AMBIENT AIR CONCENTRATION OF HEXAVALENT CHROMIUM IN DISTRICT OF COLUMBIA: ANY HEALTH CONCERN?

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Disclaimer

This presentation and the analysis therein, do not necessarily represent or express the opinion of the Department of the Environment or the District of Columbia Government.

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- ERG: Julie Swift, Ray Merraill & Jaime Hauser
- EPA: Michael Jones and Joanne Rice

Overview

- Cr(VI) Monitoring Program
- Ambient Cr(VI) Data Analysis
- Risk analysis
- Discussion and Remarks

Chromium Types (video)

- Chromium element in rocks, animals, plants, soil and volcanic dust and gases
- Common forms:
  - elemental chromium Cr
  - trivalent or Cr(III)
  - hexavalent or Cr(VI)
- Cr(III) is an essential nutrient
- Cr and Cr(VI) are product of human activities

Chromium Sources

- **Primary** sources
- **Minor** sources
- Other sources: chromium based automotive catalytic converters and tobacco smoke (ATSDR, 2008)
- In the District of Columbia, automobiles may be the primary sources.

District Cr(VI) Monitoring

- Start Date: March 2005
- Sampling is 1-in-6 schedule
- Co-Lo every 8 to 10 weeks

Monitoring Method

- Cr(VI) ambient air TSP (STP)
  - sodium bicarbonate impregnated cellulose filter
- Sampling flow rate: 15 liters per minute
- Sample duration is 24 hours per sampling period
- Exposed filters analyzed by ERG at RTP lab
- EPA Compendium Method IO-3.5 inductively coupled plasma/mass spectrometry (ICP/MS) for metals (Jones, 2009; EPA, 2007; Rice, 2003)

Sampler

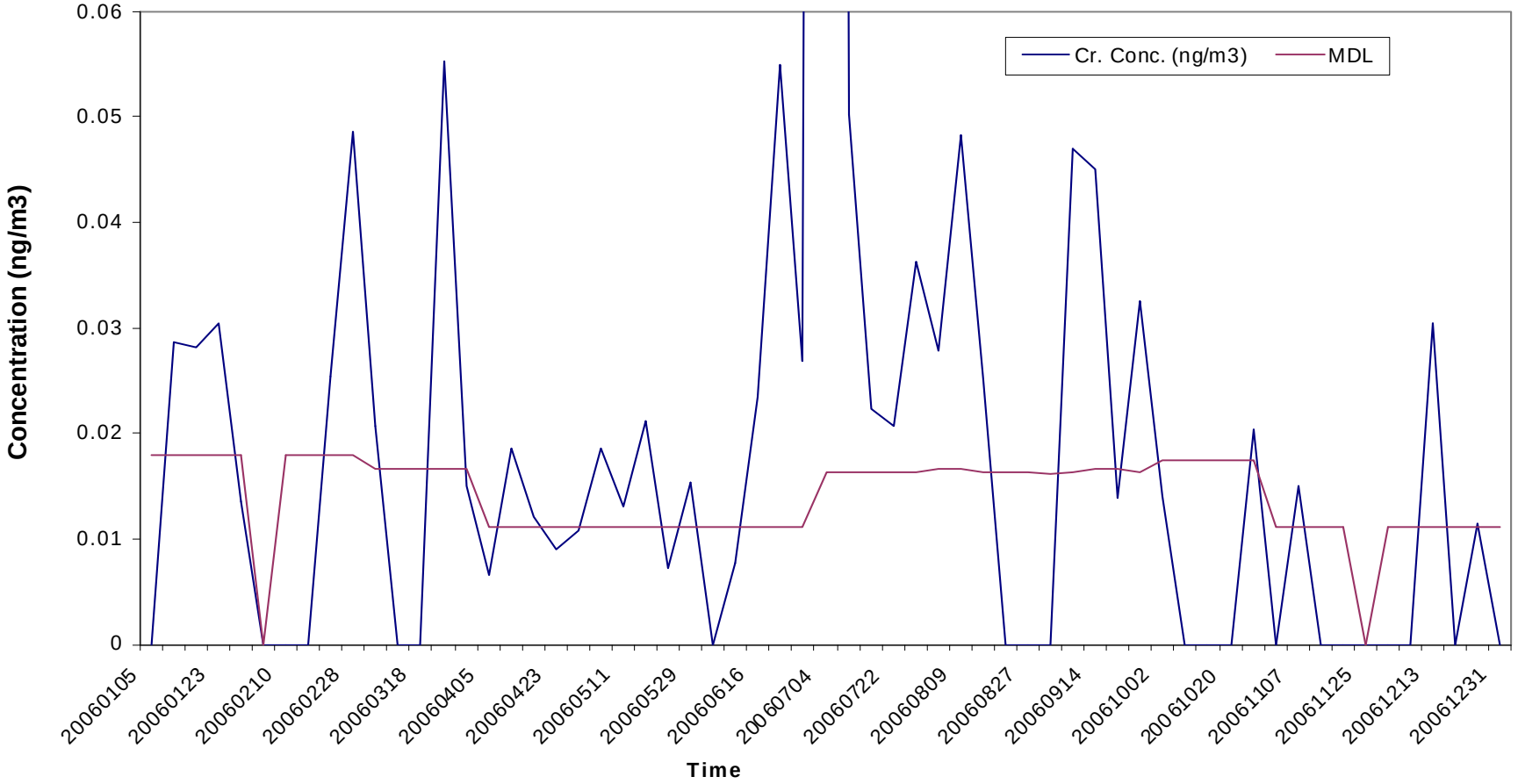
921 ERG CHROMIUM VI SAMPLER

Primary

Project Data Quality Objectives Ambient Cr(VI) in DC

- Cr(VI) data for 2006-2008 period considered
- Cr(VI) AQS Code 12115 (TSP-STP)
- Method Detection Limit (MDL) availability a major factor in use of this method
- Minimum of 85% data completeness
- Data checks and comparisons with other Cr(VI) monitoring sites

2006 Sampled Concentration vs MDL



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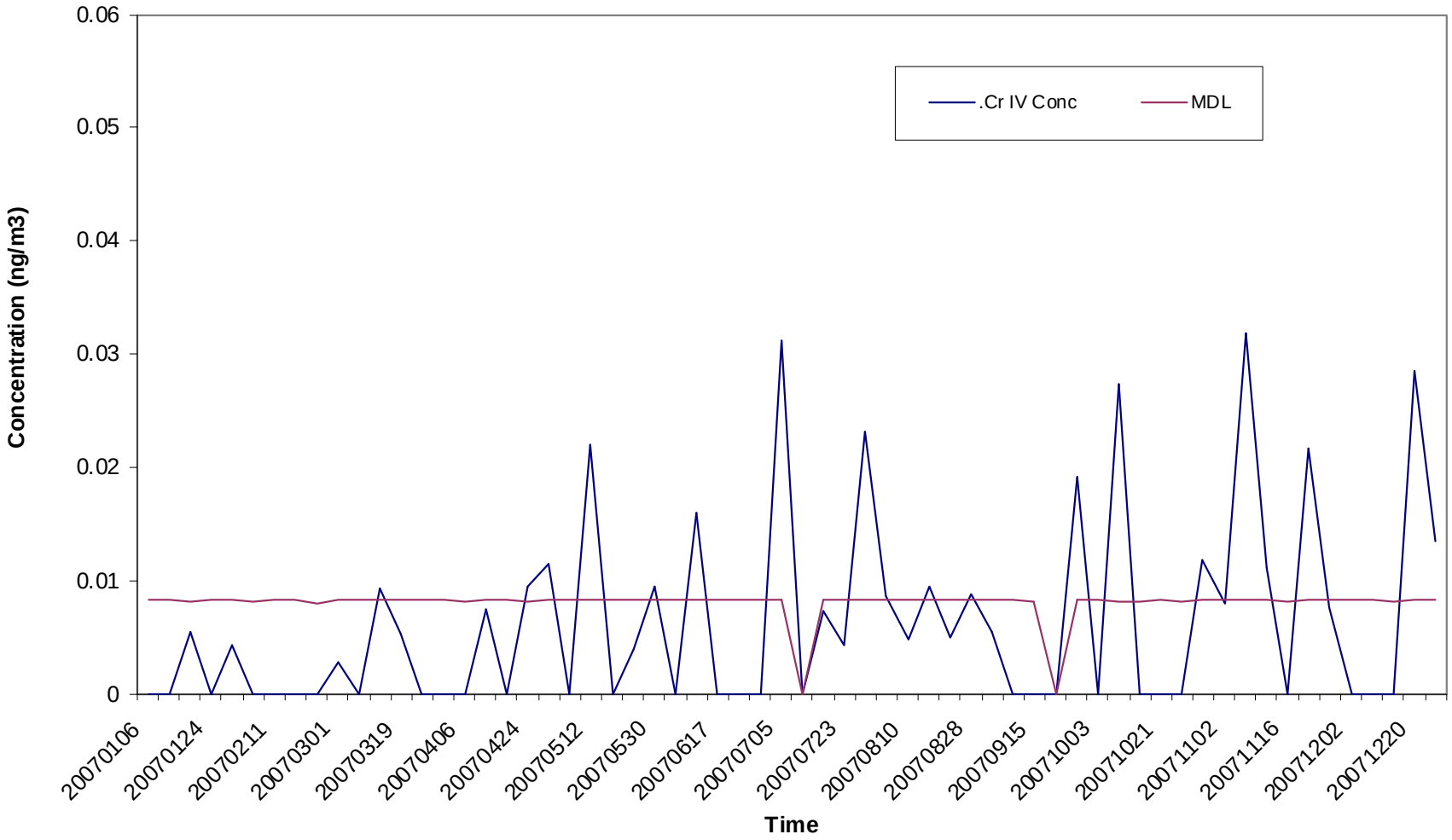
2007 Sampled Concentration vs MDL



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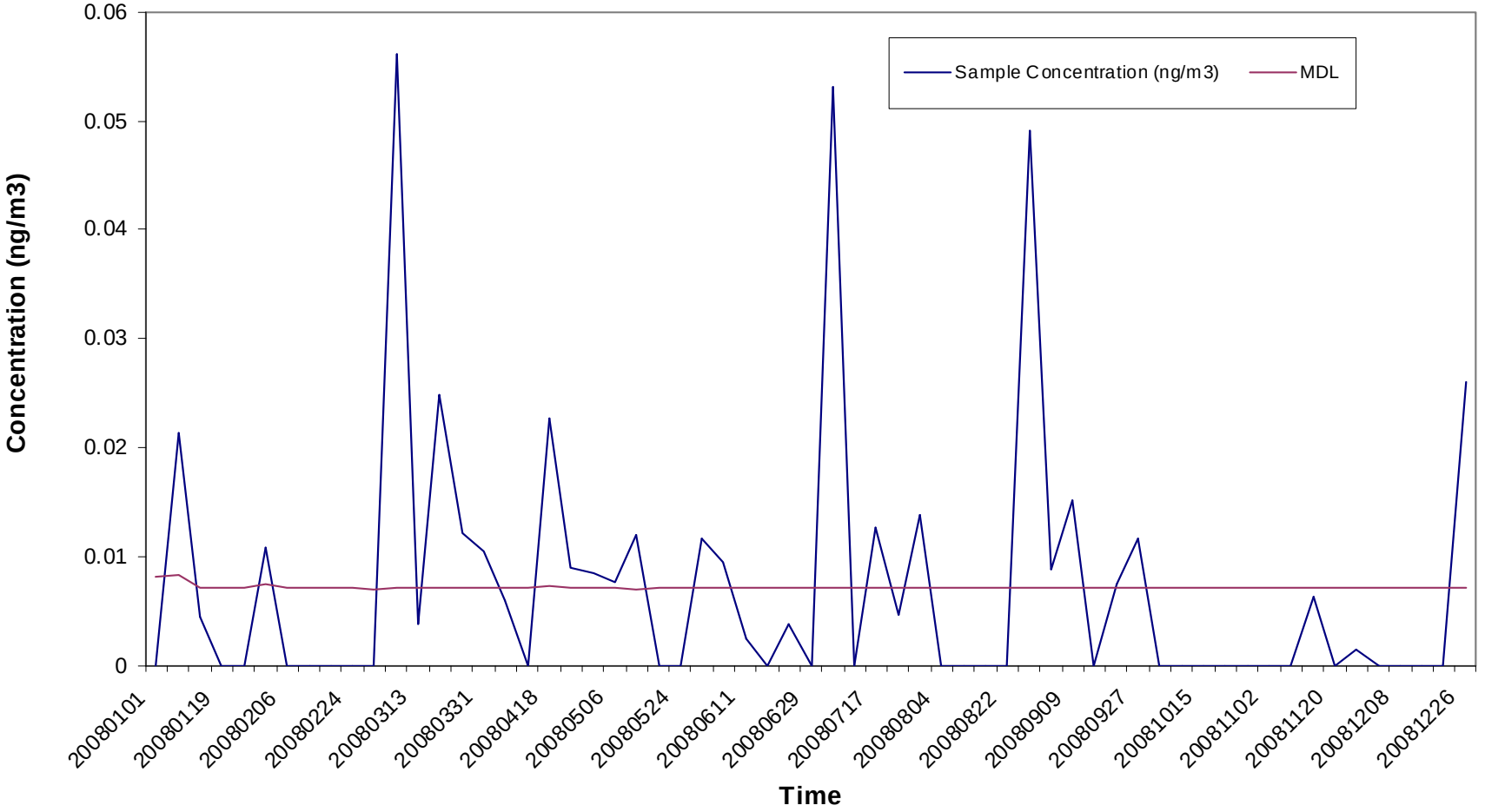
2008 Sampled Concentration vs MDL



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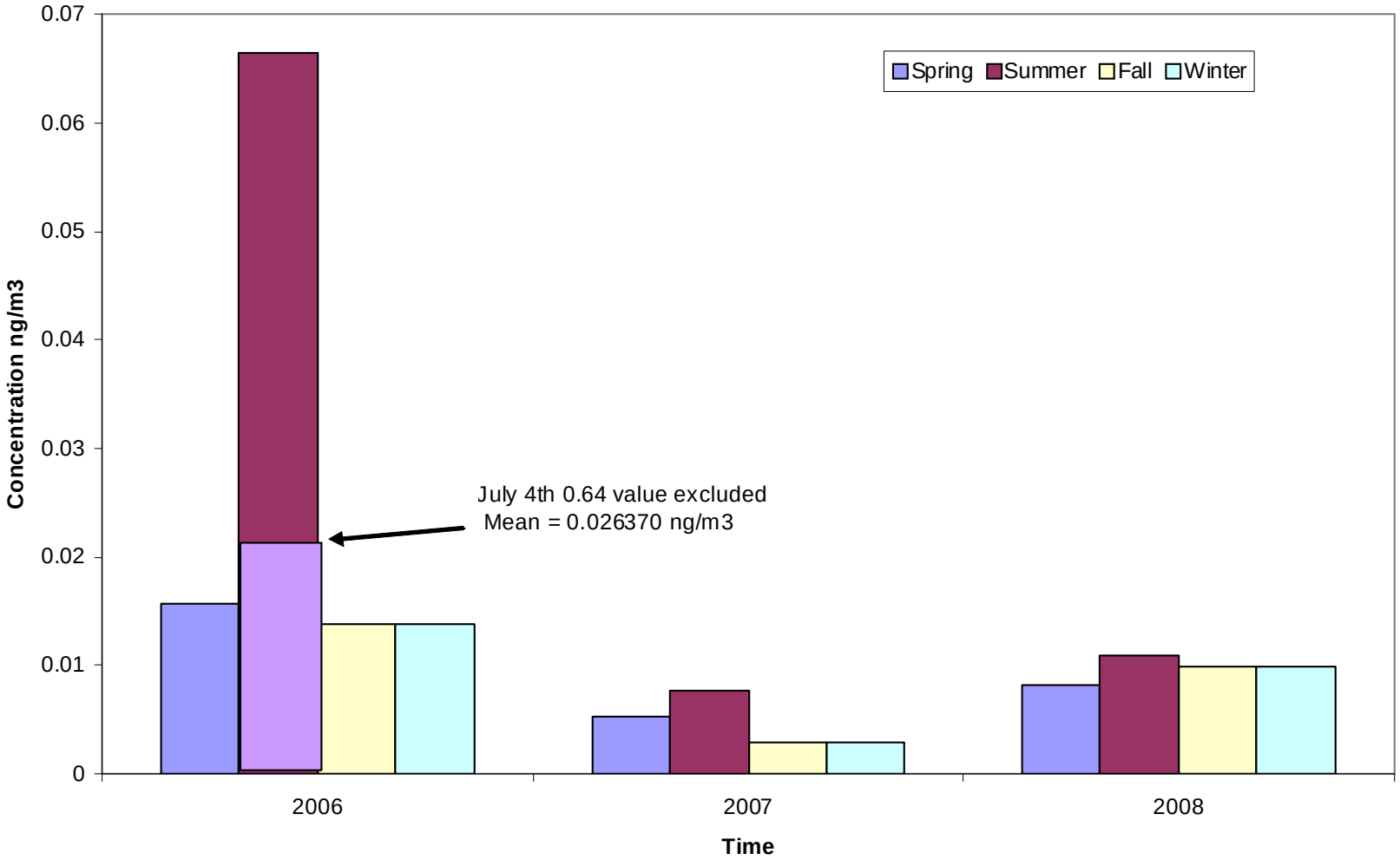
RawData Averages by Season



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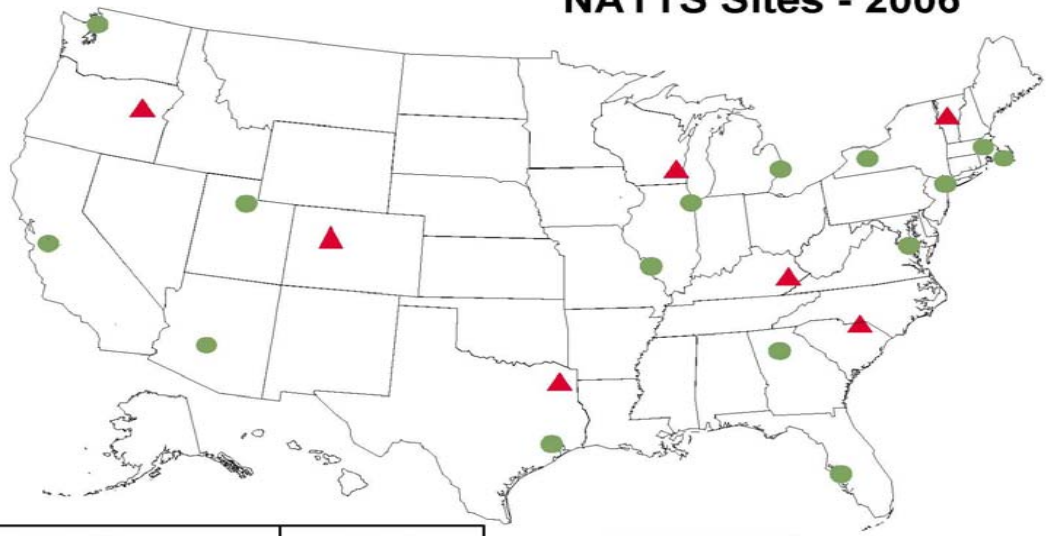
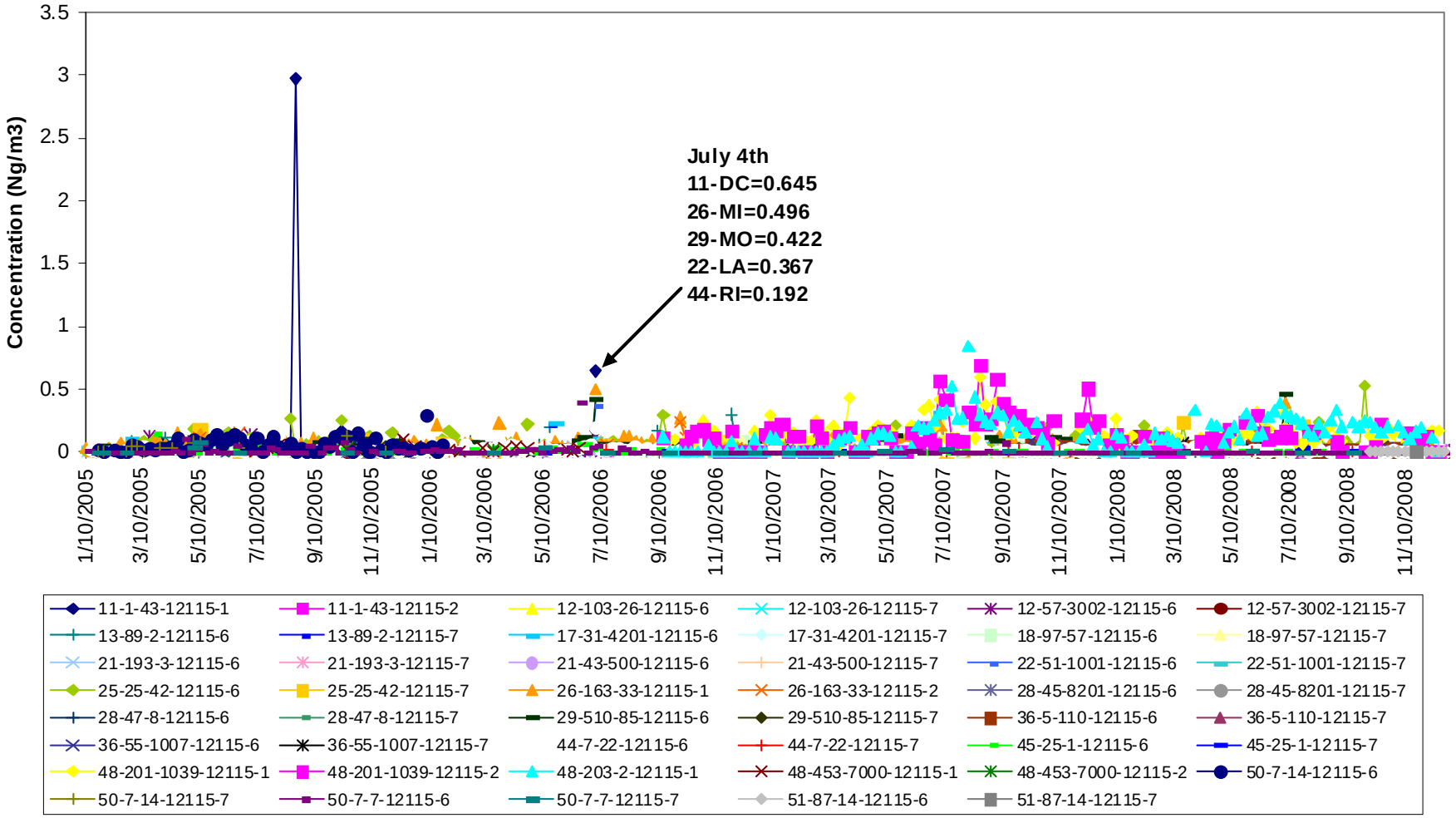
NATTS Sites - 2006



•Urban Sites		•Rural
•E. Providence, RI •Boston (Roxbury), MA •New York, NY •Rochester, NY •Washington, DC •Decatur, GA •Tampa, FL •Detroit, MI	•Chicago, IL •Houston (Deer Park), TX •St. Louis, MO •Bountiful, UT •San Jose. CA •Phoenix, AZ •Seattle WA	•Underhill, VT •Hazard, KY •Chesterfield, SC •Mayville, WI •Grand Junction, CO •La Grande, OR •Harrison County, TX

Source: Dennis K. Mikel
EPA–OAQPS-AQAD

CrVI 12115 All Sites



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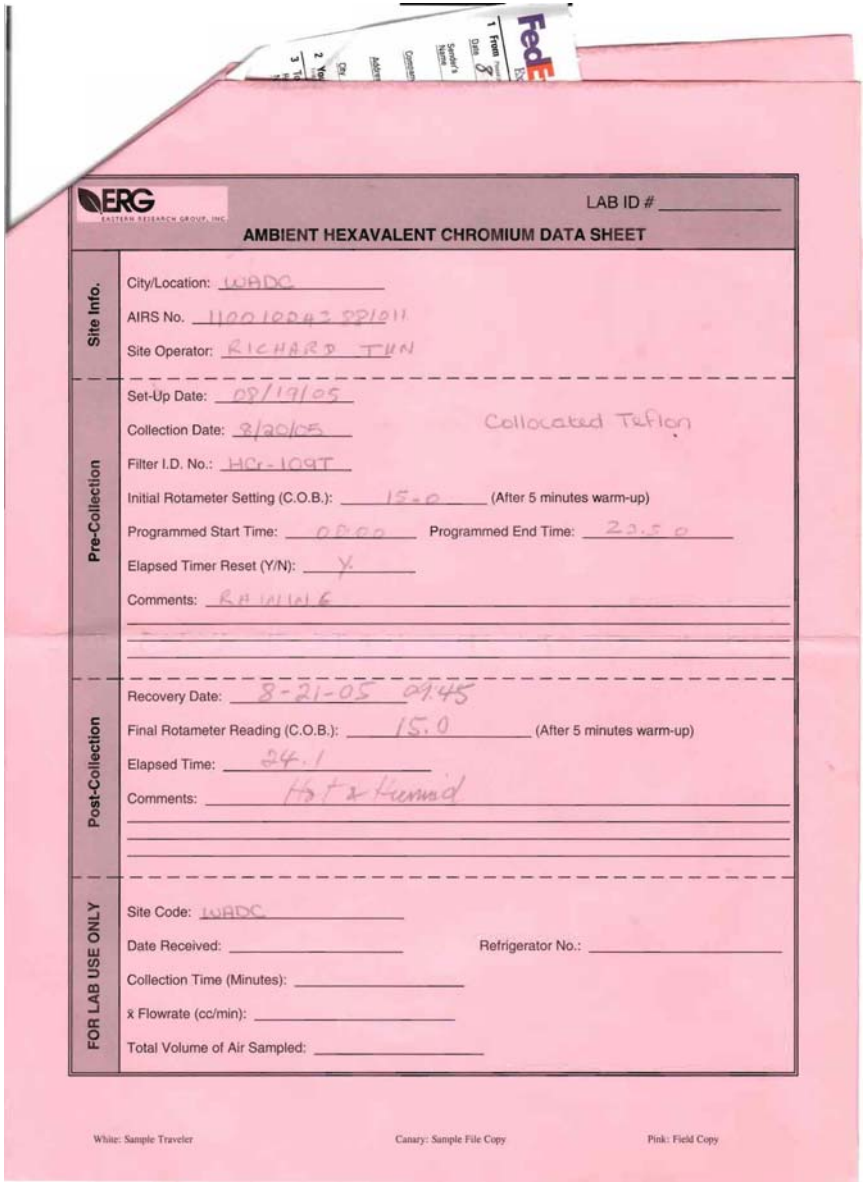
August 20, 2005
Outlier
Unknown issue

2005 did not have 85% DC



ERG
EASTERN RESEARCH GROUP, INC.

LAB ID # _____

AMBIENT HEXAVALENT CHROMIUM DATA SHEET

Site Info.

City/Location: WADC

AIRS No. 110010043 881011

Site Operator: RICHARD TUN

Pre-Collection

Set-Up Date: 08/19/05

Collection Date: 8/20/05 Collocated Teflon

Filter I.D. No.: HCr-109T

Initial Rotameter Setting (C.O.B.): 15.0 (After 5 minutes warm-up)

Programmed Start Time: 0000 Programmed End Time: 2350

Elapsed Timer Reset (Y/N): Y

Comments: RAIN/6

Post-Collection

Recovery Date: 8-21-05 0145

Final Rotameter Reading (C.O.B.): 15.0 (After 5 minutes warm-up)

Elapsed Time: 24.1

Comments: Hot & Humid

FOR LAB USE ONLY

Site Code: WADC

Date Received: _____ Refrigerator No.: _____

Collection Time (Minutes): _____

x̄ Flowrate (cc/min): _____

Total Volume of Air Sampled: _____

White: Sample Traveler Canary: Sample File Copy Pink: Field Copy

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Health Concerns

- Typical routes of exposure ingestion, inhalation and absorption.
- As mentioned earlier, chromium has different forms, depending on the oxidation state, which ranges from -2 to +6 valence (ATSDR, 2008)
- Its health effect is a function of its valency.
- Elemental, trivalent and Hexavalent states have been noted to be most stable

Health Concerns

- Mutagenic DNA lesions results from Cr(VI) reduction to Cr(III)
- Epidemiological results among Cr exposed workers show Cr to be carcinogenic via inhalation route of exposure.
- Animal data further supports human data and implicates Cr(VI), against total Cr, as the carcinogen.

Source: EPA, 1998a

Health Concerns cont.

Weight-of-Evidence Narrative

- Group A - known human carcinogen via inhalation (EPA 1986, 1998a & b) .
- Carcinogenicity by the oral route of exposure cannot be determined and is classified as Group D (EPA 1998a & b).

Risk Analysis Assumptions

- Sample collection/analysis is devoid of significant errors
- Total ambient concentrations are captured and accounted for in analysis
- District population is exposed to total ambient concentration
- Population respond equally to ambient concentration of the pollutant
- No significant confounding factors in overall analysis
- Focus here is health risk from population exposure via inhalation only

Analysis Method

- 50% of yearly data below MDL, except 2006(48% below)
- 2 treatment types:
  - ND (non detect)=MDL/2
  - ND=MDL
- Other treatments of interest
  - Maximum Likelihood Estimate or Cohen's Distribution considered better (Helsel, 2005; Gilbert, 1987)

Is 1-in-6-sampling sufficient for calculating annual statistics using this technique?

  - Robust Regression Order Statistics (ROS)
  - Kaplan Meier (KM)

Ref Conc. & Unit Risk

- Reference Concentration (RfC)
  = 1X10-4 mg/m3 Cr(VI) particulates
- Inhalation Unit Risk
  =1.2 X 10-2 per mg/m3

Inhalation conc. @specified risk levels:

1 in 1,000,000 is 8X10-5µ/m3

(IRIS-USEPA, 1998)

Risk Estimates

Cancer Risk

- 2 comparisons:
  - Inhalation Unit Risk (IUR)*Annual Mean Conc.
  - Annual mean compared with Regional Screening Levels (2.9E-05) Region III

Risk Estimates

Non-cancer risk or Margin of Exposure (MOE)

MOE= Cr(VI) average concentration/RfC

Example: 2006

ND=MDL/2: 2.98E-05µg/m3 / (1X10-1 µg/m3)
=0.000298

ND=MDL: 3.21034E-05 µg/m3 / (1X10-1 µg/m3)
= 0.000321034

MOE is less than 1

Risk Estimates: Cancer

Cancer Risk

(Inhalation Unit Risk)*(annual Cr(VI) Mean)

Example 2006

ND=MDL/2: 1.2 x10^{-2} per µg/m^3***0.0000298**µg/m^3
=**3.57E-07**

ND=MDL: 1.2 x10^{-2} per µg/m^3***0.0000321**µg/m^3
=**3.85241E-07**

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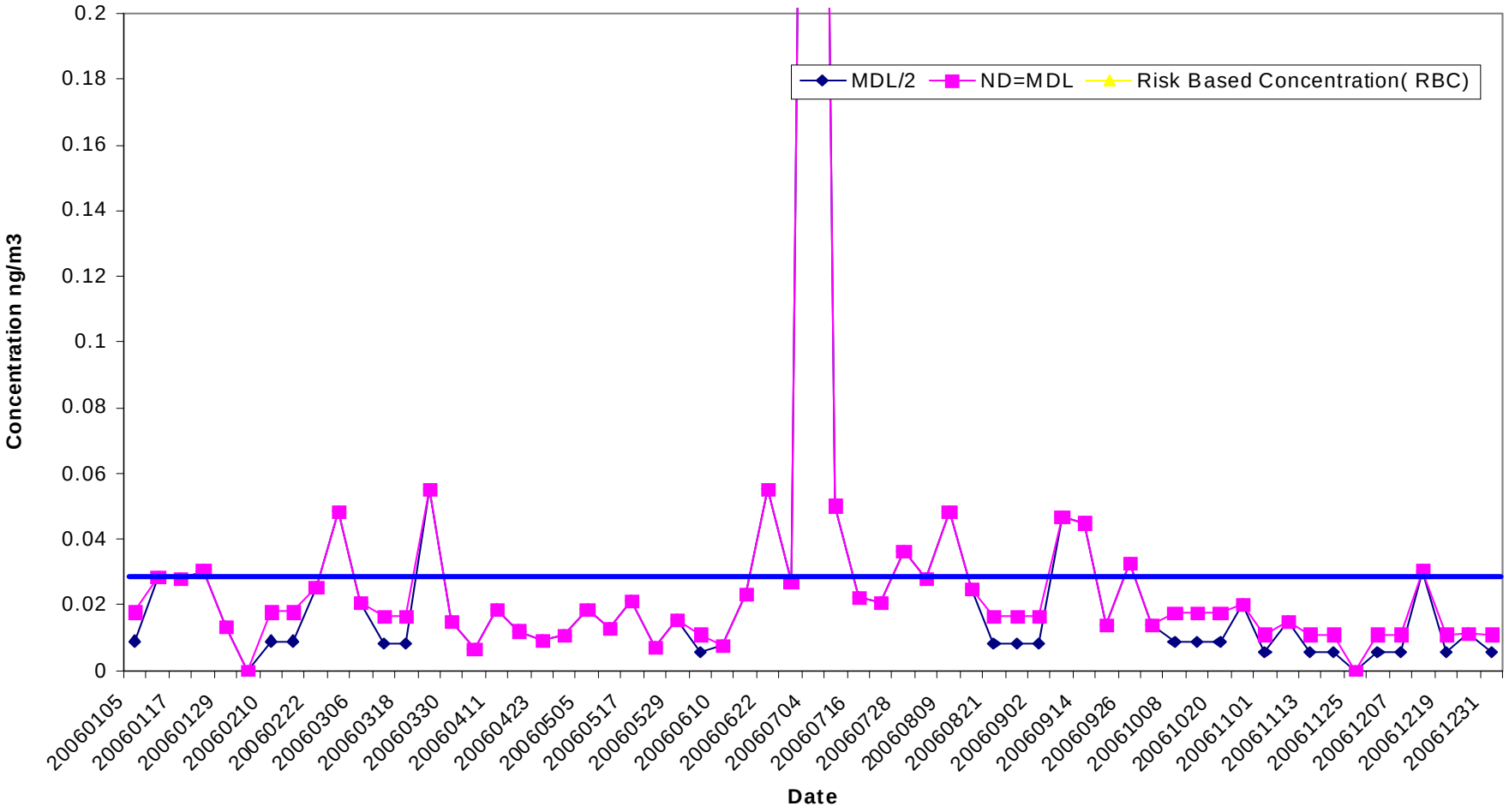
Exposure Risk Estimate

YEAR	Non-Cancer Risk (MOE)		CANCER RISK	
	ND=MDL	ND=MDL/2	ND=MDL	ND=MDL/2
2006	0.0003	0.0003	4E-7	4E-7
2007	0.0001	0.00009	1E-7	1E-7
2008	0.0001	0.00009	1E-7	1E-7

Risk Based Concentration Comparision 2006



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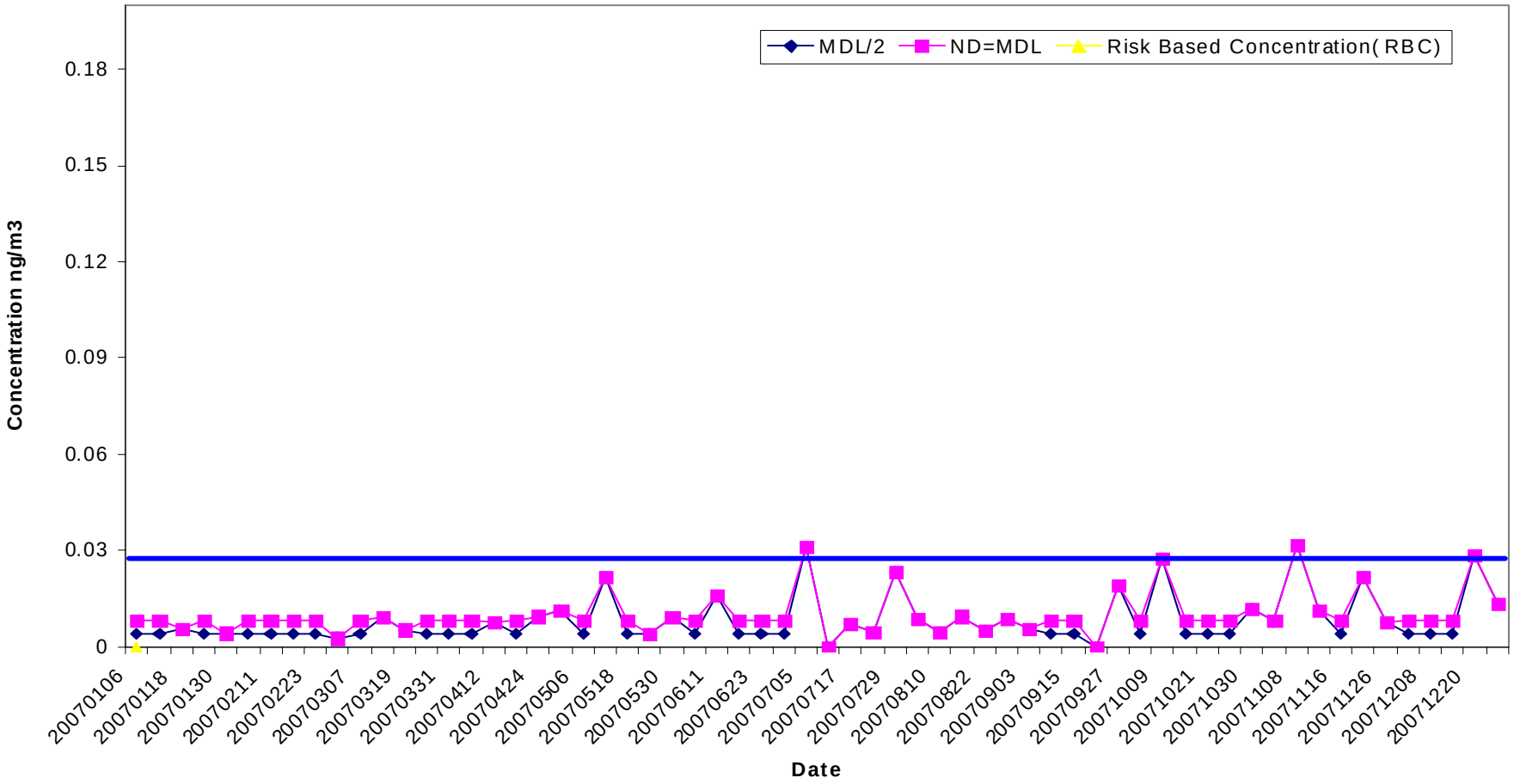
Risk Based Concentration Comparision 2007



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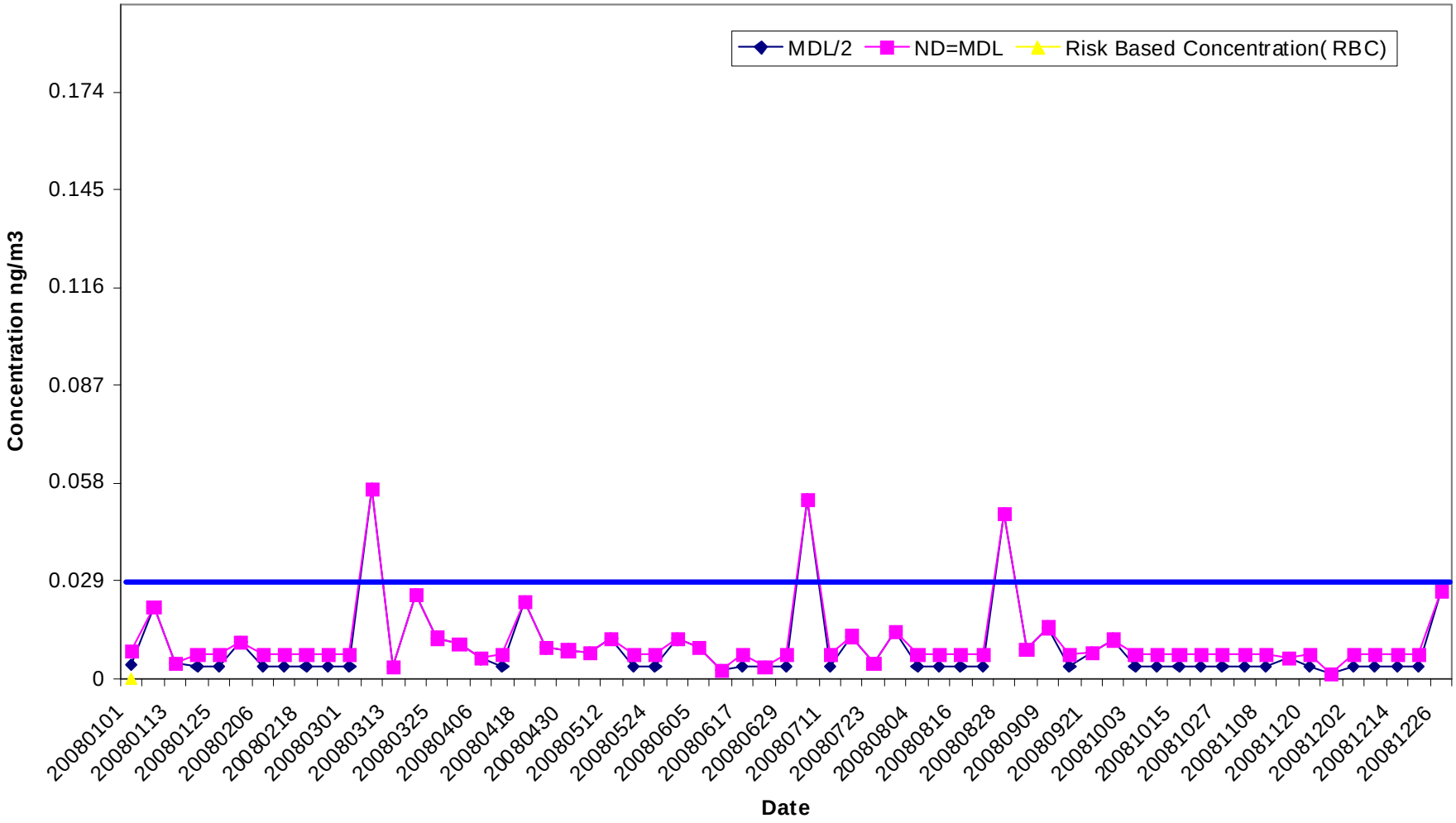
Risk Based Concentration Comparision 2008



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Discussions

- Substituting non-detect with MDL is very conservative; (EPA, 2009).
- The MDL/2 does not give a true estimate of ambient concentration and the subsequent exposure measure either, as it tends to give a measure that is considered higher than the true ambient concentration (EPA, 2009; Helsel, 2005; Warren and Nussbaum, 2009).
- The true statistical reflection of ambient concentration is considered to be maximum likelihood estimation (MLE), (ibid). Doubts however, have been casted on this approach, with regards to 1-in-6 samples.

Discussions

- Acceptable cancer risk level is 1E-06 or 1 in 1,000,000 (EPA 1998b).
- Current estimate using the conservative non-detect=MDL or MDL/2 still shows an estimate below the acceptable level.
- Indoor concentration is worth noting too, as build up, resulting from proximity to road ways, and/or smoking may raise level to several fold higher than the ambient concentration.

Limitations

- Errors from using new sampling method
- MDL and MDL/2 are too conservative to give a true reflection of ambient air concentration and subsequent exposure analysis
- Cohen method suggested need to be looked at even though sampling is 1-in-6.

Conclusions

- Cr(VI) concentration in the District's ambient air is generally well below levels considered harmful.
- Occasional spikes of short duration observed
- High percentage of non-detect needs to be accounted for

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