



Welcome to ITRC's Internet Training



Thank you for joining us.

Today's presentation is focused on the technical and regulatory guidance document entitled:

"Users Guide For Polyethylene-Based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells"

Sponsored by ITRC, EPA-TIO, and USGS



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INTERNET TRAINING TITLE: Passive Diffusion Bag Samplers for Volatile Organic Compounds in Ground Water

Based on the document: *"Users Guide For Polyethylene-Based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells"*

Available at: www.itrcweb.org

PRESENTATION OVERVIEW: Passive diffusion bag (PDB) samplers are a simple and inexpensive way to sample ground water monitoring wells for a variety of volatile organic compounds. A typical PDB sampler consists of low-density polyethylene lay-flat tubing that is filled with distilled, deionized water and heat sealed at both ends. The bags are suspended in the monitoring well at the target horizon by a weighted line and allowed to equilibrate with the surrounding water (typically 2-weeks). The PDB samplers are retrieved from the well after the equilibration period and the enclosed water is immediately transferred to appropriate sample containers for analysis [40 ml VOC vials]. Field-tests show good correlation between samples obtained with PDB samplers and samples obtained using traditional methods (i.e. purge 3-5 casing volumes and sample with a bailer). Currently, the samplers are recommended only for long-term ground water monitoring of VOCs at well-characterized sites. The number of sites where they can be appropriately deployed is large and the associated cost savings are significant

The ITRC internet training for this technology will discuss the technical and regulatory considerations associated with deployment of diffusion samplers, and summarize major points of the recently issued USGS document "Users Guide For Polyethylene-Based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells," which was developed in cooperation with the ITRC Diffusion Sampler Work Group.

ITRC – Interstate Technology and Regulatory Council (www.itrcweb.org)

EPA-TIO – Environmental Protection Agency – Technology Innovation Office (www.clu-in.org)

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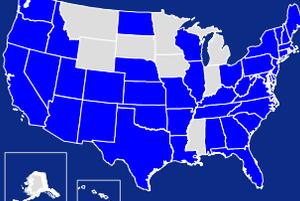
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- ★ Natural Attenuation
- ★ EISB (Enhanced In Situ Bioremediation)
- ★ Permeable Reactive Barriers (basic and advanced)
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- ★ ISCO (In Situ Chemical Oxidation)
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The **Interstate Technology and Regulatory Council (ITRC)** is a state-led coalition of regulators, industry experts, citizen stakeholders, academia, and federal partners that work to achieve regulatory acceptance of environmental technologies. ITRC consists of 40 states (and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and streamline the regulation of environmental technologies. Together, we’re building the environmental community’s ability to expedite quality decision-making while protecting human health and the environment. With our network approaching 6,000 people from all aspects of the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

ITRC originated in 1995 from a previous initiative by the Western Governors’ Association (WGA). In January 1999, it affiliated with the Environmental Research Institute of the States, ERIS is a 501(c)3 nonprofit educational subsidiary of the Environmental Council of States (ECOS). ITRC receives regional support from WGA and the Southern States Energy Board (SSEB) and financial support from the U.S. Department of Energy, the U.S. Department of Defense, and the U.S. Environmental Protection Agency.

To access a list of ITRC State Point of Contacts (POCs) and general ITRC information go to www.itrcweb.org.

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Don Vroblesky is a research hydrologist with the U.S. Geological Survey (USGS). He has worked at the USGS for approximately 20 years. He received an M.S. degree and a Ph.D degree at the George Washington University. He has authored or coauthored over 50 published reports on various aspects of ground-water contamination and hydrology. He is the primary developer of PDB samplers for wells and passive vapor diffusion samplers for mapping contaminant-discharge zones to lakes and streams, and he developed a methodology for mapping VOC contamination in ground water using headspace analysis of tree cores.

George Nicholas is a Supervising Geologist with the New Jersey Department of Environmental Protection. He has over twelve years of experience in overseeing ground water investigations and remedial actions at Superfund sites, RCRA facilities, and privately owned industrial sites throughout the state of New Jersey. He also serves as a Brownfields Coordinator for the NJDEP and works on redevelopment projects with the Hackensack Meadowlands Development Commission and the City of Long Branch. George became involved with the ITRC as a proctor at several of the ITRC Natural Attenuation Training Seminars, and later became the Team Leader for the Diffusion Sampling Team.

Presentation Logistics

- ✓ Technical Information
- ✓ Questions and answers
- ✓ Technical Information
- ✓ Regulatory Information
- ✓ Questions and answers
- ✓ Links to additional resources
- ✓ Your feedback

Course Time = 2 hours

Logistical Reminders

- ✓ Phone Audience
 - Keep phone on mute
 - * 6 to mute your phone and again to un-mute
 - Do NOT put call on hold
- ✓ Simulcast Audience
 - Use  at top of each slide to submit questions

No Associated Notes

- ★ PRIMARILY DISCUSSING PASSIVE DIFFUSION BAG (PDB) SAMPLERS, AND TOUCHING ON SOME OTHER TYPES
- ★ Background on diffusion samplers
- ★ Theory – Why diffusion samplers work, field applications of PDB samplers and diffusion samplers for inorganic constituents
- ★ Question and Answer Period 1
- ★ Discussion of User's Guide and practical applications
- ★ Data interpretation – comparison between different methods
- ★ Regulatory Considerations
- ★ Questions and Answer Period 2
- ★ Wrap-up and links to additional information and resources



Instructor Notes:

None

Typical Applications of Passive Diffusion Bag (PDB) Samplers

- ★ Long-term monitoring of VOCs in wells
- ★ Delineating contaminant stratification
 - This information can aid in site characterization
 - More accurate identification of the contaminated horizon can be an aid in optimizing remediation by allowing more accurate targeting by the remediation effort.

Instructor Notes:

None

Passive Diffusion Bag (PDB) Samplers

- ★ PDB samplers are used to obtain ambient concentrations of volatile organic compounds (VOCs) in wells.
- ★ Why are they a desirable alternative?
 - Very inexpensive (about \$16-\$26 ea) (typically 40-60% cost savings over conventional methods)
 - Sampling - rapid and easy with minimal field equipment required
 - Disposable, so no equipment decon is needed between wells
 - Potential to eliminate pumps and reduce waste water
 - Sometimes can provide information difficult to obtain with conventional methodologies
 - Practical for use for access is a problem or discretion is desirable
 - Not subject to interferences from alkalinity or turbidity.

Instructor Notes:

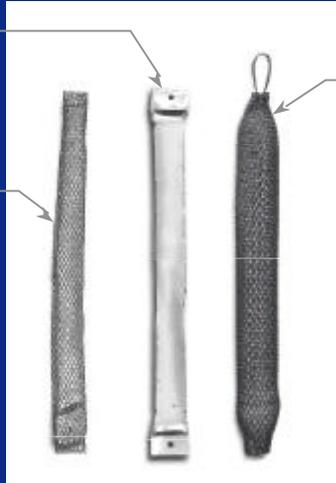
None

Typical Water-Filled PDB Samplers

PDB sampler
 without protective
 mesh

PDB sampler with
 protective mesh

Must purchase from
 vendor or obtain
 license from USGS
 (703 648:4344)



PDB sampler
 attached to
 bailer bottom

Passive Diffusion Bag (PDB) samplers consist of a low-density polyethylene sleeve, filled with laboratory-grade deionized water, and closed at both ends. Pictured here are three types of diffusion samplers commonly used and commercially available. The samplers on the left are supplied prefilled with laboratory-grade deionized water, and the sampler on the right is field-fillable. PDB samplers employ patented technology (U.S. patent number 5,804,743), and therefore, require that the user purchase commercially produced samplers from a licensed manufacturer or purchase a non-exclusive license for sampler construction from the U.S. Geological Survey Technology Enterprise Office, Mail Stop 211, National Center, 12201 Sunrise Valley Drive, Reston, Virginia 20192 (telephone 703 648-4344; fax 703 648-4408).

★ Law of Diffusion

- Compounds tend to migrate from an area of high concentration to an area of low concentration until equilibrium is achieved

★ Fick's Law

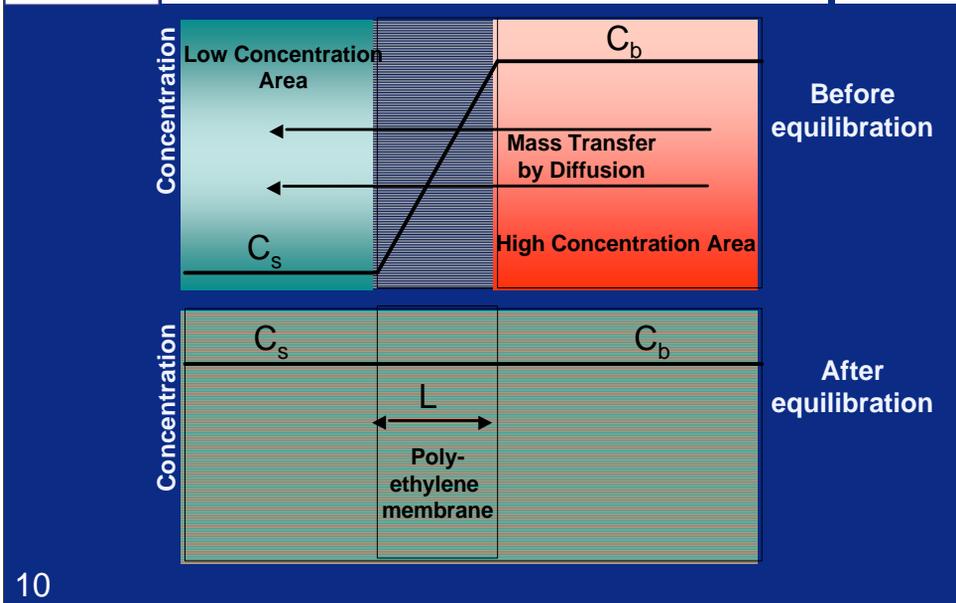
- The rate of diffusive mass transfer through a unit area (J) is proportional to the difference in concentrations ($C_1 - C_2$) divided by the distance separating those concentrations (L). The constant of proportionality is also called the diffusivity, or diffusion coefficient (D).

Fick's Law:
$$J = D \frac{(C_1 - C_2)}{L}$$

Passive Diffusion Bag (PDB) samplers rely on the mass transfer of dissolved gasses through a polyethylene membrane. The rate of diffusion is described by Fick's Law, which states that the rate of diffusive mass transfer through a unit area is proportional to the difference in concentrations divided by the distance separating those concentrations.

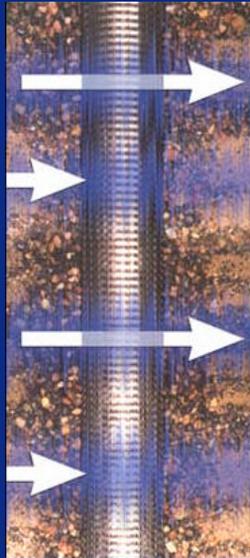
Principle

Law of Diffusion (cont.)



Volatile organic compounds (VOCs) diffuse from an area of high concentration through the polyethylene membrane, to an area of low concentration. After sufficient equilibration time, the concentrations are the same on both sides of the membrane.

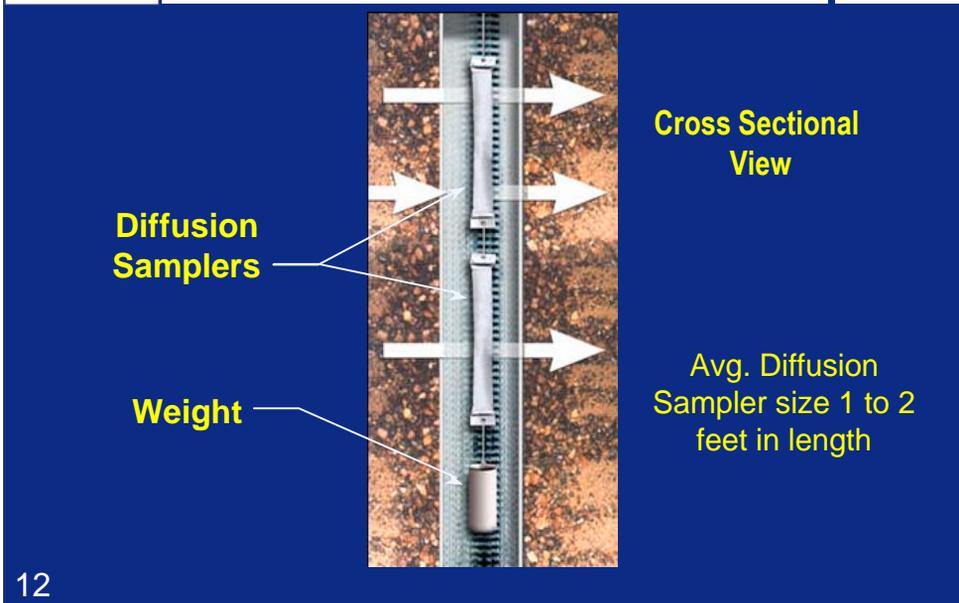
Cross Section View



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In a well where water flows horizontally in one side of the well screen and out the other, the water in the screened interval probably has VOC concentrations characteristic of the formation water adjacent to the well screen. Sampling this water requires inserting a sampling device to the target horizon. However, this disturbs the stratification in the well and mixes water outside the screened interval (which doesn't readily exchange with the formation) with water inside the screened interval. This disturbance obscures the equilibrium concentrations in the screened interval, resulting in sampled concentrations that may not match those in the adjacent aquifer. A variety of methods can be used to compensate for this effect, including purging 3 or more casing volumes of water prior to collecting a sample, or low-flow sampling to ensure that formation water is being sampled. If, however, a passive sampler is placed in the screened interval and the well and sampler are allowed to re-equilibrate, then there is the potential for collecting a ground-water sample without purging.

Diffusion Samplers Deployed in Well



That is where the diffusion samplers come in. PDB samplers are deployed in the screened interval and allowed to equilibrate. After sufficient equilibration, the samplers are removed and the enclosed water is transferred to volatile organic analysis (VOA) vials. Thereafter, the samples are treated as ordinary VOA samples.

Lab Tested VOCs in PDB Samplers

Tested compounds showing good correlation (11 or less percent difference)

| | | | |
|---------------|--------------------|----------------------------------|-----------------------|
| Benzene | 2-Chlorovinylether | <i>cis</i> -1,2-Dichloroethene | 1,1,1-Trichloroethane |
| BDCMethane | DBChloroMethane | <i>trans</i> -1,2-Dichloroethene | 1,1,2-Trichloroethane |
| Bromoform | DibromoMethane | 1,2-Dichloropropane | Trichloroethene |
| Chlorobenzene | 1,2-DCBenzene | <i>ci s</i> -Dichloropropene | TCFMethane |
| Carbon Tet. | 1,3-DCBenzene | EDB | 1,2,3-TCPA |
| Chloroethane | 1,4-DCBenzene | <i>trans</i> -1,3-DCPE | 1,1,2,2-PCA |
| Chloroform | DCFMethane | Ethyl benzene | Tetrachloroethene |
| Chloromethane | 1,2-Dichloroethane | Naphthalene | Vinyl chloride |
| | 1,1-Dichlorethene | Toluene | Xylenes |

Tested compounds showing poor correlation (> 20 percent difference)

| | | | |
|----------|------|---------|-------|
| Acetone* | MTBE | Styrene | MIBK* |
|----------|------|---------|-------|

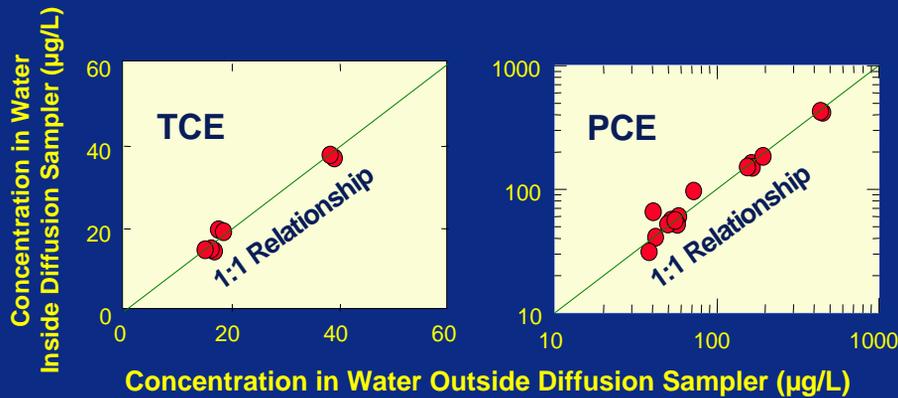
Laboratory tests have shown that PDB samplers are applicable to a wide variety of volatile organic compounds. Other compounds, such as MTBE, acetone, styrene, and most semivolatiles are transmitted slowly through the polyethylene, but lab tests have shown that the resulting concentrations were lower than in ambient water.

- ★ PDB sampler results are an integration of concentrations over the equilibration time associated with the most recent part of the deployment period
- ★ Not appropriate for some compounds
 - i.e. MTBE, acetone, most semi-volatiles, most ions
- ★ Rely on water movement through the well
- ★ Constitute point samples
 - not necessarily a disadvantage

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1. PDB samplers integrate concentrations over time. This may be a limitation if the goal of sampling is to collect a representative sample at a point in time in an aquifer where VOC-concentrations substantially change more rapidly than the samplers equilibrate. Laboratory results obtained indicate that a variety of compounds equilibrated within 48 hours (Vroblesky and Campbell, 2001). Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane may require between 96 and 168 hours to equilibrate (T.M. Sivavec and S.S. Baghel, 2000, General Electric Company, written commun.). The initial equilibration under field conditions may be longer to allow well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment.

2. Water-filled polyethylene PDB samplers are not appropriate for all compounds. For example, although methyl-*tert*-butyl ether and acetone (Vroblesky, 2000; Paul Hare, 2000, General Electric Company, oral commun.) and most semivolatile compounds are transmitted through the polyethylene bag, laboratory tests have shown that the resulting concentrations were lower than in ambient water. A variety of factors influence the ability of compounds to diffuse through the polyethylene membrane. These factors include the molecular size and shape and the hydrophobic nature of the compound. Compounds having a cross-sectional diameter of about 10 angstroms or larger (such as humic acids) do not pass through the polyethylene because the largest (transient) pores in polyethylene do not exceed about 10 angstroms in diameter (Flynn and Yalkowsky, 1972; Comyn, 1985; Hwang and Kammermeyer, 1975). The samplers are not appropriate for hydrophilic polar molecules, such as inorganic ions. A detailed discussion of the relation between hydrophobicity and compound transport through polyethylene can be found in Gale (1998). Unpublished laboratory test data (D.A. Vroblesky, 1998, U.S. Geological Survey, written commun.) of semivolatile compounds in contact with PDB samplers showed a higher concentration of phthalates inside the PDB sampler than outside the PDB sampler, suggesting that the polyethylene may contribute phthalates to the enclosed water. Thus, the samplers should not be used to sample for phthalates.



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Slide 15 notes: Shown here are some laboratory data for trichloroethene (TCE) and tetrachloroethene (PCE) showing a close comparison of concentrations between water inside and outside the PDB samplers for a range of concentrations.

Slide 14 notes (continued)

3. PDB samplers rely on the free movement of water through the well screen. In situations where ground water flows horizontally through the well screen, the VOC concentrations in the open interval of the well probably are representative of the aquifer water in the adjacent formation (Vroblecky and Hyde, 1997; Gillham and others, 1985; Robin and Gillham, 1987; Powell and Puls, 1993; Karl and others, 1992). In these situations, the VOC concentration of the water in contact with the PDB samplers, and therefore, the water within the diffusion samplers, probably represents local conditions in the adjacent aquifer. However, if the well screen is less permeable than the aquifer or the sandpack, then under ambient conditions, flowlines may be diverted around the screen. Such a situation may arise from inadequate well development or from iron bacterial fouling of the well screen. In this case, the VOC concentrations in the PDB samplers may not represent concentrations in the formation water because of inadequate exchange across the well screen. PDB samplers have not yet been adequately tested to determine their response under such conditions.

4. VOC concentrations in PDB samplers represent ground-water concentrations in the vicinity of the screened or open well interval that move to the sampler under ambient flow conditions. This is a limitation if the ground-water contamination lies above or below the well screen or open interval, and requires the operation of a pump to conduct contaminants into the well for sampling. In cases where the well screen or open interval transects zones of differing hydraulic head and variable contaminant concentrations, VOC concentrations obtained using a PDB sampler may not reflect the concentrations in the aquifer directly adjacent to the sampler because of vertical transport in the well. However, a vertical array of PDB samplers, used in

Two standard methods

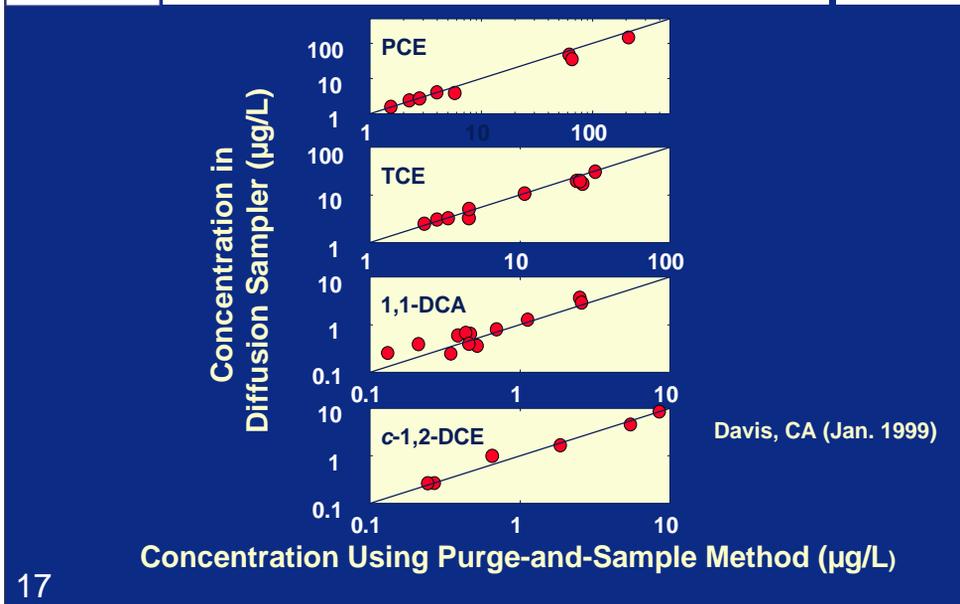
- ★ Purge-and-Sample
 - Remove 3 or more casing volumes of water prior to collecting a sample

- ★ Low-Flow (LF) or Low-Volume Sampling
 - Slowly purge with no drawdown until field parameters stabilize prior to collecting a sample

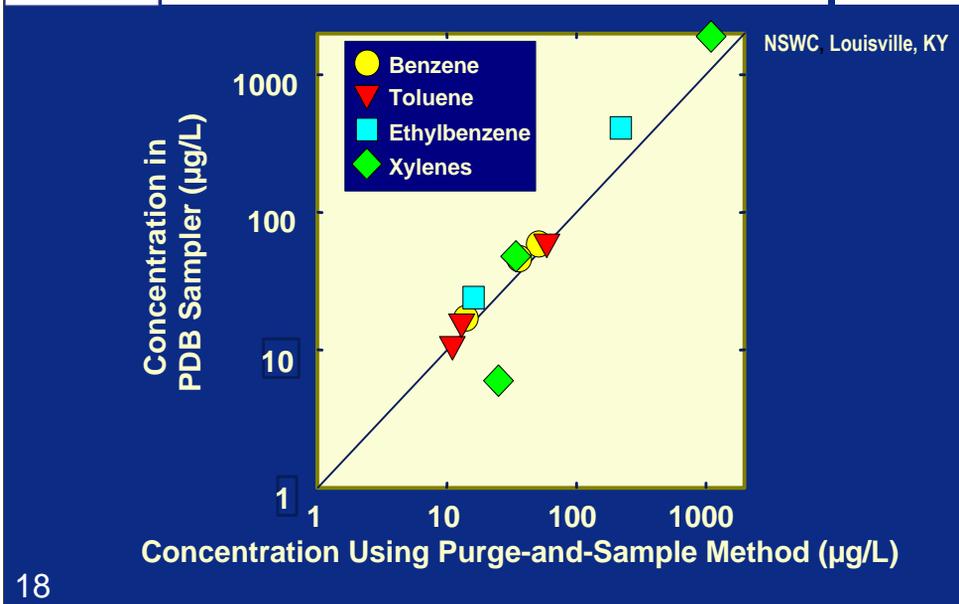
Instructor Notes:

None

PDB vs. Purge-and-Sample under Field Conditions



A close relation also is seen under field conditions between VOC concentrations from PDB samplers and VOC concentrations from conventional sampling methods. In this case, the comparison is made to a purge-and-sample methodology.

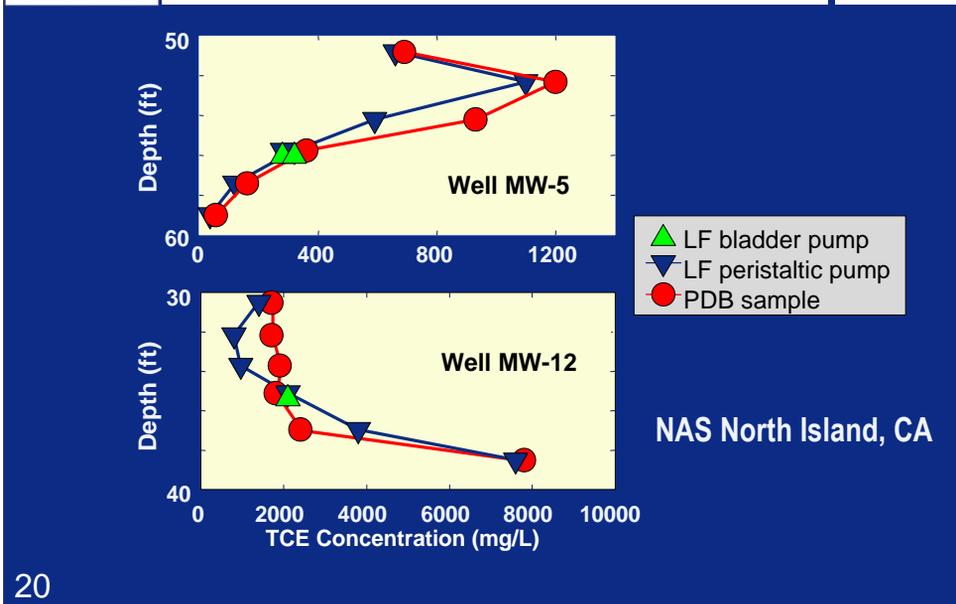


These are field data for petroleum hydrocarbons from a fractured-rock aquifer. In general, there is a good correlation between results from each method. One or two data points on this graph don't correlate particularly well. This illustrates a good point. At many tested sites, there are at least a few wells in which the data obtained by using a single PDB sampler do not match data obtained by using a traditional method. In most cases where we took the time to determine the source of the difference, the source of the discrepancy turned out not to be a deficiency of the PDB samplers. Rather it typically was a difference in the type of sample obtained using various methods in the presence of chemical or hydraulic heterogeneity. The following slides illustrate such situations.



This is an example of using multiple PDB samplers attached to a weighted line.

TCE Stratification in 10-Ft Well Screens



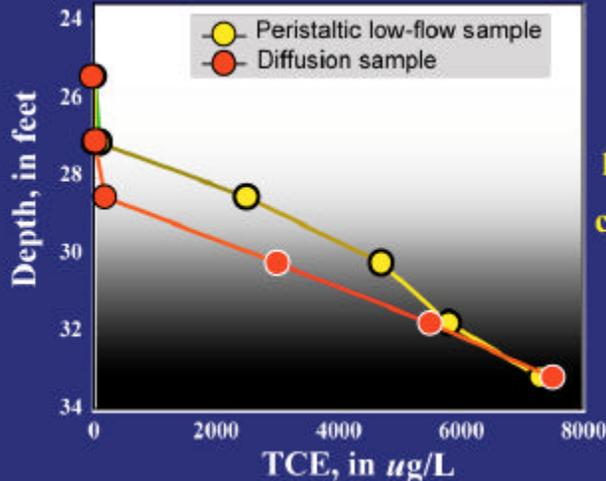
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This is a comparison between low-flow sampling and diffusion (PDB) sampling in two wells having 10-ft well screens. In both wells at most depths, the two methods approximately agreed. Because PDB samplers represent a “point” sample in a well, these data imply that the low-flow sampling in these wells also approximated a point sample. Perhaps of equal interest is the large amount of contaminant stratification in these wells. Typically, these wells are sampled by using a commonly accepted approach of placing a low-flow bladder pump in the center of the screened interval. These data suggest that if the low-flow pump in well MW-5 was lowered about 3 ft, the pump would sample almost clean water, but if raised about 3 ft, it would sample water having concentrations of about 1,200 ug/L. If the pump at well MW-12 were lowered about 3 ft, it would sample concentration of TCE about 6,000 ug/L more than at its present position.

These data also imply that a possible application for PDB samplers is to locate the zone of maximum concentration for, perhaps, optimizing remediation by more effectively targeting the contaminated horizon.

It should also be noted that the correlation between the two methods is not perfect here. Despite the nearly identical trends, there is a substantial difference between the two sampling methods at a depth of about 54 ft in well MW-5. The reason for this becomes more clear in the following example.

Low-flow Sampling effects near TCE stratification



As the sequential low-flow sampling approaches a chemical interface, in-well mixing obscures the TCE profile

This is a different well again with substantial vertical stratification of TCE. The numbers show the sequence that the low-flow samples were collected. A very close match between the two methods was found for the first two (uppermost) sampling points. However, in the vicinity of stratification interface (point 3), the concentrations between the two methods diverged. The samples collected deeper in the zone of high concentrations (samples 5 and 6) again matched up. The data strongly suggest that the PDB samplers represent a point sample, and the low-flow samples in this well represent a mixing over some relatively small interval. The mixing is more obvious near the chemical-stratification interface.

Thus, although the results from the two methods don't match well at certain points, the reason is not that either method is deficient. They are simply telling two different things. The PDB samplers are providing a high-precision delineation of the contaminant stratification. The low-flow sampling is providing a somewhat obscured delineation of the contaminant stratification.

**Comparison of PDB and Purge Sampling
 Methods at Well 18S**
*(deployment of single PDB sampler in
 approximate center of screened interval)*

| | PDB Sampler Method (µg/L) | Purge-and- Sample Method (µg/L) |
|--------------------------|--|--|
| Total 1,2-DCE | 130 | 650 |
| TCE | 570 | 2,300 |

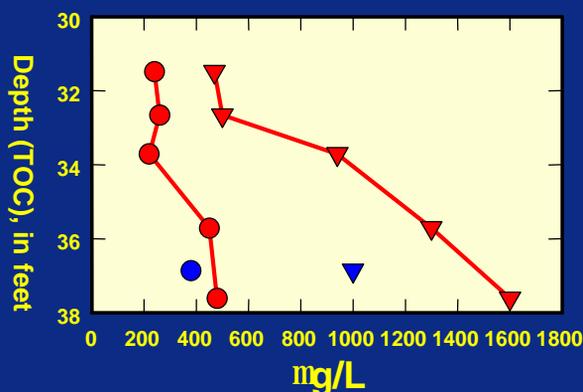
**4-casing-volume
 purge**

Fridley, MN (Nov. 1999)

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This is another situation in which the PDB sampler method did not agree with a traditional method. In this case, the standard method by which the well usually was tested was a 3 or more casing-volume well purge prior to sample collection. The chlorinated solvent concentrations from the single PDB sampler were substantially lower than the concentrations from the purge-and-sample method. To determine the source of the difference, we reinstrumented the well with multiple diffusion samplers and tried sampling using low-flow methodology as a less invasive conventional approach.

- ★ These data imply that the low-flow sampling results can be a mixture of waters within the screened interval



Fridley, MN (May 2000)

When we recovered and analyzed water from the multiple PDB samplers in well 18S, it became apparent that the TCE and total 1,2-DCE concentrations substantially increased with increasing depth in the 10-ft well screen. The increase implies that the highest concentrations are at the base of or below the depth of the well. Thus, the sphere of water sampled during the the 4-casing-volume-purge sampling method previously used in this well probably included water from a more contaminated horizon immediately below the well, while the PDB sampler showed concentrations in the immediate vicinity of the well screen. In this slide, the low-flow sampling results (about 1,000 $\mu\text{g/L}$ for TCE) are substantially lower than the previous purge-and-sample results (2,300 $\mu\text{g/L}$ for TCE), supporting the hypothesis that the water sampled by the purge-and-sample method differed from the water in the immediate vicinity of the well screen. Although the low-flow sample and the adjacent PDB sample differ in concentration, the low-flow sample visually appears to be an approximate average of the concentrations across the screened interval. Thus, it appears that the low-flow sample mixed water over a larger interval than in the previous example at NAS North Island.

Varying degrees of mixing during sampling

- ★ Thus, diffusion samplers typically constitute a point sample. Useful for targeting the high concentrations. Avg. concentrations for a screened interval are obtained by multiple samplers.
- ★ Low-flow samples sometimes constitute an approximate point sample (selected horizons at NAS North Island) providing no information on average concentrations in a well screen. In other wells, LF samples constitute a mixed sample over varying intervals.
- ★ 3 or more casing-volume purge sampling averages aqueous concentrations even more by mixing, sometimes inducing flow from horizons not in the vicinity of the well screen.

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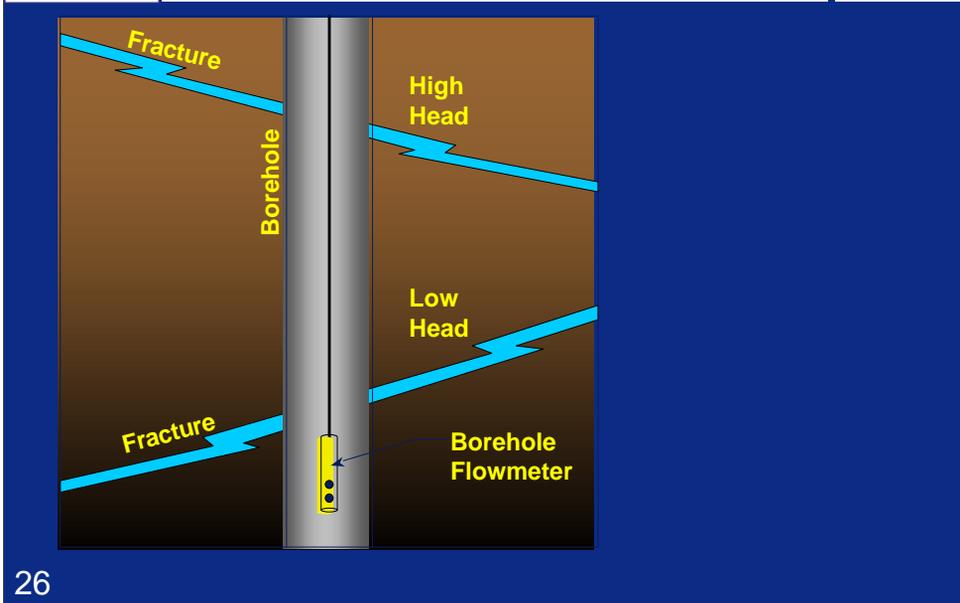
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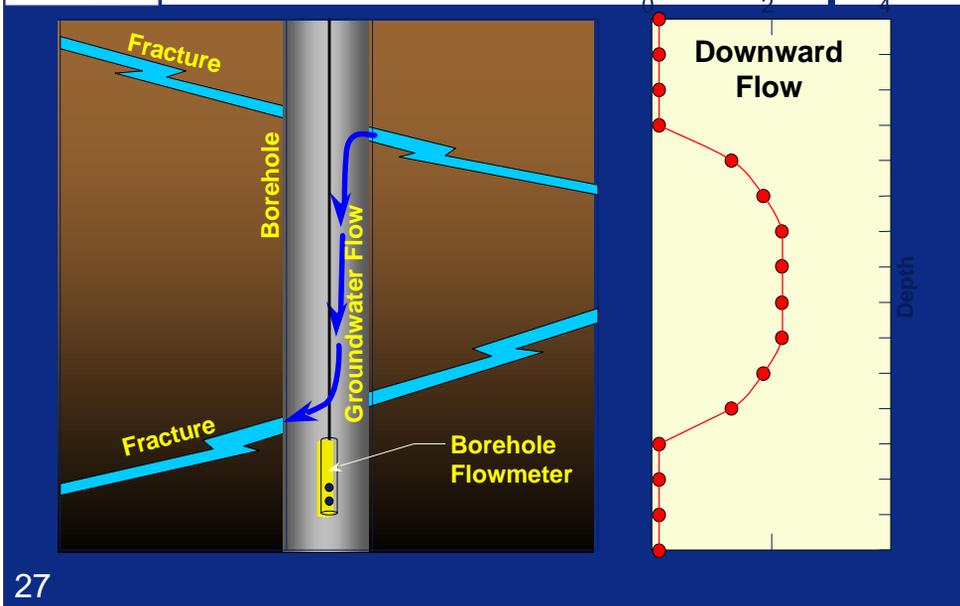
- ★ In some cases, VOC stratification in a well and disagreement between sampling methods can result from inadequate wells.
- ★ Examples include wells that connect zones of significantly different hydraulic head or contaminant concentration.
- ★ **CONSIDER THE FOLLOWING EXAMPLES:**

Instructor Notes:

None



In a well intersecting two fractures of differing hydraulic head, the well may provide a conduit of water movement between the two horizons. Although the example here is a fractured-rock system, the same logic applies to an unconsolidated system, where two zones of differing head may be separated by a confining unit. We can gain some information of the vertical component of water movement by using a borehole flowmeter. Consider the situation in which the upper zone is a higher hydraulic head than the lower zone.

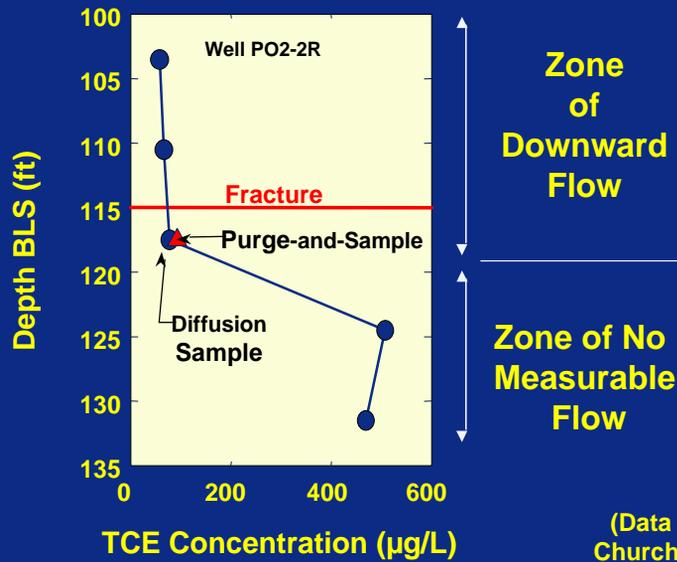


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In this case, water can move into the well from the zone with the higher head, move downward (or upward, depending the direction of the hydraulic gradient) and discharge out of the well into the zone with the lower hydraulic head. By taking a series of readings with the borehole flowmeter, the zones of inflow and outflow can be identified. The readings typically are taken under static and pumping conditions. Identifying this situation is important because if the zone that water is flowing into from the well is the contaminated horizon, then you may not be able to obtain representative concentrations from that zone no matter what sampling methodology that you use in this well. The reason is that, in this case, the contaminated horizon does not contribute water to the well under static conditions. Instead, water from other horizons with higher hydraulic head will invade the contaminated horizon by way of the well screen. Under pumped conditions, the majority of the extracted water will be from the most permeable interval, which may not be the contaminated zone. Even when pumping induces inflow from the contaminated interval, much of that inflow will be a reflection of the residual invaded water from other horizons. In this situation, a substantial amount of purging would be required before water representative of the aquifer could be obtained. Such sampling is not likely to reflect a significant contribution from the contaminated zone, and concentrations in the contaminated zone probably will be underestimated.

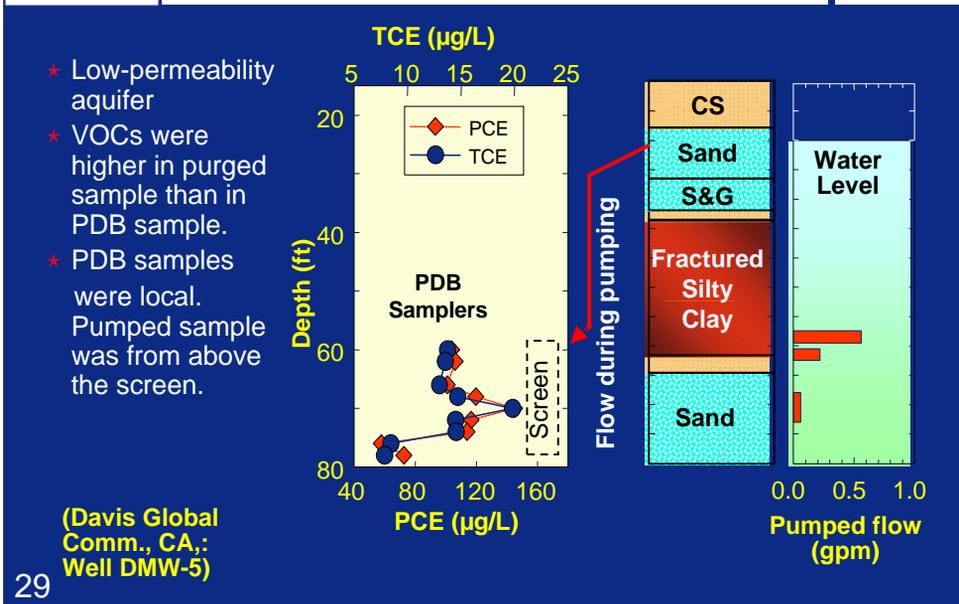
Similarly, if VOC-contaminated water is flowing into the well and is exiting the well at a different horizon, then VOCs will be present along the screened interval between the two horizons. In this case, VOC concentrations in the screened interval may be representative of aquifer concentrations at the inflow horizon, but may not be representative of aquifer concentrations near the outflow horizon.

High TCE Concentrations in the Zone of Stagnation



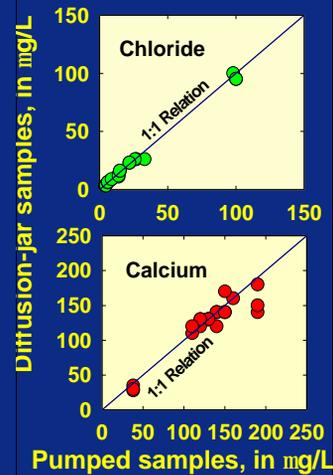
28

This slide illustrates the point. TCE stratification was present in well PO2-2R, with the highest concentrations below a fracture zone identified from the boring log near the bottom of the well. Borehole flowmeter data showed that no measurable movement of water into or out of the well in the zone of highest contamination. In the upper, less contaminated, part of the well, water was entering the well from some shallower zone and flowing downward, exiting the well in the vicinity of the fracture. Thus, water sampled by using either the purge-and-sample method or the PDB method in the well near the fracture at 115 ft represented concentrations from a shallower horizon rather than in the vicinity of the fracture. A simple explanation for the high concentrations detected by the PDB samplers below the fracture is that these represent equilibrium concentrations in that poorly connected part of the aquifer, and they may represent the concentrations that would be seen in the fracture zone at 115 ft if the actual concentrations were not obscured by the downward movement of less contaminated water from a shallower horizon. The high TCE concentrations between 120 and 135 ft probably would not be seen by using purge-and-sample methodology because the purge would remove the static water and replace it with water from the shallower, more permeable part of the well.



This is an additional site where a higher concentration was observed in the pumped sample than in the PDB sample. The maximum concentration of tetrachloroethene (PCE) from the PDB samplers was 145 $\mu\text{g/L}$, while the concentration from the purge-and-sample approach was 211 $\mu\text{g/L}$. Results from the PBD samplers implied that the maximum concentration under static conditions was in the center of the well screen in a sand formation. However, flowmeter testing showed that under pumped conditions, most of the water entered the well from the top of the well screen in a silty clay. In a situation when most of water flow to a well is derived from the top of the screen in a clay, the simplest explanation is that the water is derived from a shallower horizon and is moving downward outside the casing through leaking well seals or fractures in the silty clay. Other investigations showed that the shallower horizon at this site was contaminated with PCE. Thus, it is probable that, in this well, the PDB samplers represent PCE concentrations in the screened horizon under non pumping conditions, and the pumped sample represents a mixture of water from the screened interval and from a shallower, possibly more contaminated water-bearing zone. In this case, the PDB samplers probably provide concentrations more representative of the screened interval than the pumped sample.

Nylon-screen diffusion samplers



Can be used to provide concentrations of inorganic constituents in wells or at contaminant-discharge zones in streams

(Vroblesky and others, 2002, USGS WRI 02-4031)

Up to now, we have been looking exclusively at PDB samplers. We also can construct various other types of samplers if we wish to look at inorganic solutes. The samplers shown here are simply 30-mL wide-mouth plastic jars filled with deionized water and with the opening covered by a nylon screen. The screen shown here is about 48 micron mesh. It is secured onto the mouth of the jar by screwing on the cap over the mesh after the top of the cap has been drilled or cut open. The samplers can then be slid vertically or horizontally into a mesh sleeve and deployed down wells. The equilibration time is less than about 20 hours, but again it is prudent to leave them in for 2 weeks to account for well equilibration. The graphs show a very close match between low-flow samples and nylon-screen samples for chloride and calcium. Various manifestations of this type of sampler have been used primarily in marsh and lakebed pore-water studies, but the data here show that they also can be used in wells.

Regenerated cellulose dialysis diffusion sampler

Dialysis membrane (regenerated cellulose)

Inner perforated tube (to prevent collapse)

Protective outer mesh

Chloride

Dialysis samples (mg/L)

Low-flow samples (mg/L)

Sulfate

Dialysis samples (mg/L)

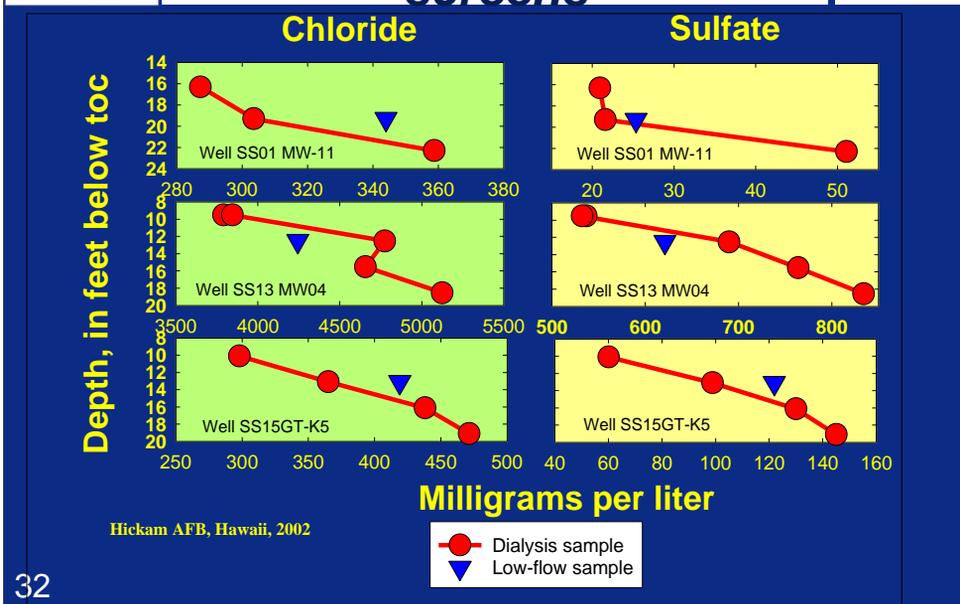
Low-flow samples (mg/L)

(Vroblesky and others, USGS WRI 02-4031)

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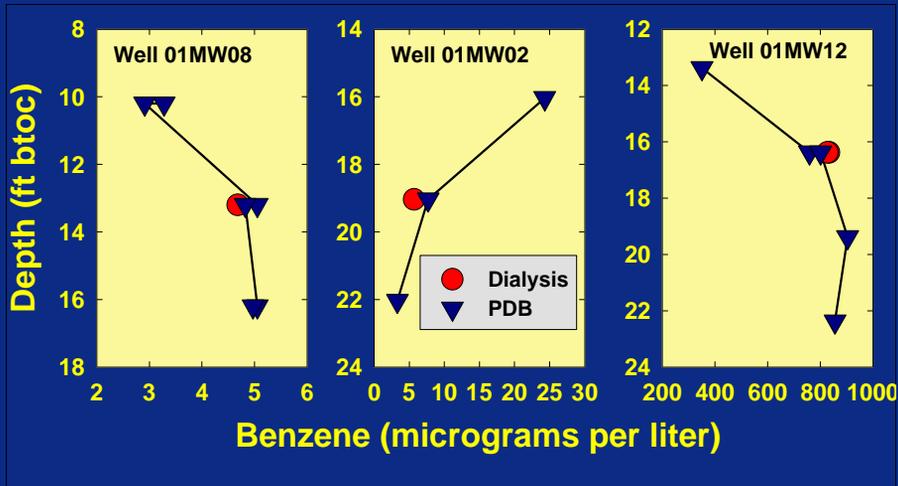
Dialysis membranes have been used to sample inorganic and organic solutes. In this slide, the membrane is regenerated cellulose, which is commercially available as tubing in various diameters. Both water and solutes move through dialysis membranes. When the sampler is filled with deionized water, equilibration with the well water is achieved by well-water solutes moving into the sampler and sampler-deionized water moving out of the sampler into the well. The dialysis bag collapses as the water moves out. The inner perforated tube shown here prevents bag collapse and water loss, so the equilibration is dominated by solute movement rather than water loss. The graphs show a close correspondence between low-flow and dialysis-sample chloride and sulfate concentrations.

Stratification of inorganic solutes in 10-ft well screens



Diffusion samples show that, like VOCs, inorganic constituents can show substantial stratification across 10-ft screened intervals. Chloride and sulfate are shown here in three wells. It is clear that the low-flow sample (blue triangle) represents some mixing of the concentrations found in the dialysis samples (red circles). However, the concentrations in the low-flow sample and the single dialysis sample from the low-flow sampling depth do not always agree. This is because the diffusion sample represents a point (about 1-ft long) and the low-flow sample represents a mixture. The important thing to note here is that simply because concentrations in a single diffusion sampler and a low-flow sample do not agree does not mean that the sampler is inaccurate.

Benzene in dialysis and PDB samples, Hickam AFB

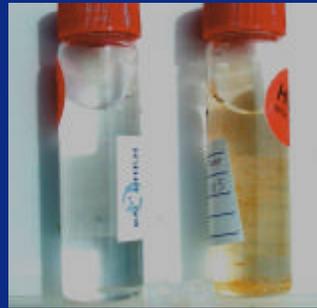


Dialysis samplers also can be used to sample VOCs, as shown by this comparison between a dialysis sampler and a series of PDB samplers in wells.



(1) Regenerated cellulose showing membrane degradation within two weeks of deployment

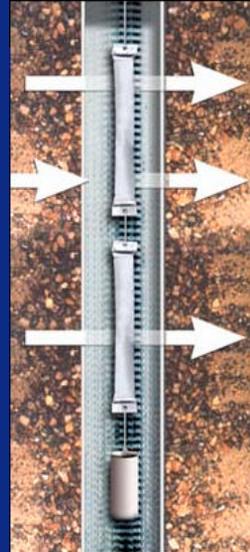
(2) Regenerated cellulose should be refrigerated and must be thoroughly cleaned and kept wet prior to use



LF sample Diffusion sample

(3) Iron can precipitate in both nylon-screen and dialysis samplers, affecting metals concentrations

But, like most things, inorganic diffusion samplers also have weaknesses. Regenerated cellulose is biodegradable. The photo on the left shows membrane biodegradation within two weeks of deployment. The sampler was still intact, but you probably wouldn't want to leave in the well much longer. The membrane comes either comes dry (which requires extensive washing prior to use) or precleaned in a solution. The precleaned still must be rinsed to remove methanol, but the washing is not as extensive. Once the samplers are wet, they need to be refrigerated and must remain wet until deployment to prevent degradation. The nylon-screen samplers are extremely durable and probably can be deployed for very long periods; however both types of samplers should be used with caution for redox-sensitive solutes (like iron). For these solutes, the samplers should be filled with anaerobic deionized water. If iron or other metals are dissolved in the well water and they contact oxygen (either from the sampler or from a recharge event leaking into the well) they can precipitate out of solution. If this happens in the sampler, iron precipitate can accumulate in the sampler giving misleading total iron concentrations.



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No associated notes

Available for download from:
In the links page at the end of
this presentation

OR

<http://www.itrcweb.org>

<http://www.frtr.gov>

[http://www.sc.er.usgs.gov/
publications](http://www.sc.er.usgs.gov/publications)

Multi-Agency Document

- * U.S. Geological Survey
- * U.S. Air Force
- * U.S. Naval Facilities
Engineering Command
- * U.S. EPA
- * Federal Remediation
Technologies Roundtable
- * Defense Logistics Agency
- * U.S. Army Corps of
Engineers
- * Interstate Technology
Regulatory Cooperation
Work Group (ITRC)

Instructor Notes:

None

- ★ **Executive summary**
- ★ Introduction
 - Summary of limitations and advantages
- ★ PDB sampler deployment
- ★ Sampler and sample recovery
- ★ Determining applicability
 - Influences of hydraulic and chemical heterogeneity on sample quality
 - Comparison of PDB sampling to conventional methodologies
- ★ Quality control and assurance
- ★ Summary
- ★ References

Part 1 of the document covers deployment, recovery, data interpretation, and quality control and assurance.

- ★ Comparison to purge-and-sample
 - Davis Global Commun., CA (Vroblesky and others)
 - McClellan AFB, CA (McClellan AFB EMD)
 - NIROP Fridley, MN (Vroblesky and Petkewich)
- ★ Comparison to low-flow sampling
 - NAS North Is., CA (Vroblesky and Peters)
 - Hanscom AFB, MA (Church)
 - NIROP Fridley, MN (Vroblesky and Petkewich)
- ★ Comparison to a variety of methods
 - (Tunks and others)

Part 2 of the “User’s guide for polyethylene-based passive diffusion bag samplers to obtain volatile organic compound concentrations in wells” is a series of field tests. This section includes 6 field investigations. PDB- sampler methodology was compared to conventional purging methods (purging at least three casing volumes) used at McClellan AFB and Davis Global Communications, and to low-flow methods used at NAS North Island and Hanscom AFB. Both conventional purging and low-flow purging were compared with using PDB samplers at NIROP Fridley. The study by Tunks and others at McClellan AFB compared the PDB samplers to conventional and low-flow techniques, as well as another type of diffusion device, the DMLS sampler.

Comparison of Methods (AFCEE/Parsons Eng.)

| CRITERIA | USGS PDB | DMLS | MICROPURGE | CONVENTIONAL |
|-----------------------------------|-------------|--------------|--------------|--------------|
| Ease of use | Excellent | Fair | Poor | Fair |
| Labor hours per sample | 0.66 | 1 | 2.75 | 3.66 |
| IDW Generation (liters) | <1 | <1 | 100 | 500 |
| Costs for dedicated equip. | Low | High | Low | High |
| Between-well decon. | Minimal | High | Moderate | Moderate |
| Immediacy of results | Slow | Slow | Rapid | Rapid |
| Analytes other than VOCs? | No | Yes | Yes | Yes |
| Evaluation of VOC stratification? | Possible | Possible | Partial | No |
| OK MNA sampling? | No | No | Yes | Partial |
| Cost per Sample | \$65 | \$555 | \$308 | \$444 |

AFCEE and Parsons's Engineering did a study comparing methods under field conditions at McClellan AFB. All tested methods produced comparable analytical results but they differed in other criteria, as shown here. The DMLS sampler is a diffusion sampler that uses dialysis cells as passive collection devices. This report is available in Part 2 of the User's Guide.

Deployment of PDB sampler with attached weight (Eon sampler)

Protective Mesh Sock

Weight Hanger

Weight

Diffusion Bag (inside mesh sock)

Filling and Sampling Port



This is an example of one of the types of commercially available PDB samplers. This one is supplied unfilled and can be filled by the user.



The unfilled samplers can be filled in the field by pouring deionized water into the sampler directly or through a funnel (provided).

Commercially Available Prefilled PDB Sampler



Sampler



Weight

PDB Samplers also are available prefilled with laboratory-grade deionized water.

Methods of Attaching PDB Samplers to the Line or Weight

- ★ The PDB sampler can be attached to the weighted line by a variety of methods.
 - Wire ties through a knot
 - Stainless steel clamp
 - Direct attachment to the weigh
- ★ Nonbuoyant nonstretch rope can be used as the line, however, stainless steel line is preferable
- ★ Sufficient weight should be added to counterbalance the buoyancy of the PDB samplers



Instructor Notes:

None

- ★ Weight suspended above the well bottom
 - Measure the line and attach the PDB sampler at a distance corresponding to the depth of the target zone
 - Be careful that the line doesn't slip or stretch
- ★ Rest weight on the well bottom
 - Attach the PDB sampler to the line at a distance from the bottom of the weight equal to the distance from the well bottom to the target horizon
 - Usually this involves less measuring than measuring the line from the top down.

Instructor Notes:

None

- ★ Measure the well depth
 - Compare measured and reported (from well logs) depths to the well bottom
 - This is to check on whether
 - sediment has accumulated in the bottom of the well,
 - there is a non-screened section of pipe (sediment sump) below the well screen, and
 - on the accuracy of well-construction records.
- ★ If there is an uncertainty regarding length or placement of the well screen, then an independent method, such as video imaging of the well bore, is strongly suggested.

Instructor Notes:

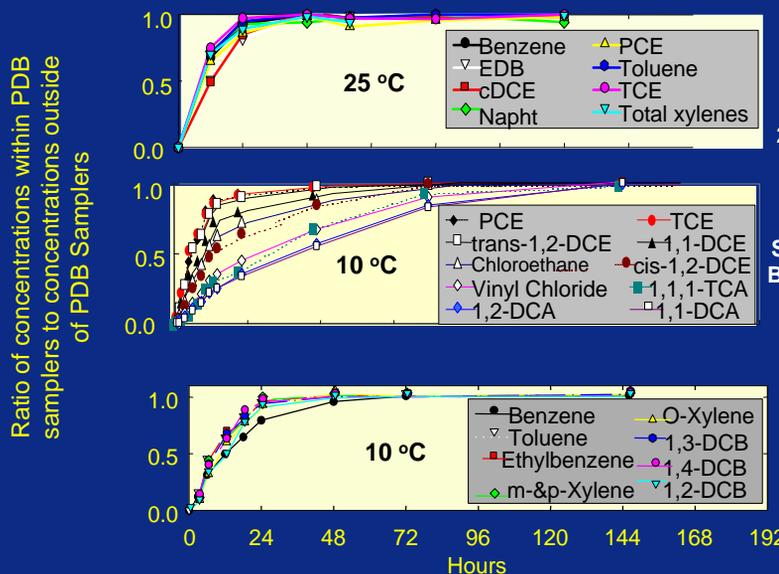
None

Consider the Screen Length Deploying PDB Samplers

- ★ Screen length/saturated interval 5 ft or less
 - PDB sampler in the center
- ★ Screen length 5-10 ft
 - Advisable initially to use multiple PDB samplers to ascertain the presence of contaminant stratification
- ★ Screen length >10 ft
 - Only use in conjunction with borehole flow meters or other techniques to characterize vertical variability in hydraulic conductivity and contaminant distribution or use strictly for qualitative reconnaissance purposes

In well screens >10 ft long, the caution is because of the increased potential for cross contamination of water-bearing zones and hydraulically driven mixing effects that may cause the contaminant stratification in the well to differ from the contaminant stratification in the adjacent aquifer material. If it is necessary to sample such wells, then multiple PDB samplers should be installed vertically across the screened or open interval to determine the zone of highest concentration and whether contaminant stratification is present.

Equilibration of selected compounds in PDB samplers



Vroblesky and Campbell, 2000, USGS

Sivavec, and Baghel 2000, GE Co.

Sivavec, 2001, GE Co.

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Laboratory tests of PDB samplers showed relatively rapid equilibration. The compounds shown here equilibrated at about 24 to 48 hours at 21 °C in tests vials (top graph). A subsequent test at 10 °C showed that PCE and TCE were mostly or completely equilibrated by 48 hours, while other tested compounds required longer equilibration times (center graph). Vinyl chloride, 1,2-dichloroethane, 1,1,1-trichloroethane, and 1,1-dichloroethane were not equilibrated at 93 hours but were equilibrated by 166 hours. Further tests at 10 °C by General Electric Co. showed that most BTEX compounds and the tested dichlorobenzene isomers were approximately equilibrated by about PCE and TCE were mostly or completely equilibrated by 48 hours, with benzene equilibrating slightly more slowly (bottom graph). Benzene appeared to not quite be equilibrated at 48 hours but was equilibrated by 72 hours.

- ★ 48 hours for TCE and several tested compounds at 25 C (Vroblesky, 2000, USGS)
- ★ 93 to 166 hours for VC and some chloroethenes and 48 to 72 hours for BTEX compounds and selected dichlorobenzenes at 10 C (Sivavec and Baghel, 2000, 2001 General Electric Company)
- ★ **But samplers should equilibrate long enough for well water, contaminant distribution, and flow dynamics to restabilize (2 weeks for permeable formations, possibly longer for poorly permeable formations)**

The data indicate that the PDB samplers equilibrate rapidly to the tested VOCs (48 to 166 hours). However, the samplers should be left in place long enough for the well water, the contaminant distribution, and the flow dynamics to restabilize following sampler deployment. In many wells, these factors may restabilize in minutes to hours. However, other wells may require days to reequilibrate. As a simple guideline to encompass a variety of situations, a minimum equilibration time of two weeks should be adequate for most wells in permeable formations. In poorly permeable formations, longer equilibration times may be needed.

*One water-transfer method is to insert
a discharge tube through the
polyethylene*



Inserting the tube
through the
polyethylene into
the PDB sampler



Transferring water
to a VOA vial

One method of transferring water from the PDB sampler to VOA vials is by piercing the sampler near the base with a discharge tube. The rate of water flow can be controlled by tilting or manipulating the sampler.

Attaching a Bottom-Discharge Device



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The water also can be removed from the PDB sampler by attaching a bottom-discharge device.

*Water Also can be Removed Simply by
Cutting the Sampler Open and Gently
Pouring into VOA Vials*



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Water also can be recovered from the PDB sampler simply by cutting open with a clean pair of scissors and pouring it into vials in a manner that minimizes agitation. Good comparisons to conventional sampling have been shown using all three water-transfer methods.

Determining applicability of PDB Samplers

- ★ Common approach is to do a side-by-side comparison to conventional technology
 - Particularly important in wells with high temporal chemical variability

- ★ In Wells with low temporal chemical variability, comparison of PDB-sampler results to historical concentrations may be adequate.

Instructor Notes:

None

- In general, if the results agree in a range deemed acceptable by local, state, and Federal regulatory agencies and meet the site-specific data-quality objectives, then a PDB sampler may be approved for use in that well to monitor ambient VOC concentrations.

Notice that specific criteria for acceptable concentration ranges are not given. This is done for a variety of reasons. The primary reason is to allow regulatory flexibility in designing sampling programs to meet site-specific data-quality objectives. Thus, the specific ranges of acceptable values may vary from site to site. When reporting the comparisons, it probably is appropriate to consider the differences in terms of percent difference at high concentrations (for example, >50 micrograms per liter) and in terms of differences in actual micrograms per liter at lower concentrations (for example, < 15 micrograms per liter). This is because a relatively high percent difference can be reported for two samples differing by only 2 or 3 micrograms per liter in the low-concentration range.

*If PDB-sampler VOC concentrations
are higher than VOC concentrations
from the conventional method*

- Then the PDB sampler probably adequately represent ambient conditions
 - This is because there is a greater potential for dilution from mixing during sampling using conventional technology

Instructor Notes:

None

If the conventional method VOC concentrations are higher than PDB-sampler VOC concentrations – then:

- Uncertain whether the PDB sampler or the conventional sampler conc.'s represent local conditions.
 - Further testing (borehole flowmeter and/or multiple PDB samplers) can be used to clarify the situation.
- PDB samplers may be more locally representative if the pumped samples
 - Mixed chemically stratified zones
 - Incorporated water containing higher concentrations from other areas not adjacent to the screened interval
 - along inadequate well seals
 - through fractured clay

Instructor Notes:

None

The decision on whether to use PDB samplers in such situations depends on the data quality objectives

- If the goal is to determine and monitor higher concentrations or to examine contaminant stratification within the screened interval
 - PDB samplers may be appropriate
- If the goal is to determine the average concentrations for the entire screened interval
 - An average of multiple PDB samplers may be appropriate.
 - A pumped sample may produce an average concentration across the screened interval, but several field tests suggest that low-flow samples sometimes constitute approximate point samples and sometimes constitute an average concentration over intervals that may vary from well to well

Instructor Notes:

None

Vertical stratification of VOCs

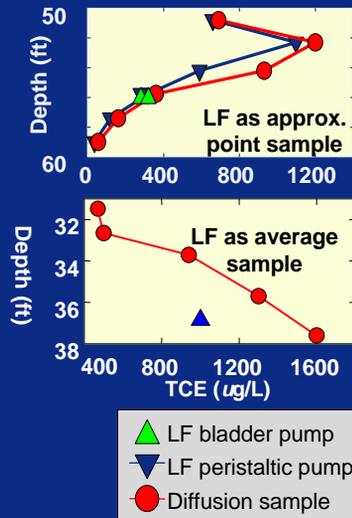
- In areas where vertical stratification of VOCs is anticipated, using multiple PDB samplers may more fully characterize the contaminated horizon than using a single PDB sampler.
 - Particularly true in well screens 10 ft or longer, but significant VOC stratification has been observed in intervals less than 5 ft
- Because of the influences of chemical and hydraulic heterogeneity, discussed earlier, it is advisable that both the vertical distribution of VOCs and the potential for intra-borehole flow be determined in wells having screens longer than 10 ft.



Instructor Notes:

None

- Resulting concentrations may differ because each methodology is sometimes influenced in different ways by aquifer hydraulic and chemical heterogeneity
 - PDB sampler: typically an approximate point sample
 - 3-Casing-volume purge-and-sample: integrates water over a relatively large area
 - Low-flow sampling: Sometimes an approximate point sample and other times an average concentration over a larger area.



Instructor Notes:

None

Replicate samples

At least 10 percent are recommended.

Fill water blank

Tests should be done on the PDB sampler fill water since some VOCs introduced in the fill water (such as acetone) will not readily diffusion out (false positive).

Trip blanks

Required for lab filled PDBS to determine whether contaminants have affected the samplers during shipment or prior to deployment.

Equipment blanks

Required for field-filled PDBS.

Note: Blanks are taken at the time of sampler deployment and sent immediately for analysis

Instructor Notes:

Replicate (a.k.a. duplicate) samples should be collected at a rate of 10 per cent of the total number of samples collected. A replicate sample must be obtained from the same bag as the original sample or from another PDB sampler that has been deployed side-by-side at the same sampling interval.

Fill water blank: The fill water blank is required to detect any sample bias due to the quality of the water used to fill the sampler. It also checks the quality of the water being sent down the well which could potentially add to existing impact if it is contaminated.

Trip blanks are required for bags shipped pre-filled from a lab or vendor. One “extra” PDBS should be ordered and shipped to the site in the same container and stored in the same manner as the PDB samplers that will be deployed during the sampling event. When all bags have been deployed, a trip blank is taken from the “extra” PDBS and sent to a NJ Certified lab for analysis. Trip blanks are collected at a rate of one per sampling shipment, however, if there is more than one sampling crew separately, one should be collected for each sampling crew.

Equipment blanks: Equipment blanks are taken to identify any bias in sampling results attributable to the PDB samplers themselves. The equipment blank is obtained by filling a PDB sampler using the same procedure used for filling all the samplers at the site (e.g., if other samplers are filled using a funnel, follow the same procedure to fill the equipment blank sampler). After filling the sampler, seal it as you would other samplers before deployment, and then gently invert the sampler once to mix the contents. Open the PDBS and transfer a sample into a VOA vial in the same manner as will be used to obtain samples when they will be retrieved after the equilibration period.

- Regulatory Considerations / Requirements
 - Regulatory requirements specific to diffusion samplers have not been identified that would preclude their use
 - Major deterrent to deployment is lack of standard method in States Sampling Procedures Manuals
 - Strong reluctance to switch from methods already in use
 - Technical performance of the Diffusion Sampler is a key issue (this is technical not regulatory)
- Regulatory Acceptance
 - Summary of State experience

No real regulatory issues have been identified that would impede the use of diffusion samplers. The biggest problem we've identified is that there is no set procedure in any States Field Sampling Procedures Manual. The USGS document that the ITRC Work Group helped to develop was the first step to standardizing the approach for the use of Passive Diffusion Bag samplers. In NJ, we are currently revising our Field Sampling Procedures Manual and when it is issued in late Spring of 2002, it will include a section on the use of diffusion samplers. The State of Arizona is also developing guidance on the use of PDBS.

One concern that has been raised often and I think is worth mentioning is ***“how will the data be used”***. If the steps identified in the USGS document are taken to evaluate whether the use of PDBS samplers is appropriate, and regulatory approval is received, then there should be no need to qualify the data. Lab and field data demonstrate that the PDB sampler's work. The contaminants that the samplers are capable of detecting are known. The resulting sample from a passive diffusion bag sampler represents a point sample, which is similar to low flow sampling. In some cases, however, it may be better due to the passive nature of the bag sampler.

Passive Diffusion Bag samplers have been deployed at many sites throughout the country by the Navy, Air Force, and to a lesser extent, private industry. In New Jersey, PDB samplers have been approved and are currently being deployed at the Naval Air Warfare Center in Ewing, and also at the RCA Solid State Division Facility in Bridgewater Township. We have also received increased interest and proposals from other sites undergoing long term ground water monitoring, so the number of sites where they're being used is expected to increase in the near future. In California the samplers will be deployed at several Air Force Bases that are undergoing closure and the Air Force has invited the ITRC to become involved with those projects

- Focus – A Different Sample Collection Method
Once the PDB Sampler is retrieved from the well, all other sampling issues (i.e., sample containers, preservation, chain of custody, analysis, etc....) are identical to conventional sampling methodologies

It needs to be realized that the difference between conventional ground water sampling methods and PDB samplers ends once the sample is removed from the well. After that, the process is identical to convention methods in regard to sample containers, preservation, chain of custody, etc...).

After listening to Don Vrobley's presentation, it should be apparent that there is sufficient data to demonstrate that the samplers work. The main focus then, should be on the applicability of the site in relation to sampler capabilities, how the samplers will be deployed and retrieved, and how the performance of the samplers will be evaluated . Data use is a separate consideration, and clearly different for each site.

- Recommended for long term monitoring at well characterized sites
- Sentinel wells: problem w/unknown contam. depth
- Contaminants of concern must be appropriate for PDBS
- Due to inability to detect iron, sulfate, nitrate, and manganese, PDBS currently not recommended for evaluation of Natural Attenuation processes
[note: PDB samplers can detect DO, Methane, and breakdown prod]

1. PDB samplers are recommended for long term monitoring of VOC contaminated ground water at well characterized sites. This is due to the limited parameter capability of the samplers (selected VOCs), which makes it inappropriate for work associated with remedial investigations. In addition, most sites undergoing long term monitoring have a good amount of historic ground water sampling data available to help evaluate sampler performance.

2. Sentinel wells are located downgradient of contaminant plumes and designed to detect downgradient movement of the plume into clean aquifer zones. Since sentinel wells typically have well-screens greater than five-feet, and since they are predominantly installed in ground water that is not impacted by site related constituents, there is no way to vertically profile the well to determine the most appropriate sampling interval. It is also difficult to accurately estimate at what depth the contaminated ground water might be moving at when it reaches the well. As such, the well would need to be vertically profiled each sampling event to ensure that impact, if present, was detected.

3. Contaminants of concern at the site must be compatible with the capabilities of the PDB samplers (i.e. most VOCs but not acetone, styrene or MTBE).

4. Due to the inability of the samplers to detect many major electron acceptors such as iron, nitrate, sulfate, and manganese, the use of the samplers for evaluating natural attenuation processes is not recommended. However, the samplers are capable of detecting dissolved oxygen, methane, and volatile breakdown products so there is a potential for using the samplers to provide some information on contaminant degradation.

- PDB samples represent a “point sample” so you must accurately measure PDB sampler position in well
 - Use “As built” well diagrams for well info
 - Measure total depth of well, compare to “as-built”
- Must assess potential for vert. stratification
 - At least initially, use multiple bags to vert. profile well
 - based on site conditions, may need to re-assess
- Important to eval. potential for vertical flow in well
 - High potential in bedrock or unconsolidated w/clay & silt
 - Use heat pulse flow meter or similar device

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1. Where there is horizontal ground water flow through the well screen, PDB samplers represent a point sample at the exact depth interval within the well-screen where they are suspended. Because of this, it is essential to know exactly where the sampler was located within the well when evaluating resulting data. Since it is common for proposed well installation specifications to be modified in the field due to drilling difficulties, borehole cave-in or lack of desired well construction materials, it is necessary to use “as built” well diagrams to help assess the appropriate depth for PDB deployment. Occasionally wells are constructed with “sediment traps” or “sumps” which are pieces of blank casing attached to the bottom of a well-screen intended to provide an area where sediment can accumulate without obscuring the well-screen. Care must be taken to identify and account for wells that have sumps below the well-screen when determining PDBS position in the well.

2. Contaminants do not always flow uniformly through an aquifer. Studies presented in Part 2 of the U.S.G.S. Water Resources Report, “*User’s Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells*”, clearly identify common detection of a high degree of chemical variability along the vertical portion of 10-foot well-screens. PDB samplers represent a point source sample from an exact section of screen where the sampler is positioned. If contaminants are migrating through the aquifer above or below where the sampler is positioned, the PDB sampler will not detect it. It is, therefore, necessary to vertically profile a well using multiple PDB samplers to identify the presence of contaminant stratification and to document the most appropriate depth interval for future single sampler deployment.

3. As previously mentioned, in some instances vertical flow can be present within the well. This condition is more common in bedrock aquifers, but it can also be present in unconsolidated formations where the screened interval intersects zones of differing hydraulic head. If vertical flow is present in a well, the VOC concentration in the PDB sampler will be more representative of the water flowing vertically past it from another portion of the aquifer rather than from horizontal ground water quality in the adjacent formation. In these cases, it is necessary to know where the water is coming from and where it is going. This can be accomplished by using a heat-pulse borehole flow meter to take readings at multiple intervals within the well-screen or open borehole. This data can be used in conjunction with vertical profiling to provide a better understanding of contaminant distribution within the aquifer. It will also ensure that generated data is not misinterpreted.

2-week minimum

- may need longer timeframe in tight formations to allow stabilization of water column
- Field studies show longer deployments, up to 3-months, did not encounter problems [i.e. bio-fouling, bag rupture]

- Simple site conditions – comparison to historic data acceptable
- More complicated site conditions: side-by-side comparisons appropriate
- Poor correlation DOES NOT indicate failure
- Identify and agree upon evaluation criteria before deployment

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1. When evaluating the appropriateness of PDB use at a particular well, a common approach is to do a side-by-side comparison with a conventional sampling method. In wells where there is little variation in concentration and ground water elevation, comparison of PDB sampler results to historical sampling results may provide enough information to determine whether PDB samplers are appropriate for the application.
2. At sites where the hydrogeology and ground water flow is more complicated, and/or where there is considerable variability in contaminant concentrations over time, the use of historic data should be supplemented with side-by-side comparisons using conventional ground water sampling methods.
3. It should be emphasized that poor correlation does not indicate the samplers are inappropriate for use. Poor correlation with the sampling method already deployed at the site may merely mean additional investigation is needed to determine the cause of the discrepancy. However, it must also be kept in mind that there are inherent problems with every ground water sampling method. When pumping a well, contaminants could be drawn into the well from locations that would not naturally flow into the well. As such, results from pumping and passive sampling could be significantly different. Considering this, it would not be unusual for results to differ slightly since different sampling methods may be telling different stories. It's more important to look at the magnitude of the difference and the data trends.
4. It is best to identify the criteria which will be used to evaluate sampler performance prior to deployment. As a regulator, I'd might have a tendency NOT to approve use of PDB samplers if there is poor correlation to historic data or side-by-side comparisons. But as you've seen with some of Don Vroblesky's work, the poor correlation may be the result of a problem with the method you are using for comparison, not necessarily the PDB sampler.



Future Work for ITRC Diffusion Sampler Team



Website Development

Enhance website and track PDBS performance, post information on lessons learned and keep updated on advances in passive sampling approaches

ITRC Diffusion Sampler Information Center

<http://DiffusionSampler.itrcweb.org>

Additional Guidance:

Decision Tree, Position Paper, Cost performance template

Continue to Serve as Information Resource

For State / Federal Regulators, Stakeholders, RP's, Consultants

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1. The ITRC Diffusion Sampler Team has developed a website designed to provide up to date information on passive sampling techniques. Information is provided on deployment locations, guidance documents, field reports and lessons learned. The current focus is on the use of PDBS, however, work is currently being conducted on methods for other passive sampling approaches that would permit the collection of samples for semi-volatile and inorganic analysis. As additional information becomes available, it will be posted on the website.
2. The ITRC's mission in general is to assist in the development and use of innovative technology so contaminated sites can be cleaned up more more efficiently and more cost effectively. In this respect, the ITRC-DS Team will continue to act as an information resource to State Regulators, Stakeholders, and interested parties to assist in the successful deployment of diffusion sampler technology.



Helpful Hint:
*Securely Attach
the Line at the
Well Head*

Thank you for
attending this ITRC
training course.

Instructor Notes:

None

[Links to Additional Resources](#)

ITRC – Shaping the Future of Regulatory Acceptance
www.itrcweb.org

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Links to additional resources: <http://www.clu-in.org/conf/itrc/diffusion/resource.htm>

Your feedback is important – please fill out the form at: <http://www.clu-in.org/conf/itrc/diffusion/feedback.cfm>

The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:

- helping regulators build their knowledge base and raise their confidence about new environmental technologies
- helping regulators save time and money when evaluating environmental technologies
- guiding technology developers in the collection of performance data to satisfy the requirements of multiple states
- helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations
- providing a reliable network among members of the environmental community to focus on innovative environmental technologies

•How you can get involved in ITRC:

- Join a team – with just 10% of your time you can have a positive impact on the regulatory process
- Sponsor ITRC's technical teams and other activities
- Be an official state member by appointing a POC (Point of Contact) to the State Engagement Team
- Use our products and attend our training courses
- Submit proposals for new technical teams and projects
- Be part of our annual conference where you can learn the most up-to-date information about regulatory issues surrounding innovative technologies