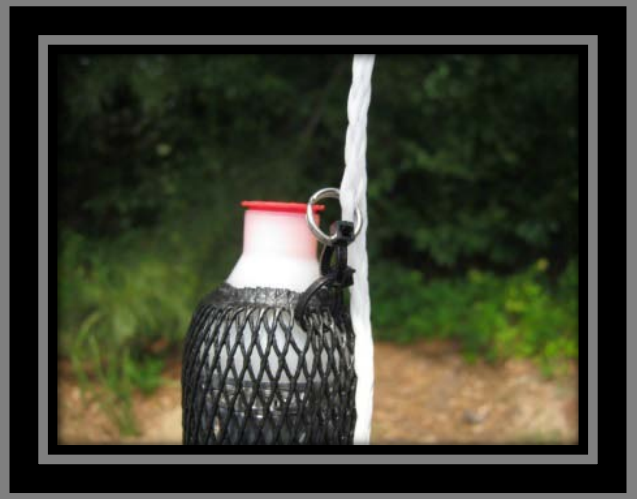
PASSIVE SAMPLING TECHNOLOGIES



Passive Diffusion Sampling (Time weighted average)

Equilibrated Grab Sampling (instant)

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GROUNDWATER FLOW REQUIREMENTS*

- **Hydraulic Conductivity >10-5 cm/sec or,**
- **Velocity >0.5 ft / day or,**
- **Hydraulic Gradient >0.001 or,**
- **Yield >100 ml/min**

Note: All sampling techniques require flow, also:

- **Passive sampling may enable better recovery in low recharge wells.**
- **Longer residence time may compensate for low recharge.**

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II. One Regulator's Experience…

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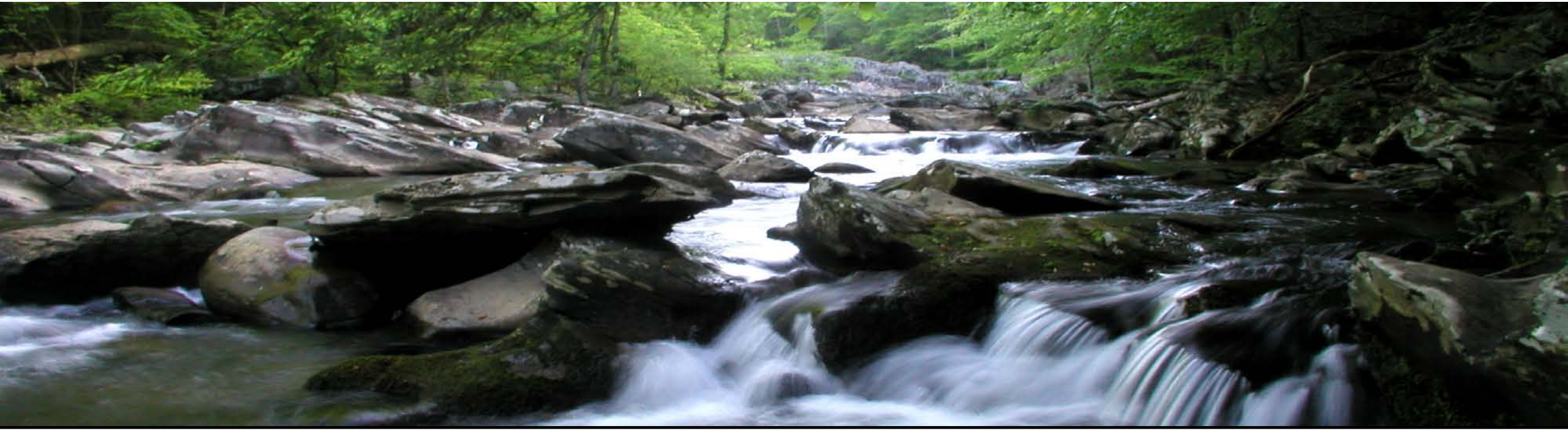
Annual Georgia Environmental Conference

August 24, 2016

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

One Regulator's Experience: Passive Groundwater Sampling Techniques vs. Low Flow



August 24, 2016

Adam Otis Hanley, PE

Disclaimer

- **EPD does not have formal guidance on this subject and this presentation is not meant as such.**
- **The information in this presentation is based on my experience and information reviewed from various sources.**

Region 4 US EPA SESD Operating Procedure Groundwater Sampling SESDPROC-301-R3

4.5 Micro-Purge or No Purge Sampling Procedures

The Micro-Purge or No Purge sampling procedures are usually employed when it necessary to keep purge volumes to an absolute minimum. Among the Micro-Purge or No Purge procedures that might be employed are:

- Low pump rate sampling with peristaltic or submersible pumps (typical Micro-Purge sampling),
- HydraSleeve™ or
- Passive diffusion bag (PDB) sampling

The use of these procedures is acceptable only when the site hydrogeology is well understood, with respect to the hydraulic conductivity of geologic materials within the well screen interval. The underlying assumption, when employing these procedures, is that the formation in which the well is screened has a high hydraulic conductivity ($K>10^{-5}$ cm/sec, for example), resulting in a state of equilibrium existing between the water standing in the screened interval and the formation water in which the well is screened. In this situation, the well is considered to be in a perpetually "purged" state and purging is not required.

Objective

- **Transition Framework**
  - **Desktop review**
  - **Comparability Study and Acceptance Criteria**
  - **Data Evaluation**

Desktop Review

- **Is passive sampling appropriate for the current stage of the project?**
- **Are site specific parameters consistent with the passive sampling specifications?**

Comparability Study and Acceptance Criteria

- **Comparability Study**
  - **Number and location of wells**
  - **How many rounds of sampling**
- **Evaluation Criteria**
  - **How will the data be evaluated**
  - **An acceptance criteria will need to be specified for each evaluation method.**
- **How does the CSM affect the above parameters?**

Data Evaluation

- **Process with multiple off-ramps**
  - **Graphical Comparison**
    - **1:1 Plot**
  - **Statistical Comparison**
    - **Various methods ranging from relatively simple to complex**

Data Evaluation

Graphical Comparison

- The 1:1 Plot represents perfect correlation.
- Simple to prepare.
- Provides Qualitative assessment of correlation.
- Acceptance criteria is based on the +/- percent of perfect correlation.

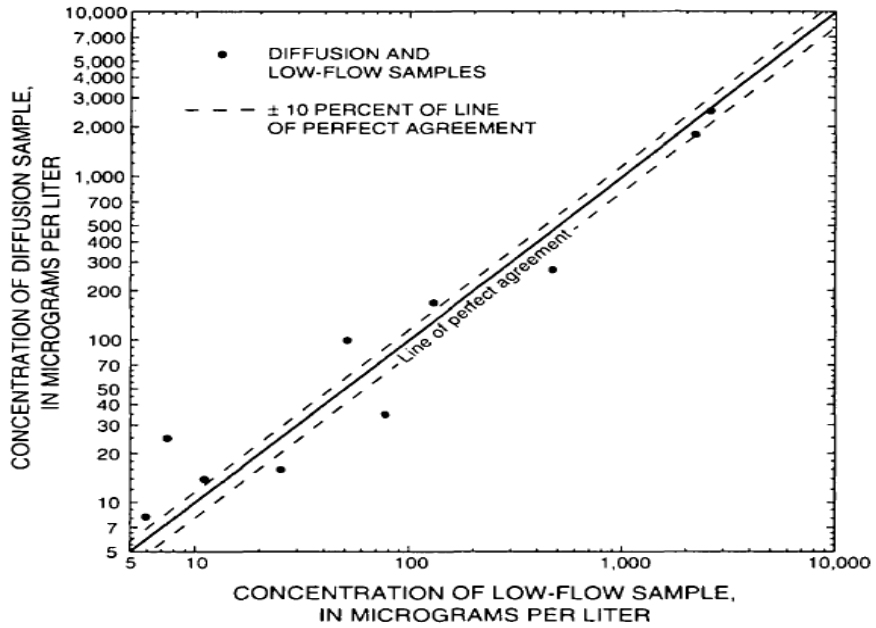


Figure 2. Comparison of 1,2-dichloroethylene isomers in ground water collected with diffusion and low-flow sampling methods, Hanscom Air Force Base, Bedford, Massachusetts, May 1999.

Data Evaluation

Statistical Comparison

- **Relative Percent Difference (RPD) was most common in the documents reviewed**
- **Relatively simple statistical method with minimal data requirements.**
- **Acceptance criteria is based on the calculated RPD.**

$$\text{RPD} = \text{absolute value}\left(\frac{sample1\text{-}sample2}{\left(\frac{sample1 + sample2}{2}\right)}\right) \times 100$$

Data Evaluation

Statistical Comparison

- **If calculated RPD are not within the acceptance criteria more complex statistical methods may be applied.**

- **Lots of guidance from EPA, ITRC, USGS, etc. on the various methods that may be applied to site data.**

Two Experiences

Data Dump

- **Initial document:**
  - ***"Results from each sampling technique compare well."***
  - **Data tables were provided in an appendix.**
  - **No evaluation of the data was presented.**

- **RTC and Revised document:**
  - **Appendix included data transformation and statistical analysis.**
  - ***"In general the PDB samples were biased high relative to the low flow samples."***

Two Experiences

Partnering

- **Stakeholders engaged during the project planning stage**
- **Collaborative approach to comparability study**
- **Multi-step data evaluation process**

III. CASE STUDY: A SWITCH TO PASSIVE SAMPLING

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August 24, 2016

CASE STUDY: A SWITCH TO PASSIVE SAMPLING

Appropriate?

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CASE STUDY OVERVIEW

- Project Management View Point
- Advantages and Limitations – PDBs
- Stakeholder Buy-in
- Data Correlation
- Finances

Pro's and Con's

Advantages

- Eco Friendly
- Inexpensive
- Ease of Use
- Rapid Sample Recovery
- Characterize trad-boreholes
- Average concentrations
- Remote sites
- Long-term cost savings

Limitations

- Remote sites – initially
- Compound limited
- Only characterize water flowing through the well
- Upfront additional cost

STAKEHOLDERS

- Client
- Regulator
- Other responsible Parties

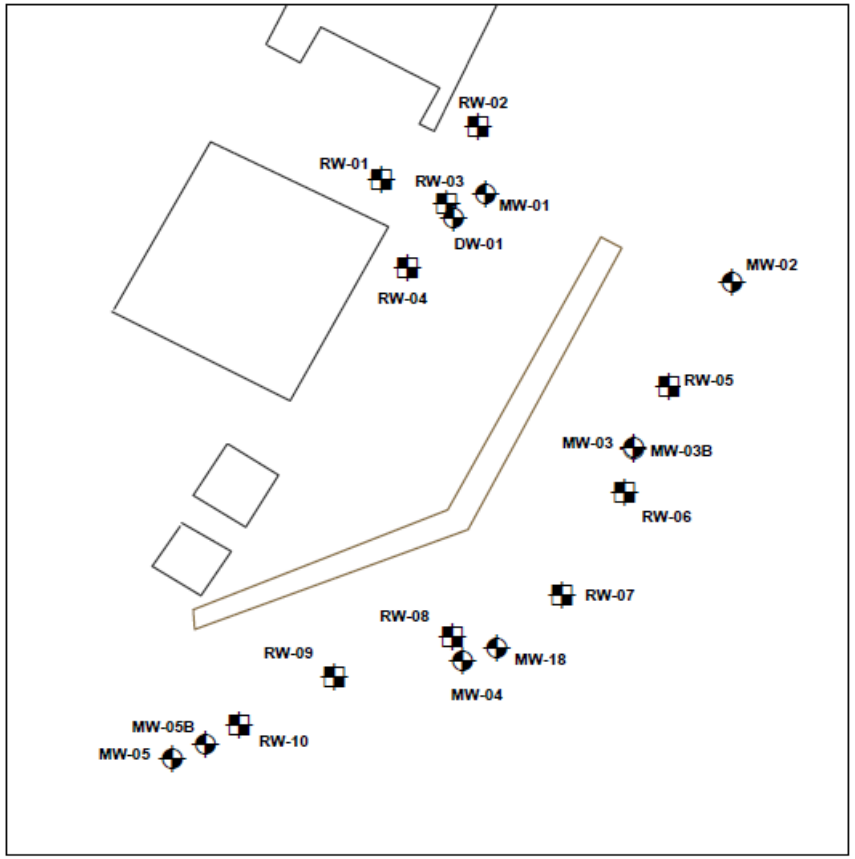
GREENVILLE, SC – CHEMICAL MANUFACTURER

- 1994 Consent Agreement with SCDHEC
- PCE groundwater plume
- MNA Remediation Strategy
- Semi-annual sampling of:
  - 8 on site monitoring wells
  - 3 off site monitoring wells
  - 6 onsite recovery wells
  - 3 surface water samples

GREENVILLE, SC – STAKEHOLDER BUY-IN

- 2011/2012 looking into alternate methods
- Oct 2012 meeting with SCDHEC
- SCDHEC required data correlation between methods
- Separate data submittal required

GREENVILLE, SC – METHODS ASSESSMENT



Location	Event	Traditional Method	Depth x Diameter	Distance from Source
MW-01	April	Bailer	26' x 2"	At Source
MW-3B	April	Peristaltic	60' x 4"	75 ft
MW-04	April	Bailer	16' x 2"	120 ft
MW-02	July	Bailer	20' x 2"	65 ft
MW-03	July	Bailer	14' x 2"	75 ft
MW-05	July	Bailer	23' x 2”	165 ft
RW-09	July	Peristaltic	25' x 4"	130 ft

Traditional samples were collected immediately after the passive sample during each event

GREENVILLE, SC – ANALYTICAL DATA

Location	Event	Total VOCs Traditional Methods (ppb)	Total VOCs PDB Method (ppb)
MW-01	April 2013	268.5	355.4
MW-3B	April 2013	<1	<1
MW-04	April 2013	<1	<1
MW-02	July 2013	21.2	38.8
MW-03	July 2013	56.5	36.2
MW-05	July 2013	31.7	6.9
RW-09	July 2013	91.2	67.5

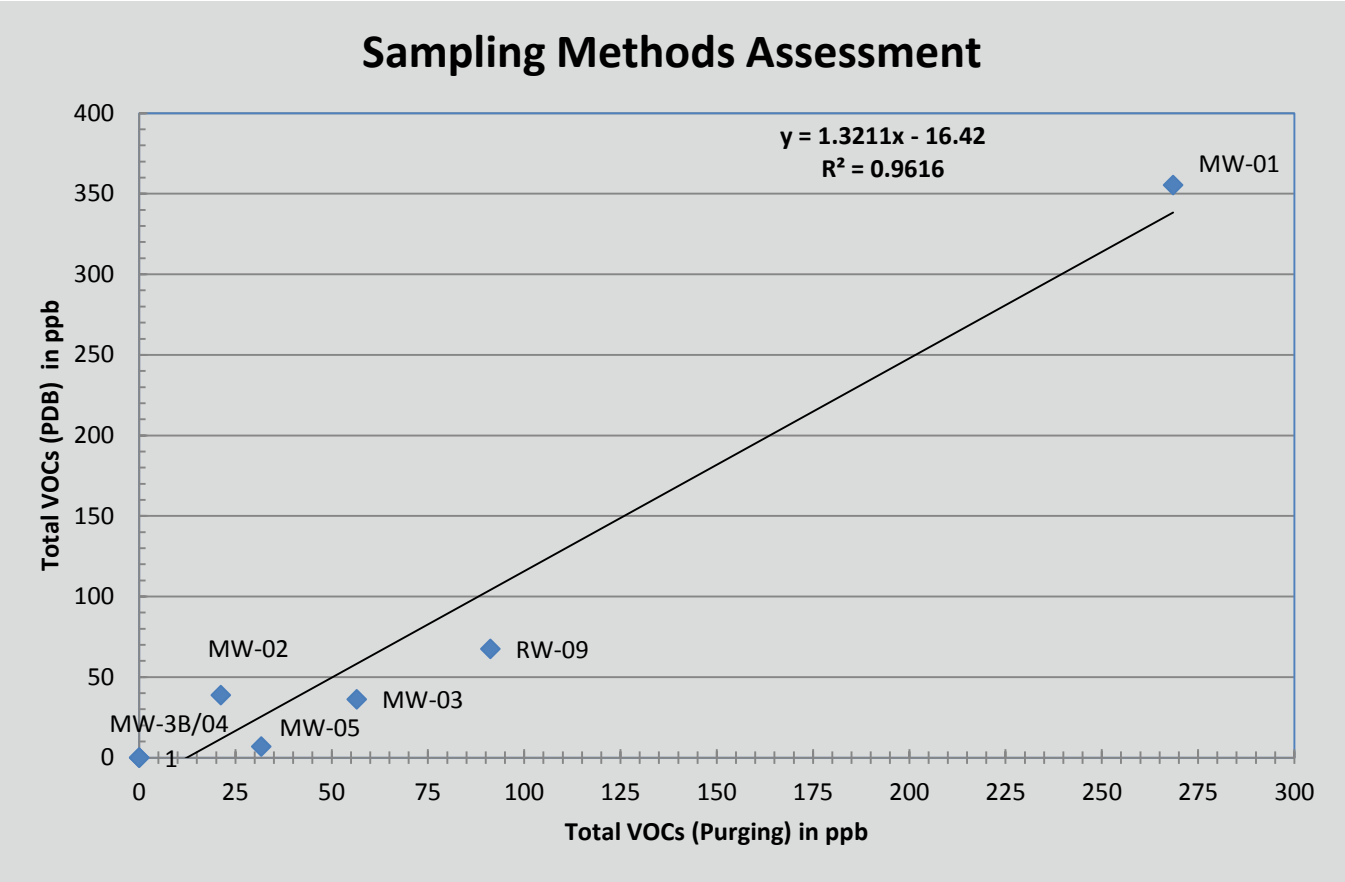
- 6 wells were consistent with historic trends
- All the results were within the same order of magnitude
- MW-04 “ND” – unexpected

GREENVILLE, SC – STATISTICAL EVALUATION

- SD = 7.8 to 12.9, except MW-01
- CI (95%) = 10.8 to 17.9, except MW-01
- MW-01 expected larger variability
- MW-01 still an order of magnitude less than concentrations

Location	Total VOCs Traditional Method (ppb)	Total VOCs PDB Method (ppb)	Mean	SD (ppb)	CI (95%)
MW-01	268.5	354.4	311.5	43.0	59.5
MW-3B	<1	<1	Not Analyzed		
MW-04	<1	<1	Not Analyzed		
MW-02	21.2	36.8	29	7.8	10.8
MW-03	56.5	35.2	45.9	10.7	14.8
MW-05	31.7	5.9	18.8	12.9	17.9
RW-09	91.2	67.5	79.4	11.9	16.4

GREENVILLE, SC – LINEAR REGRESSION MODEL



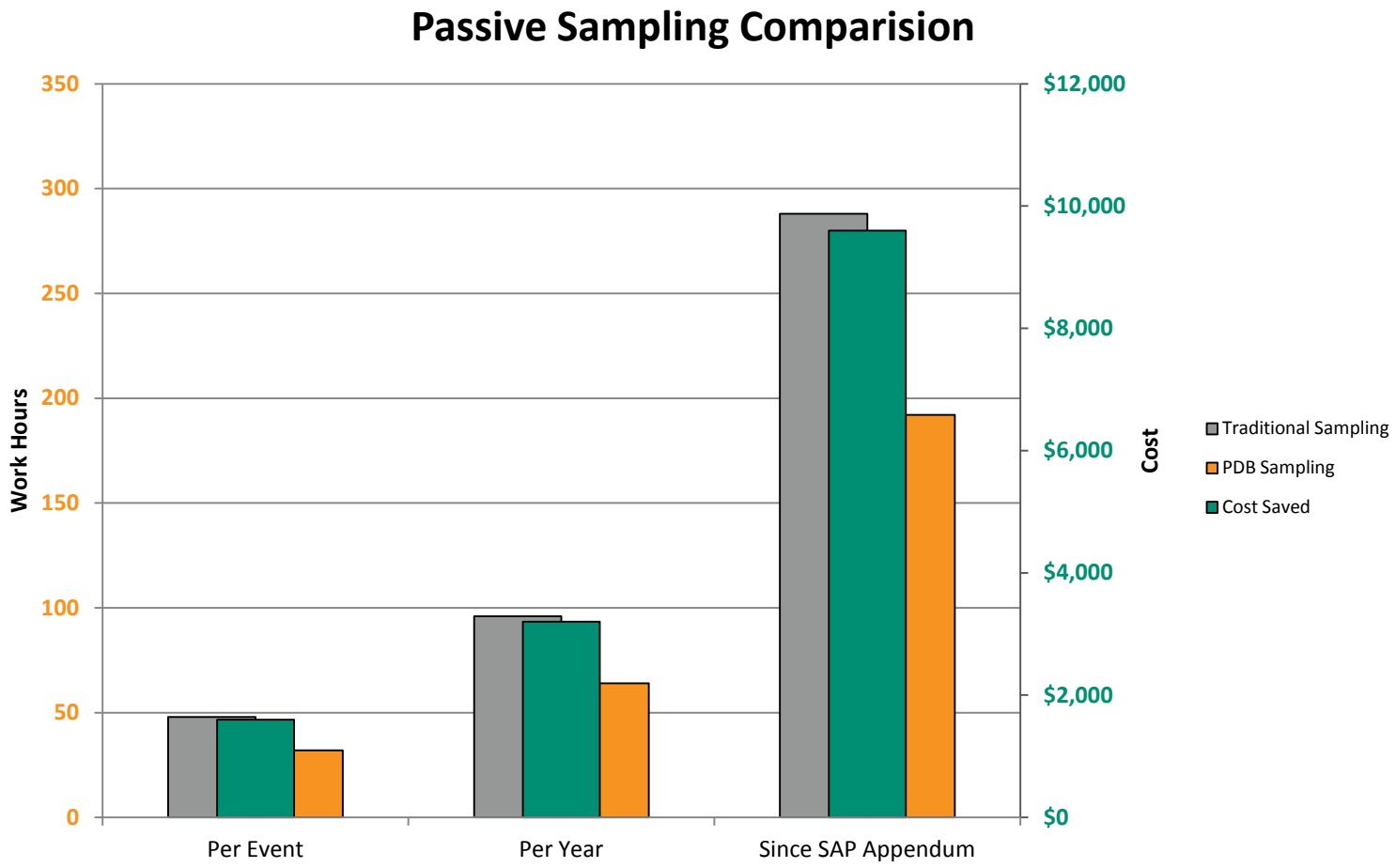
- Slope = 1.32
- R^2 = 0.96
- PCC = 0.98

GREENVILLE, SC – CASE STUDY CONCLUSIONS

1. Analytical results – similar ppb between methods, demonstrated by SD and CI (95%)
2. Statistical variation at MW-01 was expected due to source well
3. Strong correlation between methods – R^2 and PCC
4. Non-detect values at wells were consistent per method
5. A trend was not observed between methods
6. Minimal variability between methods
7. Variability will always be observed within a natural setting

RESULT = SAP Addendum implemented for the October 2013 sampling event

GREENVILLE, SC – PROJECT FINANCES



THANK YOU.

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