Results from Recent Studies Evaluating the Snap Sampler

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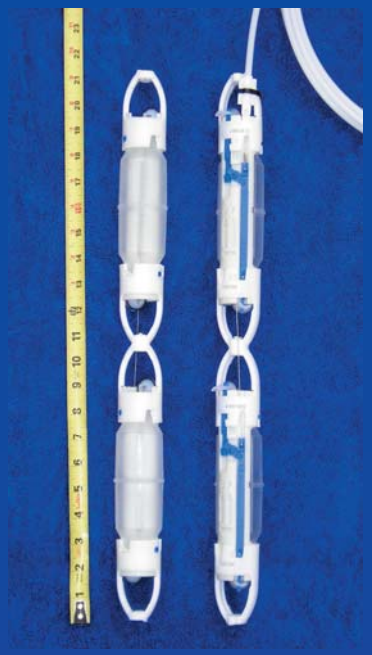
What is the Snap Sampler?



- **Equilibrated-grab sampler (ITRC 2006, 2007)**
  - **Grab sampler left in well for equilibration period prior to sample collection**
    - **Allows well to recover from disturbance caused by placing sampler in well**
      - **2 week minimum (ITRC 2001, 2004, 2006, 2007)**
    - **Gives materials in sampler time to equilibrate with analytes in well water**
- **Collects sample from discrete interval in well screen**
- **Collects whole water samples**
- **Collects samples in “real time”**

Components of the Snap Sampler

- **Sampler body with trigger mechanism**
- **Snap Sampler bottles**
  - **Openings on 2 ends with spring-activated caps**
  - **Teflon caps**
  - **Teflon-coated spring**
  - **40-mL VOA vials**
  - **250-mL PP bottles**
- **Trigger line**
  - **Teflon-coated wireline cable inside PE tube**
- **Docking station**
  - **Holds sampler in place**

Deploying the Snap Sampler

- Place bottle in sampler body
- Place end caps (of bottles) in open position
- Cock sampler & attach trigger line to sampler
  - Can deploy up to 4 samplers on single trigger line
- Lower sampler by trigger line to sampling depth & attach to docking station
- Leave sampler in well for next sampling event
  - Quarterly, semi-annual, or annual sampling event
  - 2 week minimum equilibration time (ITRC)

Advantages

- Sample is sealed under *in-situ* conditions*
- No chance for interaction with water column as sample is brought to surface
- No sample transfer at well head required*

* Can be important for VOCs, gases, metals subject to oxidation/precipitation reactions

Experimental Approach

Conduct laboratory and field studies to evaluate the performance of these samplers

Lab Studies- Compare concentrations of analytes in samples taken with sampler with control samples taken from a standpipe containing a test solution with known concentrations of analytes

Field Studies- Compare concentrations of analytes in samples taken with sampler with samples taken using EPA's low-flow purging & sampling protocol

Lab Studies Protocol

- Used a 8-in. ID, 8-ft. tall PVC standpipe
- Test Solution contained a suite of either VOCs, explosives, or inorganics
- Samplers deployed at same depth as sampling spigot
- Samplers left to equilibrate with test solution, typically 24 hours
- Control samples collected from spigot
- Alternate sampling order between samplers & control samples

Standpipe Study – Six Explosives

(Parker and Mulherin 2007)

Test solution: HMX, RDX, 2,4,6-TNT, 1,3,5-TNB, 1,3-DNB, & 2,4-DNT

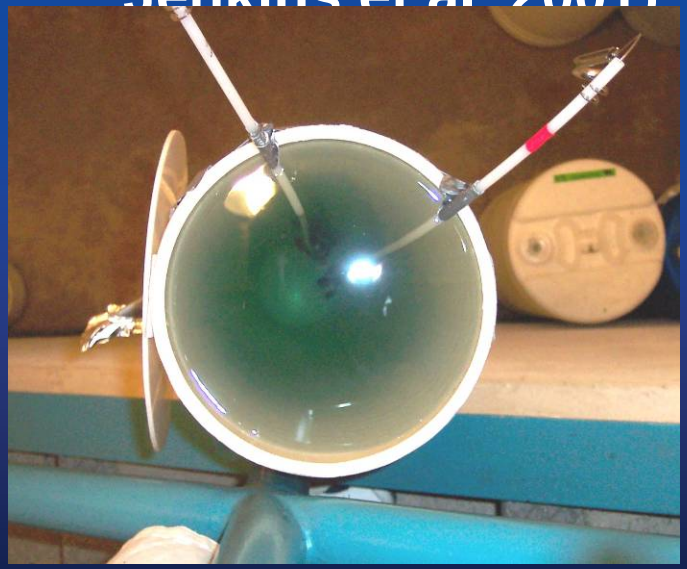
Deployed 5 samplers (125-mL glass bottles) in standpipe

Equilibration time = 24 hr

Analyses: next day by RP-HPLC (Walsh & Ranney 1999, Jenkins et al. 2001)

Mean Conc. (mg/L)

	Control	Snap S
HMX	0.682	0.704
TNB	1.94	1.94
RDX	5.93	5.92
TNT	1.40	1.39



No significant differences for any of 6 explosives at 95% confidence level using a paired t-test

Holding-time Study – Explosives (Parker & Mulherin 2007)

Previous samples analyzed almost immediately

Objective : Determine if analyte recovery the same for samples held maximum holding time

Similar protocol except that samplers held for max. holding time prior to analyses (i.e., 7 days with no preservative)

	Percent recovery of Snap Sampler
TNB	99.8
RDX	99.3
DNB	99.4
TNT	99.4
NB	99.1
DNT	100

Essentially 100% recovery with 24-hr equilibration time

Standpipe Study – VOCs (Parker & Mulherin 2007)

Deployed 6 samplers (40-mL VOA vials)

Equilibration time = 24 hr

Analyses: RP-HPLC (Parker & Ranney 1998)

	Mean Conc. (mg/L)	
	Control	Snap Sampler
t-DCE	0.940	0.930
BENZ	0.994	0.989
TCE	0.970	0.965
TOL	0.970	0.962
o-DCB	1.02	1.01
m-XYL	0.958	0.947
PCE	0.906	0.895

No significant differences for any of 7 VOCs at 95% confidence level using a paired t-test

VOCs Holding-Time Study (Parker & Mulherin 2007)

Deployed 5 samplers

Samples acid preserved & held for max. holding time (14 days)

Mean percent recovery

Equilibration time =	1 day	3 days
t-DCE	95.4*	101.5
BENZ	99.5	102.9*
TCE	94.1*	100.5
TOL	94.1*	96.5*
o-DCB	91.1*	98.0*
m-XYL	64*	77*
PCE	84*	96.2*

*Values were significantly different from control values

Conclusions: After 3 days equilibration, differences < 5% except for *m*-xylene

~3 days equilibration is needed for VOCs

Standpipe Study – Metals

- Similar protocol to previous studies
  - Used 125-mL PP Snap Sampler bottles
- Deployed 5 trigger lines with 3 samplers per line
- Test solution contained suite of metals
  - As, Cd, Cr, Pb, Ni, & Zn
  - Concentrations ranged from ~200 to 400 mg/L
- Recovered one set of samples after 24, 48, & 72 hr
- Analyses by ICP– Atomic Emission Spectroscopy
  - ERDC-EL using EPA method 6010B

Standpipe Study – Metals

Percent recovery of metals[1] for different equilibration times

Analyte	24 hr	48 hr	72 hr	
As	100.0	99.6	100.1	
Cd	100.7	98.0	100.5	Good recovery
Cr	98.5	98.4	99.5	
Pb	95.1	94.3	94.4	
Ni	94.5	91.7	91.9	Not as good
Zn	78.3	80.9	79.6	

[1] (Snap Sampler conc./ Control conc.) * 100

Standpipe Study – Metals

Percent recovery of metals[1] for different equilibration times

Analyte	24 hr	48 hr	72 hr	50 day
As	100.0	99.6	100.1	100.9
Cd	100.7	98.0	100.5	100.7
Cr	98.5	98.4	99.5	100.2
Pb	95.1	94.3	94.4	89.5
Ni	94.5	91.7	91.9	93.4
Zn	78.3	80.9	79.6	69.2

[1] (Snap Sampler conc./ Control conc.) * 100

Standpipe Study – Metals

Mean conc. (mg/L)

	Arsenic		Lead		Nickel		Zinc	
Time	C	Snap	C	Snap	C	Snap	C	Snap
24 hr	195	195	197	188	373	353	438	343
48 hr	195	194	198	187	387	355	428	346
72 hr	194	194	199	188	398	365	441	351
50 day	188	190	231	207	478	447	1031	714

% increase in controls from day 1

17% 28% 135%

C = Control sample

Conclusions

- Lower concentrations of Pb, Ni, & Zn in Snap Sampler samples due to leaching of metals from spigot into control samples
- Snap Sampler able to recover representative concentrations of As, Cd, & Cr
- Need confirmation for wider range of inorganics

Standpipe Study – Cations & Anions

- Similar protocol to previous study
  - Used replacement HDPE spigot
- Deployed 3 trigger lines with 2 samplers per line
- Test solution contained suite of cations and anions
  - Ca, K, Mg, Mn, & Na
  - Bromide, chloride, nitrate, perchlorate, & sulfate
  - Concentrations ranged from 10 to 80 mg/L
- Recovered one set of samples after 24, 48, & 72 hr
- Analyses by IC
  - ERDC-EL-MS using EPA methods 300.0 & 314.0 (perchlorate)

Standpipe Study –Cations

	Snap Sampler % recovery	
Analyte	24 hr	48 hr
Ca	98.7	100
K	100	102
Mg	97.4	100
Mn	98.3	99.4
Na	99.2	101

Standpipe Study – Anions

	Snap Sampler % recovery	
Analyte	24 hr	48 hr
Bromide	99.1	100.6
Chloride	96.2	107
Nitrate	100.0	100.8
Perchlorate	100.8	106
Sulfate	102	102

Conclusion: Able to recover 99% or more of all anions and cations after equilibrating sampler for 48 hours

CRREL Field Study – TCE (Parker & Mulherin 2007)

- Used CRREL 4-in. well contaminated w/ TCE
- Low-flow samples collected with ¾-in. bladder pump
- Deployed Snap Sampler at same depth as pump inlet
  (1 VOA vial on trigger line)

- Equilibration time = 24 hr
- Triggered Snap Sampler closing sampler
- Collected low-flow samples
- Removed Snap Sampler from well and recovered sample vial
- Placed new vial in Snap Sampler & returned it to well
- Repeated the process until 5 sets of samples were collected
- Samples taken to lab & analyzed same day using RP-HPLC (Parker and Ranney 2000)

CRREL Field Study – TCE

(Parker & Mulherin 2007)

	TCE conc. mg/L	
	Low-flow	Snap S
10- May	0.070	0.070
11- May	0.064	0.067
12- May	0.066	0.067
13- May	0.062	0.063
17- May	0.061	0.063
Mean	0.064	0.066

No significant difference at 95% conf. level

Field Study – VOCs

Silresim Super Fund Site Lowell (Parker & Mulherin 2007)

Analytes: 13 VOCs included chloroethanes, chloroethenes, & BTEX compounds

Used similar protocol to previous study except that

- Sampled four wells; each well sampled once
  - Three 2-in. wells & one 6-in. well
- Deployed a ¾-in. bladder pump in each well

- Deployed one trigger line with 2 Snap Samplers in tandem in each well
  - Used 40-mL VOA vials
  - Samplers straddled pump inlet
- Allowed the samplers to equilibrate 3 or 4 days
- Samples shipped samples on ice to lab for analyses by GC/MS (EPA Method 8260B)

Field Study- VOCs Silresim Site

(Parker & Mulherin 2007)

Examples:	Analyte	Well #	Conc. (µg/L) Snap	Low-flow
	Benzene	701B	80	80
		702B	2500	3000
		703A	150	170
	1,1-DCE	EW-10	75	70
		701B	495	445
		702B	9500	11500
		703A	2	2

No statistically significant differences for any of VOCs
Using either paired t-test (95% confidence level) or Wilcoxon signed rank test

Field Study – Explosives

Former Louisiana Army Ammunition Plant

(Parker & Mulherin 2007)

Protocol similar to previous study except that

- **Sampled five 4-in. diameter wells**
- **Each trigger line had three 125-mL glass bottles**
- **Analyses by RP-HPLC (EPA Method 8330)**

Deployment time was 3 or 4 days

Field Study – Explosives (Parker & Mulherin 2007)

	Mean Concentration (mg/L)					
	HMX		RDX		TNT	
Well #	LF*	SS	LF*	SS	LF*	SS
104	2.39	2.18	16.6	16.9	7.50	7.56
105	0.448	0.424	4.30	4.28	0.736	0.676
108	0.025	0.031	0.330	0.407	0.896	0.771
110	0.526	0.497	5.43	5.37	0.749	0.604
140	0.087	0.079	1.36	1.26	0.345	0.312

No significant difference for any of the 6 analytes at 95% confidence level using a paired t-test

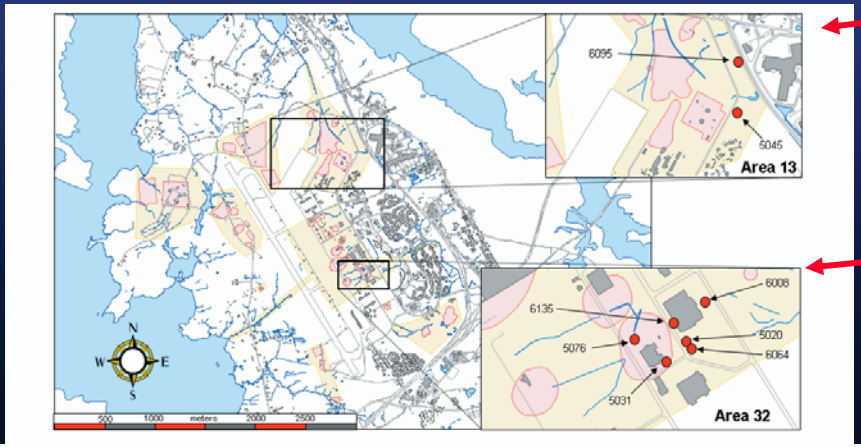
* LF = Low-flow samples

ESTCP-Sponsored Demonstration at former Pease AFB

Analytes: Inorganics (As, Ca, Fe, Mg, Mn, K, & Na)
Location: Newington & Portsmouth, NH
Geology:
- **Unconsolidated Units: Fill, Upper Sand, Marine Clay & Silt, Lower Sand, & Glacial Till**
- **Bedrock: Kittery or Elliot formation**

Eight monitoring wells used in the study
- **Six 10-ft screens, one 5-ft screen, two 15-ft screens**

Bottom of wells ranged from 13’ to 60’ bgs
Top of screens were 2’ to 35’ below the water table

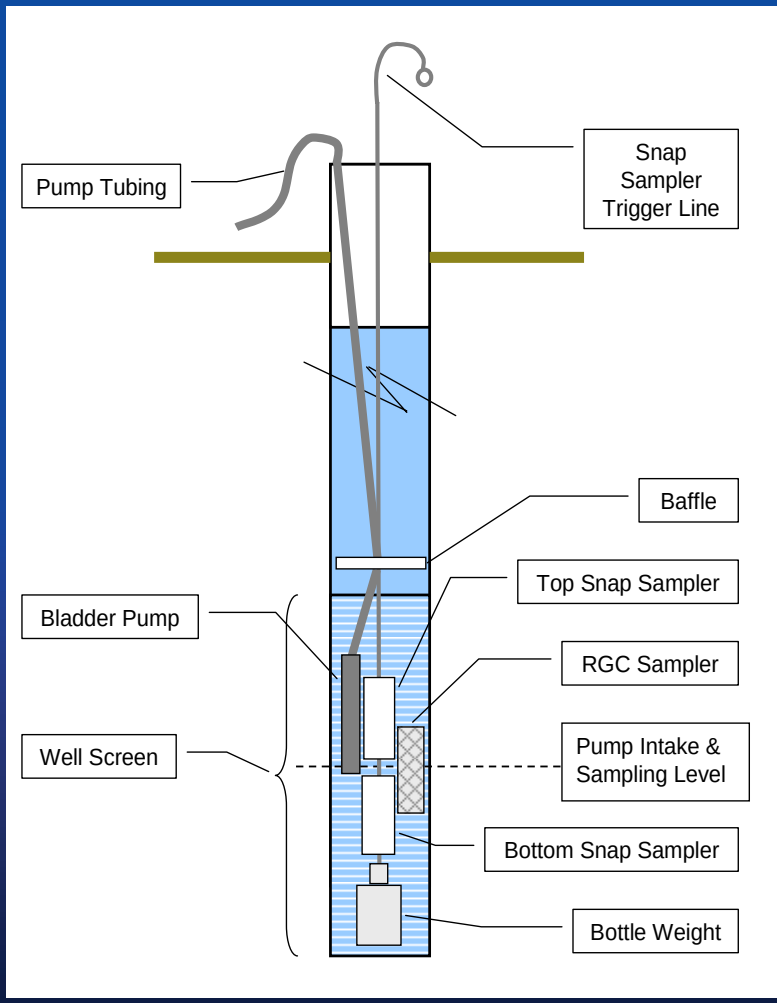


Area 13 Bulk fuel storage area
- **1 overburden well**
- **1 bedrock well**

Area 32 Building 113 UST
- **3 overburden wells**
- **3 bedrock wells**

Pease Field Demonstration– Inorganics

- Ten sampling events
  - Two wells sampled twice
- Deployed at same depth
  - ¾-in. bladder pump
  - 1 RGC sampler
  - 2 Snap samplers w/ baffle & weight
- Deployment time 14 - 17 days
- Samples collected
  - Snap Sampler, filtered & unfiltered
  - RGC sampler
  - Low-flow Purging & Sampling
    - filtered & unfiltered
  - QA/QC samples
    - Field duplicates (10%)
    - Matrix spikes & MSDs (5%)



Pease Field Demonstration Plan continued

- **Sampling order**
  - ***First two wells*** **(32-6064, 32-5020)**
    - **Snap (left in well), RGC, & low-flow**
  - ***All remaining wells***
    - **Snap (left in well), low-flow, RGC**
- **Chemical Analyses**
  - **EPA Method 6020B, ICP/MS**
- **Data Analyses**
  - **For each analyte, concentrations in Snap Sampler were compared with concentrations in the low-flow samples & RGC samples**
    - **Filtered samples were compared with RGC samples**
    - **Unfiltered samples were compared w/ RGC samples**
- **Statistical Analyses**
  - **Repeated Measures ANOVA (RM-ANOVA) or Freidman RM-ANOVA (non-parametric)**

Pease Demonstration Results

Example: Conc. Calcium (mg/L)– unfiltered samples

Well #	Low-flow	RGC	Snap
13-5045	72	71	66
13-6095	42	43	41
32-5020	230	250	190
32-5020	150	30	150
32-5031	75	86	97
32-5076	58	58	53
32-6008	98	98	100
32-6064	170	170	180
32-6064	110	110	110
32-6135	4.3	4.4	5.1
Mean	101[c]	102[c]	99[c]

No statistically significant difference between values with same letter

Results for Unfiltered Low-Flow and Snap Samples vs. RGC Samples

Analyte	% RSD*	Mean conc. (mg/L) for 10 events *Unfiltered* Low-flow	RGC	*Unfiltered* Snap
As	0-3.8%	0.086[c]	0.090[c]	0.10[c]
Ca	0-4.9%	101[c]	102[c]	99[c]
Fe	0-12%	3.8[c]	4.2[c]	7.4[d]
Mg	0%	27[c]	27[c]	27[c]
Mn	2.7- 5.7%	1.8[c]	1.9[c]	1.9[c]
K	3.1- 6.4%	6.7[c]	6.7[c]	7.0[c]
Na	2.0- 10%	77[c]	68[c]	66[c]

* For field duplicates

No statistically significant difference between values with same letter

Results for filtered Low-Flow and Snap Samples vs. RGC Samples

Analyte	% RSD*	Mean conc. (mg/L) for 10 events *filtered* Low-flow	RGC	*filtered* Snap
As	0 - 2.6%	0.055[a]	0.090[b]	0.045[a]
Ca	1.7 - 5.1%	100[a]	102[a]	103[a]
Fe	0%	1.1[a]	4.2[b]	1.2[a]
Mg	4.4 - 9.3%	27[a]	27[a]	27[a]
Mn	1.8 - 3.3%	1.9[a]	1.9[a]	1.9[a]
K	4.0 - 4.4%	6.8[a]	6.7[a]	6.7[a]
Na	0 - 11%	74[a]	68[b]	69[a,b]

* For lab duplicates
No statistically significant difference between values with same letter

Summary of Findings from Demonstration at former Pease AFB

- Snap Sampler shown to be able to recover equivalent concentrations of inorganic analytes to those recovered using low-flow sampling
  - True for both filtered and unfiltered samples,
    - –with possible exception of unfiltered Fe
  - True for both bedrock and overburden wells

Final Conclusions

- **Lab Studies** ***Snap sampler samples compared with control samples***
  - **Able to recover equivalent concentrations of explosives, with equilibration time of 1 day**
  - **Able to recover equivalent concentrations of VOCs, with equilibration time of ~3 days**
  - **Able to recover equivalent concentrations of metals, with equilibration times of 1 to 2 days**

- **Field Studies** ***Snap Sampler samples compared with samples taken using EPA's low-flow purging & sampling method***
  - **Able to recover equivalent concentrations of VOCs**
  - **Able to recover equivalent concentrations of explosives**
  - **Able to recover equivalent concentrations of inorganics**

Thanks to our sponsors!

ESTCP, Dr. Andrea Leeson, Environmental Restoration Program Manager

ERDC, Dr. Denise MacMillan, Program Manager

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To download Parker & Mulherin (2007):

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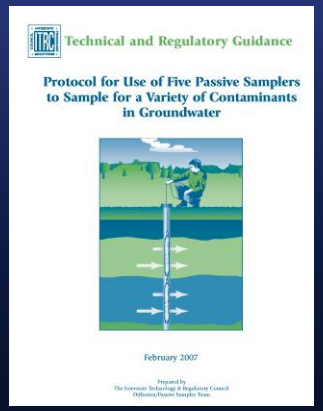

For additional information on this & other passive samplers:

http://www.itrcweb.org/

Questions?