45 Years of REMP: What Have We Learned?

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Point Beach Nuclear Plant

Background Information

- 2 Westinghouse 2-loop Rx at 625 MWe
- Unit 1 online December 1970, Unit 2 online March 1972
- Located on Lake Michigan (1100 cubic miles of water)
- Site Area = 1260 acres
- 30 miles SE of Green Bay
- 90 miles NNE of Milwaukee

Regulatory Requirements

10 CFR 50 Appendix A

- **Criterion 64 - Monitoring radioactivity releases-**
- **Means shall be provided for monitoring ….“plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.” [REMP]**

Point Beach GDC

Point Beach was licensed under AEC GDC 17

Atomic Industrial Forum 1967

- **Criterion 17:**
  - Means shall be provided for monitoring… radioactivity released from normal operations, from anticipated transients, and from accident conditions. An environmental monitoring program shall be maintained to confirm that radioactivity releases to the environs of the plant have not been excessive.

10 CFR 20.1302(a) Compliance with dose limits for individual members of the public

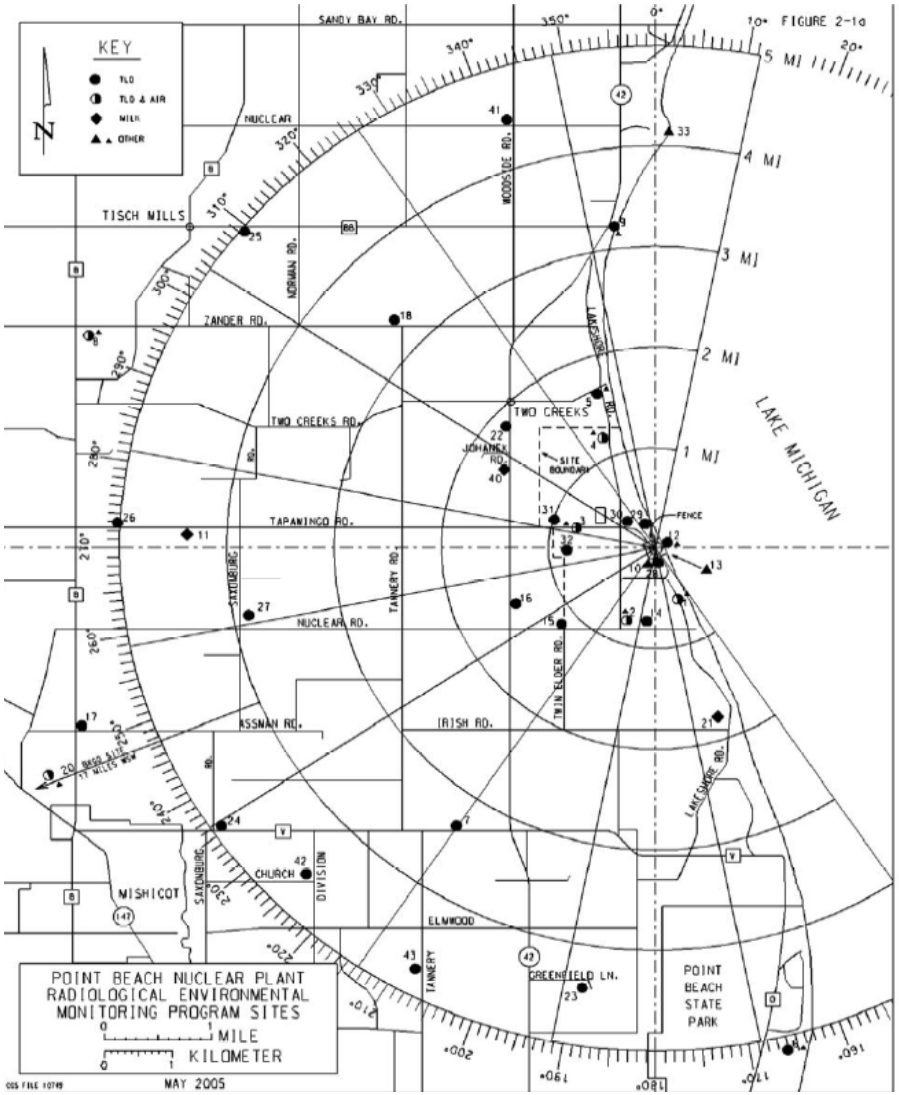
- **"The licensee shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas…" [TLDs]**

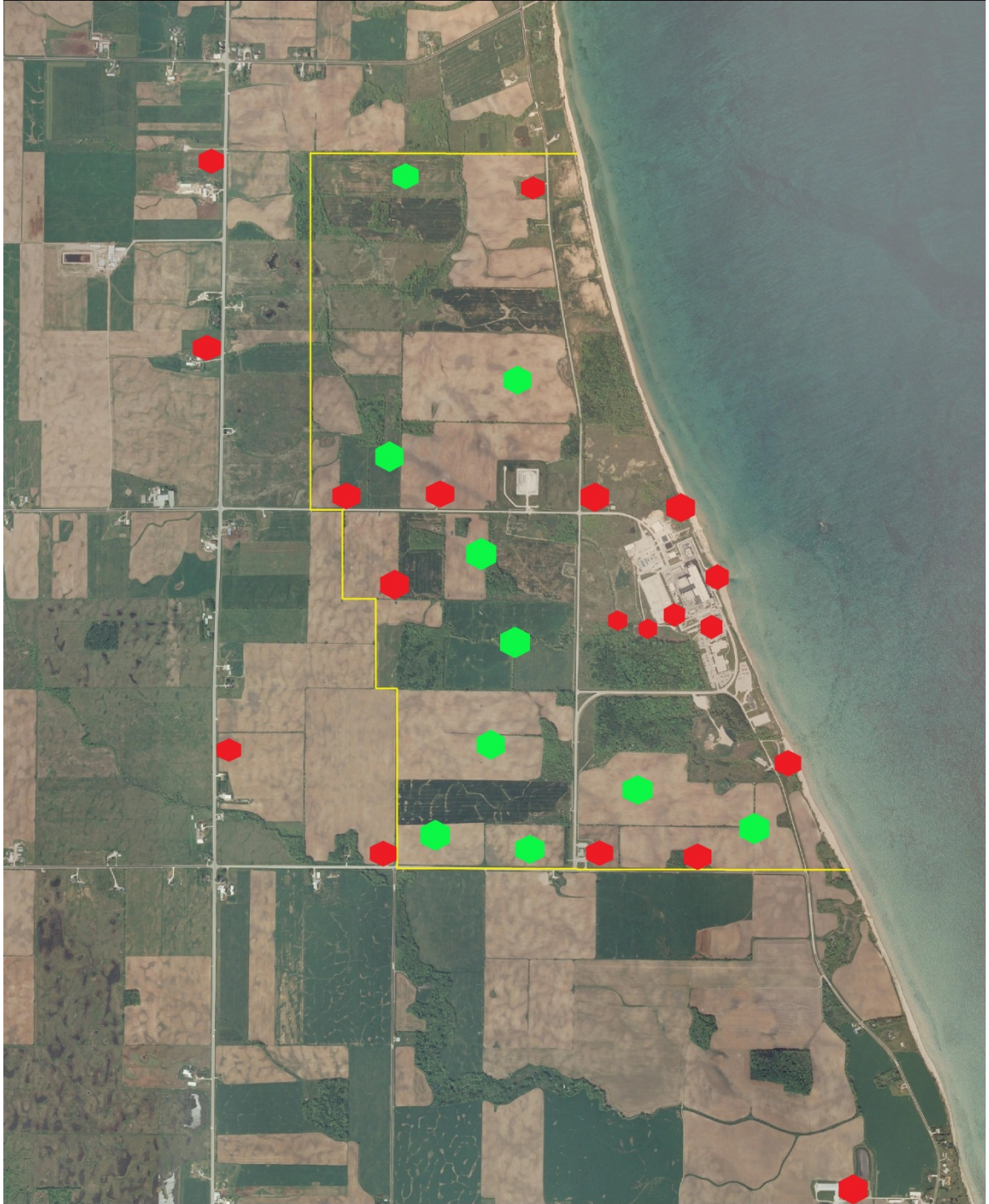
10 CFR 50 Appendix I

- **Section IV.B The licensee shall establish an appropriate surveillance and monitoring program to:**
- **2. Provide data on measurable levels of radiation and radioactive materials in the environment to evaluate the relationship between quantities … released …and resultant doses from principle pathways [REMP]**
- **3. Identify changes in the use of unrestricted areas (e.g. for agricultural purposes) to permit modifications in monitoring programs for evaluating doses to individuals from principal pathways of exposure [LUC]**

REMP Sampling Sites

Current REMP





REMP Data Reporting

Former Data Reporting Convention Cs-137 in Lake Water

- **Former reporting convention. What do we learn here?**

1987	E-01 +/-	E-05 +/-	E-06 +/-	E-09 +/-	E-12 +/-
Jan	*<10*	*<10*	*<10*	*<10*	*<10*
Feb	*<10*	*<10*	*<10*	*<10*	*<10*
Mar	*<10*	*<10*	*<10*	*<10*	*<10*
Apr	*<10*	*<10*	*<10*	*<10*	*<10*
May	*<10*	*<10*	*<10*	*<10*	*<10*
Jun	*<10*	*<10*	*<10*	*<10*	*<10*
Jul	*<10*	*<10*	*<10*	*<10*	*<10*
Aug	*<10*	*<10*	*<10*	*<10*	*<10*
Sep	*<10*	*<10*	*<10*	*<10*	*<10*
Oct	*<10*	*<10*	*<10*	*<10*	*<10*
Nov	*<10*	*<10*	*<10*	*<10*	*<10*
Dec	*<10*	*<10*	*<10*	*<10*	*<10*

What do These Results Mean?

- **Can you really say there is nothing there?**
- **These are a *PRIORI* <LLD values for the measurement system**
- **NUREG-0472: The *a priori* LLD is not an *a posteriori* limit for a particular measurement**

Upgrading Environmental Radiation Data

- **EPA 520/1 80 012 (August 1980)**
- **Health Physics Society Committee Report HPSR-1 (1980)**
- **Chapter 6 NBS, NRC, EPA, DOE recommendations:**
  - All measurement results should be reported directly as obtained, including negative values."
  - Neither the LLD or the MDC is intended to be an *a posteriori* criterion for the presence of activity.
  - ANSI 13.33 endorses most of Chapter 6

September 2015 Lake Water

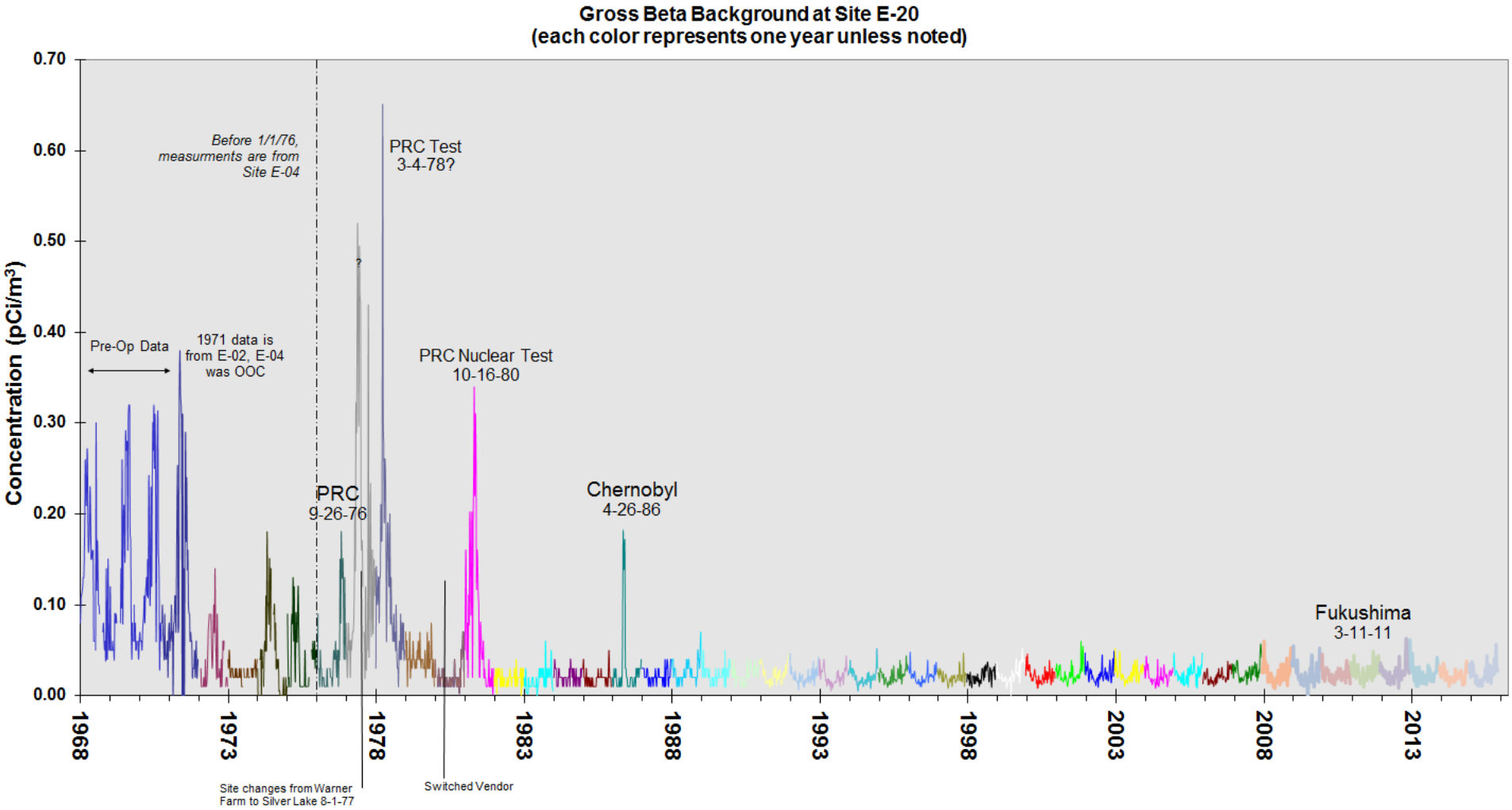
PAREMETER	pCi/L		2σ		MDA
Gross beta	0.6	±	0.5	<	0.8
I-131	0.1	±	0.2	<	0.27
Mn-54	0.3	±	0.8	<	1.7
Fe-59	1.0	±	1.6	<	3.5
Co-58	-0.3	±	0.8	<	1.8
Co-60	-0.2	±	0.9	<	1.5
Zn-65	-1.1	±	1.8	<	2.6
Zr-Nb-95	1.3	±	0.8	<	2.5
Cs-134	-0.6	±	0.9	<	1.6
Cs-137	-0.1	±	0.9	<	1.1
Ba-La-140	-4.3	±	1.0	<	4.2

Air Samples

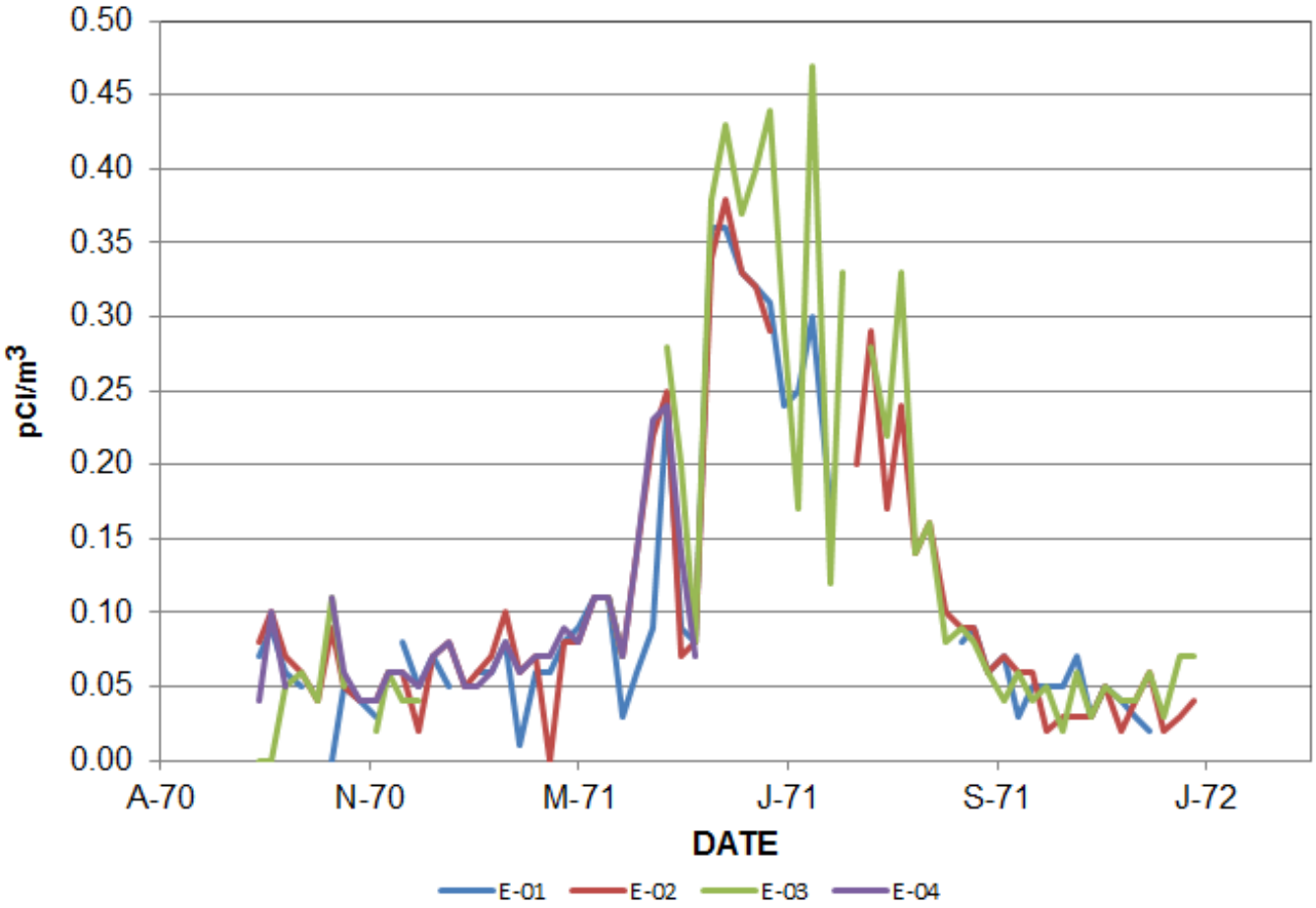
AP Gross Beta

1970 – 2015

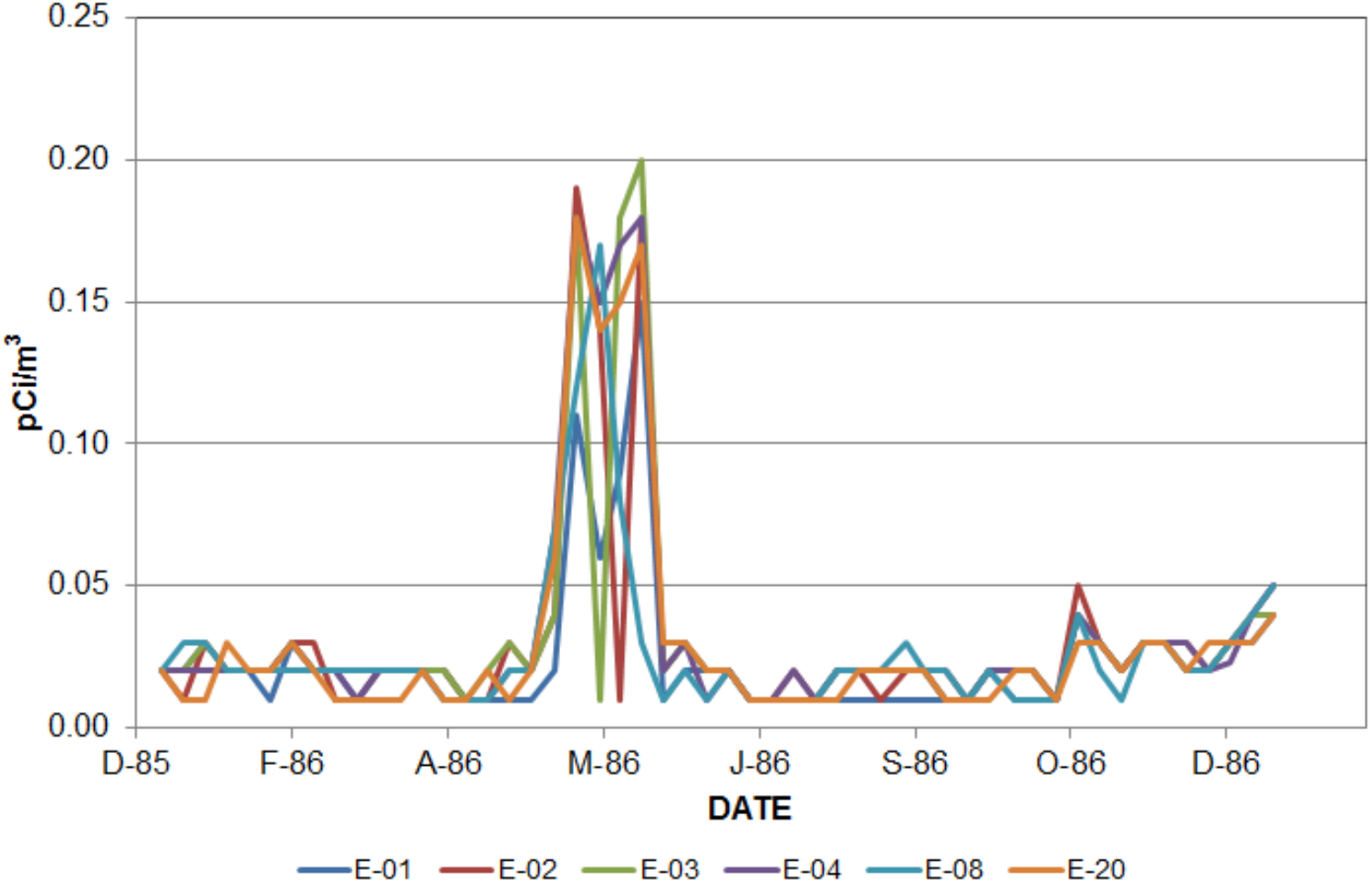
E-20 Gross β 1968 - 2015



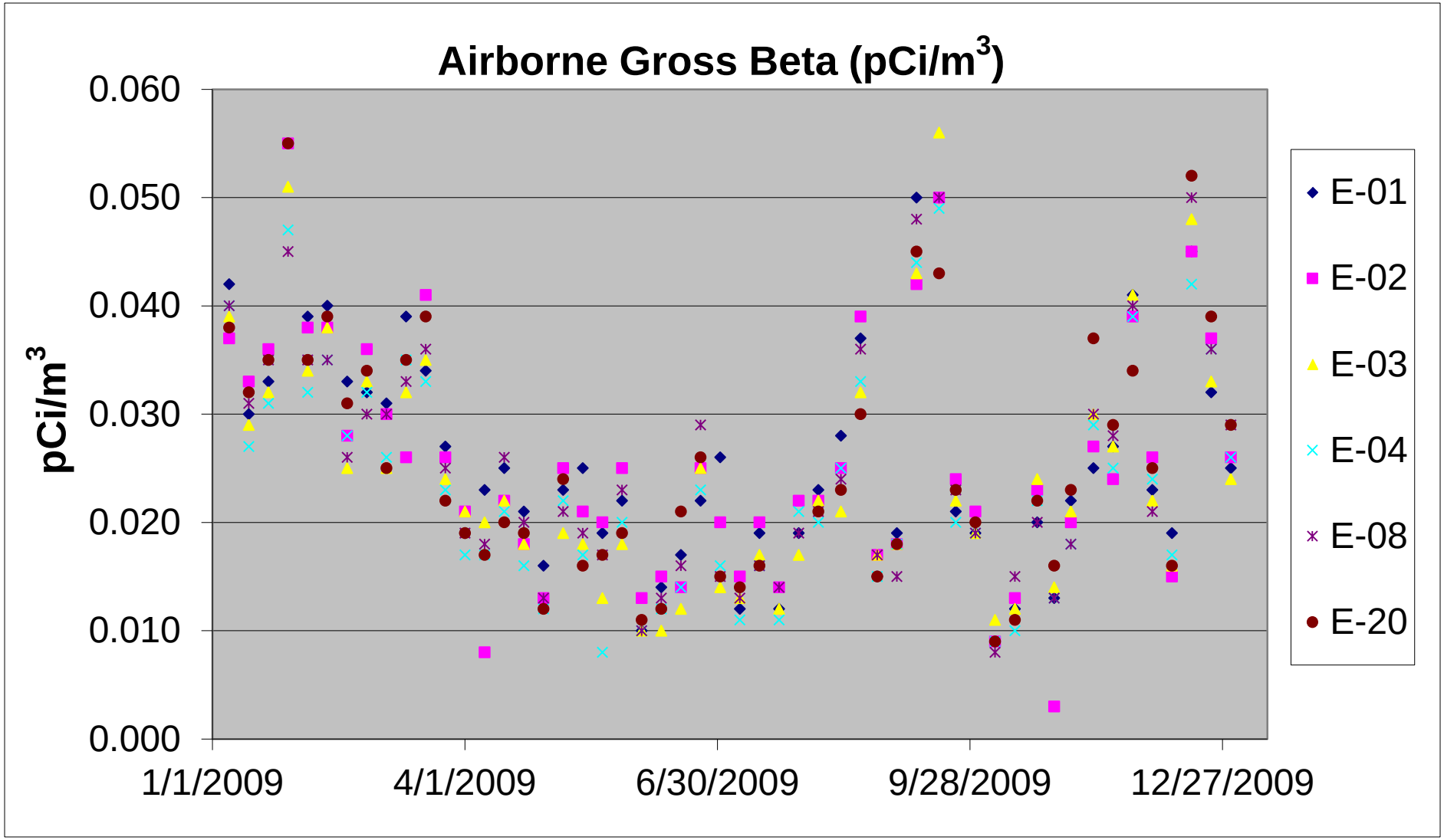
Operational REMP (10/70 – 12/71)
Air Gross Beta (pCi/m^3)



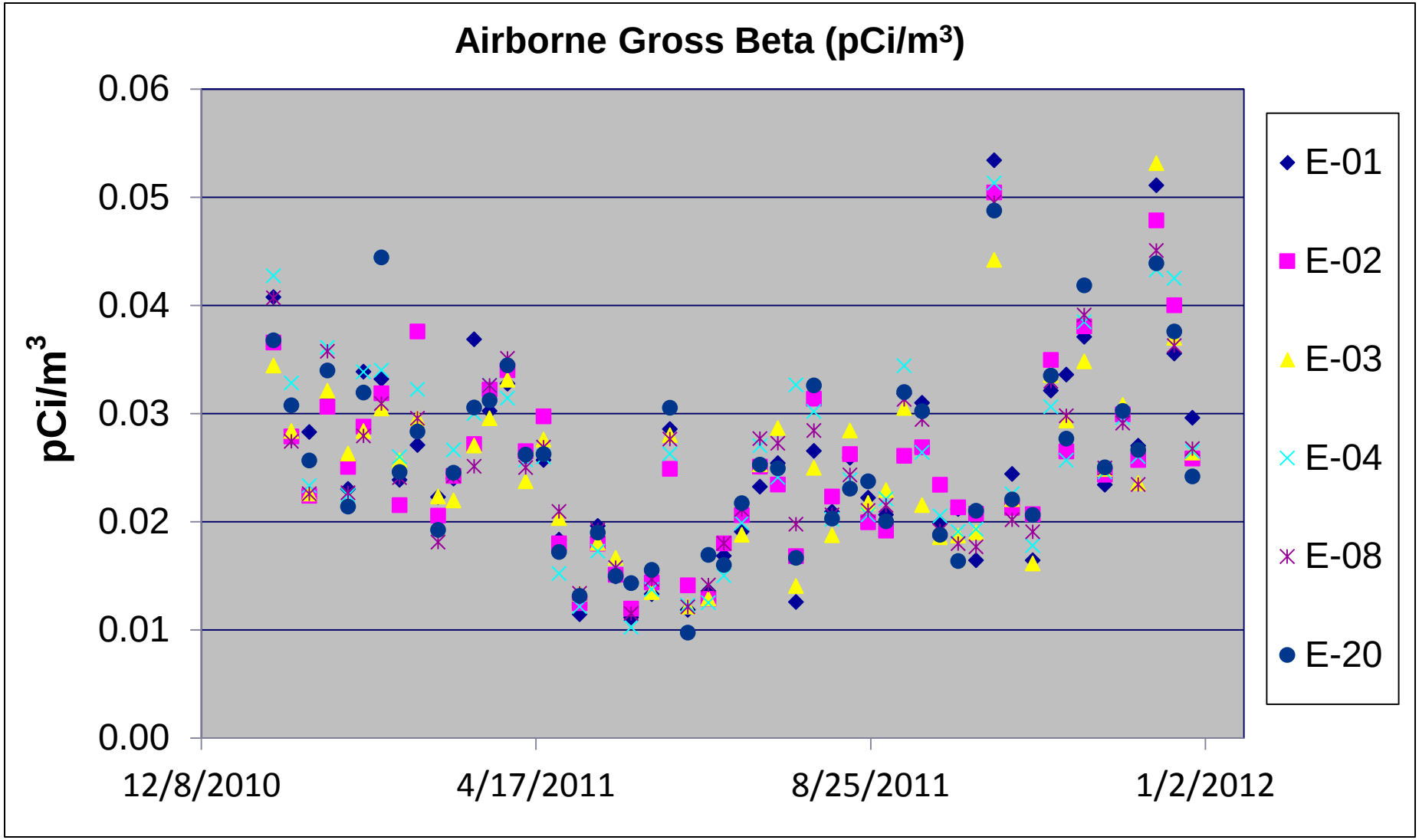
1986 Air Gross Beta (pCi/m^3)



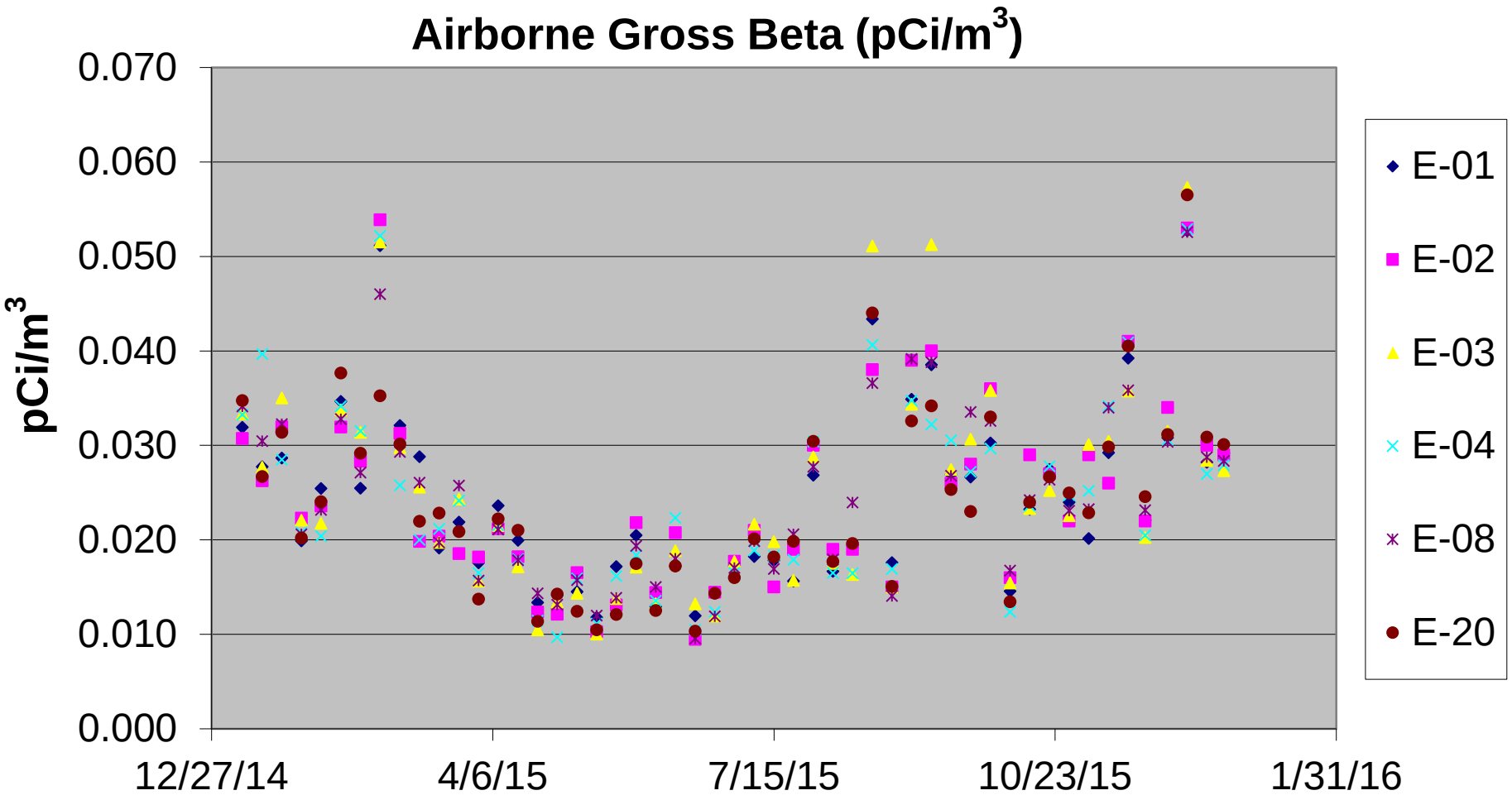
2009


Airborne Gross Beta (pCi/m3)
pCi/m3
0.060
0.050
0.040
0.030
0.020
0.010
0.000
1/1/2009
4/1/2009
6/30/2009
9/28/2009
12/27/2009
E-01
E-02
E-03
E-04
E-08
E-20

2011


Airborne Gross Beta (pCi/m³)
pCi/m³
0.06
0.05
0.04
0.03
0.02
0.01
0.00
12/8/2010
4/17/2011
8/25/2011
1/2/2012
E-01
E-02
E-03
E-04
E-08
E-20

2015

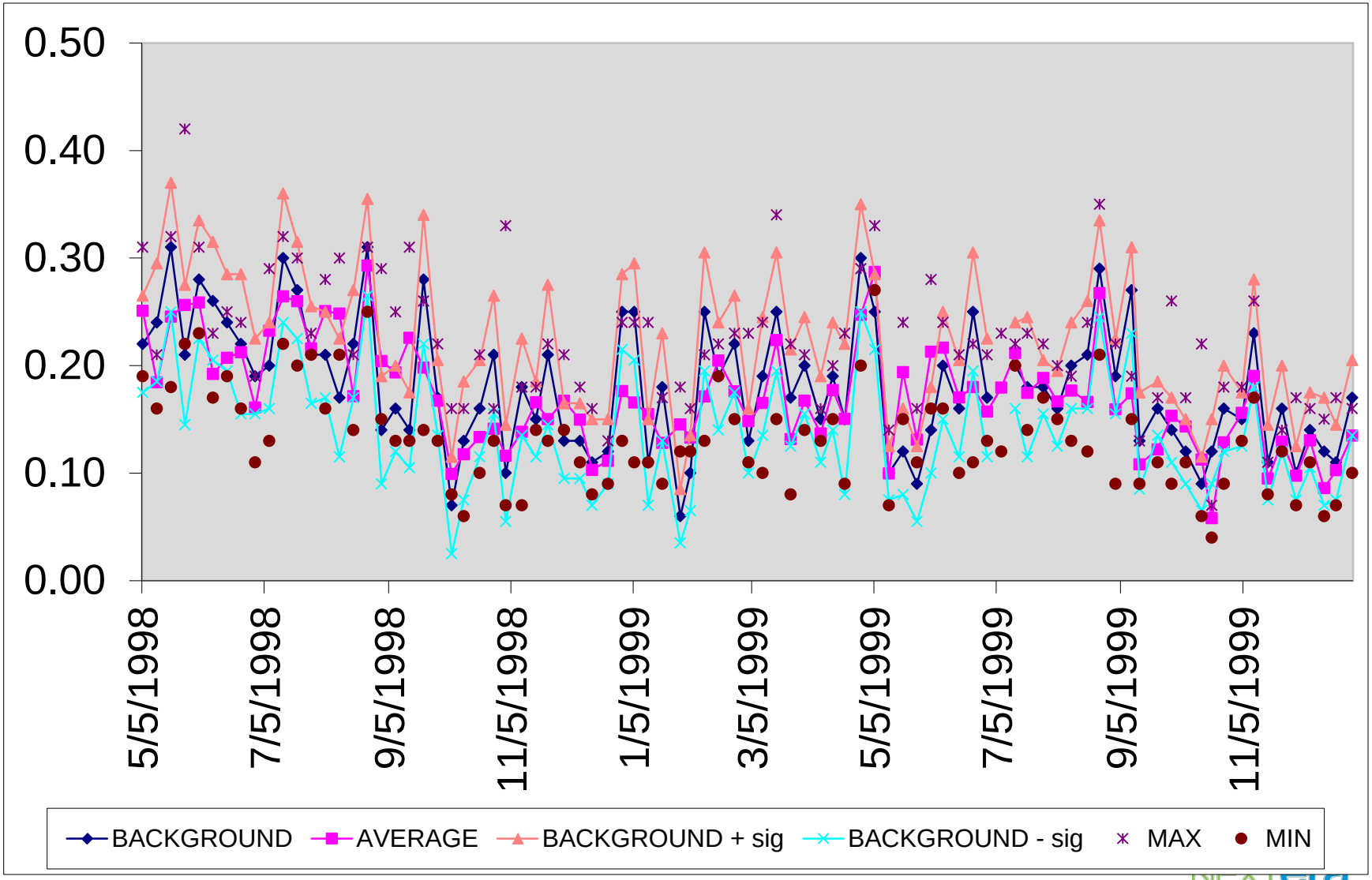


DECREASE IN SUMMER ATTRIBUTED TO MIXING OF UPPER AND LOWER AIR LAYERS DILUTING THE CONCENTRATION OF RADON EMITTED FROM THE SOIL.

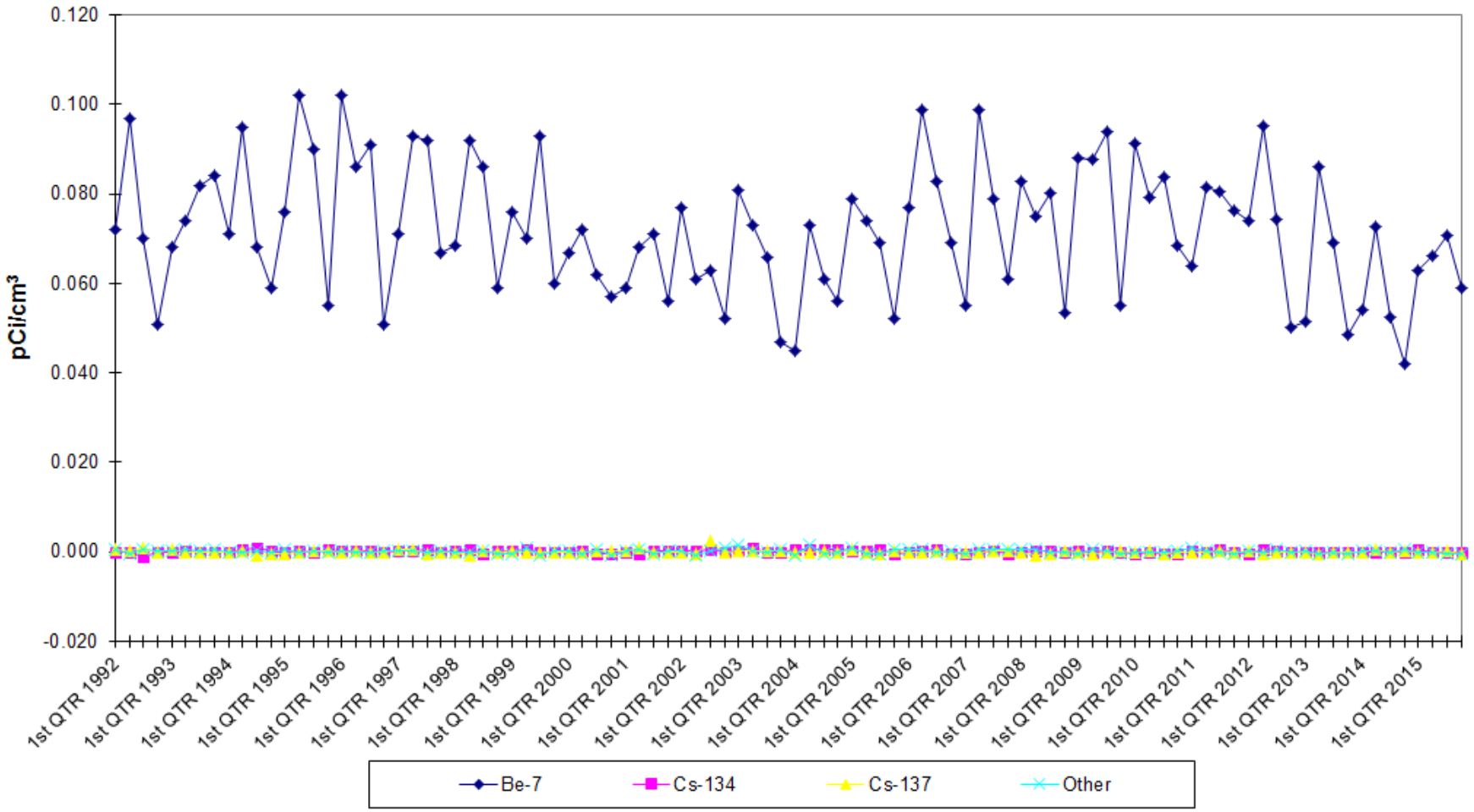
Air Samples

Be-7 Activity

Be-7 May 1998 – Dec 1999 (pCi/m^3)



E-20 Quarterly Gamma Emitters (pCi/m³)
Be-7 11-year cycle



Air Samples

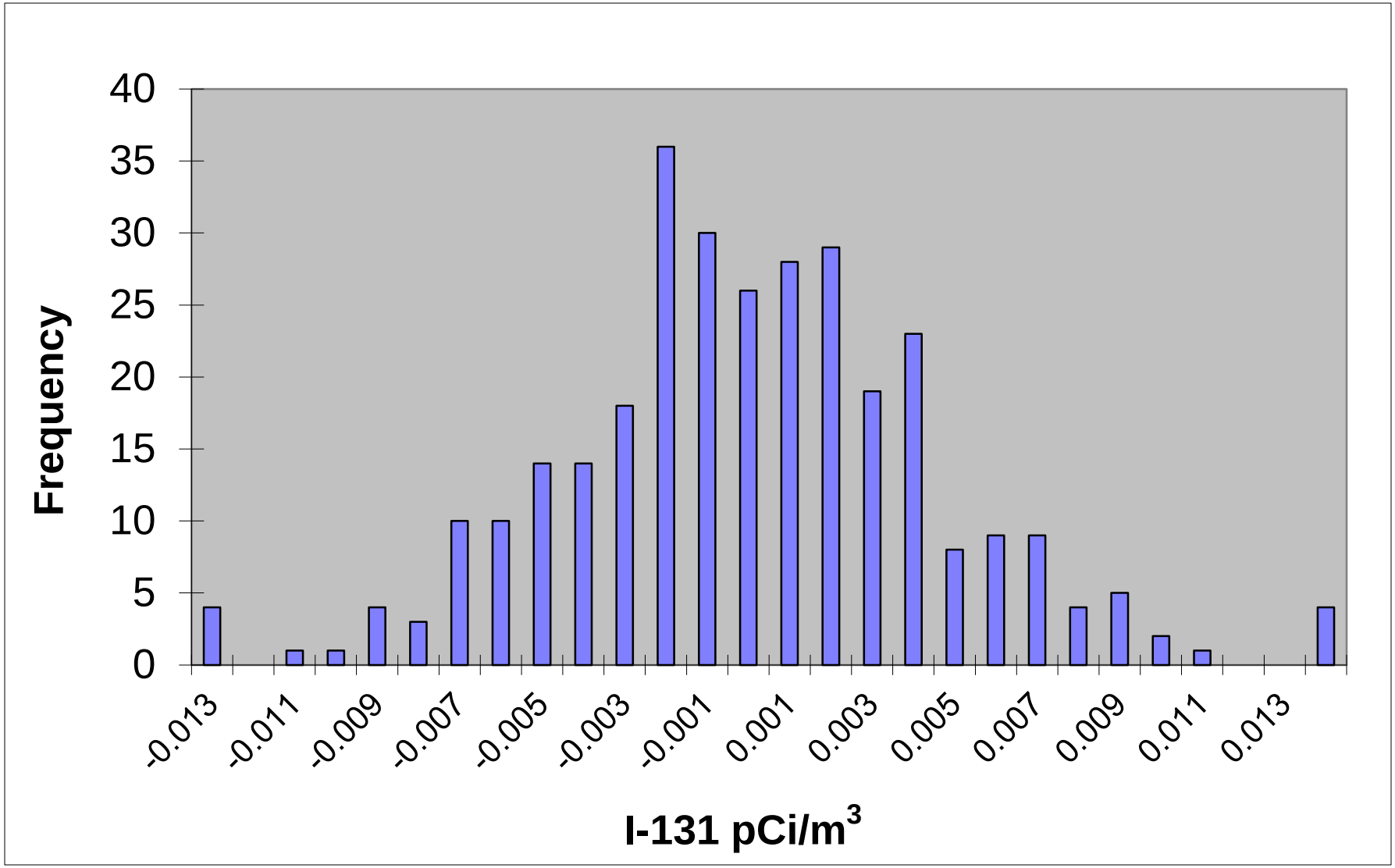
I-131

1992 - 1997

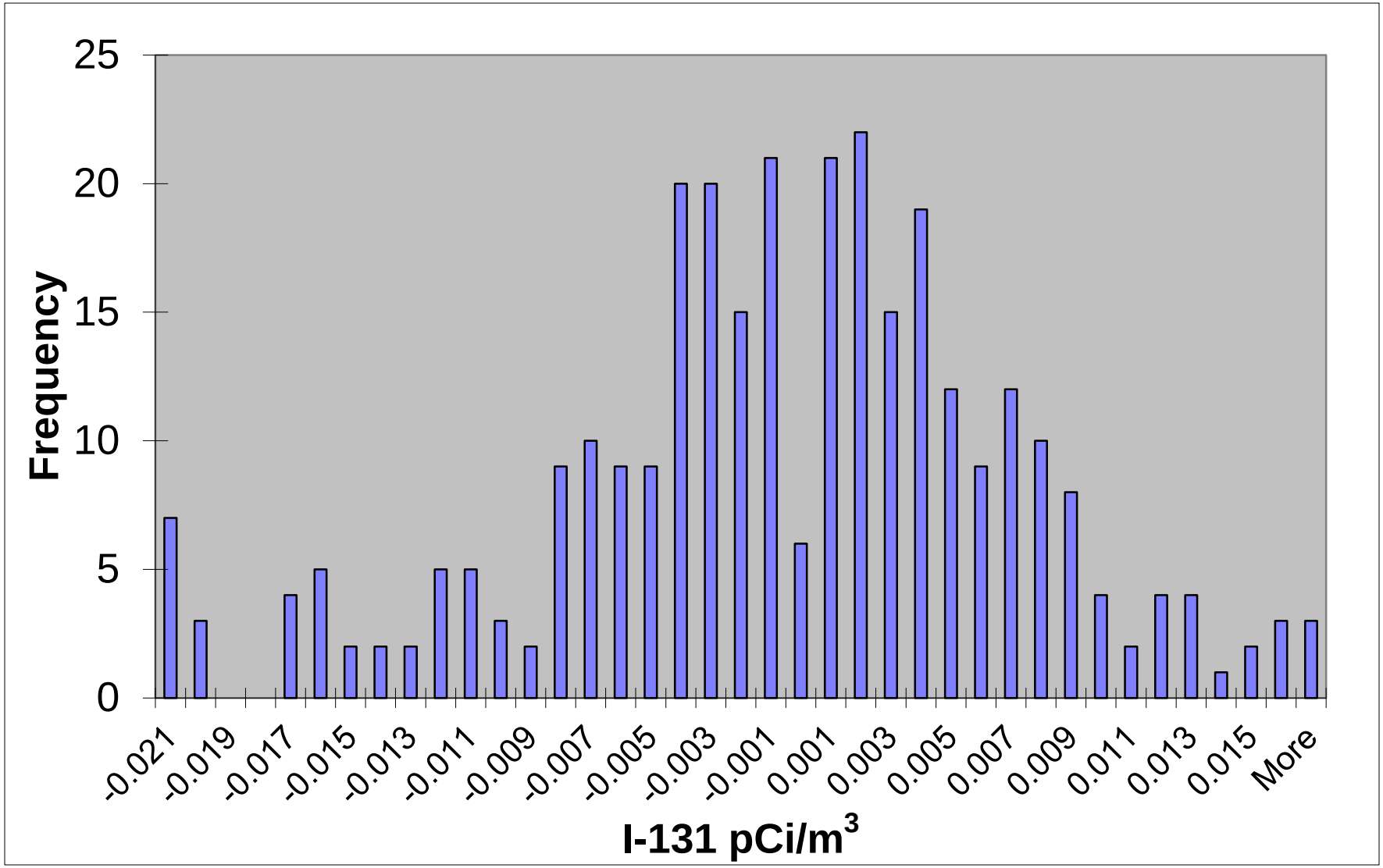
Method of I-131 Analysis

- Prior to 1992 we screened for I-131 by counting all charcoal cartridges as one sample. If positive results were found, then individual cartridges were counted.
- Starting in 1992, we began analyzing each individually and reporting results "as measured."

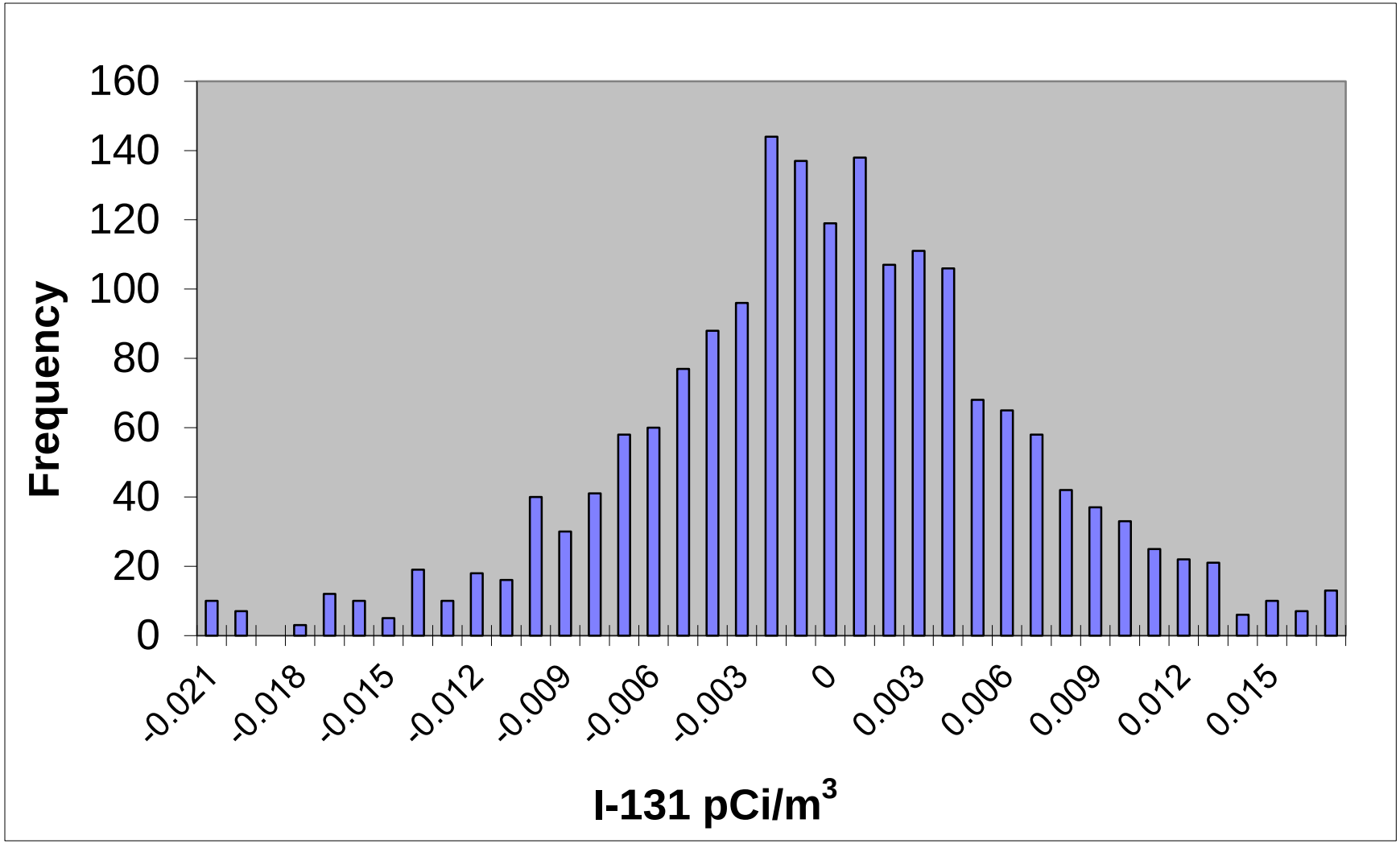
1992 Airborne I-131



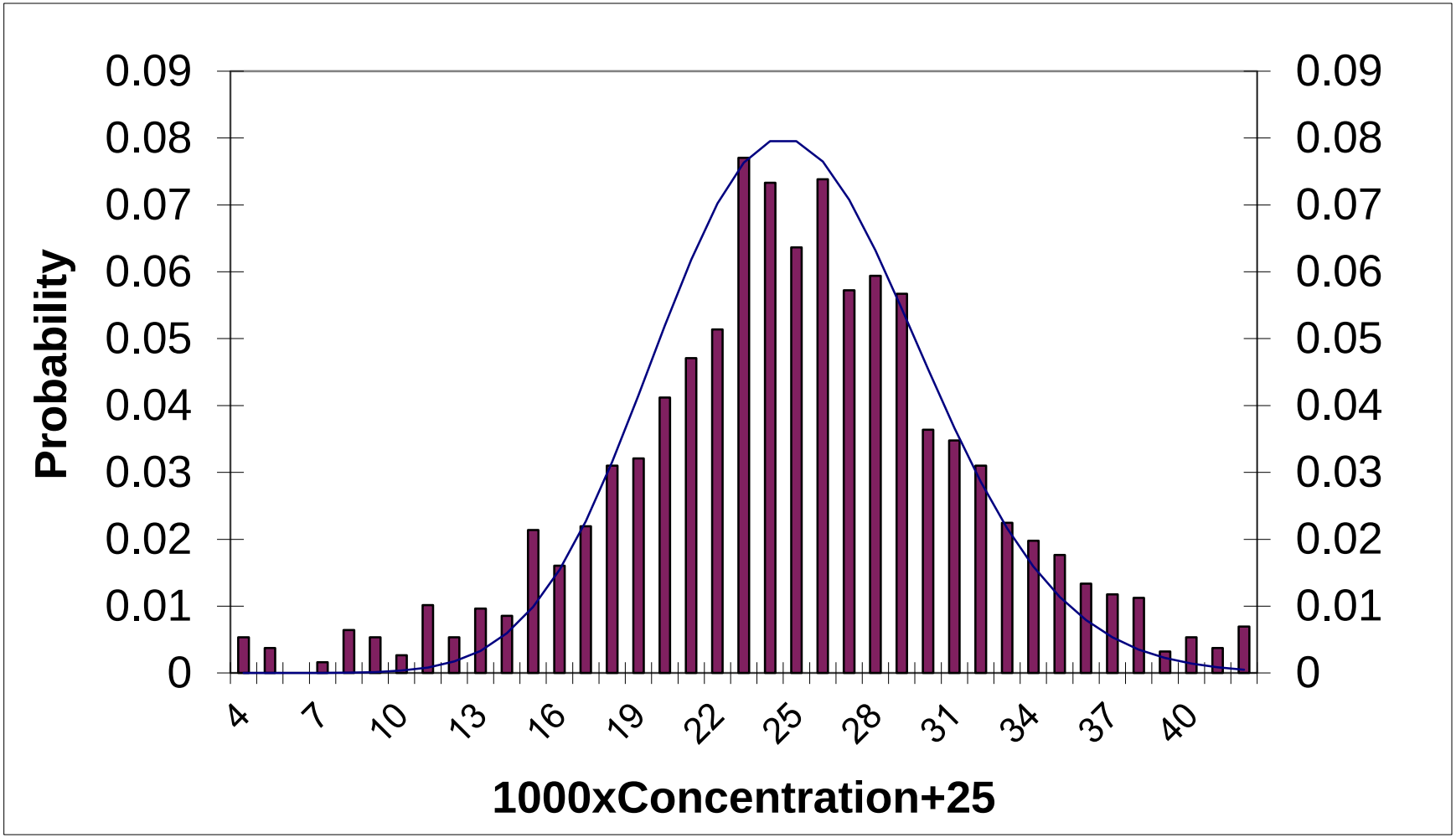
1994 Airborne I-131



1992 – 1997 Histogram for I-131



Comparison of I-131 Histogram to Poisson Distribution 1992 - 1997



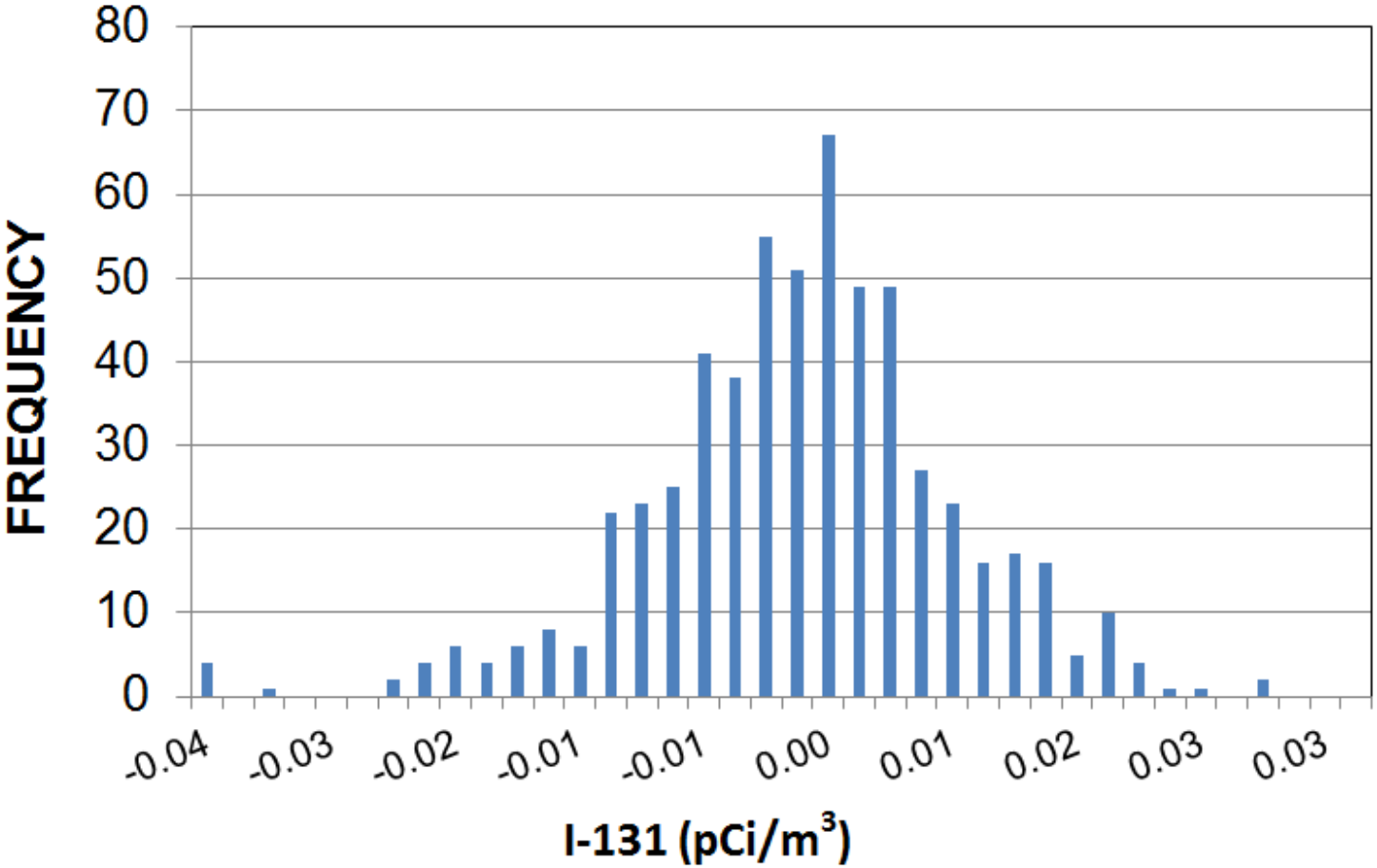
Airborne Conclusion

- **Based on the analytical measurement parameters there is no evidence of a plant effluent effect in the environment.**

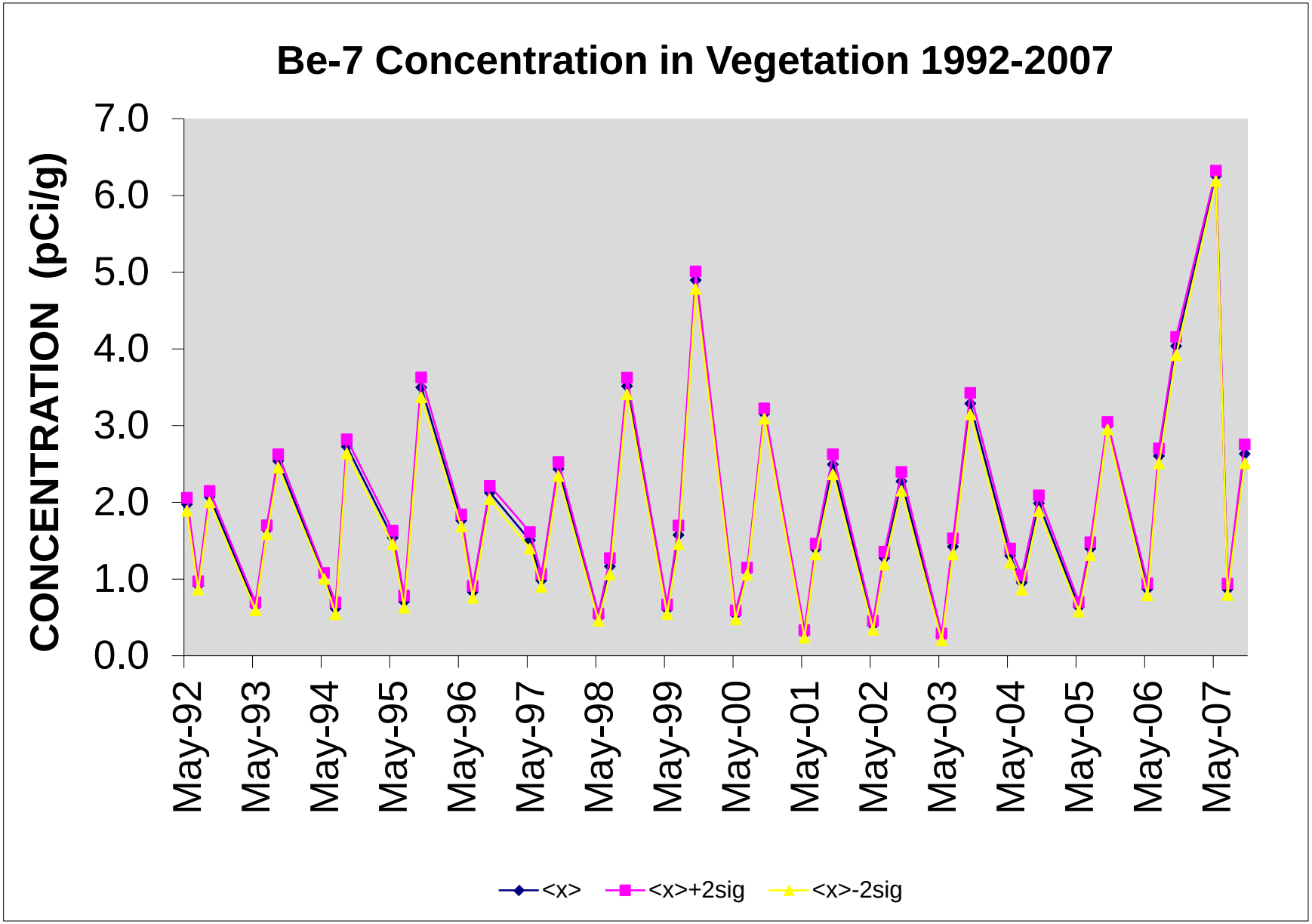
Vegetation

I-131, Be-7, and Cs-137

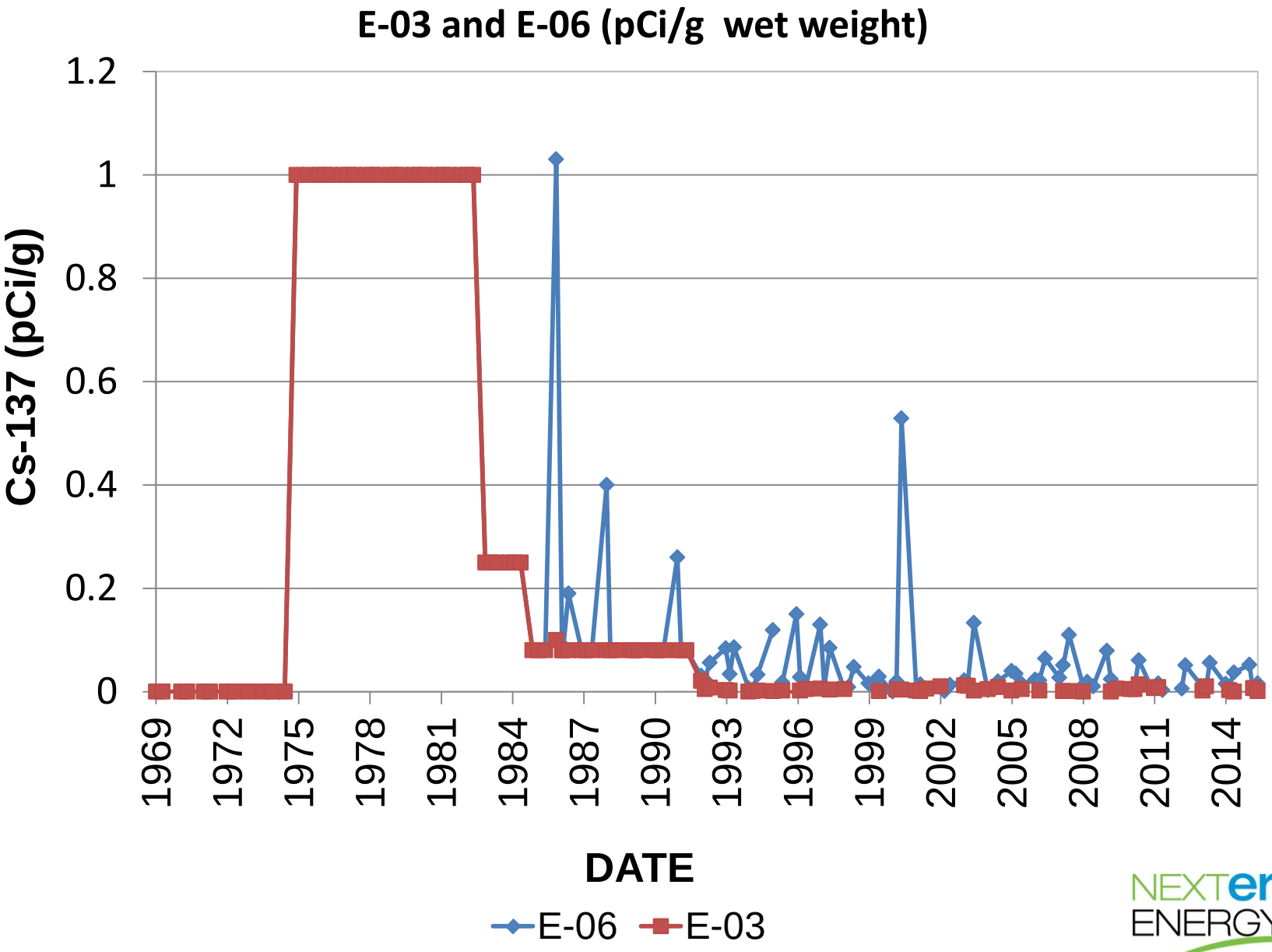
1992 – 2015 Vegetation I-131 (pCi/g)



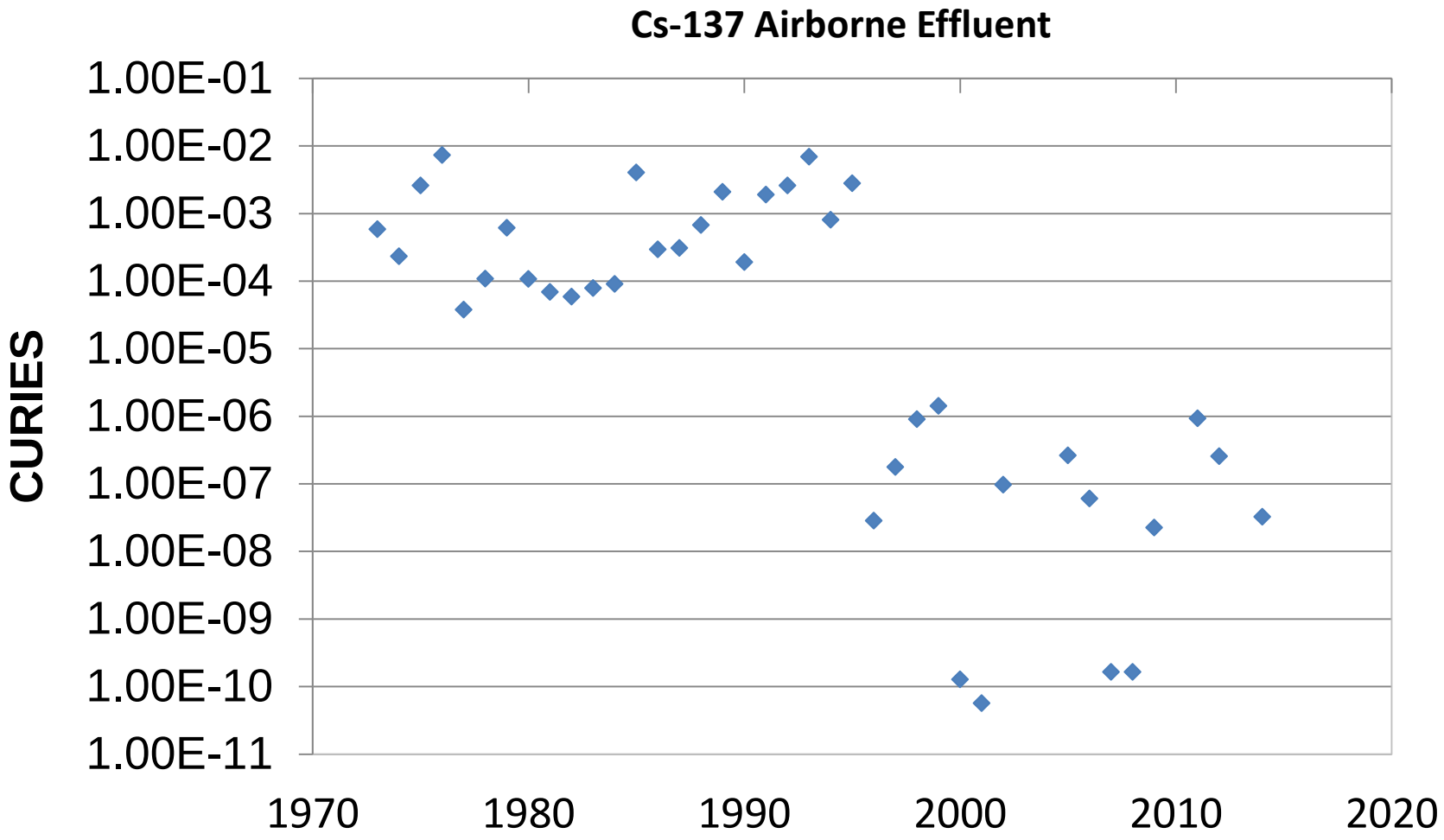
SAME PATTERN AS OBSERVED FOR AIRBORNE I-131


Be-7 Concentration in Vegetation 1992-2007
CONCENTRATION (pCi/g)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
May-05
May-06
May-07
<x>
<x>+2sig
<x>-2sig

Vegetation Cs-137

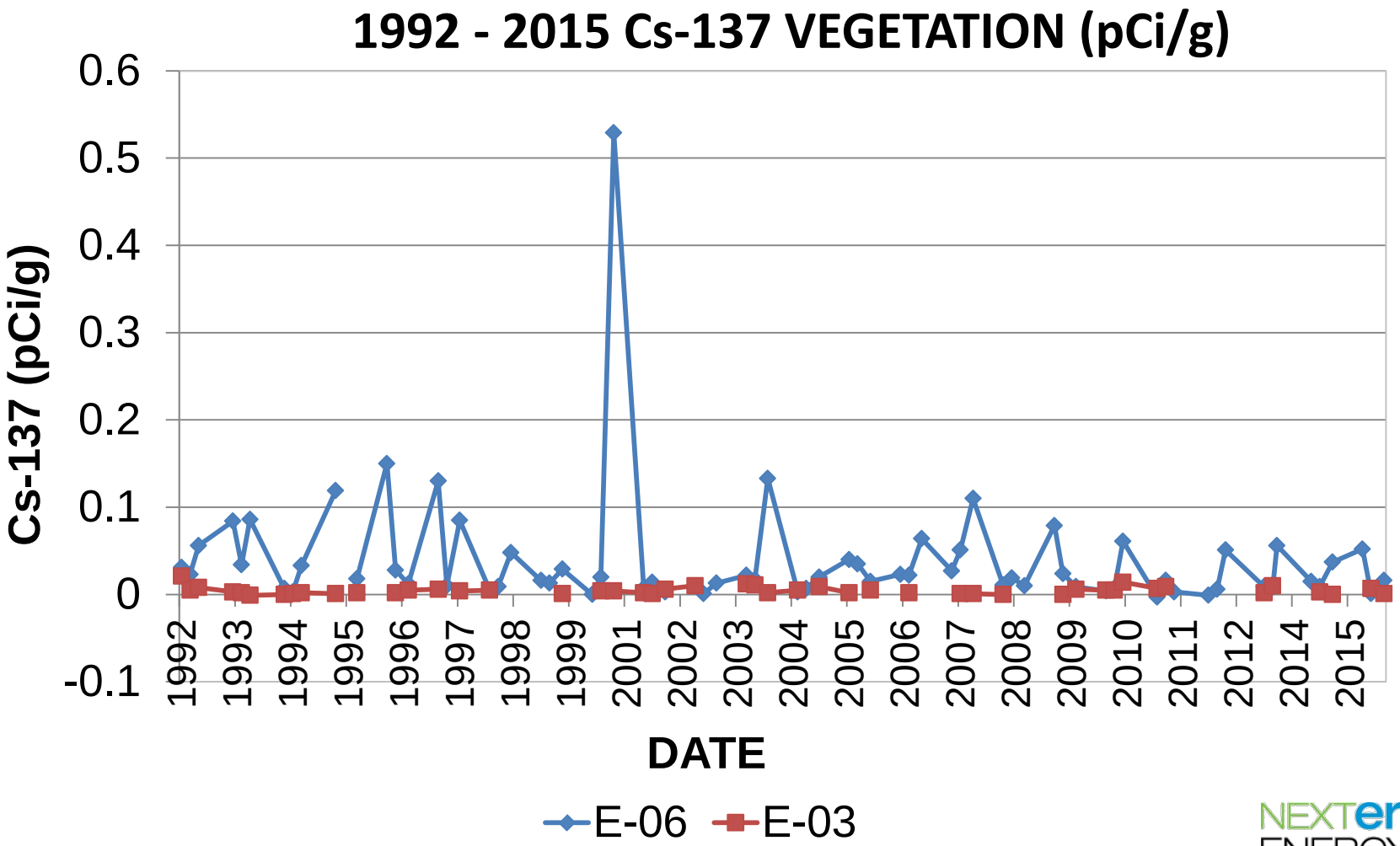


Cs-137 1970 - 2015



NEXTera ENERGY NUCLEAR FLEET

Same Plot But Using Only "as Measured" Results



Comparison of Soil and Location

- E-03 SOIL Cs-137 = 0.26 ± 0.26 pCi/g (MAX = 0.91)
- E-06 SOIL Cs-137 = 0.36 ± 0.33 pCi/g (MAX = 1.10)
- E-03 rich soil in field 0.8 miles west of plant
- E-06 very sandy soil in a forested area 6 miles south

Solution

- S. Farber April 1990 HPS Newsletter "Preliminary Study of Cs-137 Uptake by Trees"
- Cs-137 in tree ash 1.59 – 15.3 pCi/g (initial study)
- Expanded survey in 14 states
- Cs-137 in tree ash 0.079 – 21.1 pCi/g
- WI samples Cs-137 1.42 ± 0.14 pCi/g
- Sr-90 0.53 ± 0.20 pCi/g
- E-06 in a state forest where campfire ashes spread on ground
- Fallout Cs-137 from the 1960s incorporated by trees growing in nutrient poor soil

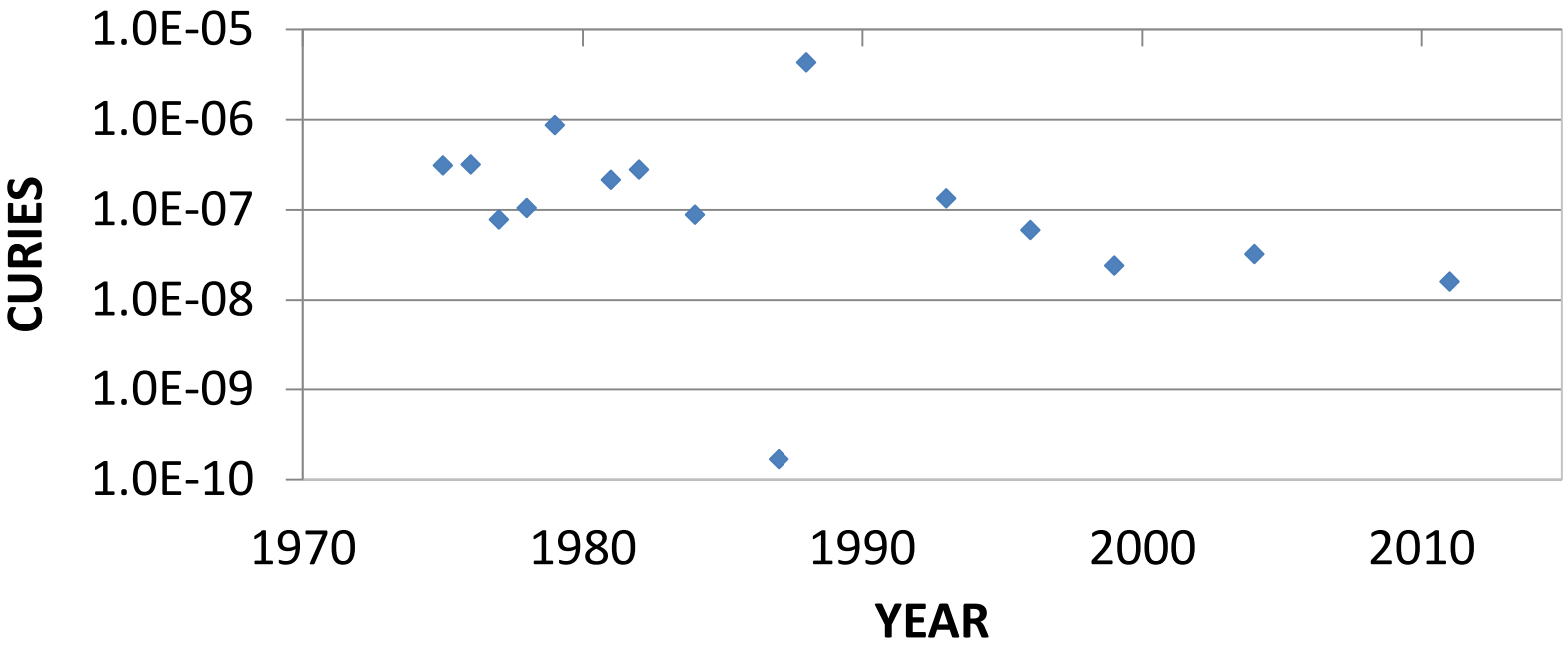
Vegetation Conclusion

- **No evidence of Point Beach effluents in general vegetation (eight sites) and in crops (10 locations on site) collected ever during 45 years of operation.**

Milk

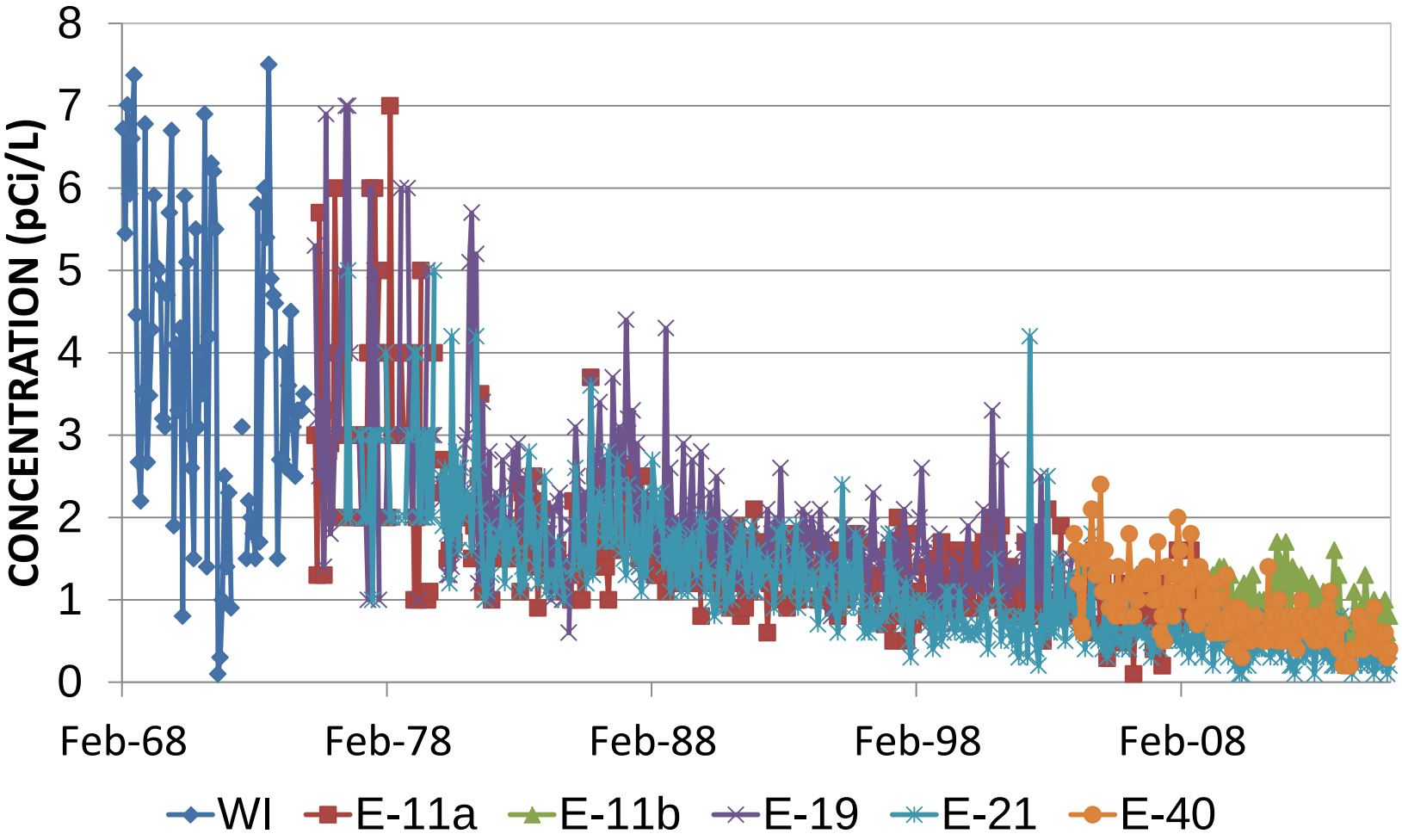
Sr-90

Air Effluent Sr-90 1970 – 2015

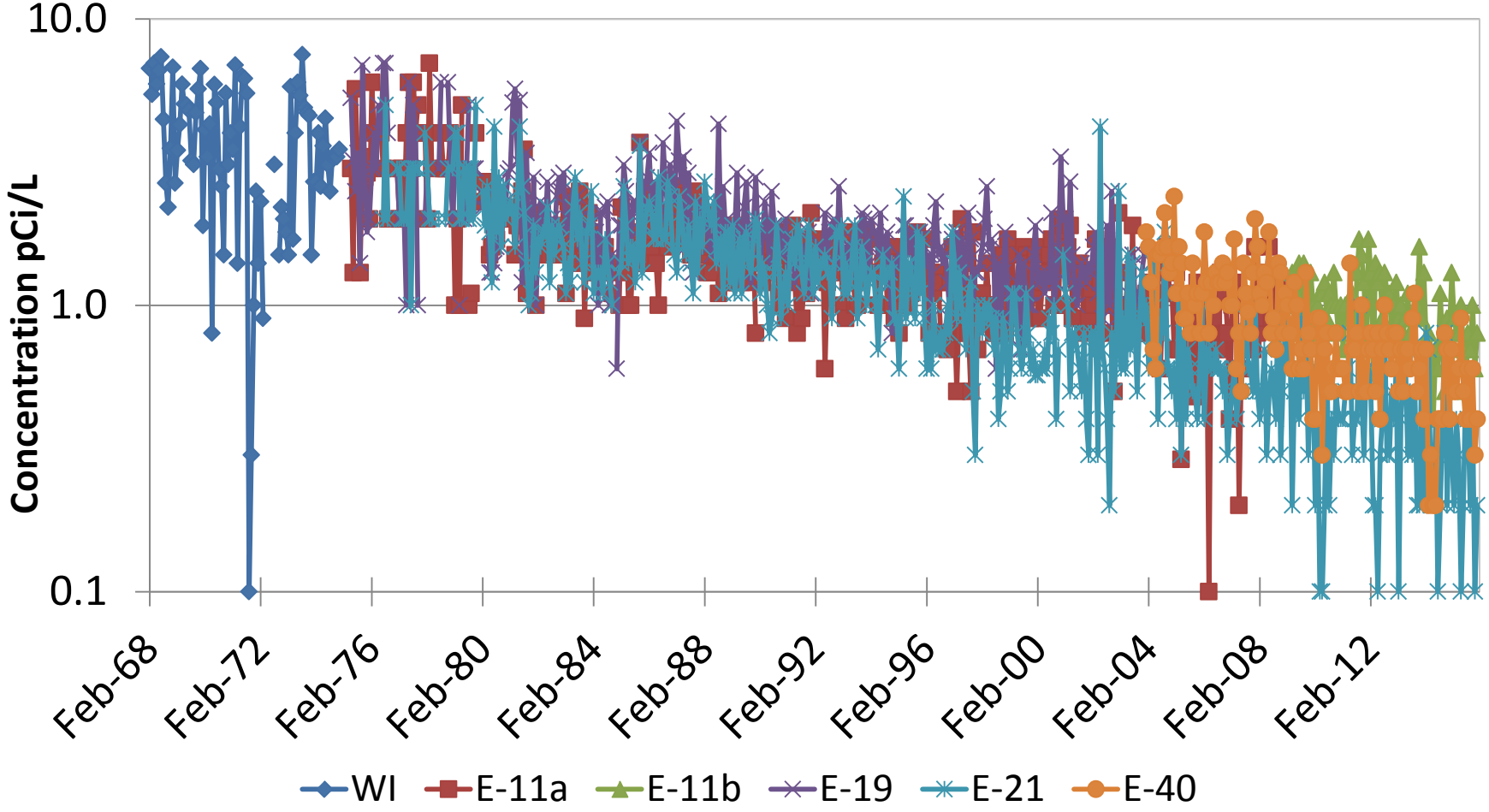


Airborne Sr-90 effluent in only 15 yeas of the 45 year operation

1968 – 2015 Milk Sr-90 (pCi/l)

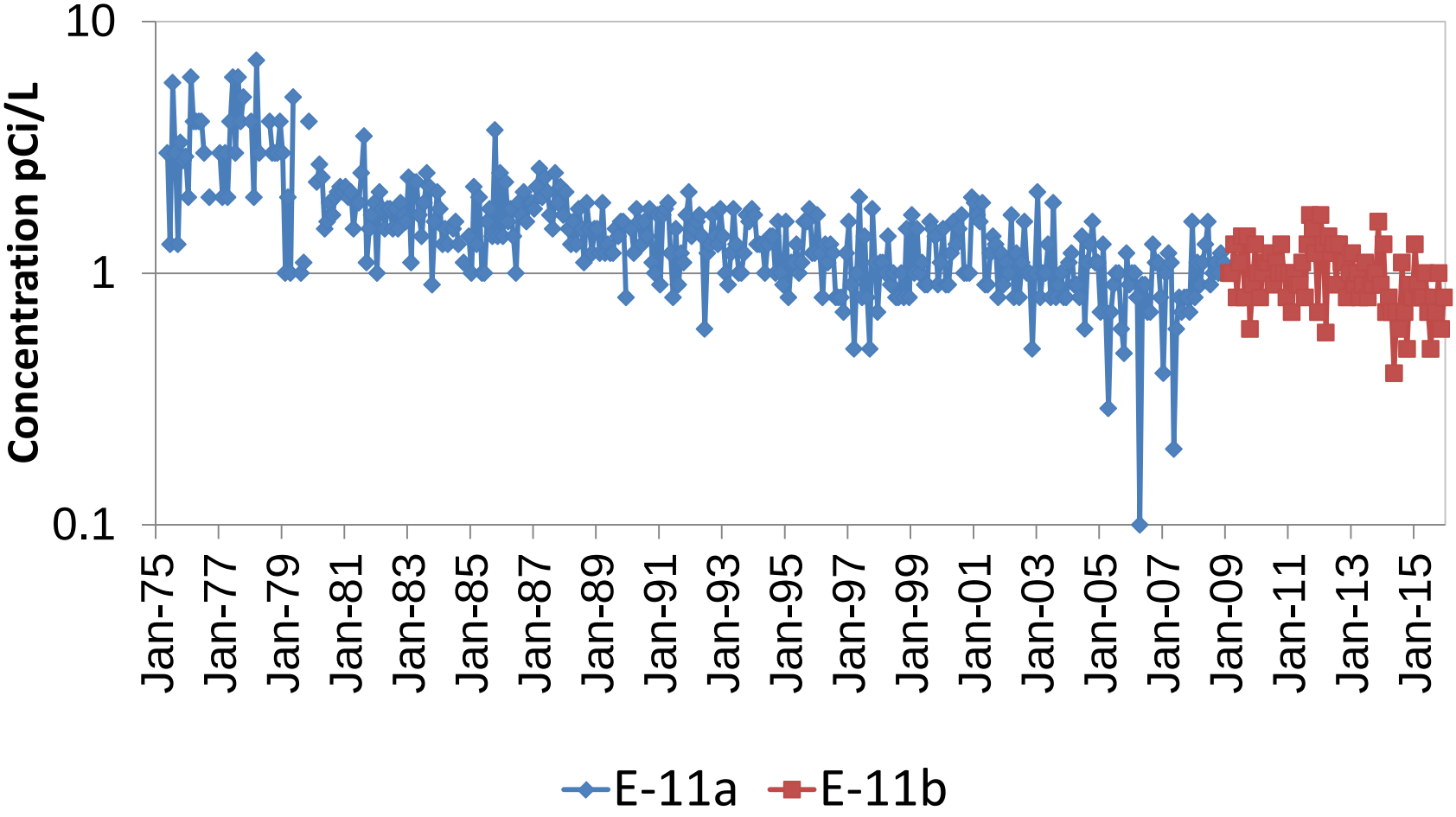


1968 – 2015 Milk Sr-90 (pCi/l)



Somewhat semi-log decrease with some locations having higher Sr-90.

E-11 Milk Sr-90 1975 - 2015



Estimate the Sr-90 Removal Half-Life

- Picking two points
- Feb 1980 (2.3 pCi/l) and Dec 2015 (0.8 pCi/l)
- Calculate the total Sr-90 half-life in milk
- ΔT = 35.4 years Sr-90 half-life 28.6 yrs.
- Total removal half–life = 23.3 years
- In good agreement with radiological $T_{1/2}$ considering just eye-balling a best fit
- If difference is real, then there is a physical removal half-life of 125 years

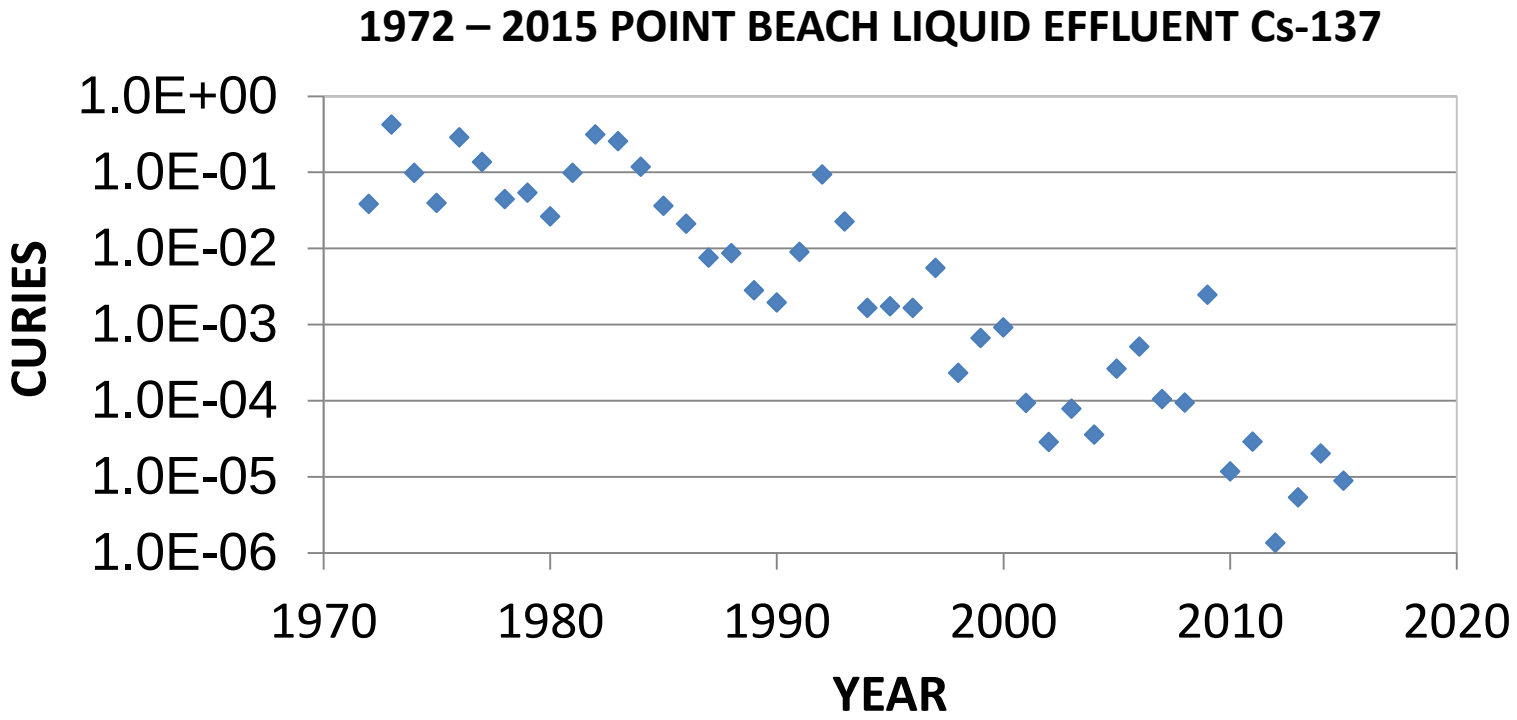
Milk Conclusion

- The milk obtained from the dairy farthest west has higher Sr-90 than the milk form the dairy that grows feed crops on the highest χ/Q and D/Q sectors within the site boundary. These latter results are, at times, not significantly different from zero.
- Therefore, there is no evidence of plant effluent in the REMP milk samples.

Lake Water

Cs-137 Input to Lake Michigan

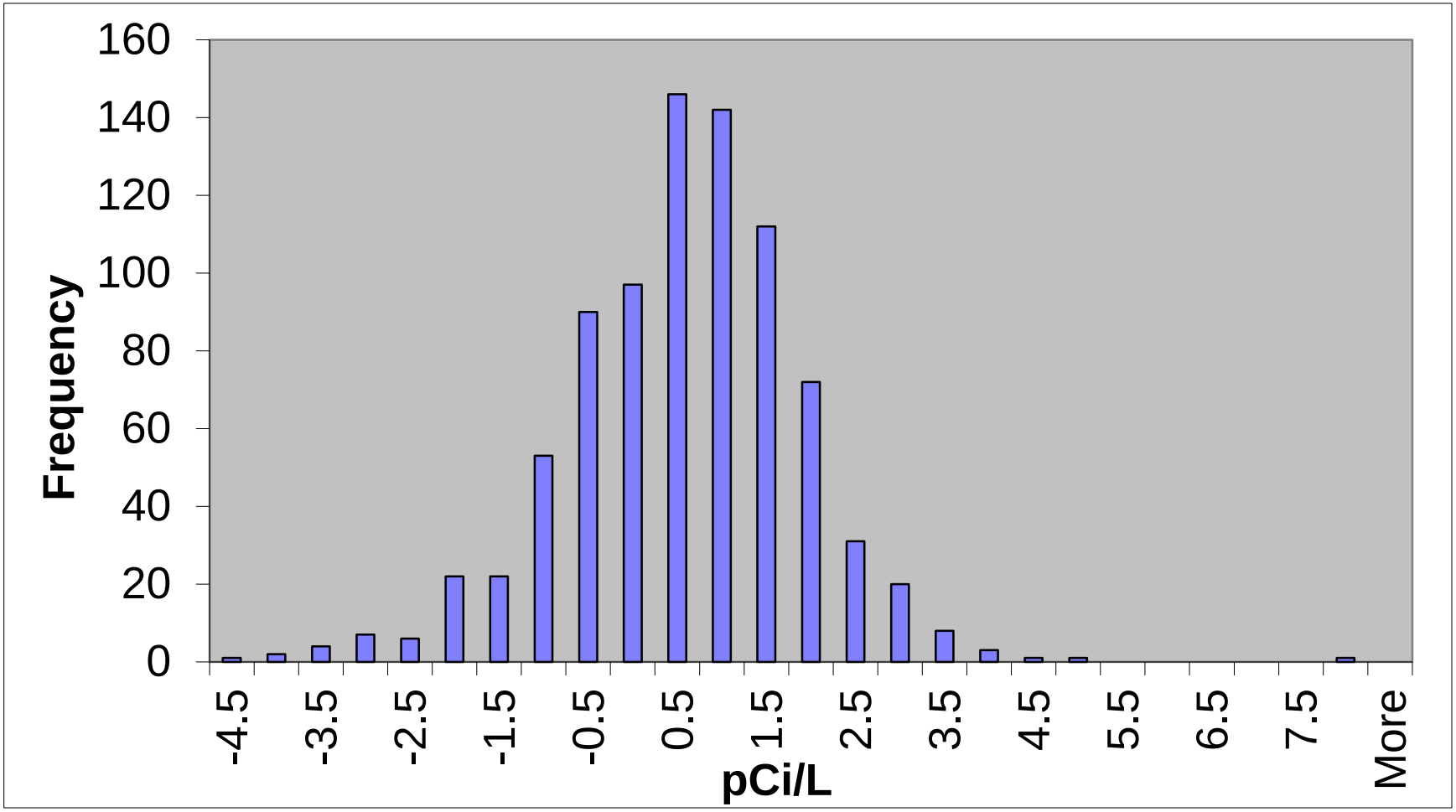
- **Total Cs-137 Weapons Testing Fallout ~ 5200 Ci**
- **Point Beach Total = 3 Ci**



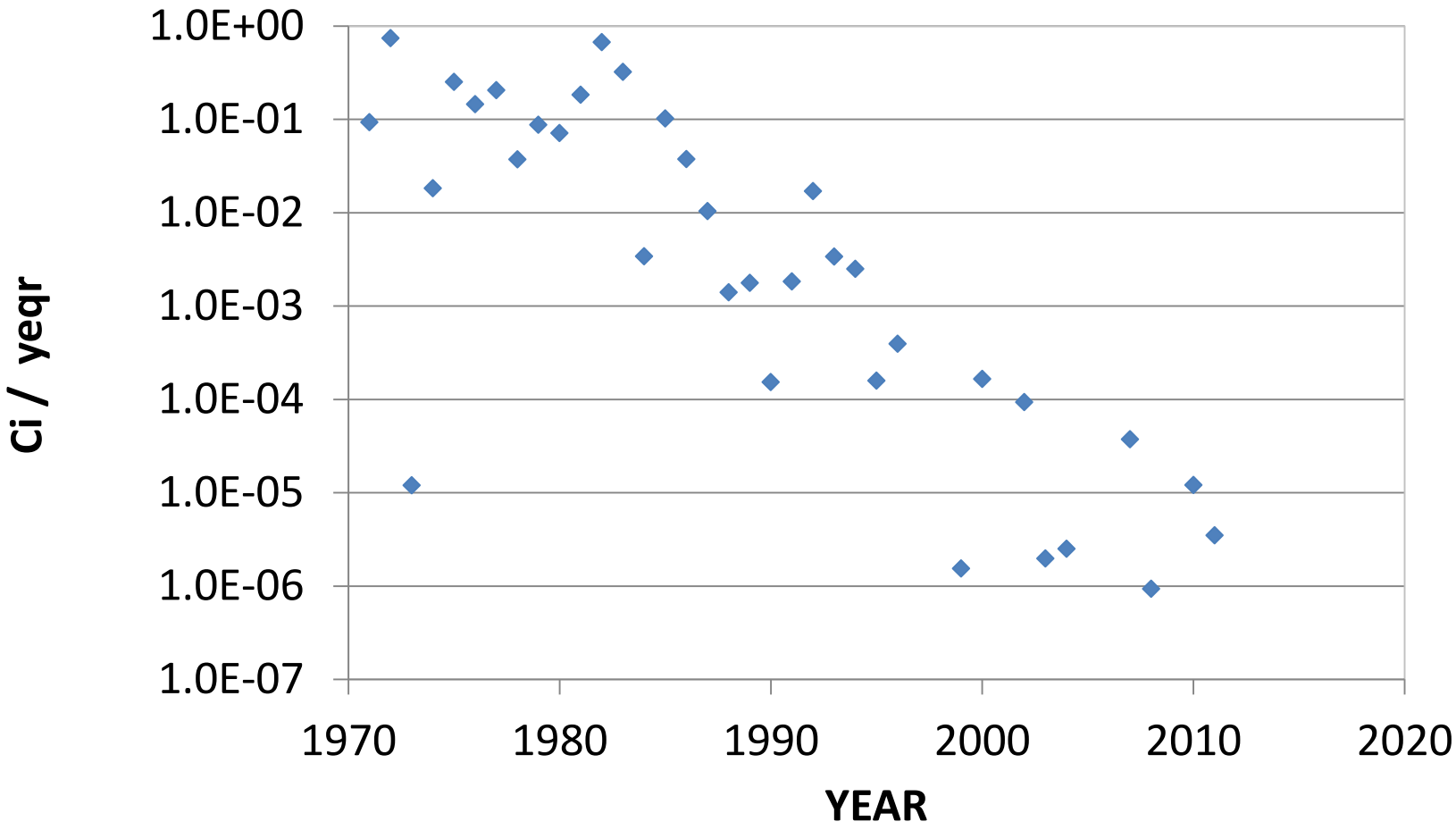
Typical Lake Michigan REMP Results

SEPTEMBER 2015 LAKE WATER				
	pCi/l	2σ		MDA
Gross β	0.6±	0.5	<	0.8
I-131	0.1±	0.16	<	0.27
Mn-54	0.3±	0.8	<	1.7
Fe-59	1.0±	1.6	<	3.5
Co-58	-0.3±	0.8	<	1.8
Co-60	-0.2±	0.9	<	1.5
Zn-65	-1.1±	1.8	<	2.6
Zr-Nb-95	1.3±	0.8	<	2.5
Cs-137	-0.1±	0.9	<	1.1
Ba-La-140	-4.3±	1.0	<	4.2

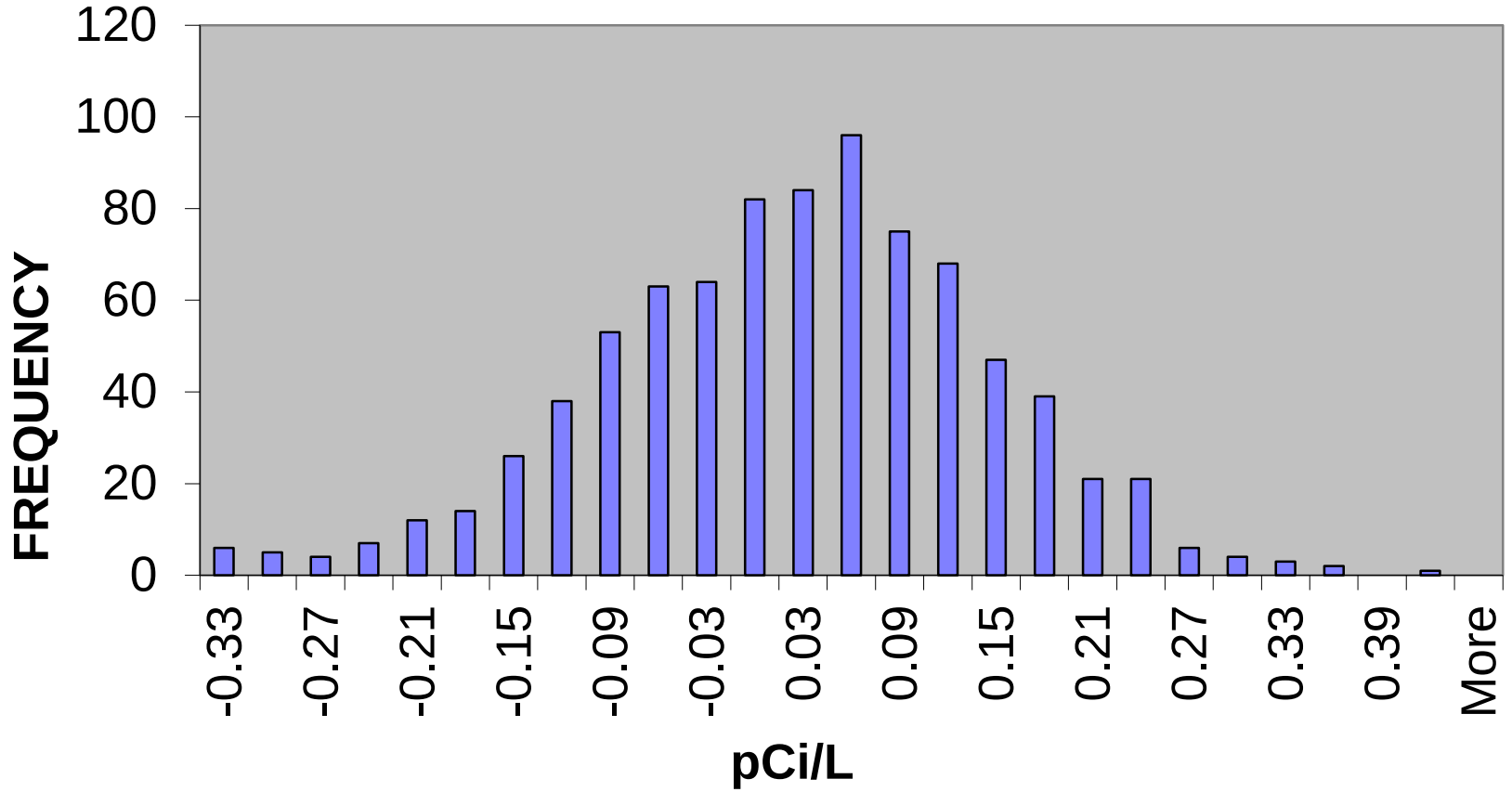
Cs-137 Lake Water 1992 - 2007



1971 – 2015 Liquid Discharge I-131 (Ci)

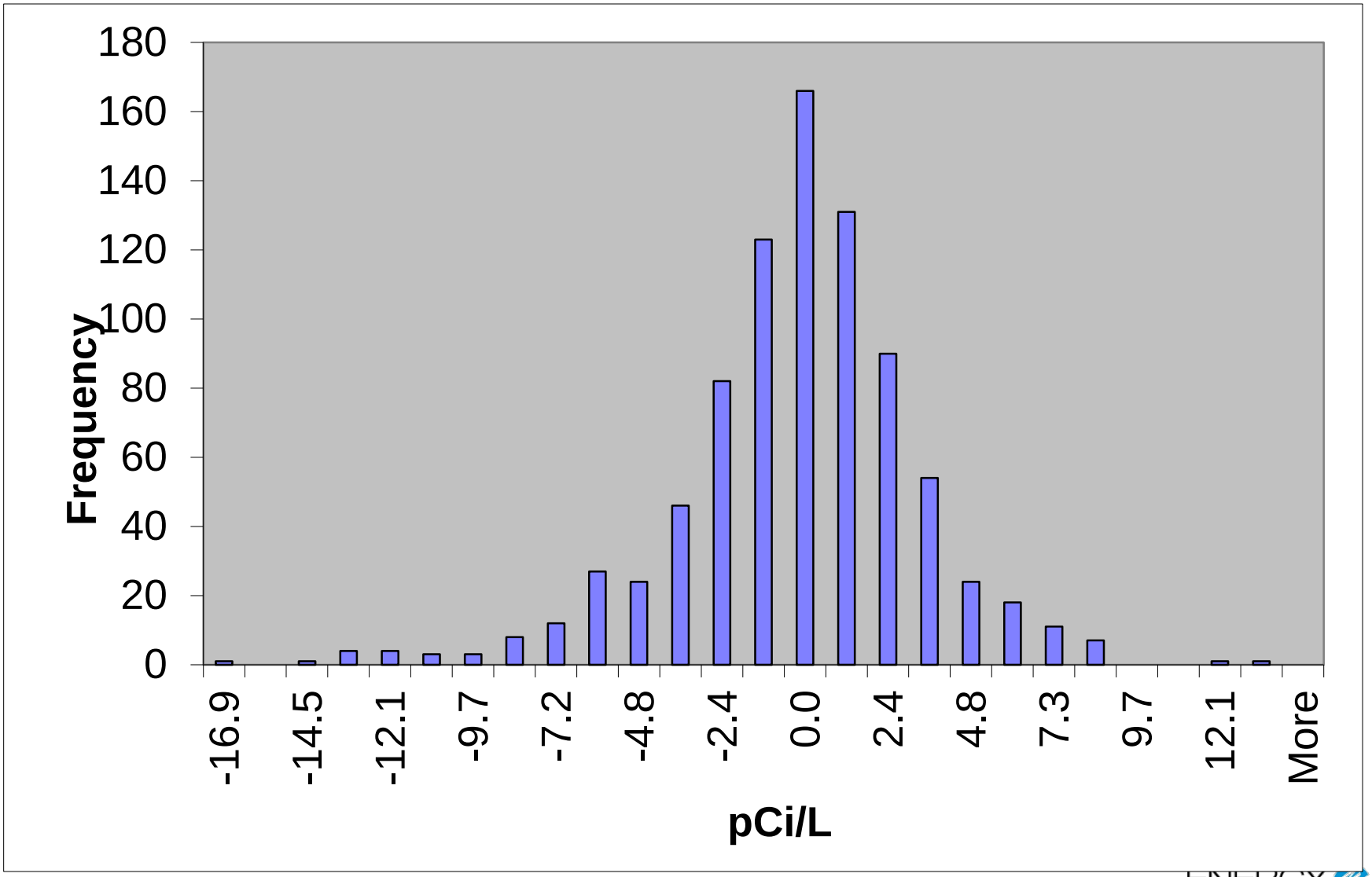


1992 - 2007 Lake Water I-131



Slight positive skew. All individual results are not significantly different from zero. May suggest a slight positive lab bias.

Ba-La-140 Lake Water 1992 – 2007



Lake Water Conclusion

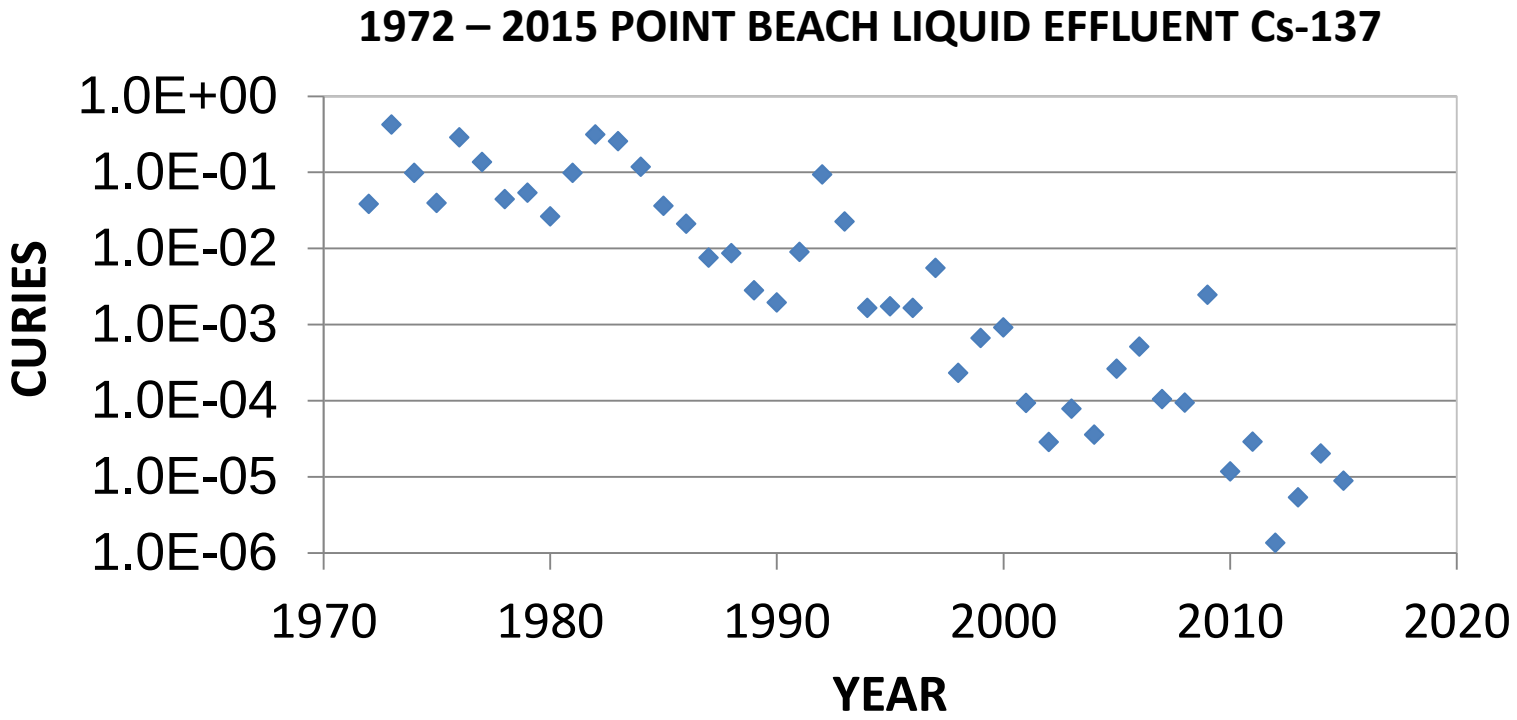
- **There is no evidence of PBNP effluents in lake water. It may be hidden in the large amount of fallout Cs-137 deposited in Lake Michigan.**

Fish

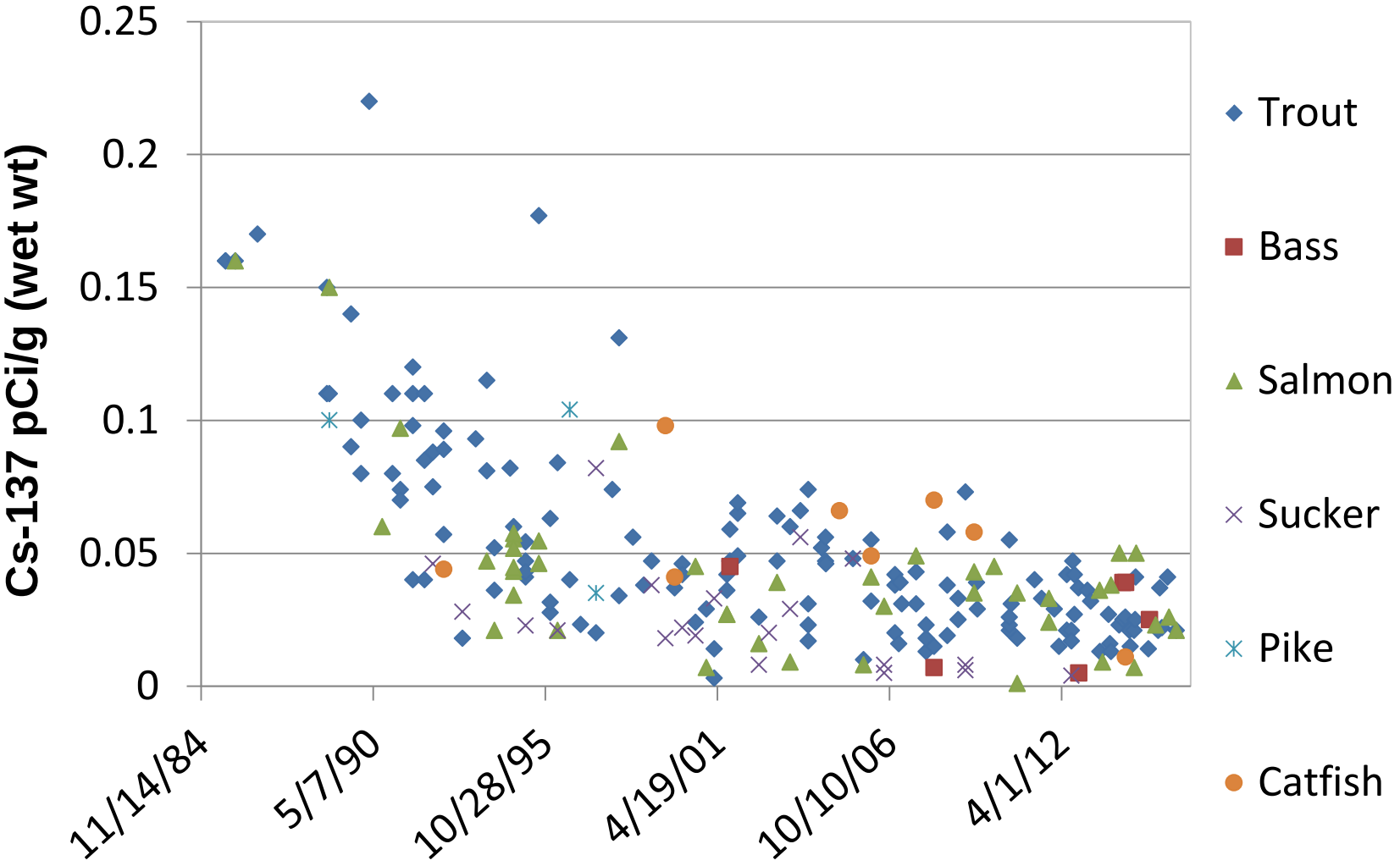
1984 -2015

Cs-137 Input to Lake Michigan

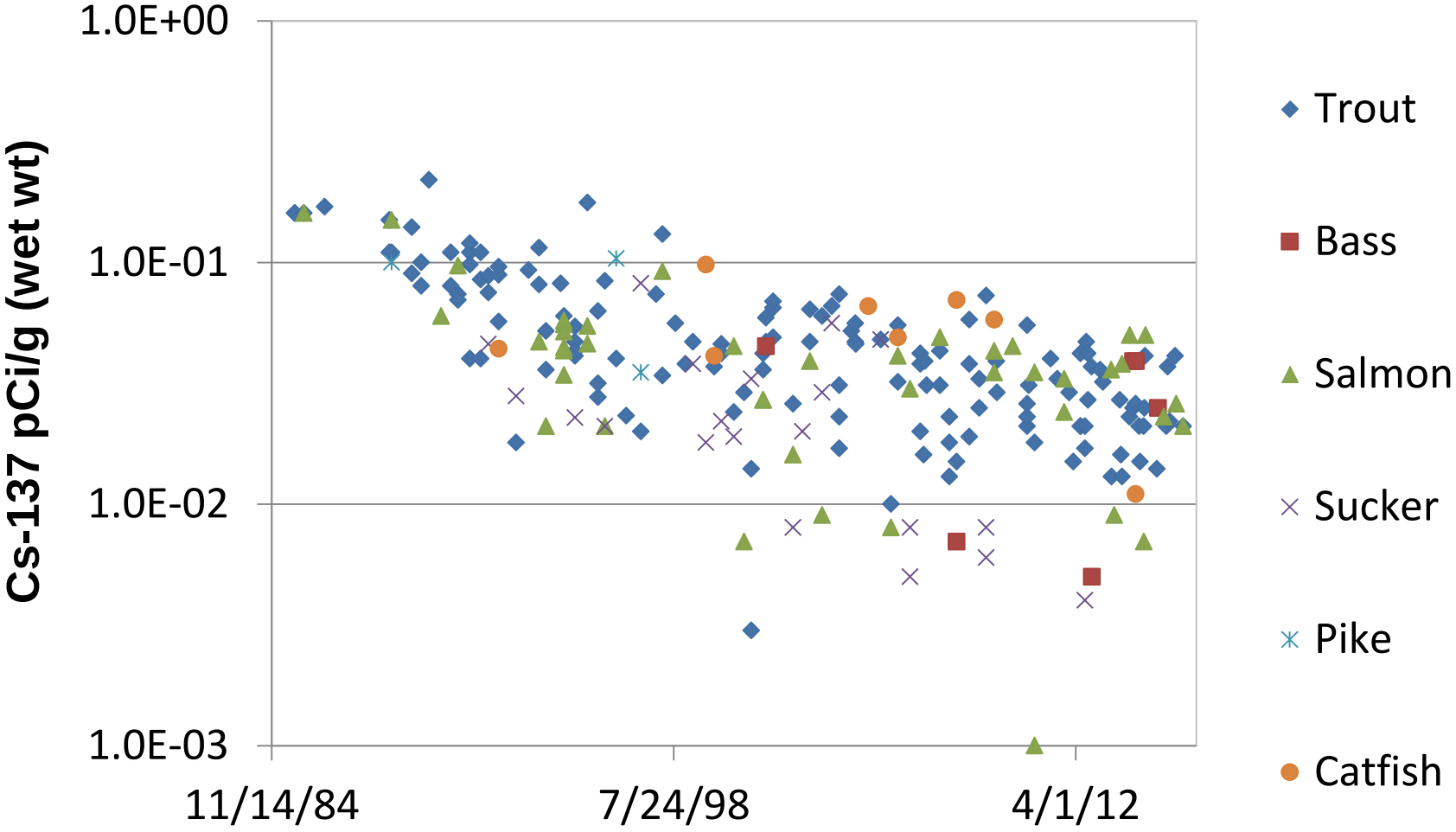
- **Total Cs-137 Weapons Testing Fallout ~ 5200 Ci**
- **Point Beach Total = 3 Ci**



Fish Cs-137 1984 – 2015



Same Data on Semi-Log Plot

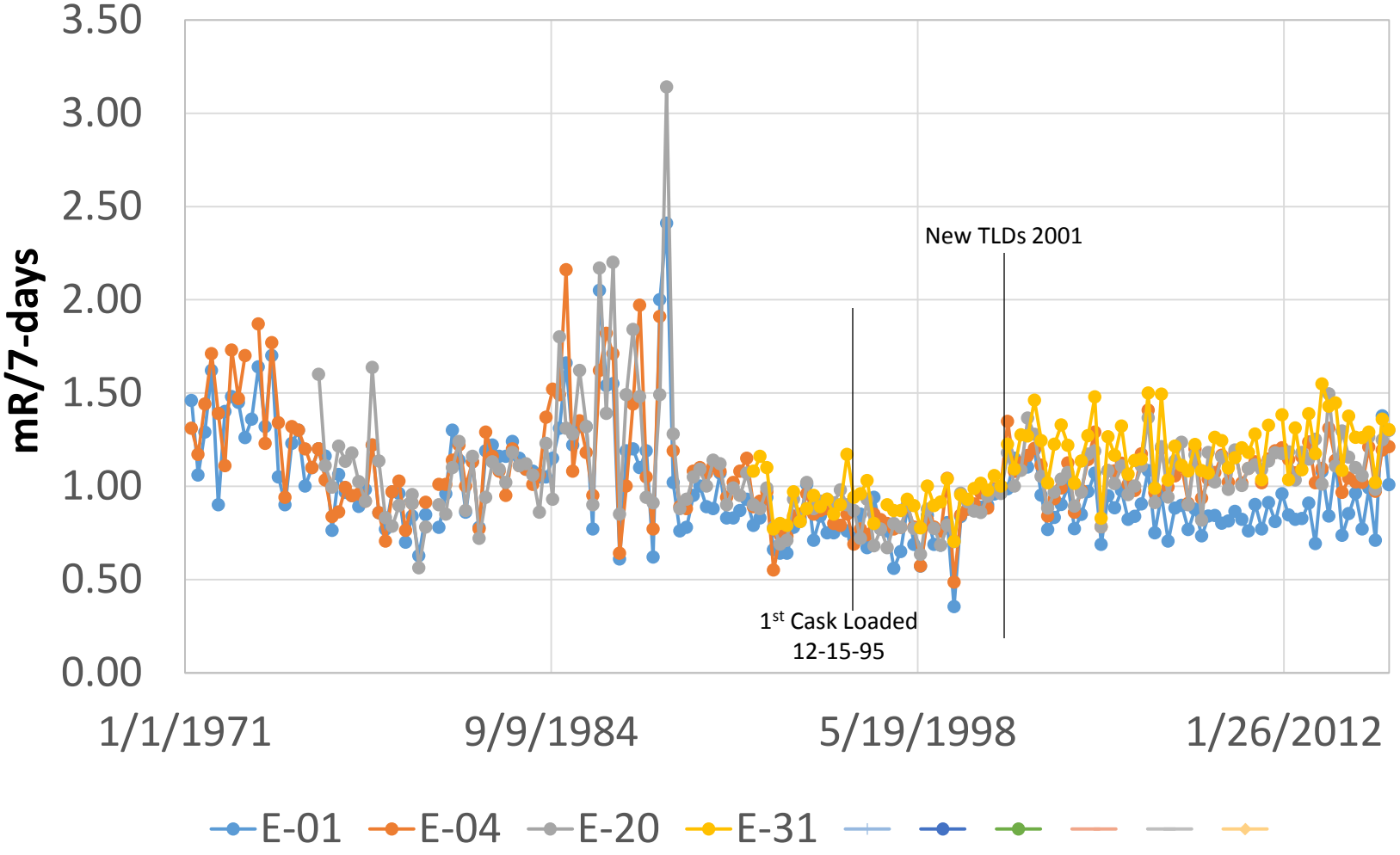


Fish Conclusion

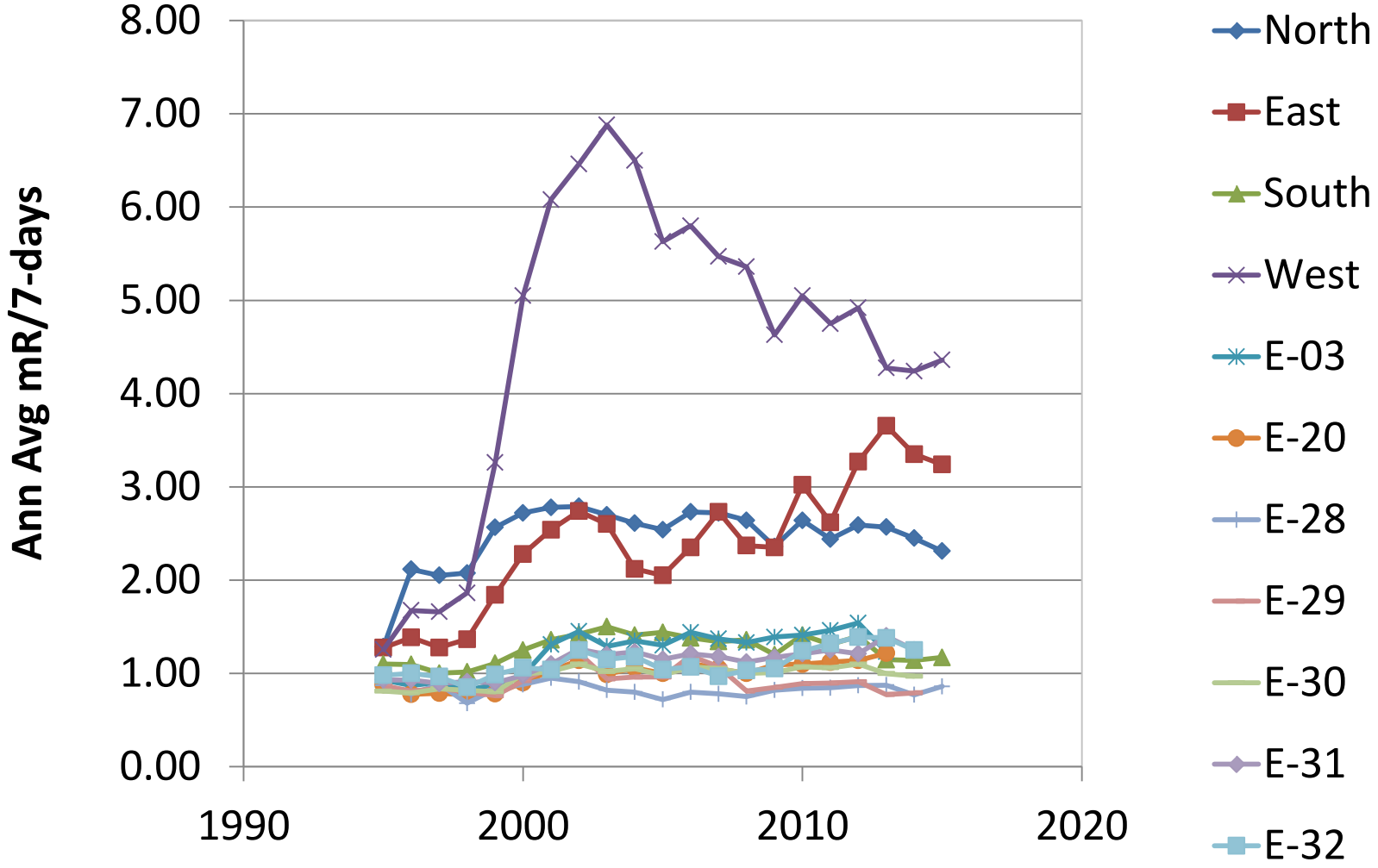
- Fish Cs-137 concentrations remain fairly constant even though Cs-137 in PBNP effluents continue to decrease
- Therefore, the Cs-137 is attributable to the cycling of Cs-137 in Lake Michigan
- No plan effect is detected

TLDs

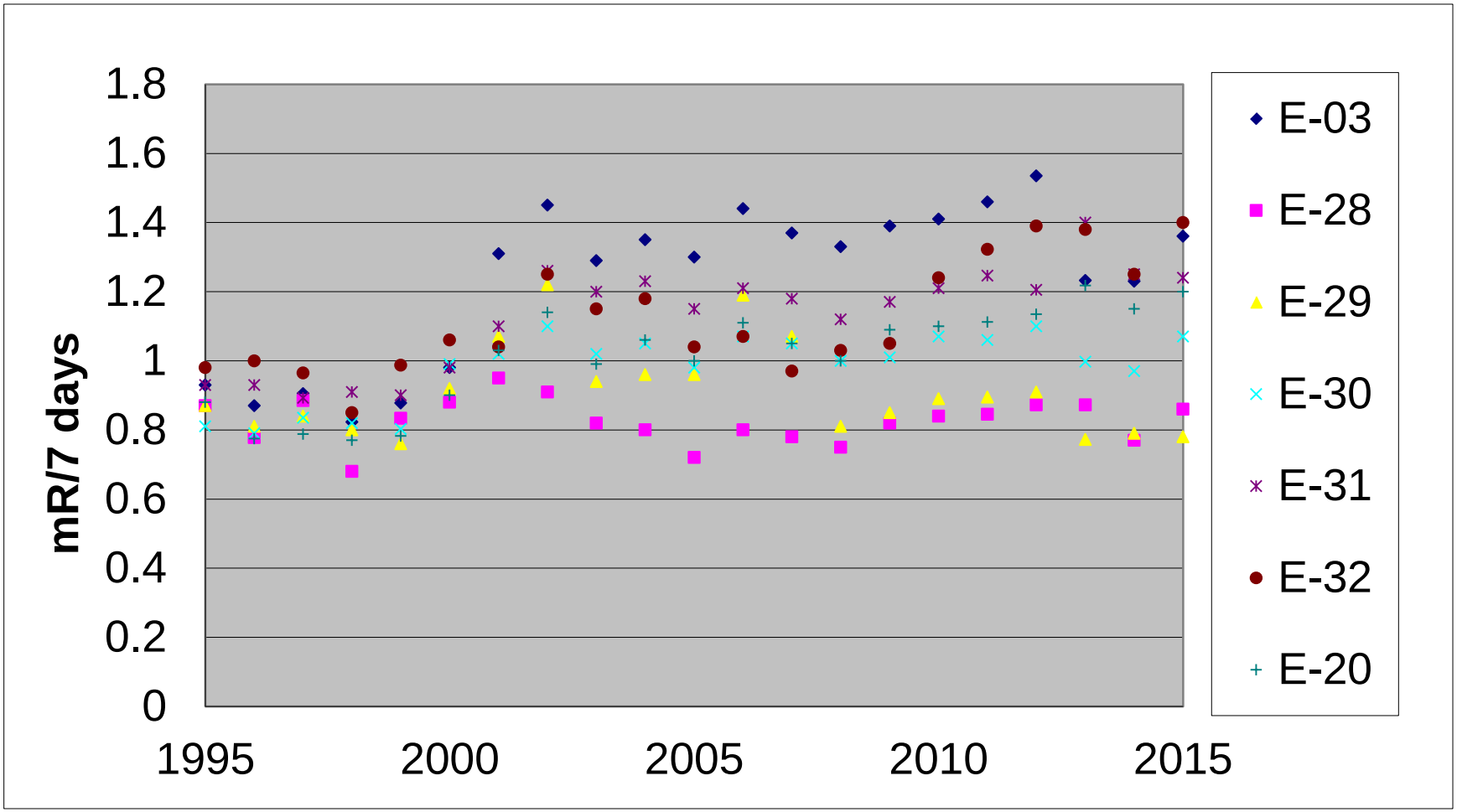
S, N, W, and Background TLD (mR/7-days)



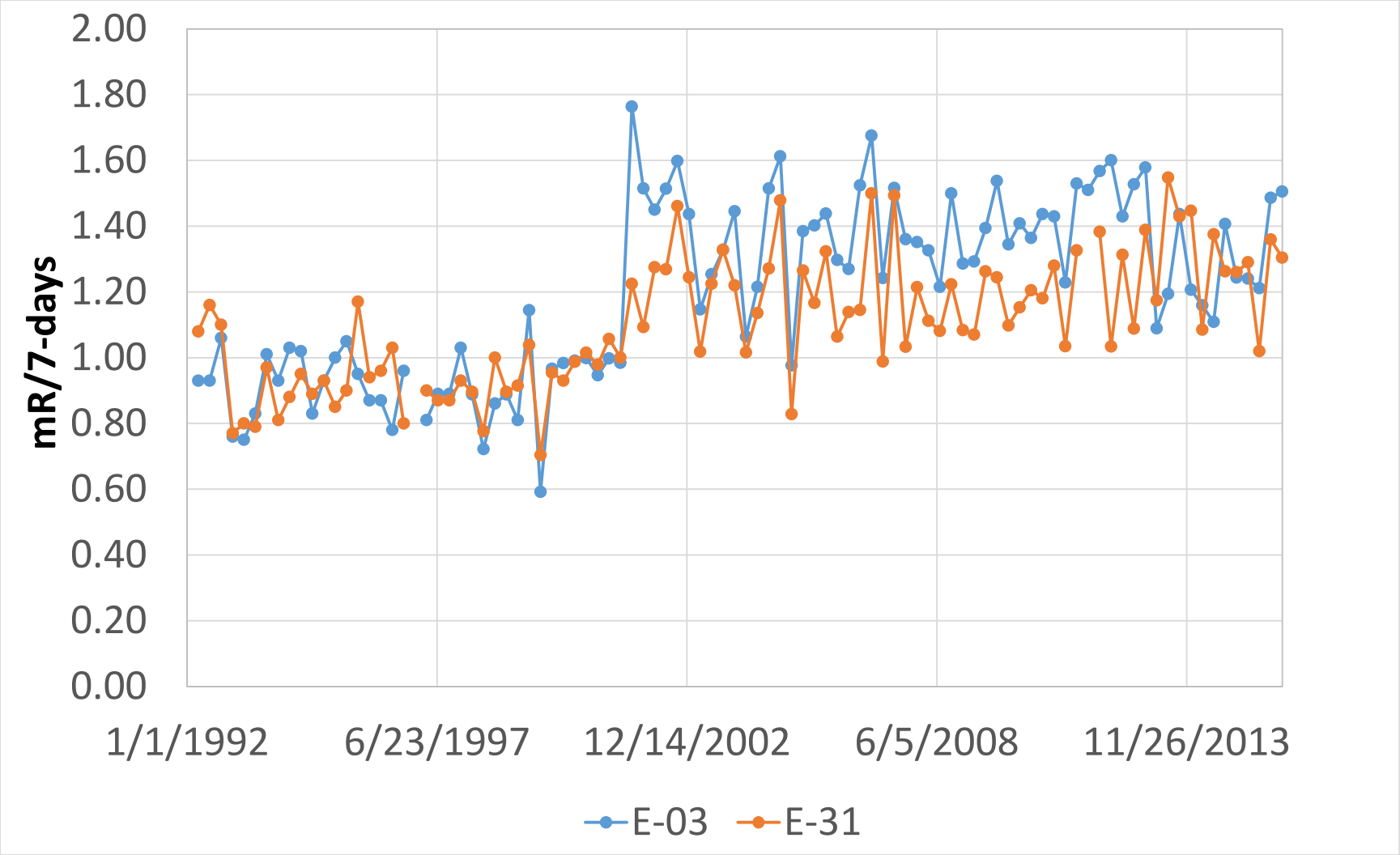
Comparison of ISFSI Fence and Nearby TLDs



1995 – 2015 ISFSI TLD Results



Comparison of Sites E-03 and E-31



Conclusion

Conclusion

- No evidence of Point Beach effluents in REMP samples
- Evidence of fallout from atmospheric weapons tests, Chernobyl, and Fukushima
- Evidence of equipment problems and switch to different TLD material

Questions?