



Operating Experience with a Near-Real-Time Ambient Airborne Metals Instrument System (Cooper Environmental Systems Xact 620)

National Ambient Air Monitoring Conference, Nashville, Tennessee

November 2-5, 2009



**Missouri Department of Natural Resources, Air Pollution
Control Program and Environmental Services Program
Washington University, St. Louis
U. S. EPA**

Introduction

- **The St. Louis Community Air Project (CAP) and the Blair St. National Air Toxics Trends Station (NATTS) have measured elevated concentrations of airborne arsenic in St. Louis.**
- **Missouri DNR and Washington University obtained a Community-Scale Air Toxics grant from EPA to better determine sources of arsenic and other species in St. Louis.**
- **A Cooper Xact 620 was purchased on this grant and operated at multiple sites.**

Project Plan

- **Phase I. Spatially and Temporally Enhanced 24-hour Integrated Measurements**
 - 1-in-3 day PM₁₀ sampling and metals analysis by ICPMS at 4 sites in the St. Louis area for 1 year (MDL~0.02-0.03 ng/m³, 24-hr samples)
- **Phase II. High Time Resolution Measurements**
 - Time-resolved near-real-time analysis at six sites in the St. Louis area for 1 month at each site (MDL<0.1 ng/m³, possibly as low as 0.01 ng/m³, 2-hr samples)
- **Data Analysis and Reporting**
 - Source apportionment, source identification, model comparisons

Cooper Environmental Services

Xact 620 Ambient Air Toxic Metals Monitor



PM10 size-selective inlet

Temperature controlled cabinet

Heater

Sampling & Analysis Module

Operator interface/control panel

Flow control module

ELEMENTS THE XACT CAN MEASURE (IN BLUE)

1	1	2															18
1	1																2
	H																He
	1.0079																4.0026
2	3	4															10
	Li	Be															Ne
	6.941	9.0122															20.18
3	11	12															18
	Na	Mg															Ar
	22.99	24.305															39.948
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	36
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br
	39.098	40.078	44.956	47.88	50.942	51.996	54.938	55.847	58.933	58.693	63.546	65.39	69.723	72.61	74.922	78.96	79.904
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	54
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	Xe
	85.468	87.62	88.906	91.224	92.906	95.94	(97.91)	101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.6	131.29
6	55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	86
	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	Rn
	132.91	137.33	138.91	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.2	208.98	(209)	(222)
7	87	88	89	104	105	106	107	108	109	110	111						
	Fr	Ra	Ac	Rf	Ha	Sg	Ns	Hs	Mt	Unn	Unu						
	(223)	(226)	(227)	(261.1)	(262.1)	(263.1)	(262.1)	(265.1)	(266.1)	(268)	(269)						

Lanthanide Series

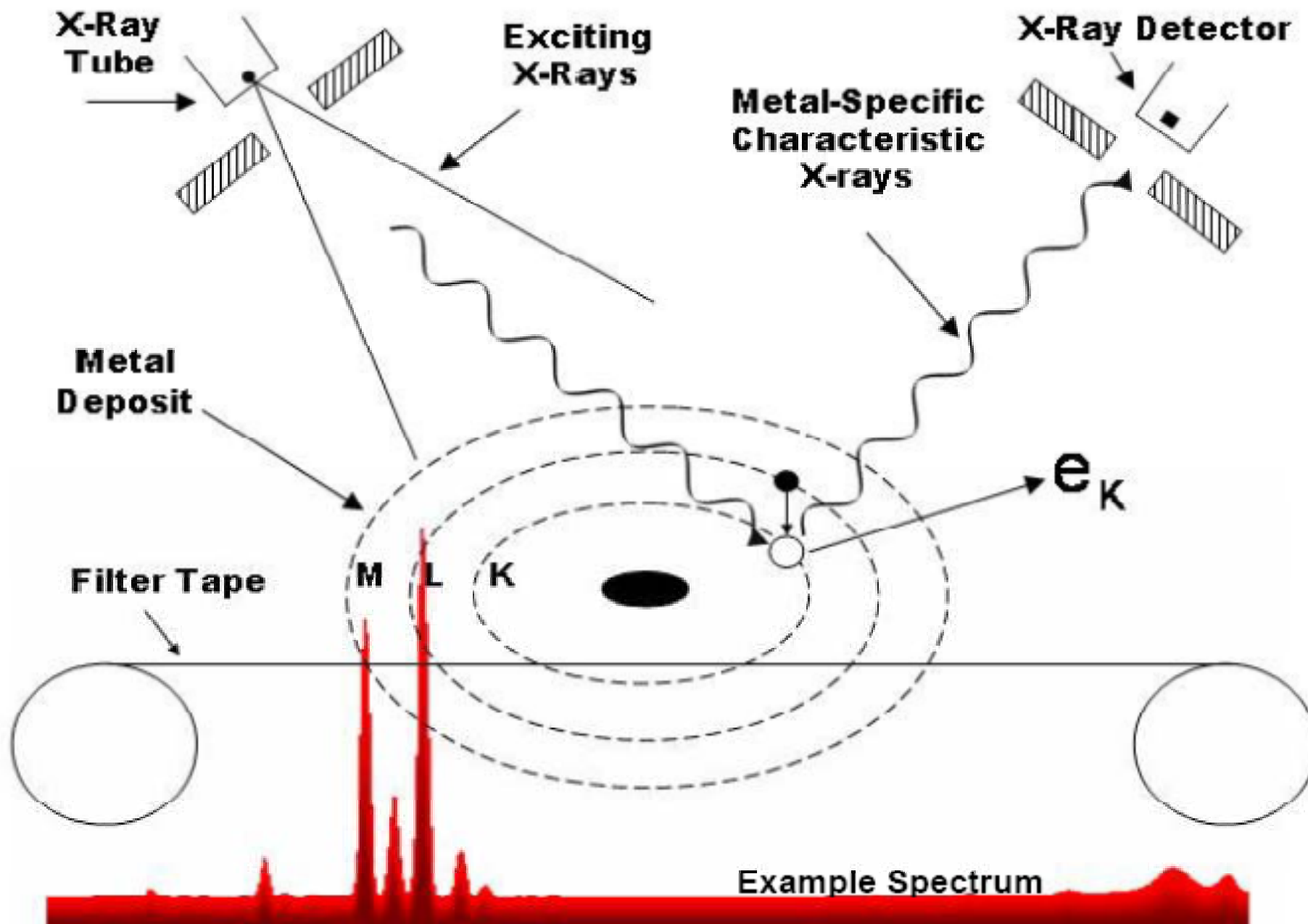
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
140.12	140.91	144.24	(144.9)	150.36	151.97	157.25	158.93	162.5	164.93	167.26	168.93	173.04	174.97
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
232.04	231.04	238.03	(237)	(244.1)	(243.1)	(247.1)	(247.1)	(251.1)	(252.1)	(257.1)	(258.1)	(259.1)	(262.1)

Actinide Series

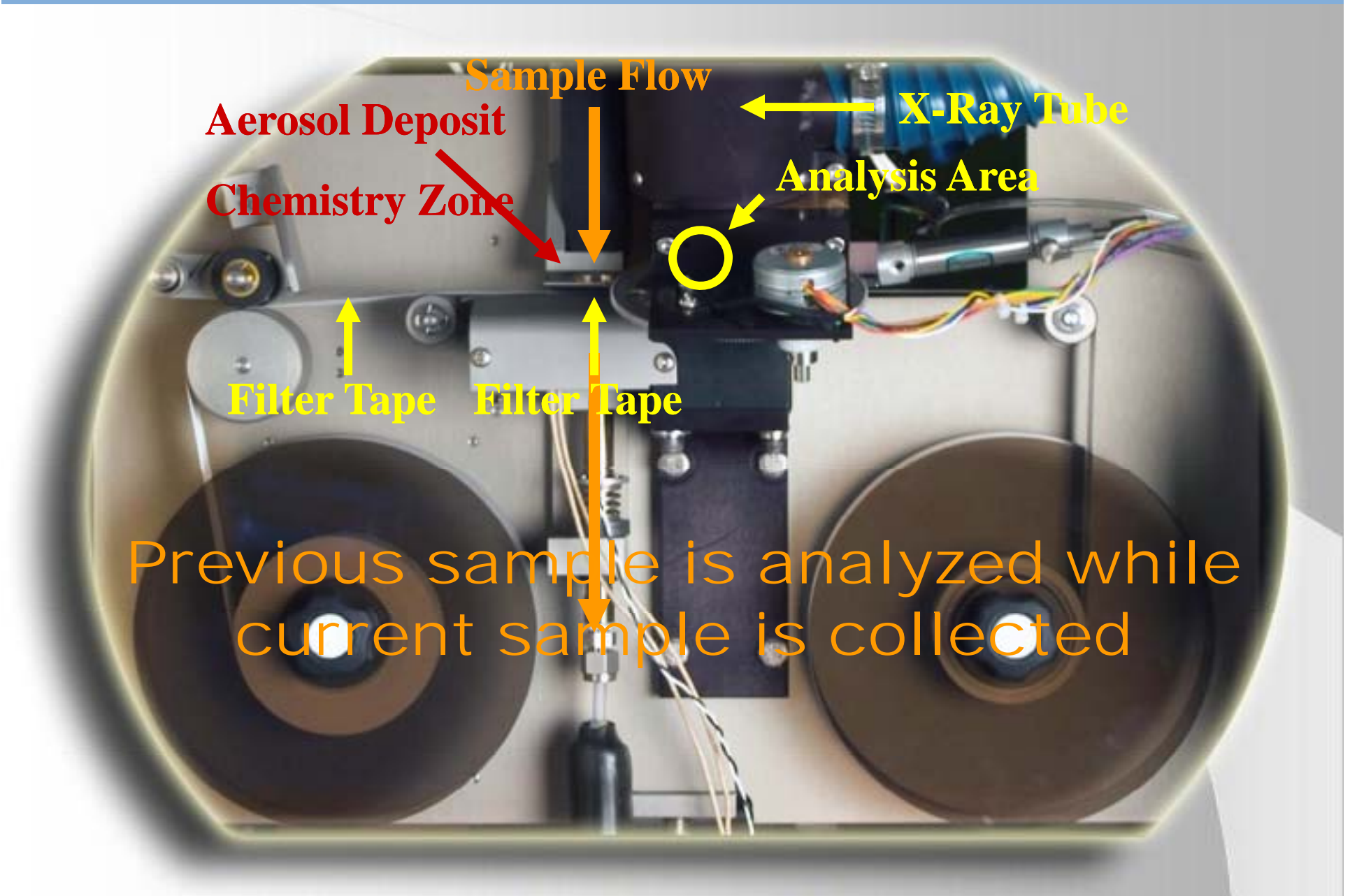
○ measured by Xact in this study

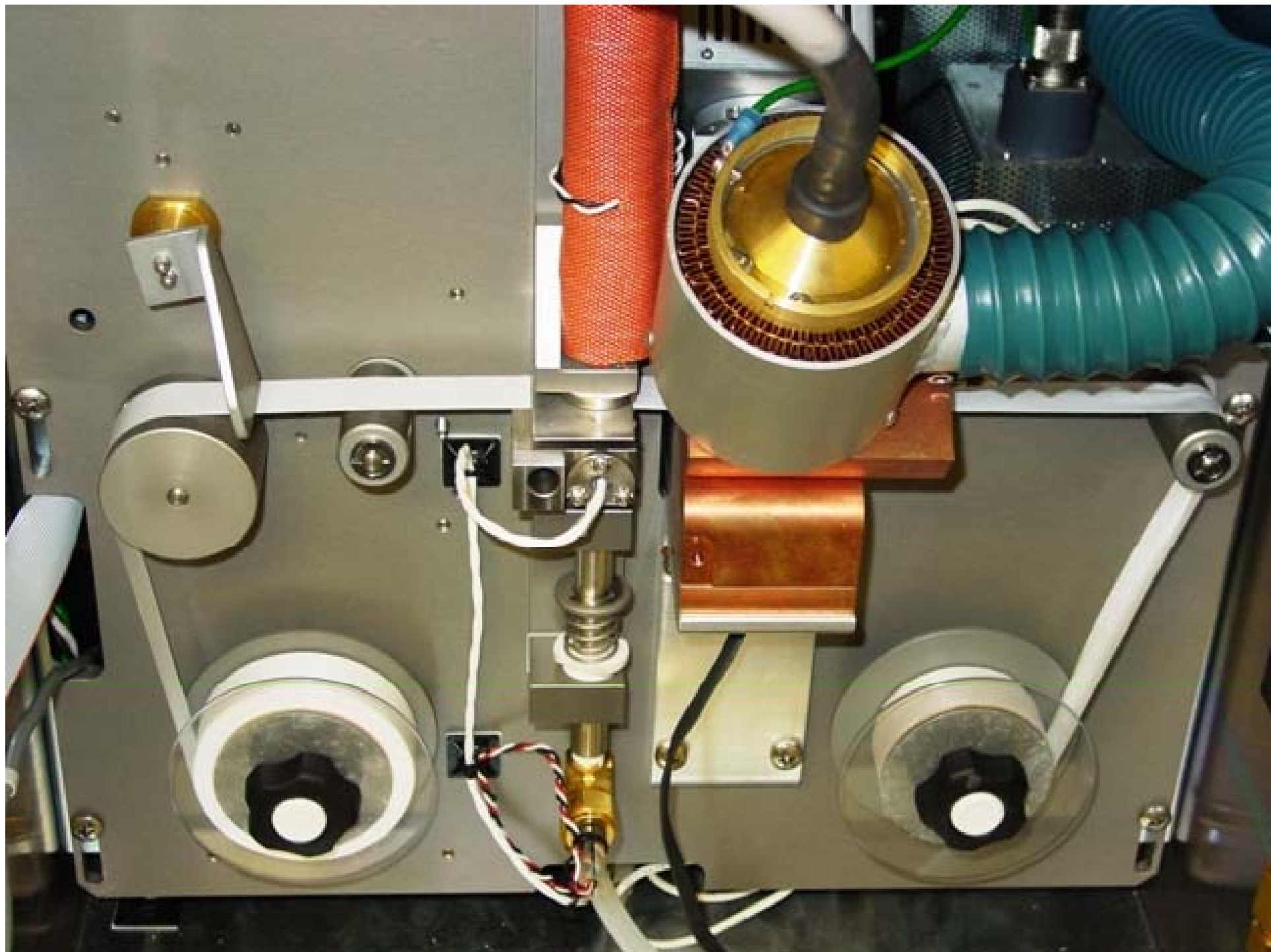
○ EPA Air Toxics PM metals

DIAGRAM OF X-RAY FLUORESCENCE TECHNOLOGY



Xact Sampling and Analysis





Xact Tape Deposits

A photograph of a white Xact Tape strip, which is a type of forensic evidence tape used for marking and measuring. The tape is laid horizontally across a dark, textured surface. Three circular deposits, likely made of a fine mesh or screen, are visible on the tape. A red arrow points to the leftmost deposit. The text 'Xact Tape Deposits' is overlaid in the upper half, and 'Deposit Area 0.747 cm²' is overlaid in the lower half.

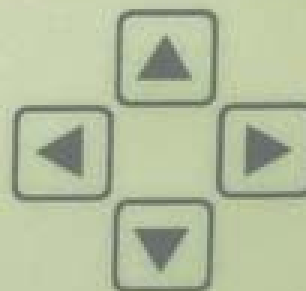
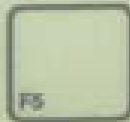
Deposit Area 0.747 cm^2



Xact 620 14-OCT-09 09:49:17
01 AT 8.9 C
02 SAMPLE 24.3 C
03 BP 751.6 mmHg
04 TAPE 744.9 mmHg
05 SAMPLE 54 %
06 FLOW 25 0.0 slpm
SETUP OPERATE STATUS TEST



CONTRAST



Remote Control

My Computer 08_02_200...

Windows Explorer Command Prompt 8832 Ethernet.bf Shortcut to Xact.exe Shortcut to CES_XRF_C...

CES Xact Power Control Program

Power OFF Xact

Power ON Xact

Xact Power is ON

Symantec pcAnywhere New Xact Terminal

UpdateCloc... Xact Terminal

MO DEQ Patches Malwarebytes' Anti-Malware

CES XRF Control

XRS-FP

state report.TXT

latest server.cfg

System

CES XRF Control

Reset Vortex

Query Vortex Status

Query VTX Connection

Query Vortex Firmware

Query Baseline Parameters

Initialize Vortex DPP

Live Time Preset Mode Setting Real Time

Set Parameters

☒ Auto Current

- Channels 2048

Bin Size 20

Preset Time 14400

Peaking Time 1.0

Slow Threshold 0

Energy Threshold 650

Energy Cal

ADC Gain = 35261

☐ LogFile ?

Start Acquire

Stop Acquire

Enable Debug

Status ?

☒ Debug Display

ABORT !

X-RAY POWER CONTROL

Target KV 49

Actual KV 48.94

Target uA 510

Actual uA 992.27

24 VDC 23.47

HYPS Temp 60.83

XRAY ON

XRAY OFF

14400 Second Acquisition in Progress
Acquire Start Time = 12:00:42 Elapsed Time = 00:51:10
Real Time = 1200.00 Accum Real Time = 2400.00
LiveTime = 979.36 Accum Live Time = 1958.93
Dead Time = 18.23
Acq No. 2 Of 12 Completed
High Voltage Power = 48.93 KV
Beam Current = 992.27
DC 24 Volt Source = 23.48
HYPS Temperature = 60.9 Degrees C

XRF Control Status = Acquiring HVPS Status = True
Acquiring State = True Multi-Acquire Flag = True

Last Error Msg None as of 10/28/2009 11:59 56 AM

Last Ecal Status Eca OK !! 10/28/2009 12:03:27 AM

XRS-FP --> Analyze()

Exit Program

Set ADC Gain

Set Status

Emergency XRAY OFF !

Load File

Modbus Read

Write

Error

XRF Control Status

1188050

683

0

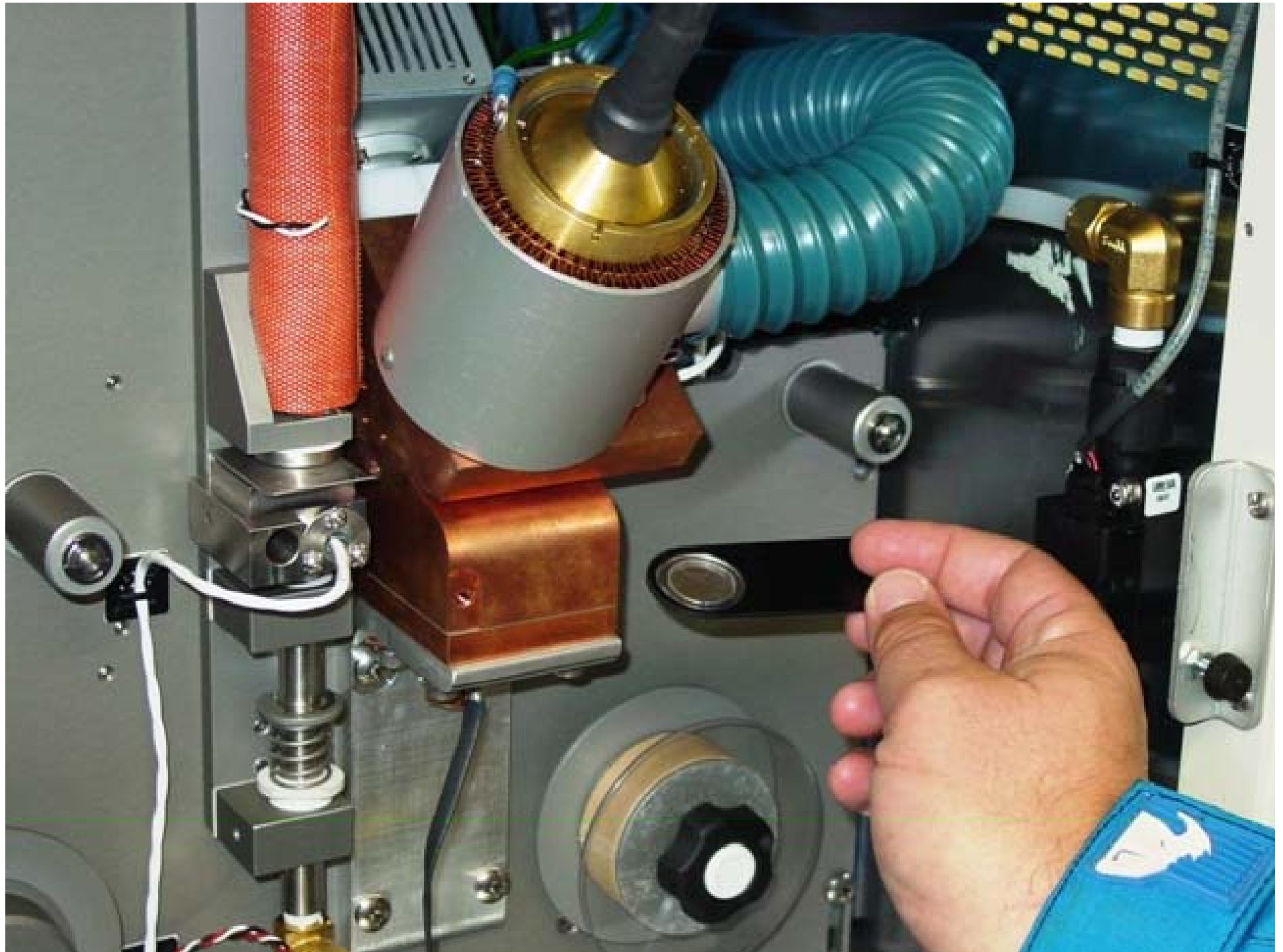
Acquiring



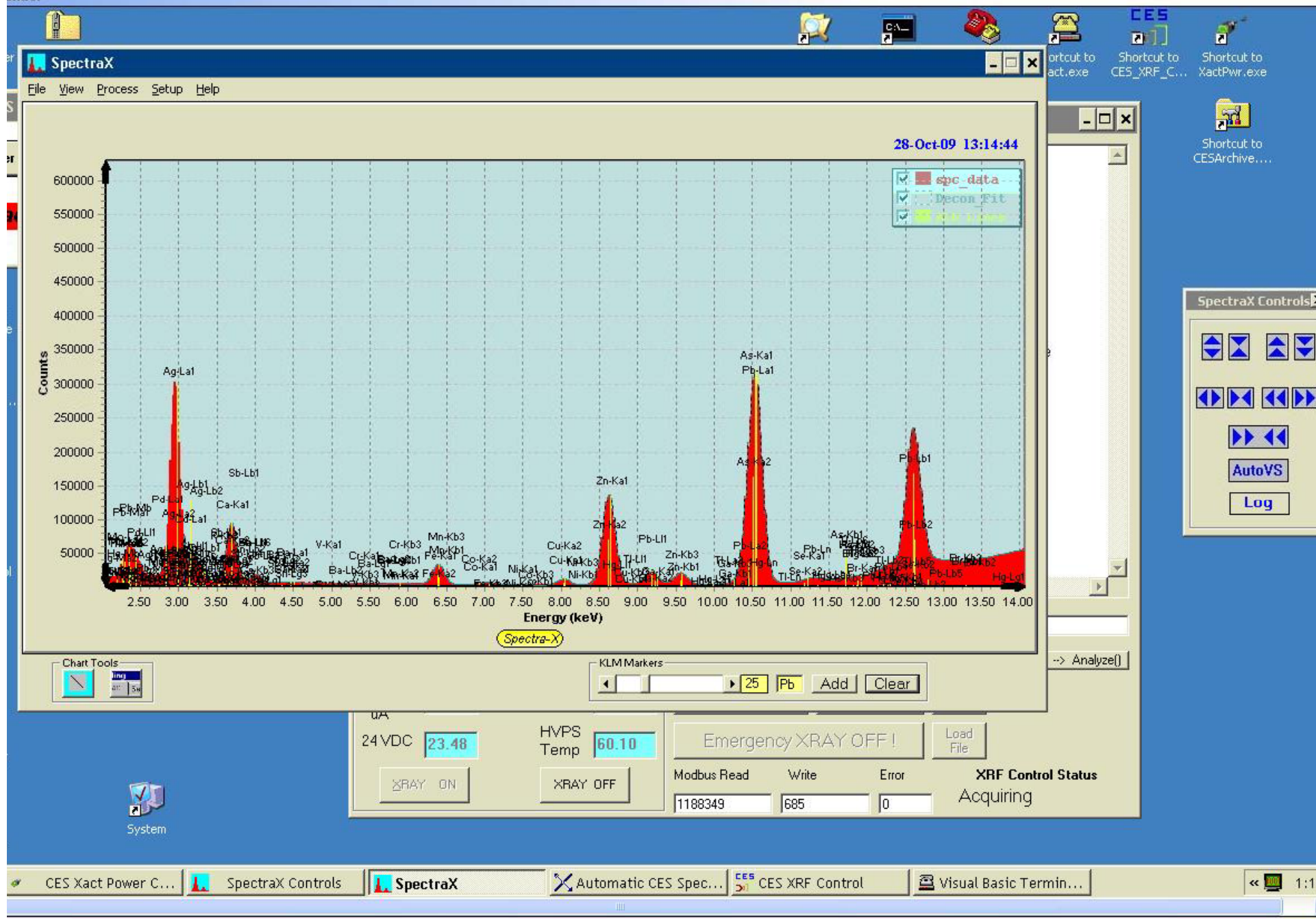
XRF Control Initialization: The parameter description

XRF Control, version 14.1, and higher use an initialization file to set the control when the parameters are not defined. The initialization file is located in the directory: `\\fs1\control\init\`. The initialization file is used to set the control when the parameters are not defined. The initialization file is used to set the control when the parameters are not defined. The initialization file is used to set the control when the parameters are not defined.

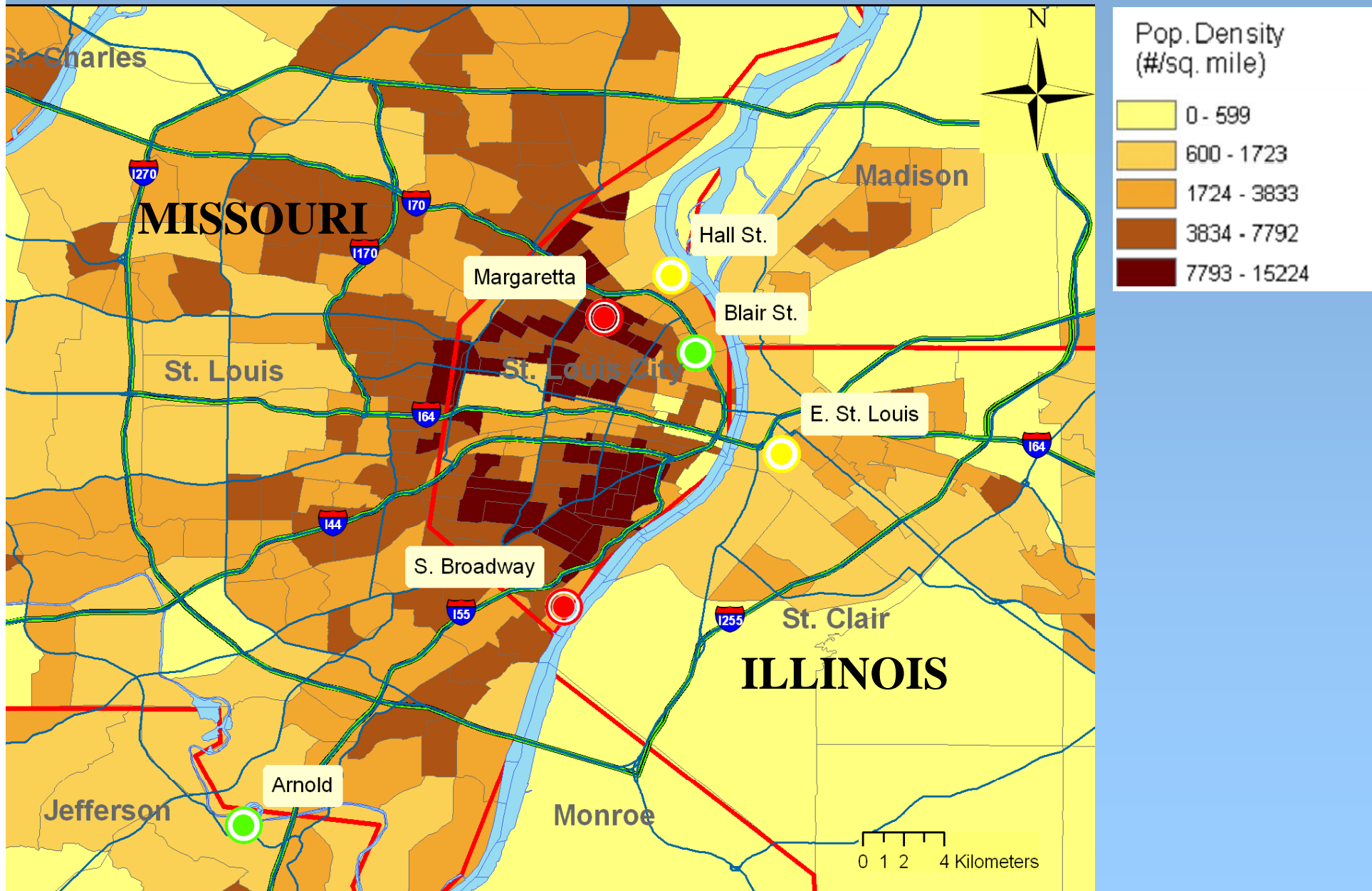
14



Control

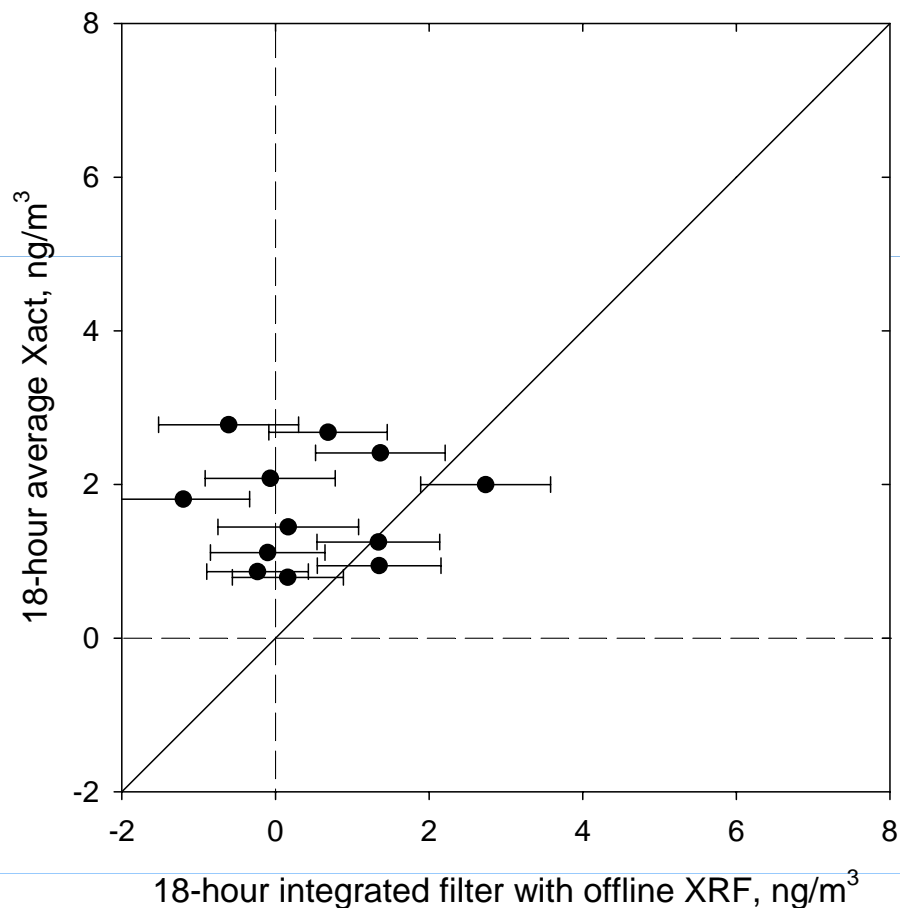


Phase II Xact Monitoring Sites

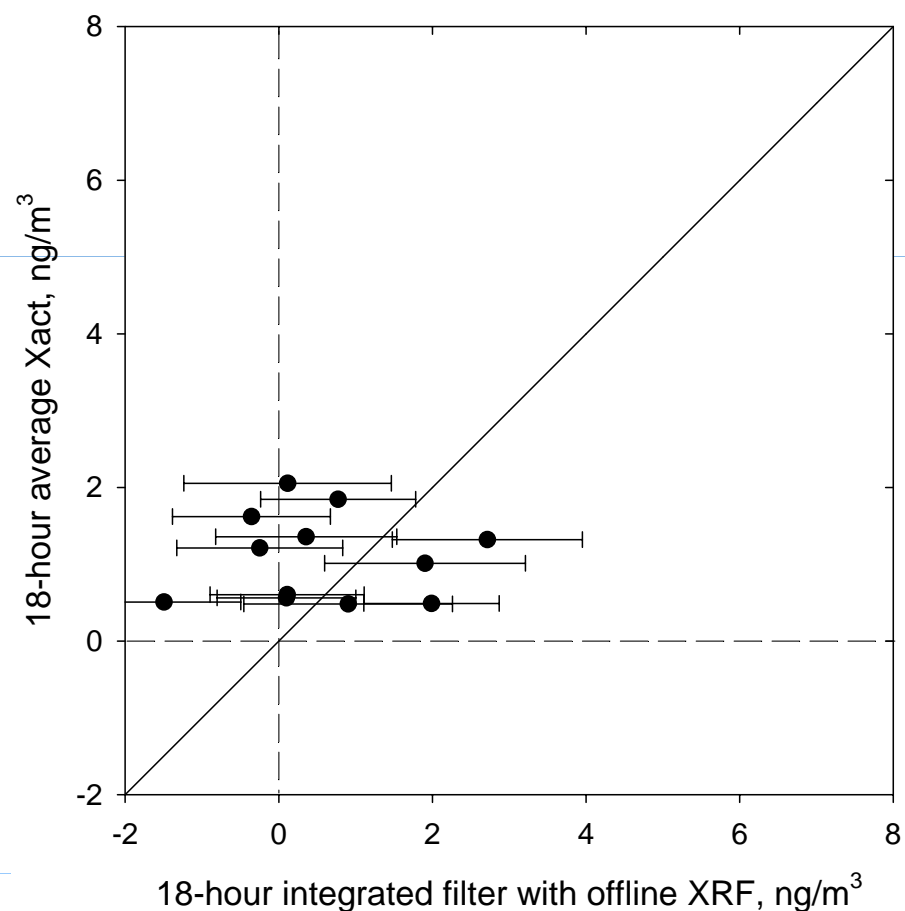


Xact vs. LowVol PM₁₀ FRM / XRF

Selenium



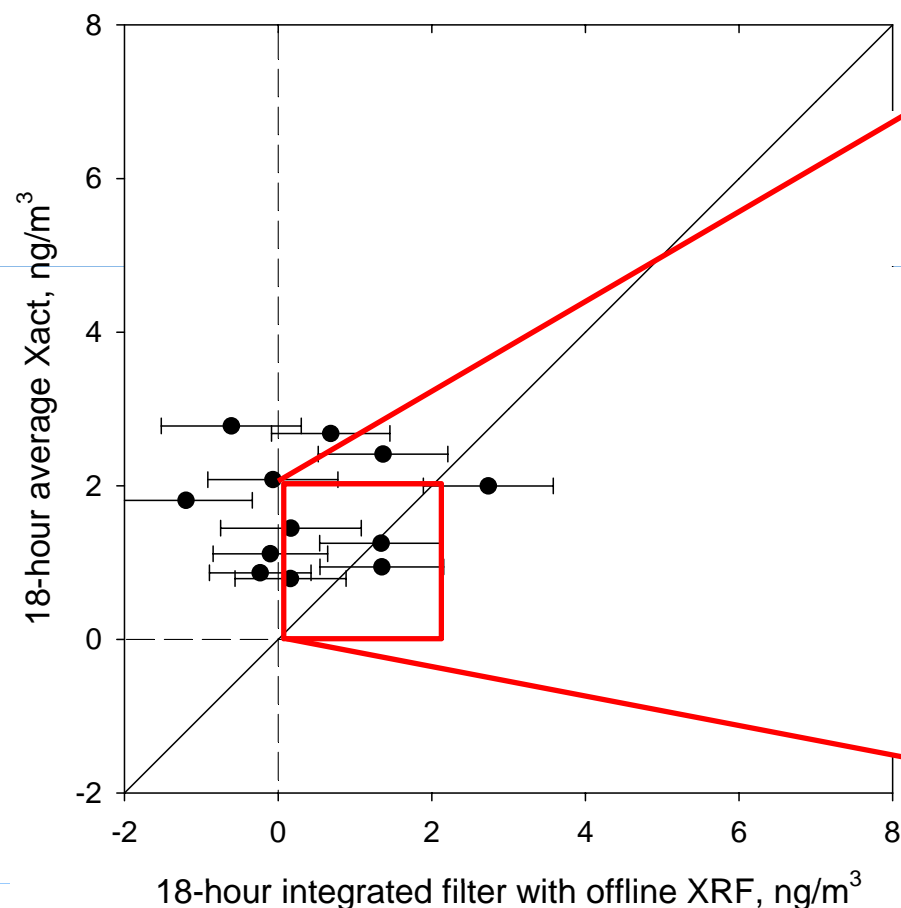
Arsenic



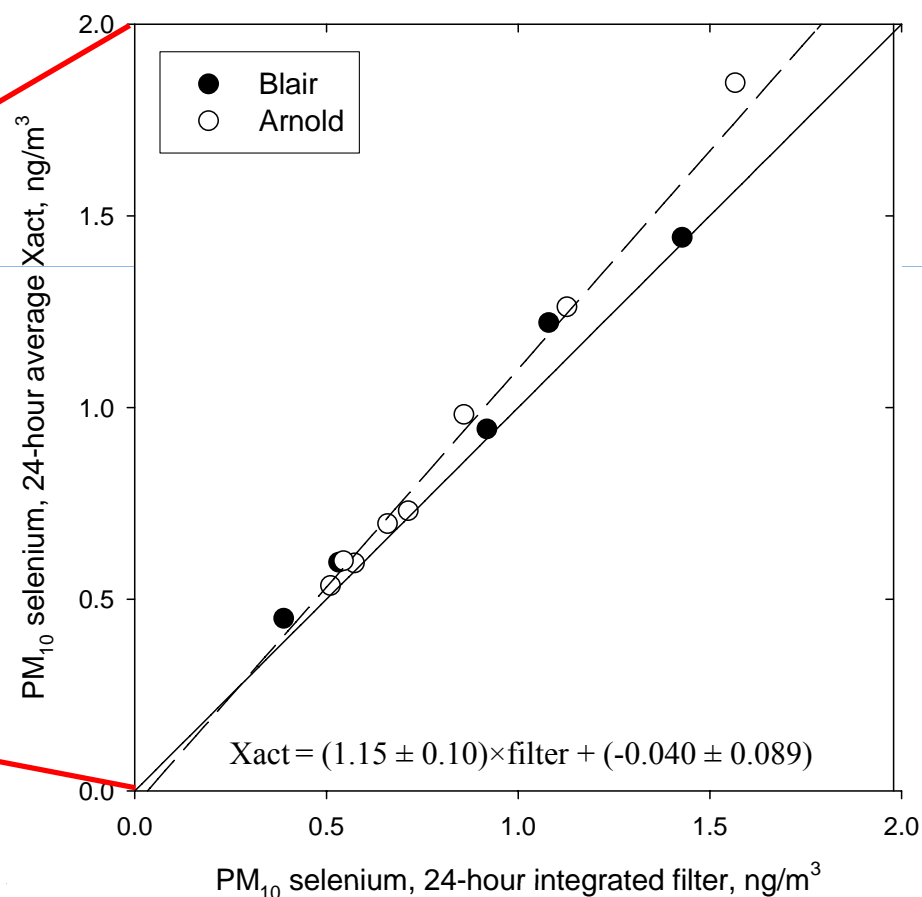
*Se and As: pushing the detection limit of the lab-based XRF.
need to compare the Xact to ICP-MS (next slide)...*

Selenium: Xact vs. Filter-Based Measurements

Xact vs. LowVol filter / lab XRF



Xact vs. HiVol filter / lab ICP-MS

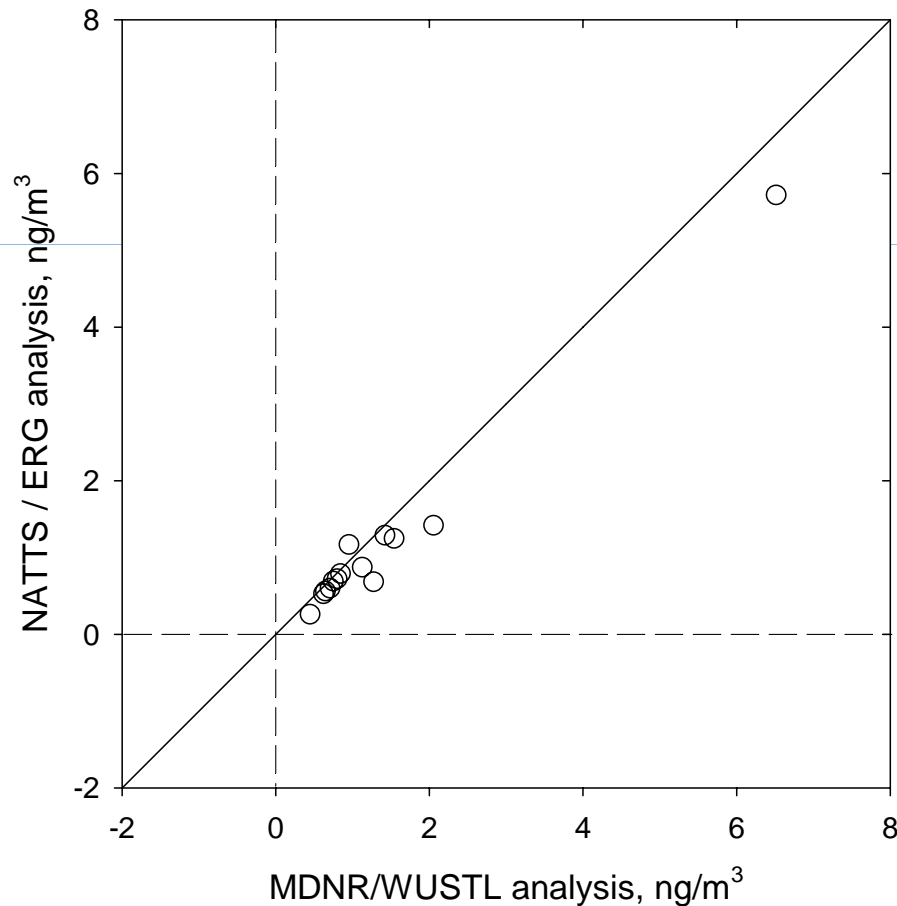


Se: favorable comparison between Xact and PM₁₀ HiVol samples with analysis by ICP-MS

Arsenic – Methods Comparisons

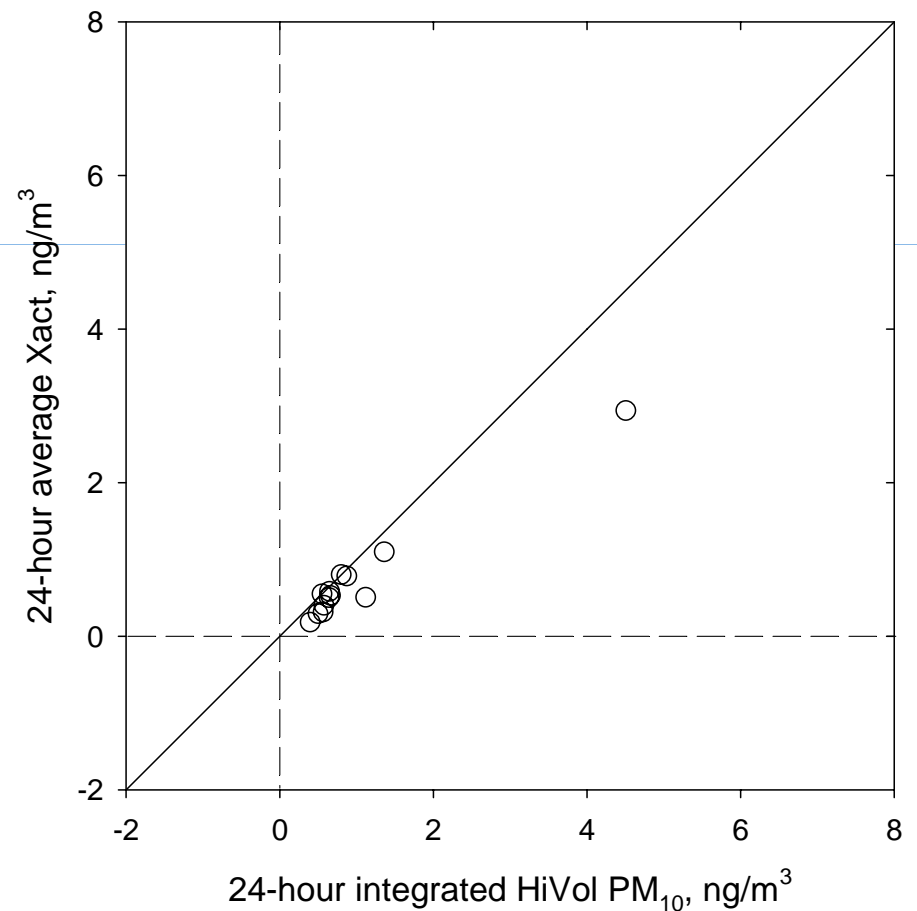
Collocated HiVol Samplers

Blair site, 4th Quarter 2008



Xact vs. WUSTL HiVol

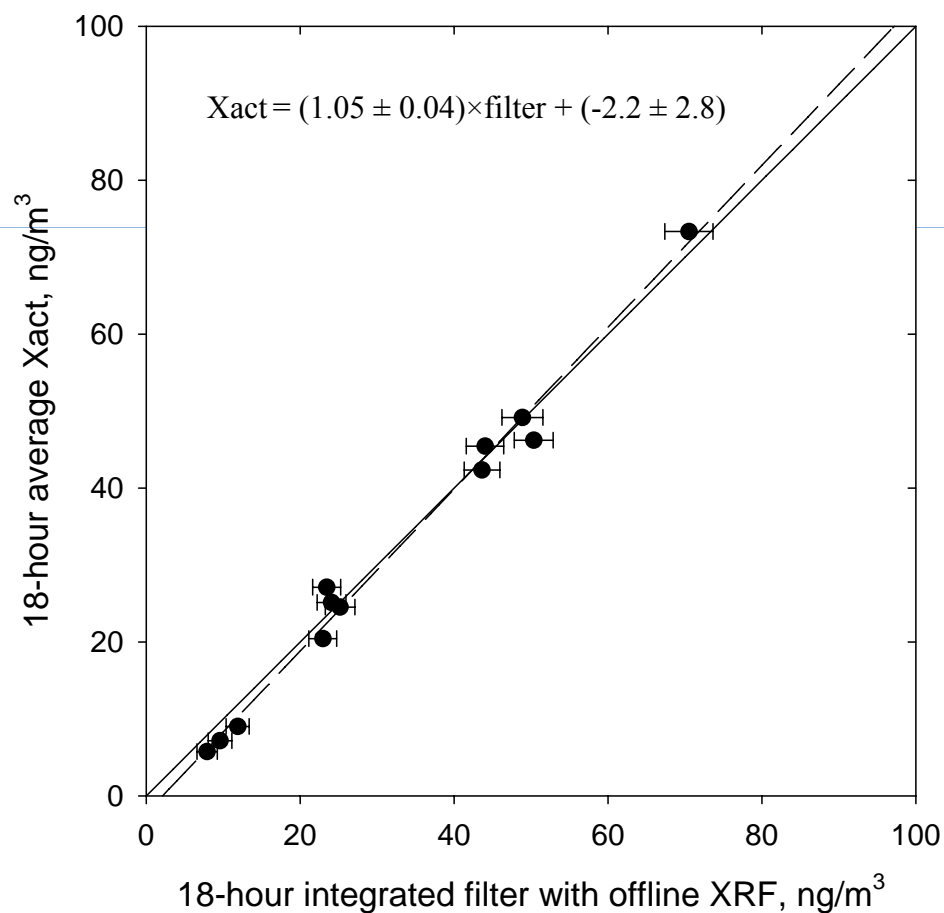
Dec 2008 / Jan 2009



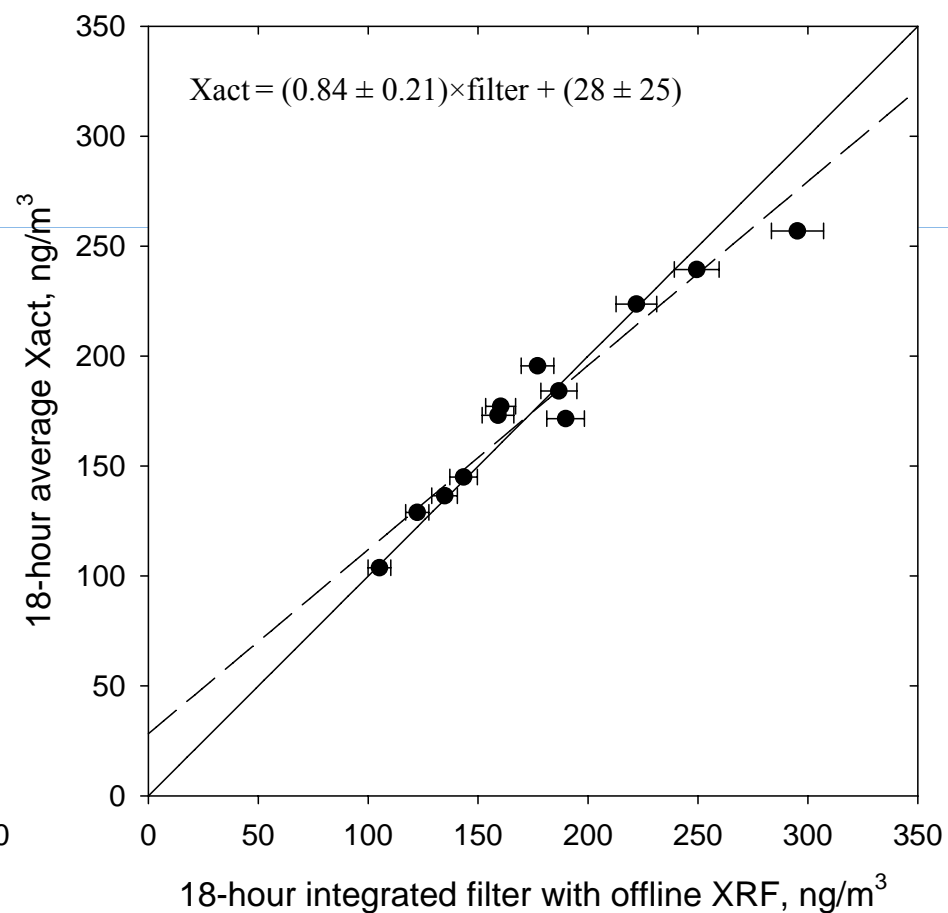
As: favorable comparison between Xact and PM₁₀ HiVol samples with analysis by ICP-MS.

Xact vs. LowVol PM₁₀ FRM / XRF

Titanium

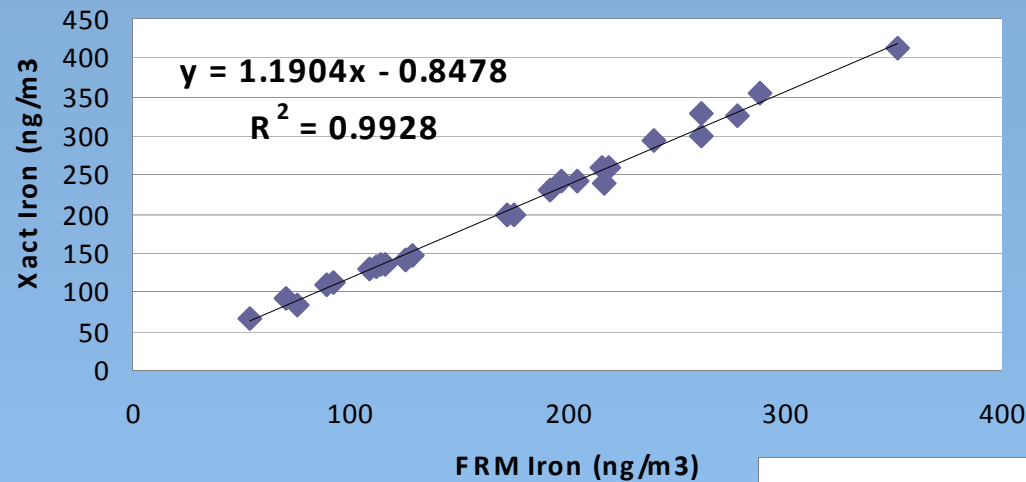


Potassium

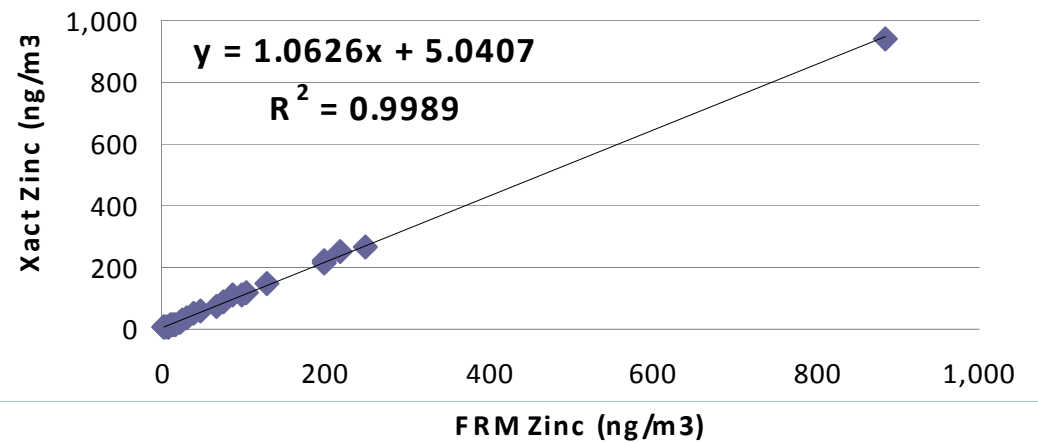


Herculaneum, MO

Xact vs FRM Iron

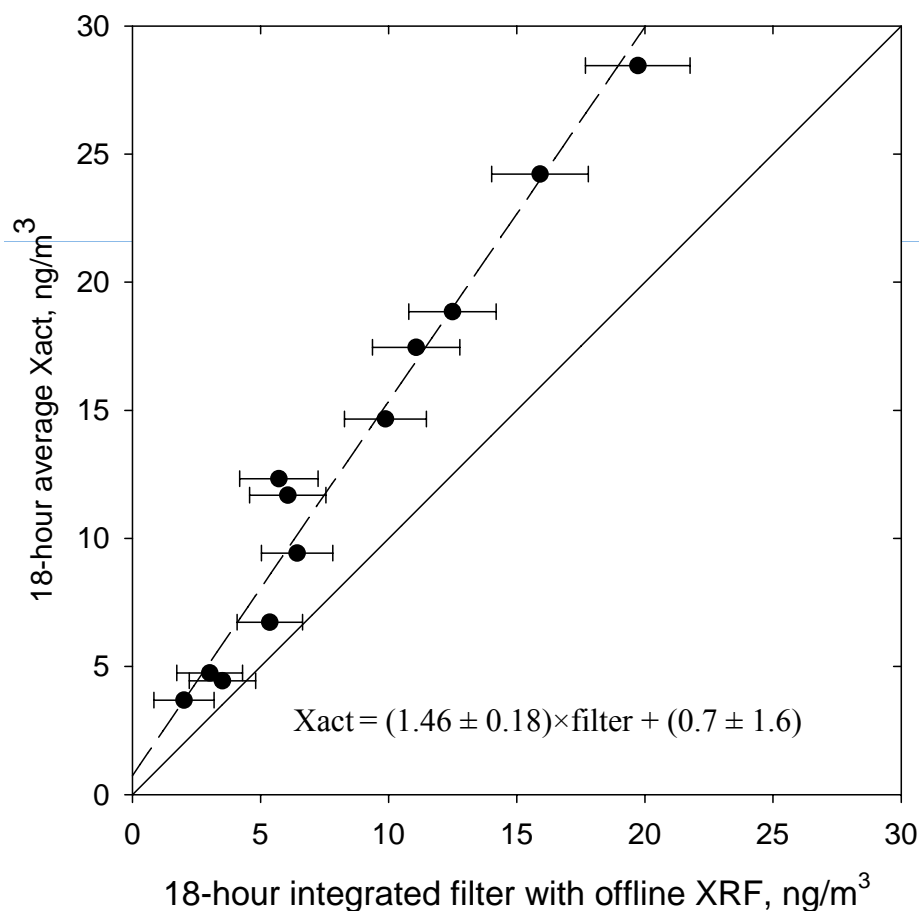


Xact vs FRM Zinc

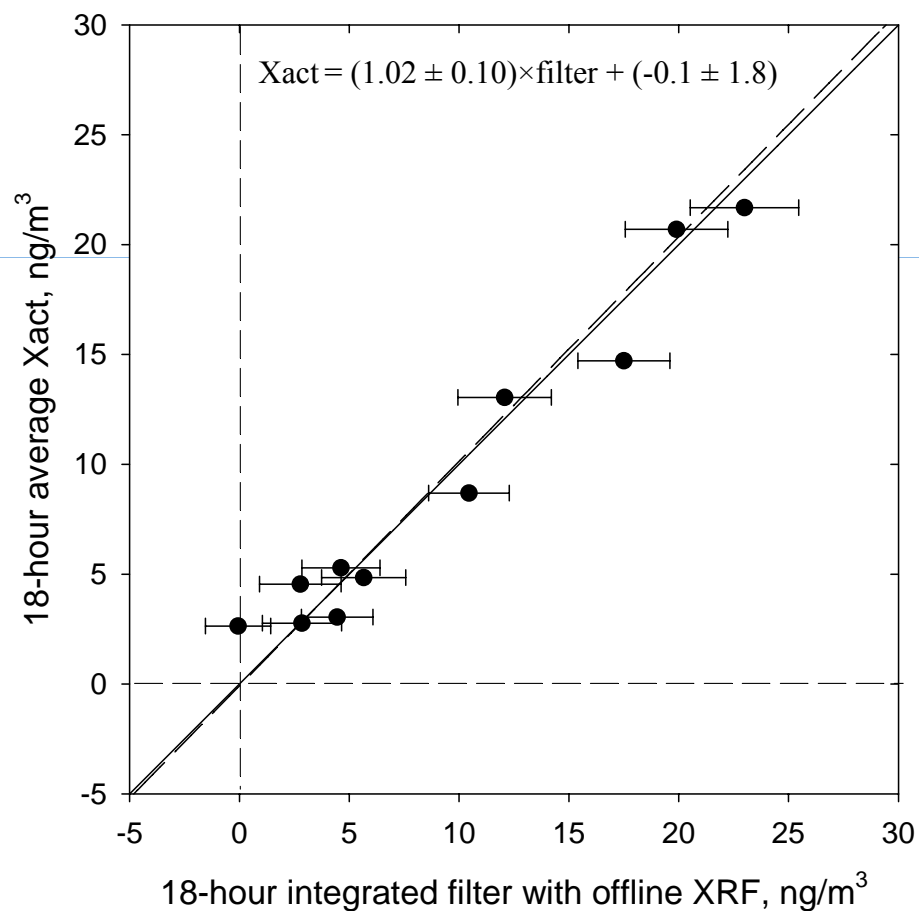


Xact vs. LowVol PM₁₀ FRM / XRF

Manganese



Lead

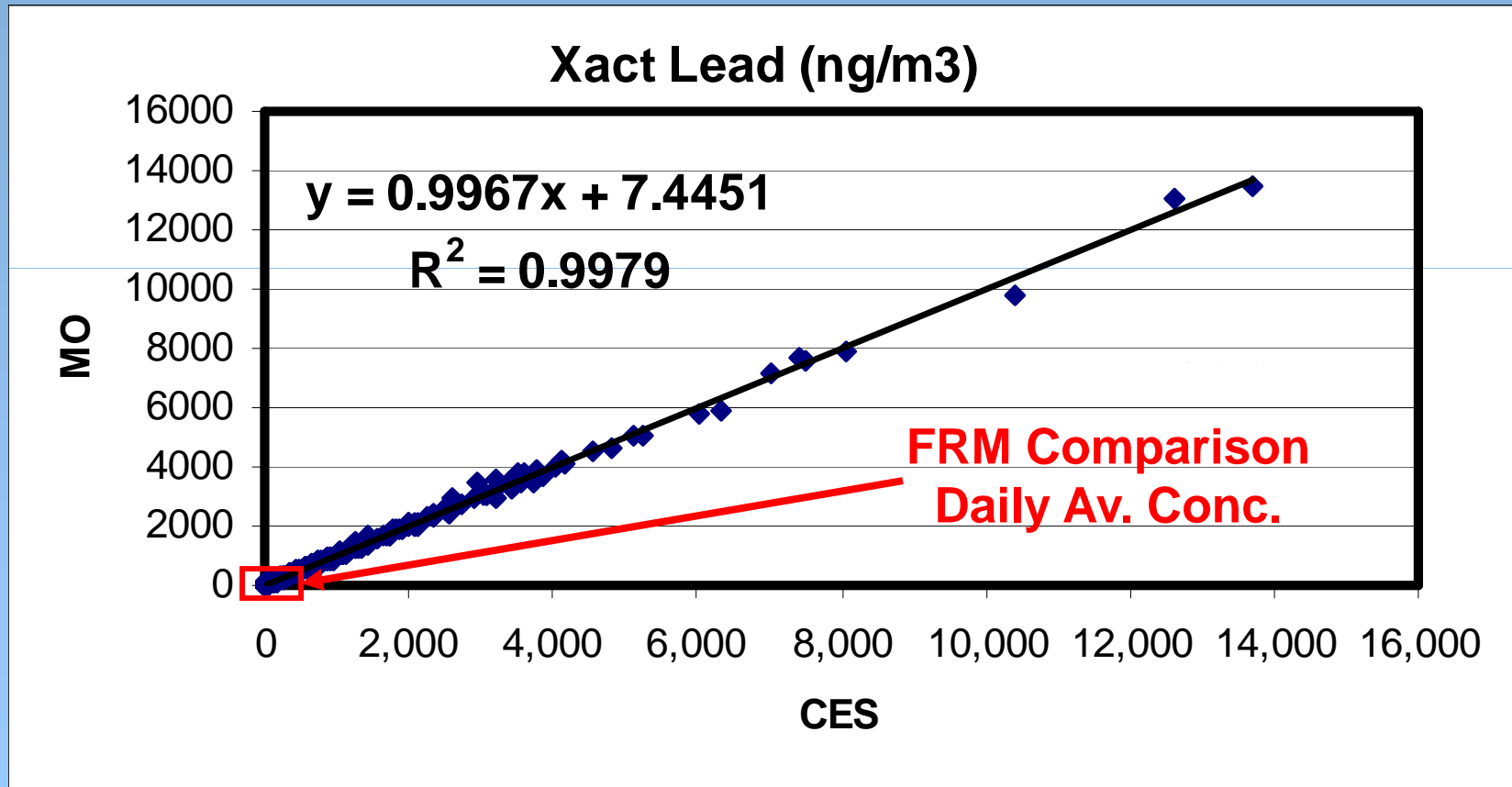


Mn: biased but highly correlated

Herculaneum

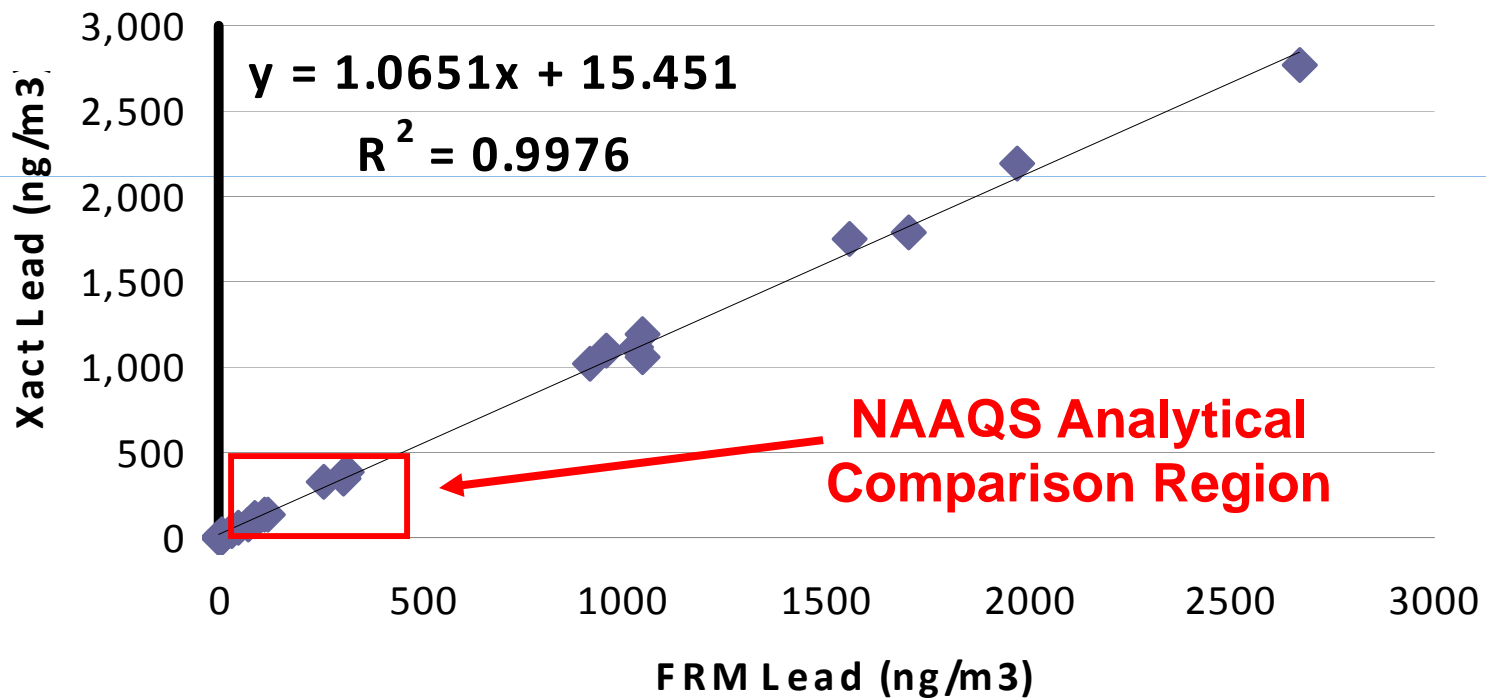


Minus High Concentration Data Point Herculaneum MO

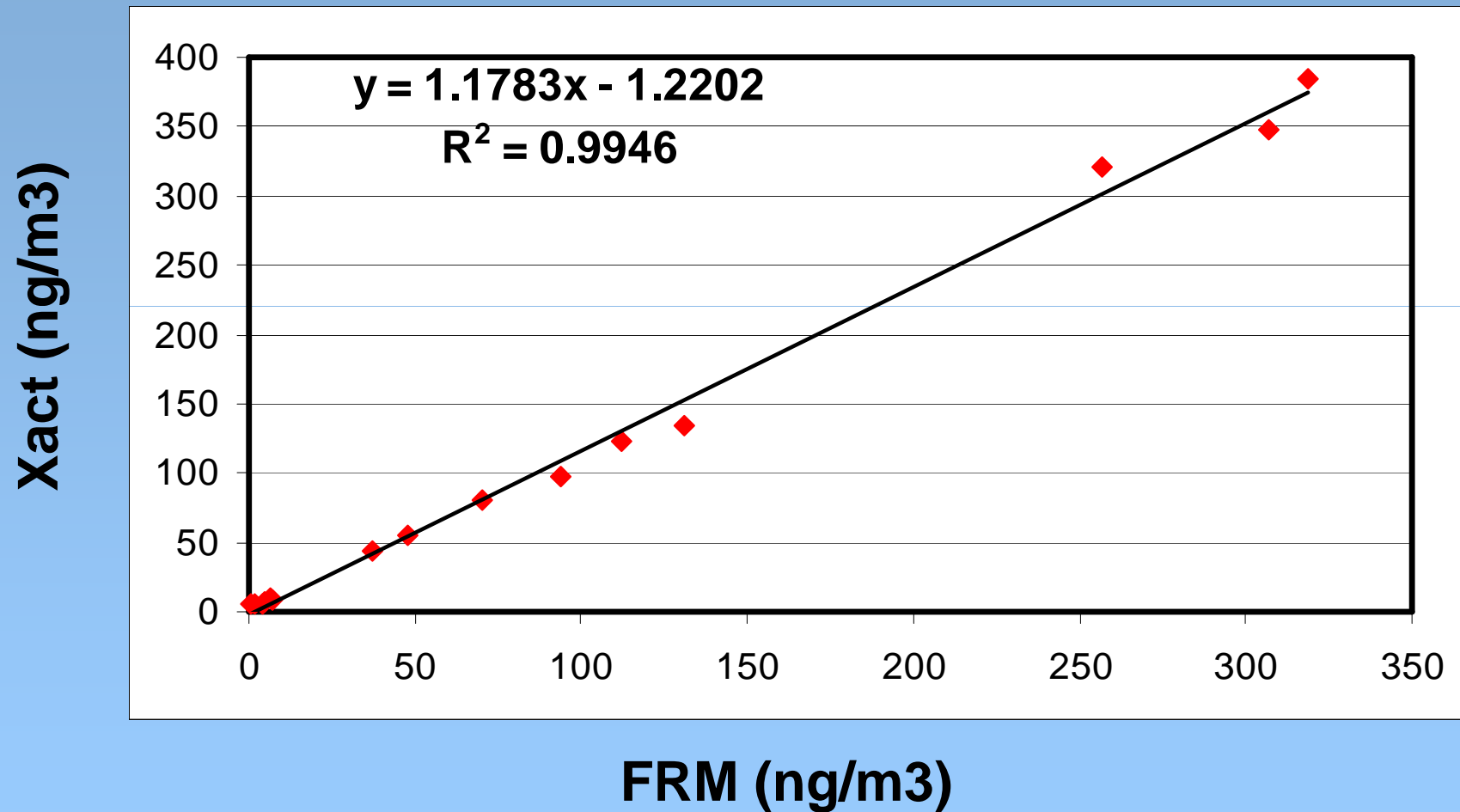


Herculaneum, MO Lead

Xact vs FRM Lead

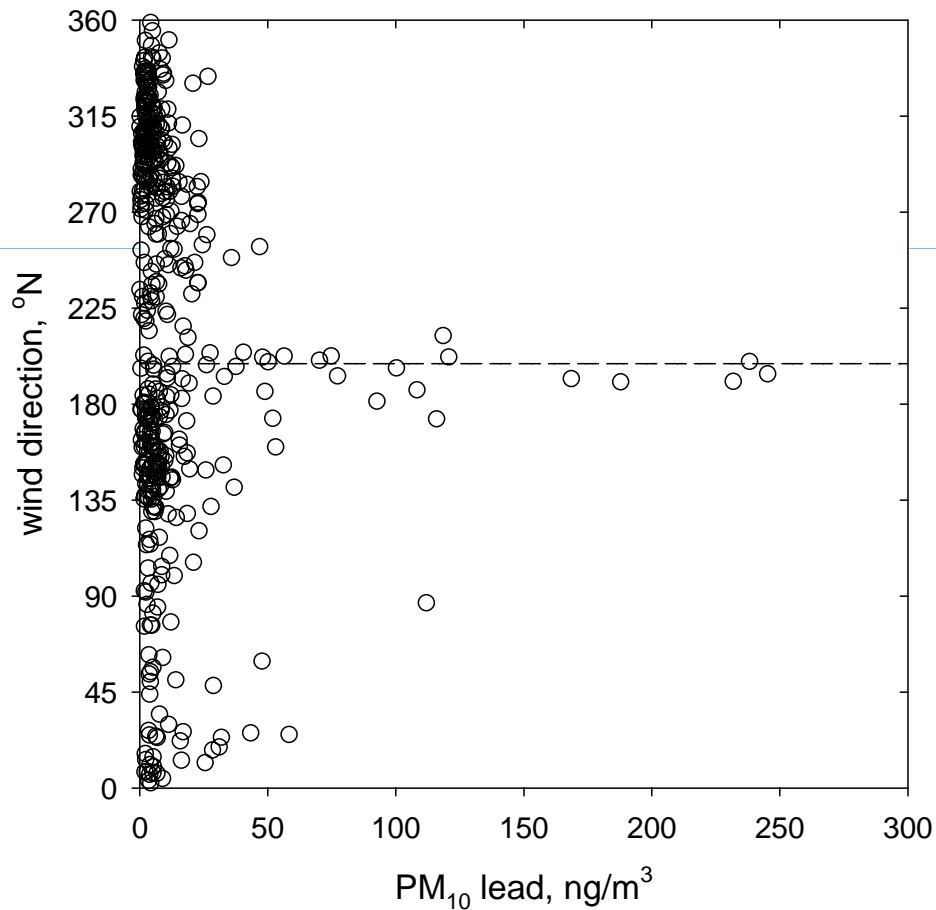


FRM v. Xact Lead Comparison

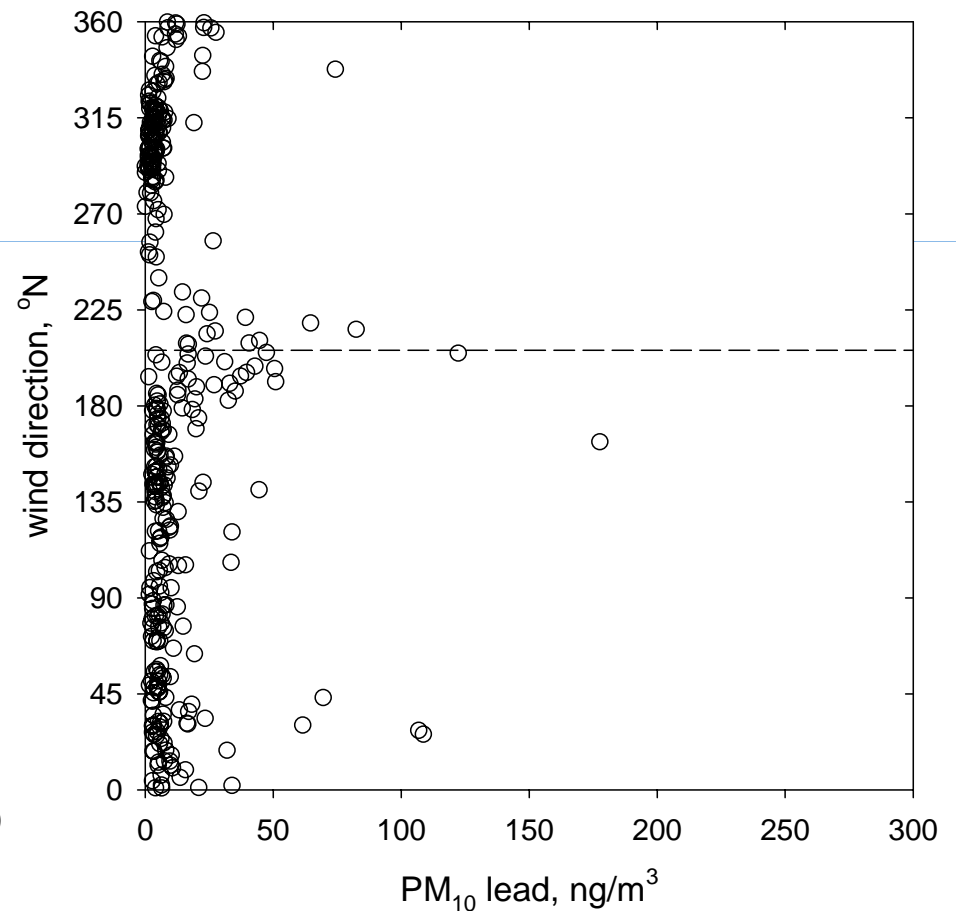


PM₁₀ Lead by Xact (2-hour resolution)

BLAIR



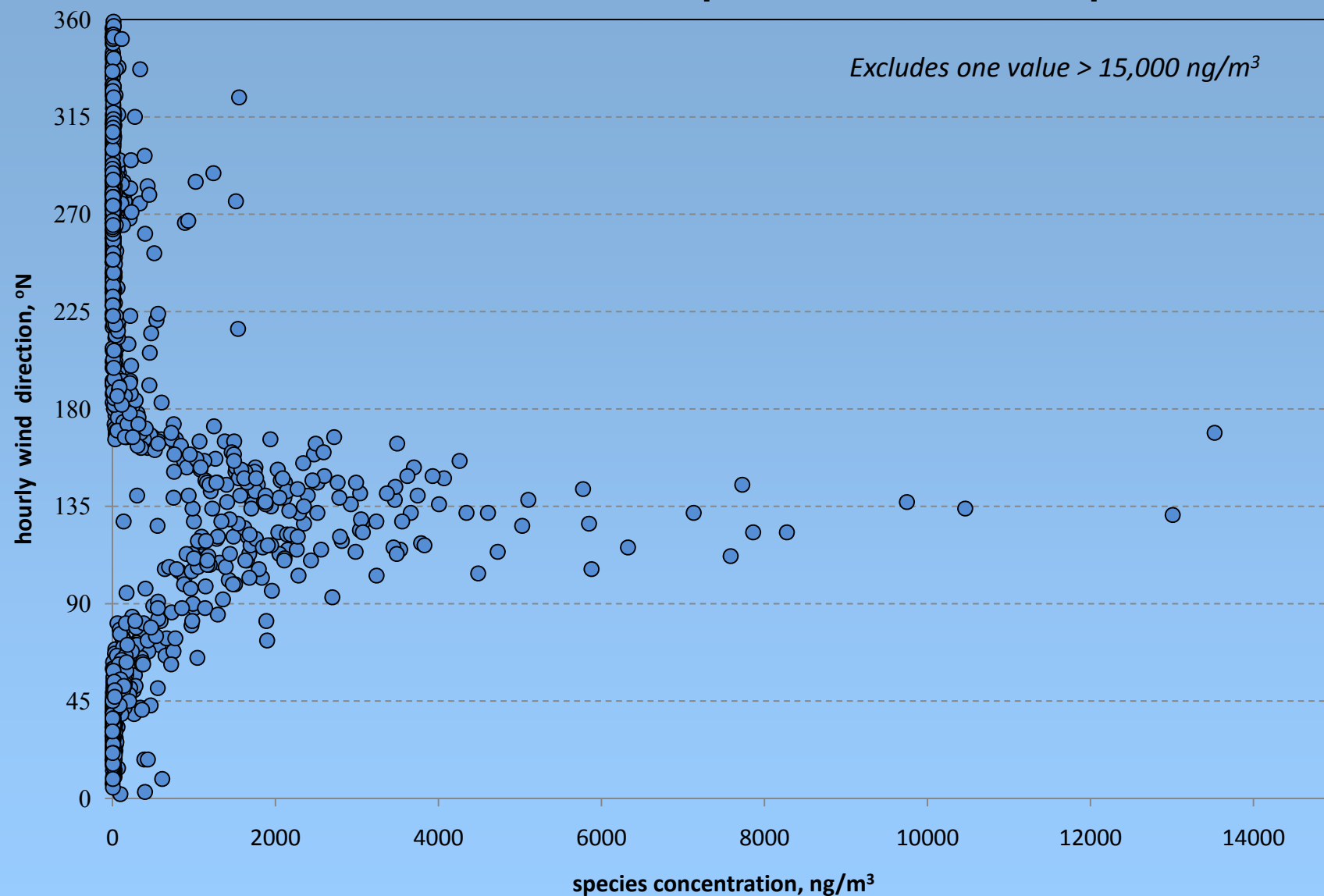
ARNOLD

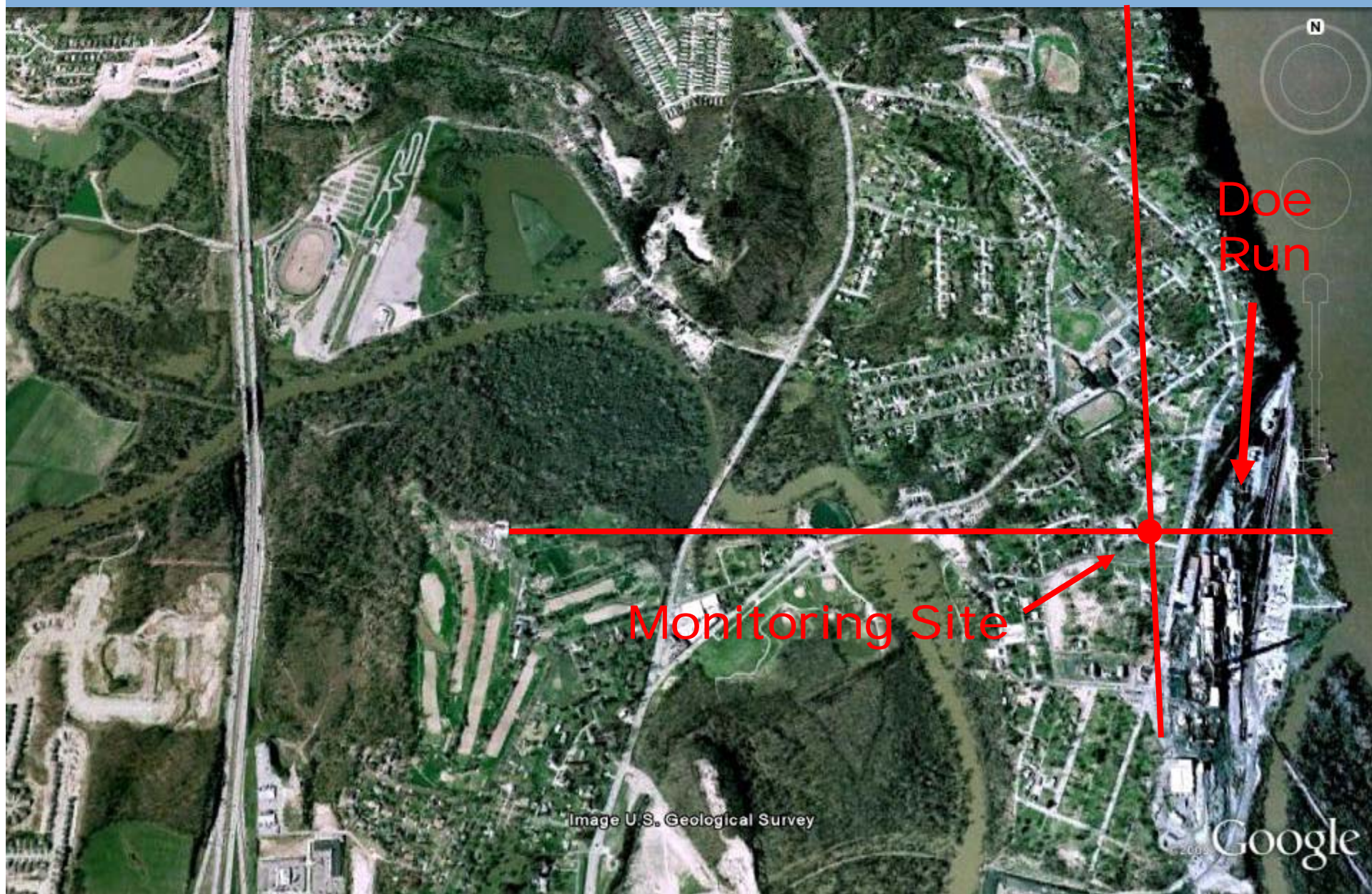


Dashed line is bearing of Doe Run – Herculanum lead smelter

Hourly PM₁₀ Lead, Herculaneum Main Street Site, 8/8/09 – 10/10/09

Excludes hours with wind speeds less than 0.5 mph



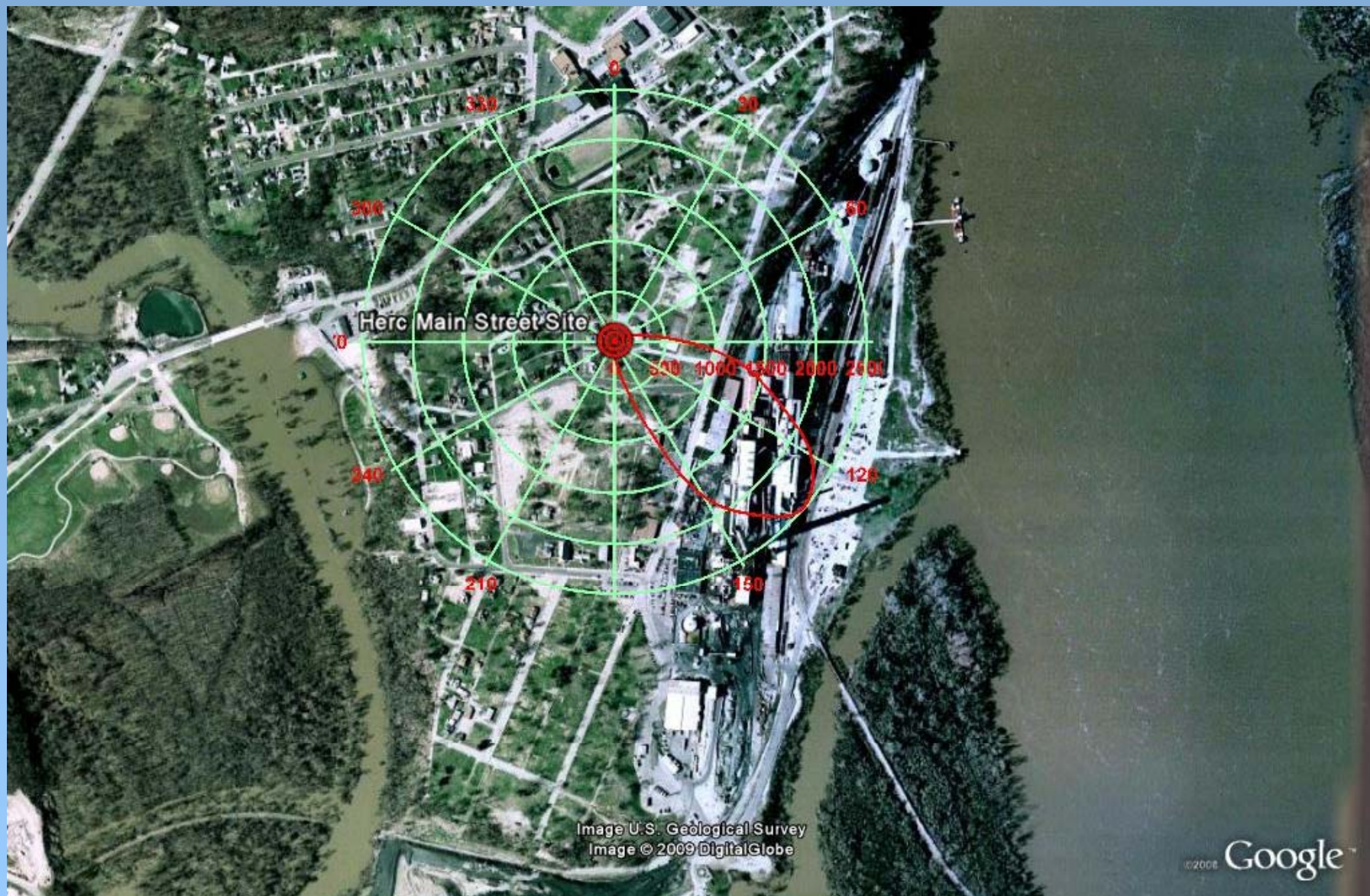


Doe
Run

Monitoring Site

Image U.S. Geological Survey

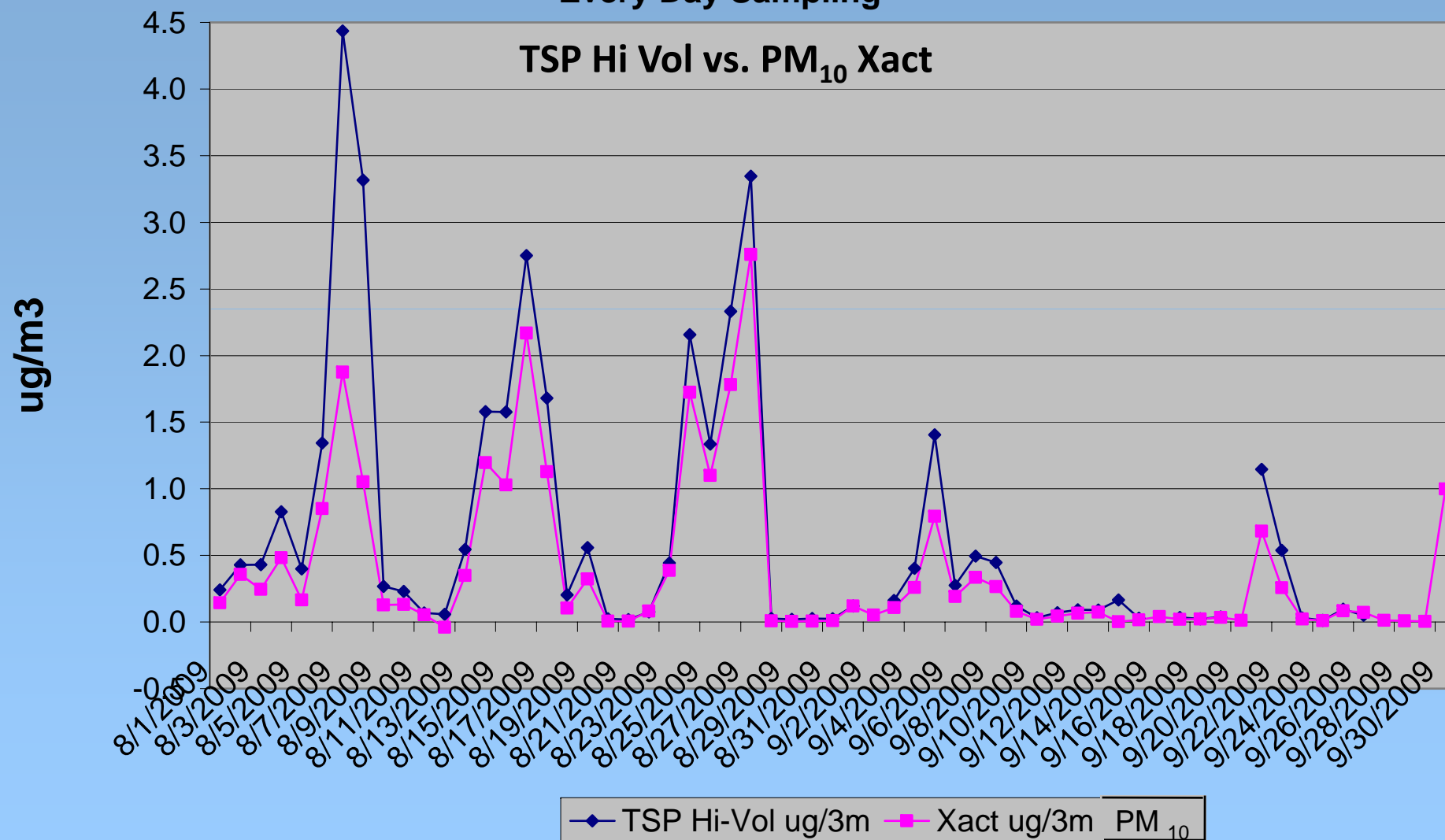
Google



Herculaneum Airborne Lead Concentration

August and September 2009

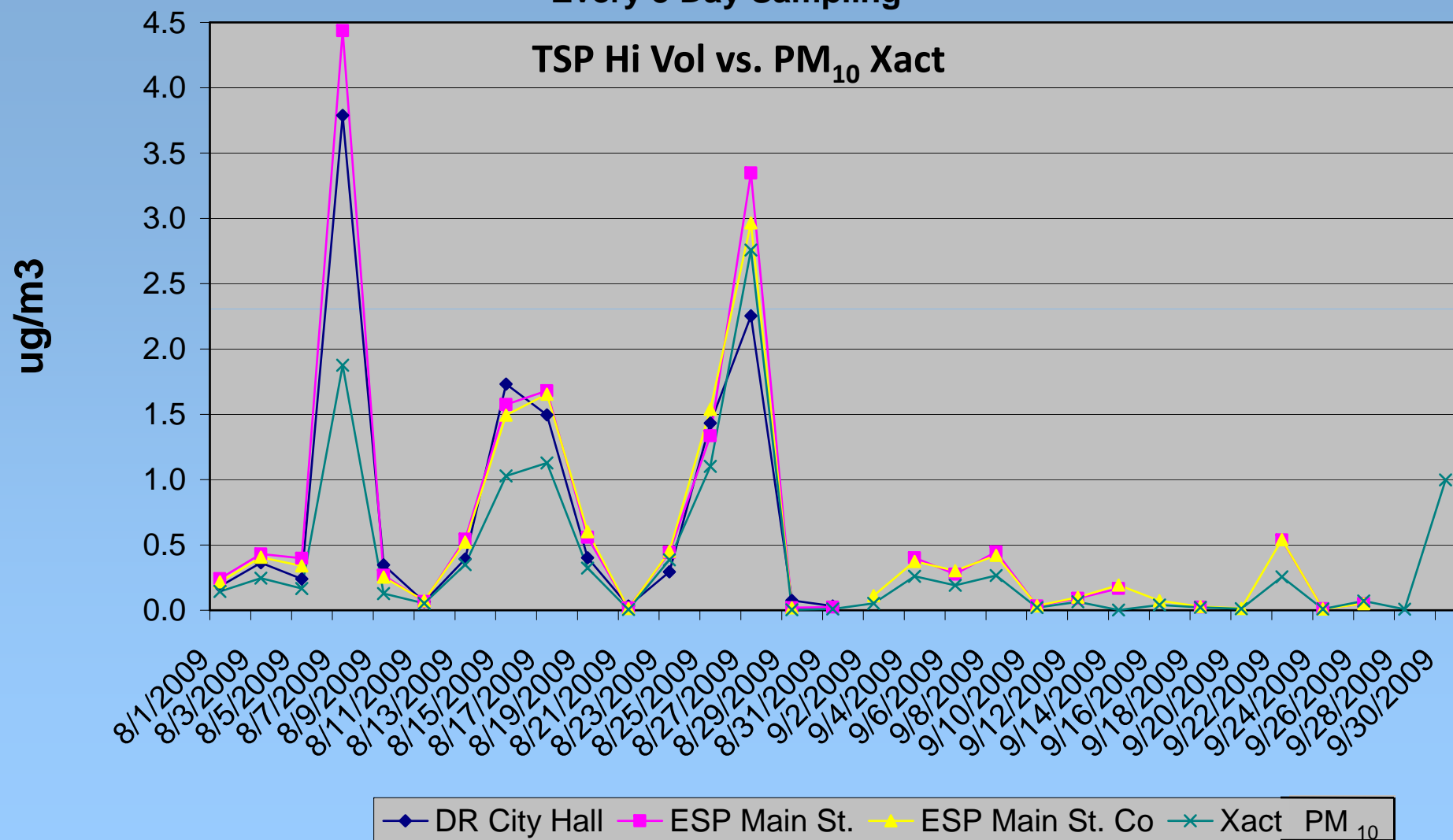
Every Day Sampling



Herculaneum Airborne Lead Concentration

August and September 2009

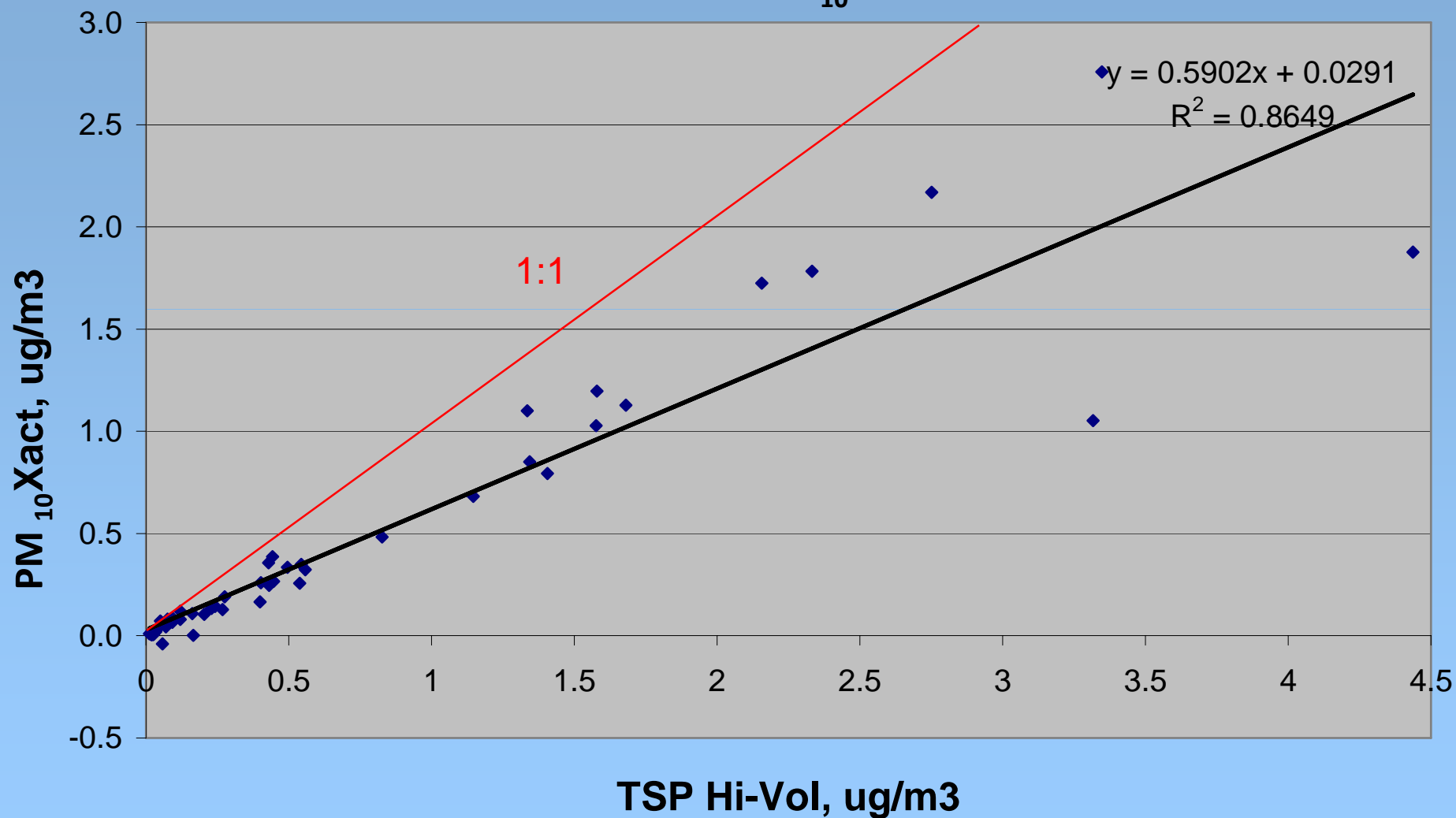
Every 3 Day Sampling



Herculaneum Airborne Lead Concentration

August and September 2009

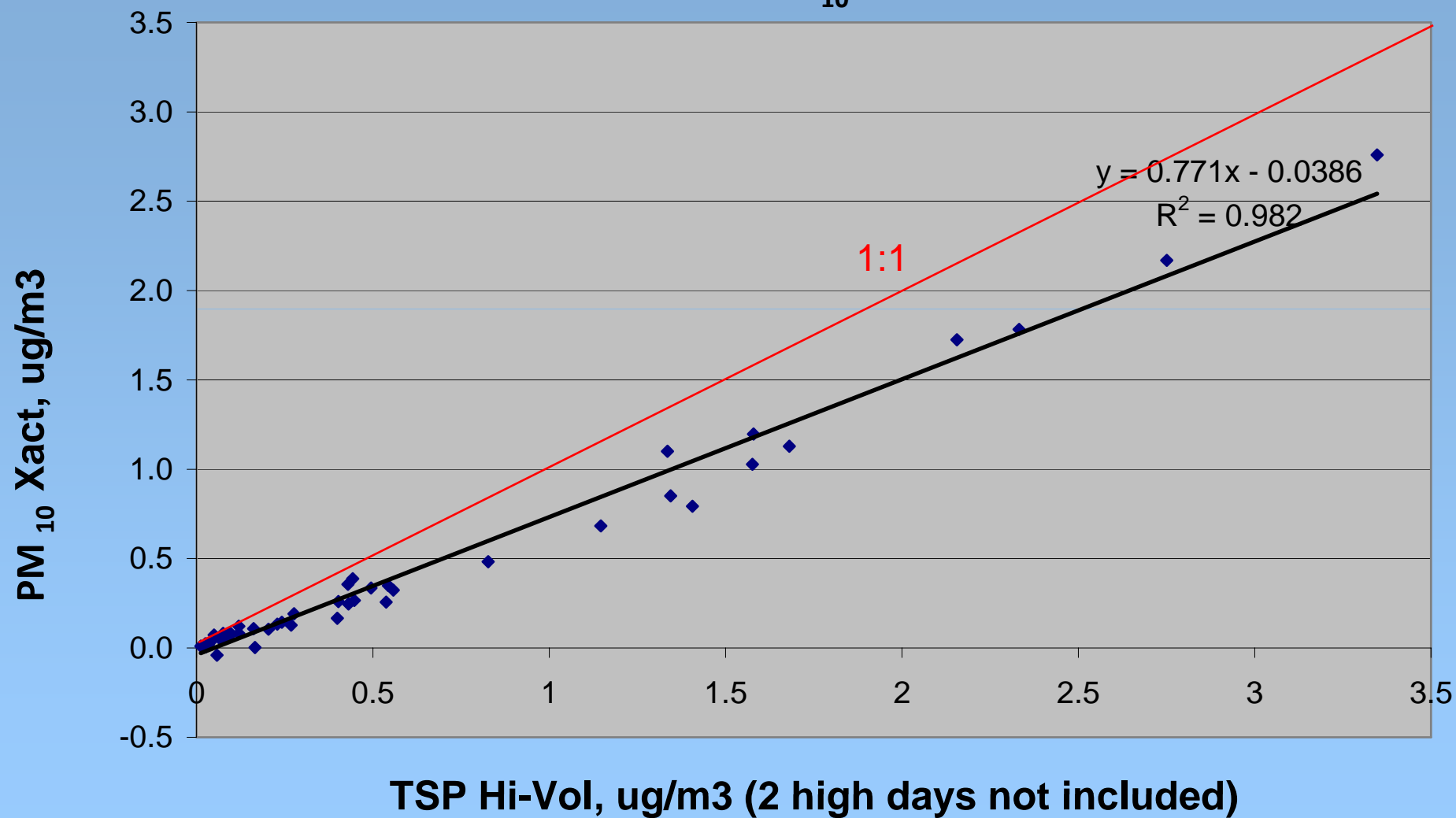
TSP Hi Vol vs. PM₁₀ Xact



Herculaneum Airborne Lead Concentration

August and September 2009

TSP Hi Vol vs. PM₁₀ Xact



Conclusions

- Maintenance and operation of the Xact is comparable to that of other air monitoring instruments. The Xact has operated reliably following initial problems addressed by software and firmware upgrades.
- Xact airborne metallic species results compare well with both low volume and high volume filter sample analysis results.
- Xact results demonstrate the utility of time-dependent measurement for source attribution.

Acknowledgements

- **Missouri Department of Natural Resources**
 - Jim Brunnert, Jerry Downs, Celeste Koon, Dustin Kuebler, Robert Nilges, Terry Rowles, Will Wetherell
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 - Mike Jones
- **U.S. EPA / Region VII**
 - Gwen Yoshimura
- **U.S. EPA / Office of Research and Development**
 - Teri Conner, Gary Norris, Bob Willis

Online Current Data

- <http://www.dnr.mo.gov/env/esp/aqm/allguide.htm>
(Click on “Current Air Pollution Data Report” at mid-page, scroll down to St. Louis Metals Data)