Final Report

Assessment of Historical and Current Trends in Mercury Deposition to New Jersey Aquatic Systems through Analysis of Sediment/Soil Cores

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BETWEEN
RENSSELAER POLYTECHNIC INSTITUTE
AND
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BY AND FOR
THE DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Executive Summary

Sediment cores were collected at six sites throughout New Jersey to assess the geographic and temporal trends in atmospheric mercury deposition. Dating information was obtained through radionuclide analysis of core sections. Peak calculated mercury fluxes occurred several decades ago, between the 1930s and 1960s at all of the sites. At five of the six sites, fluxes were significantly elevated with respect to estimates for remote areas, but comparable to recent fluxes reported for the Great Lakes. We interpret this level of atmospheric Hg deposition, on the order of 150 $\mu g/m^2/yr$, as a regional industrial signal. At five of the six sites, the typical range of Hg fluxes over the past 50 years was about a factor of two. At the other site, Woodcliff Lake in northeastern New Jersey, calculated Hg fluxes were more than an order of magnitude higher. Similar fluxes had previously been reported for Central Park Lake in Manhattan. Future efforts will be directed at better defining the extent of the high Hg flux area. The possibility of significant direct (i.e. non-atmospheric) inputs of Hg to Woodcliff Lake should also be investigated.

I. INTRODUCTION/PROBLEM STATEMENT

Several recent studies have found elevated levels of mercury (Hg) in fish sampled from many freshwater bodies including pristine lakes in remote areas (Sorensen et al., 1990; Cope et al., 1990; Porcella et al., 1996). Atmospheric deposition is an important source of Hg to aquatic and terrestrial ecosystems and has global, regional, and local components. Potentially significant sources of atmospheric Hg include coal-burning power plants, municipal solid waste incineration, and medical waste incineration (Pirrone et al., 1998). Analysis of dated sediment cores has been a most useful tool for documenting historical changes in atmospheric Hg fluxes.

This study utilized cores collected at six sites from throughout the state of New Jersey (Figure 1). Work was conducted between September 2000 and December 2001. A primary focus of this project and a long-term goal of the overall investigation is to address the following questions:

- To what extent can the sources of atmospheric Hg deposition to New Jersey be identified and characterized?
- Are there in-state sources of particular significance?

The ultimate goal is to provide information relevant to an assessment of the effectiveness of reductions in regional and/or local Hg emissions.

Our research approach is based on analyses of total Hg levels in sediment core sections. By combining Hg concentration data with results from radionuclide dating of the cores, historical Hg fluxes have been calculated for each site. The results have been compared to similar studies in both industrial and remote areas of North America, providing a new and important perspective on atmospheric Hg deposition in New Jersey.

The remainder of this report includes the following sections: Project Design and Methods, Results and Discussion, and Conclusions and Recommendations for Future Research.

II. PROJECT DESIGN AND METHODS

Sediment and soil cores were collected during the fall of 2000 and summer of 2001. Our primary goal was to collect sediment cores with continuous records of particle accumulation that could be used to reconstruct the history of atmospheric Hg fluxes. Soil cores were also collected near each lake that was cored. While soil cores do not provide any continuous record of particle accumulation and cannot be used to reconstruct the history of Hg deposition, they can provide an indication of the cumulative atmospheric Hg flux to a site. One advantage of soil cores is that they are much less likely to sample non-atmospheric sources of Hg (direct industrial inputs, e.g.) than lake cores. Our choice of sediment sampling sites was guided by the following general criteria established in consultation with NJDEP personnel:

- Man-made lakes should have been dammed or formed by 1950 to facilitate dating using fallout radionuclides and to provide chronologies that extend back in time at least several decades.
- Lakes with dams having records of frequent blow-outs will be avoided because of potential complications of the sedimentary record. Similarly, lakes with numerous dry periods related to dam repair will be avoided however, lakes with a single, well-constrained period of low water levels may be acceptable if the other criteria are met.
- The lakes selected should have a good fishery (e.g., perch, bluegills, sunfish) so that they are appropriate for follow-up studies of mercury in the food chain.
- The specific sediment core sampling sites within each lake should be areas with continuous accumulation at rates on the order of a half a centimeter per year. In lakes, such areas are almost always dominated by fine particles (muds, not sands). Fine particles are also preferred because of their high affinity for Hg. In general, the

deepest part of the lake or marshy areas along the shoreline will be sampled.
- Reservoirs are good sites because their construction tends to facilitate the deposition of fine particles leading to enhance particle accumulation rates
- The selected sites should be relatively free of inputs of Hg from sources other than atmospheric. Only lakes where motor boat traffic is prohibited or severely restricted should be considered. Similarly, to the extent possible, the drainage basins of the lakes should be protected from direct Hg inputs. These concerns focus attention on drinking water reservoirs and lakes in state forest preserves or park areas.
- The lakes must be accessible. This criterion favors lakes with hand-carry launch sites and lakes controlled by the state.

Table 1 presents specific sampling site information and Figure 1 shows locations of the coring sites. Detailed lake site maps are included as Appendix I.

Gravity and push cores were collected in 2.5 inch O.D. polybutyrate tubes and sectioned on site at 2 cm intervals (unless otherwise noted). In gravity coring, the tube is connected to a one-way valve and lowered by rope through the water column. Penetration of the sediment is aided by the addition of lead weights above the valve. In shallower water (less than about 10 feet), push coring is the preferred method. Metal pipe is connected to the valve and the polybutyrate tube is pushed into the sediments. The marsh core was collected in a 4 inch O.D. polybutyrate tube with penetration aided by pounding. It was sectioned back at the lab at ~1.2 cm intervals. Soil cores were collected by pounding a length of 2.5 inch O.D. polybutyrate core tubing into the ground. They were sectioned back at the lab in 1 cm increments from 0-4 cm and 2 cm increments thereafter. All sediment and soil core sections were oven dried at 35°C under a flow of filtered air, ground using a mortar and pestle, and stored in pre combusted glass vials with teflon-lined screw caps or PVC lined aluminum cans. Sections were analyzed by gamma spectrometry for Cs-137, Pb-210, and Be-7 using an intrinsic germanium

Table 1. Sediment Coring Site Information

Site	Cores	Lake	County	Lake Area (acres)	Latitude (N)	Longitude (W)	Elevation (ft)	Date of Core Collection	Construction or Impoundment Date	Motors Allowed on Lake
1	WOODB	Woodcliff Lake	Bergen	15	41°0.79'	74°2.79'	102	8/21/1980	1906	N
1	WOODD	Woodcliff Lake	Bergen	15	41°0.79'	74°2.79'	102	10/13/2000	1906	N
2	WAY1	Wawayanda Lake	Sussex	255	41°11.17'	74°25.93'	1154	7/9/2001	1845	E
3	MTN2	Mountain Lake	Warren	122	41°51.59'	74°59.01'	414	9/29/2000	1872	N
4	IML1	Imlaystown Lake	Monmouth	30	41°9.82'	74°30.44'	111	11/17/2000		
5	ABS1	Lake Absegami	Burlington	67	39°37.38'	74°25.62'	23	10/24/2000	1938	E
5	TUCK2	Tuckerton (marsh)	Ocean	na	39°36.66'	74°15.82'	13	5/21/2001	NA	NA
6	PAR1	Parvin Lake	Salem	95	39°30.39'	75°7.92'	72	11/17/2000	1925	E
6	PAR4	Parvin Lake	Salem	95	39°30.39'	75°7.92'	72	6/22/2001	1925	E

N = no motors allowed
E = electric motors only

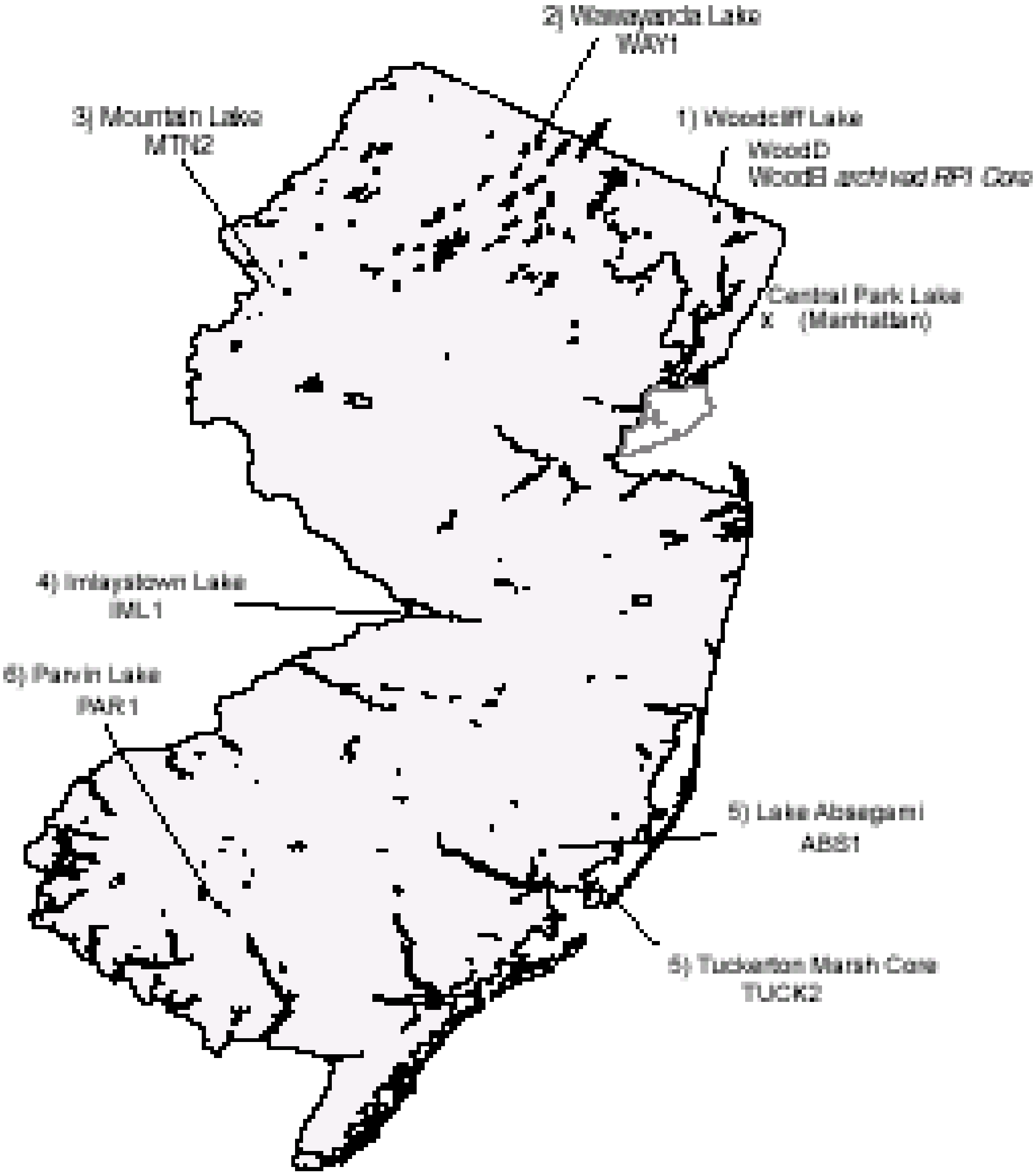


Figure 1. Map of coring sites.

crystal and multi-channel analyzer (ORTEC GWL-120, 92X Spectrum Master, and Maestro software).

Aliquots of the sections were sent to Brooks Rand, Ltd. for total Hg analysis under method BR-0002 (nitric/sulfuric acid reflux; stannous chloride reduction, gold amalgamation, and cold vapor atomic fluorescence detection.)

Quality assurance and quality control guidelines, as outlined in the QAPjP were followed. The QA/QC data is contained in Appendix III that includes information regarding gamma counting standards, blanks, and duplicates; blind duplicates for the mercury analysis as well as copies of Quality Assurance Reports supplied by Brooks Rand Ltd.

III. RESULTS AND DISCUSSION

Sediment Dating

Sections were analyzed by gamma spectrometry for Cs-137, Pb-210, and Be-7 to provide dating information and approximate sediment accumulation rates in the cores. The depth distribution of Cs-137 in sediment cores provides important information on timing of sediment deposition. In cores that contain a continuous undisturbed record of deposition, the first appearance of detectable Cs-137 is associated with global fallout derived from atmospheric testing of nuclear weapons in the early 1950s. Peak levels are associated with the fallout maximum in the years 1963-1964 (Olsen et al., 1981; Ritchie and McHenry, 1990). Small amounts of detectable Cs-137 in the Mountain Lake core (MTN2) below 12 cm and in the Wawayanda Lake core (WAY1) below 6 cm can be attributed to diffusion of Cs-137 in the sediments. Cesium diffusion can be significant in cores with high porosity and low clay mineral content (Crusius, 1992). The dry weight data (Appendix 3) indicate that among the cores analyzed, MTN2, WAY1, and ABS1(Lake Absegami) had the greatest water content and consequently the highest porosity. Our ability to detect diffusion in ABS1 is limited by the relatively low activity of Cs-137 in the upper layers of this core.

Confirmation that the uppermost section of the cores contains recently deposited sediment comes from analysis of Be-7, a short-lived radionuclide (half-life = 53.4 days) produced in the atmosphere by cosmic ray spallation (splitting) of nitrogen and oxygen. Detectable activity of Be-7 is confined to sediment samples containing a significant component of particles deposited within about a year prior to sample collection (Bopp and Simpson 1989; Bopp et al. 1991). “Detectable activity” is generally defined as a level more than two standard deviations greater than zero.

Pb-210, a naturally occurring radionuclide derived from the U-238 decay series, is also useful for dating sediment cores (Appleby and Oldfield, 1992). Pb-210 in a sediment or soil sample has two sources. The “supported” Pb-210 is produced from the decay of Ra-226 associated with the sediment particles and maintains near constant activity. “Excess” Pb-210 (xsPb-210), derived from the decay of Rn-222 in the atmosphere, provides the dating information. An ideal profile of xsPb-210 shows peak activity at the surface and an exponential decrease with depth. The half-life of Pb-210, 22.3 years, provides the time scale for calculation of particle accumulation rates. The xsPb-210 profile in a core can be significantly influenced by particle mixing and will not reflect drainage basin (or in-lake) holdup of particles and particle-associated substances. Applying both Cs-137 and Pb-210 dating methods provides a tool for identifying any significant sediment mixing or drainage basin holdup that would influence the Hg profile. Unusually high levels of supported Pb-210 were measured in sediments from the Absegami Lake and Parvin Lake sites – ~20 dpm/g, an order of magnitude higher than levels usually found in lake sediments. Such levels of supported Pb-210 require high levels of Ra-226 (and its parent U-234) in the sediment particles, and indicate influence of the Reading Prong or a similar geologic formation enriched in natural radionuclides. With respect to this study, the high levels of supported Pb-210 made accurate calculation of the xsPb-210 inventory at these sites impossible.

Sedimentation Rate Models

Net particle deposition rates were established through a consensus of the dating techniques described above. For each core the section with the peak activity of Cs-137was assumed to contain deposition reflecting the global fallout maximum of the mid 1960s. For all cores except those from Mountain Lake (MTN 2) and Wawayanda Lake (WAY 1) which showed evidence of Cs-137 diffusion (see above), the depth of Cs-137 penetration was correlated to the early 1950s. Sedimentation rates derived from the assignment of these time horizons were checked for consistency with the xsPb-210 depth profiles. Both constant length (cm/y) and constant mass ($g/cm^2/y$) accumulation rate models were considered (see Appendix III). These are referred to as constant DSR (depth sedimentation rate) and MSR (mass sedimentation rate) models, respectively. Mass sedimentation rates are often useful in accounting for changes in water content near the tops of sediment cores. In general, Hg fluxes calculated from the DSR and MSR models were very similar, the most significant difference being in the upper sections of the

Mountain Lake Core (MTN 2) (see below). With one exception, the radionuclide data was consistent with assignment of a single length or mass sedimentation rate for the entire core. In the case of the marsh core (TUCK 2), the unusually high temporal resolution of the Cs-137 data clearly indicated that the net accumulation rate between the early 1950s and mid 1960s was higher than the rate since the mid 1960s. Consequently, a two-sedimentation-rate model was applied to this core.

Sediment Focusing Factors

Cs-137 and xsPb-210 both have known cumulative atmospheric deposition histories per unit area. Cumulative deposition of Cs-137 is derived from a global network of 100-200 collection stations and analysis of monthly to quarterly composite samples (Simpson, et al. 1984). For this project, data from the nearest US Department of Energy collection site, New York City, which dates back to 1954 was used. Cumulative deposition of Pb-210 is based data from eighteen soil sampling sites in the Northeastern US (Graustein and Turekian, 1989) and a soil core from the mid Hudson valley at Rhinebeck, NY (Kada and Hite, 1992). Expected cumulative deposition of Cs-137 and Pb-210 can be compared to whole-core radionuclide inventories in sediments (integrated activity with depth/unit area of sediment). Dividing measured radionuclide inventories in a sediment core by known delivery rates from the atmosphere yields a focusing factor (Table 2). Normalizing is accomplished by dividing the contaminant flux recorded in the core by the focusing factor. This provides a first-order correction of Hg (or other atmospheric contaminant) inputs for the degree of focusing due to erosion and runoff from the watershed and the movement of particles within the lake to the core location.

Table 2. Sediment Core Focusing Factors

Core	**Cs-137 inventory (mCi/km^2)**	**Expected Cs-137 inventory from atmosphric deposition[a] (mCi/km^2)**	**Cs-137 based Focusing Factor**	**Excess Pb-210 inventory (dpm/cm2)**	**Expected whole-core xsPb-210 inventories (dpm/cm^2)**	**Excess Pb-210 based Focusing Factor**	**Notes**
WOODB	128.8	113.7	**1.1**	57.5	24.5[b] - 34[c]	**1.7 - 2.3**	
WOODD	-	-	-	-		-	both Cs-137 and xs Pb-210 inventories continued beyond the bottom of the collected sediment core[d]
WAY1	9.8	70.5	**0.14**	14.3	24.5 - 34	**0.42 - 0.58**	
MTN2	17.4	72.2	**0.24**	15.0	24.5 - 34	**0.44 - 0.61**	
IML1	19.8	72.2	**0.27**	16.9	24.5 - 34	**0.50 - 0.69**	
ABS1	2.4	72.2	**0.034**	-		-	unusually high supported Pb-210 levels
TUCK2	90.1	70.5	**1.3**	53.8	24.5 - 34	**1.6 - 2.2**	
PAR1	51.5	72.2	**0.71**	-		-	unusually high supported Pb-210 levels

[a] Expected Cs-137 inventories are decay corrected to the year of core collection/counting.

[b] Graustein and Turekian, 1989

[c] Kada and Heit, 1992

[d] Because of the rapid sedimentation rate in WOODD, the entire core contained Cs-137 and xsPB-210. Consequently, total radionuclide inventories at this site could not be calculated and focusing factors could not be determined.

Soil cores and marsh cores primarily sample direct atmospheric inputs of Hg and other particle-associated contaminants. Focusing-normalized sediment core inventories in excess of focusing-normalized soil core inventories indicate that the natural water system has received significant contaminant inputs in addition to direct atmospheric.

Background Level Determination

Determination of an accurate background mercury concentration for sediments is an important potential source of significant error in the calculation of mercury depositional fluxes. Values can vary from about 10 ppb to greater than 100 ppb (Table 3.) Values of background mercury for the mineral matter in sediments range over an order of magnitude. As illustrated in Table 4 sandstone can contain 30 ppb while "average" shale has been reported to contain 400 ppb. Significant organic matter and diatom shell (silica) components in sediments increase the complexity of an accurate background Hg determination.

Further complications may result from anthropogenic inputs of mercury to the environment from processes like gold and silver amalgamation that peaked in North America in the mid to late 1800s (Pirrone et al. 1998). Literature values reported as "background" may contain residual deposition from mercury dispersed globally during such processes. Consequently, a "background" value may very well contain significant "older anthropogenic" contributions.

For the purposes of this study, individual sediment core background levels were constrained based on concentrations in soils and deeper core section samples. Errors

Table 3. Measured Total Mercury Background Concentrations in Sediments

Study Description	Total Hg (ppb)	Reference
Minnesota, Northern WI	21 - 106	Engstrom et al., (1994)
Onondaga Lake, NY	100	Klein (1995)
Everglades, FL	10 - 134	Rood (1995)
Canada	16 - 130	Lockhart (1998)
Northern Quebec	30 - 200	Lucotte (1995)

Table 4. Mercury Background Concentrations in Rock

Study Description	Total Hg (ppb)	Reference
Shale	400	Turekian et al., (1961)
Sandstone	30	Turekian et al., (1961)
Shale	180	Marowsky et al., (1971)
Sandstones	8 - 290	Marowsky et al., (1971)

resulting from choice of a background level are greatest where total Hg concentrations are the lowest (i.e. at sites with low atmospheric Hg inputs and/or high particle fluxes).

Calculation of Mercury Fluxes

Mercury fluxes were calculated using the following equation:

$$M_{flux} = M_{xs}G/(AY)f$$

where

M_{flux} is the mercury flux (µg/m^2/yr) normalized to either Cs-137 or xsPb-210

M_{xs} is the excess mercury concentration (µg/g), calculated as:

total mercury measured – background mercury level

G is the dry mass (g) of the depth sectionA is the cross-sectional area of the core (25 cm^2 for our standard polybutyrate core tubing, and 63.6 cm^2 for the marsh core calculation)

Y is the number of years of deposition represented in the depth section

f is the focusing factor (unitless), calculated as,

$$\frac{\text{measured whole core inventory of radionuclide (Cs-137 or xsPb-210)}}{\text{cumulative atmospheric deposition of radionuclide (Cs-137 or xsPb-210)}}$$

Sample Calculation:

R1340C (MTN2 section 4-6 cm) from Mountain Lake

Total mercury measured = 0.226 µg/g

Background mercury level = 0.07 µg/g (based on deeper core sections)

Dry mass of depth section = 4.74 g

Cross-sectional area of core = 25 cm^2

Years of depositon = 9.3 yrs (based on best-fit Cs-137 dating constant depth sedimentation rate of 0.216 cm/yr)

Focusing factor = 0.24 (Cs-137 based) or
0.44 – 0.61 (xsPb-210 based)
(from Table 2)

we'll choose 0.61 for this calculation

Calculate:

$$M_{flux} = M_{xs}G/(AY)f$$

$$M_{flux} = ((0.226\ \mu g/g - 0.07\ \mu g/g) \times 4.74\ g)/(25\ cm^2 \times 9.3\ yr \times 0.61)$$

$$= 5.21 \times 10^{-3}\ \mu g/cm^2/yr$$

$$= 52.1\ \mu g/m^2/yr \text{ Hg deposition}$$

Demonstration of Variability in Flux Estimates

Considering the above calculation with slight variations

using the Cs-137 based focusing factor of 0.24

the result increases to 133.2 $\mu g/m^2/yr$

(more than a factor of two greater)

using the initial calculation, but lowering background to 0.03 µg/g

increases the result to 65.5 $\mu g/m^2/yr$

(a 20% increase)

A range on the order of a factor of two in focusing factor is typical of all our sites (Table 2) and reasonable choices of Hg background levels fall between 0.03 and 0.07 µg/g for all our cores. Consequently, while the above illustration applies specifically to a section of the core from Mountain Lake, similar results (i.e. calculated Hg fluxes that range over about a factor of three) would be obtained at all our sites. Variability in site to site comparisons and in the interpretation of temporal trends can be reduced considerably, however, by choosing focusing factors all calculated on the same basis. As indicated in Table 2, the Cs-137 based focusing factors are consistently lower than those based on Pb-210 and thus yield higher calculated Hg fluxes. Subsequent plots and tables are based, whenever possible, on the Pb-210 focusing factors derived from the Graustein and Turekian (1989) estimate of cumulative deposition. These focusing factors yield the lowest calculated Hg fluxes and were used at all sites except Parvin and Absegami where unusually high levels of supported Pb-210 made accurate calculation of xsPb-210 inventories impossible.

An additional potential source of variability in estimating the atmospheric flux of Hg from sediment core data is drainage basin holdup of particles and associated contaminants. This will attenuate the response of sediment core profiles to changes in the atmospheric deposition flux. In a core from Central Park Lake, for example, application of a drainage basin holdup model yielded an estimate of the recent atmospheric flux of Hg that was about a factor of two lower than the flux calculated directly from the core top sample (Kroenke et al., 2002). Mercury data and plots of mercury concentration and fluxes in cores from the six New Jersey sites are contained in Appendix V.

Individual Core Dating and Hg Deposition Data Interpretations

This section provides detailed description and interpretation of all the sediment cores collected as part of this study. The discussion of each core includes plots of the depth profiles of Cs-137 activity, total Hg concentration, and Hg flux. The Hg flux plots have been corrected for background and normalized to account for sediment focusing. Temporal trends in Hg fluxes are reported in Table 5. A plot of this data can be found at the end of Appendix IV. Table 6 compares the sites in terms of Hg fluxes integrated over the last half century. The radionuclide data and additional plots can be found in Appendix III. The Hg data and additional plots are contained in Appendix IV.

Table 5. Temporal Trends in Hg Fluxes to Sediments

Fluxes given in μg/m^2/yr normalized to xsPb-210 based focusing factor.
Dating based on a constant DSR model, except Tuckerton where MSRs were used

Decade	Woodcliff Lake	Wawayanda Lake	Mountain Lake	Imlaystown Lake	Tuckerton Marsh	Parvin Lake	Central Park Lake[b]
1990s	400	18	20	45	210		700
1980s	570	18	30	65	190		1200
1970s	1900	20	50	85	160		1500
1960s	3000	20	55	110	230		2000
1950s	2900	30	75	90	250		1800
1940s		30	65	90	300		1000
Average (past 50 yrs)	1750	25	50	80	225	231[a]	1400

[a] Cs-137 used for normalization, unable to calculate temporal trends due to mixing in core

[b] fluxes from Kroenke et al. (2002)

Table 6. Integrated Hg Fluxes at Six New Jersey Sites

Fluxes given in μg/m^2/yr normalized to xsPb-210 based focusing factor.

Period	Woodcliff Lake	Wawayanda Lake	Mountain Lake	Imlaystown Lake	Tuckerton Marsh	Parvin Lake
1963 - 2000	2600[a]	20	45	85	200	280
1954 - 2000	2500[b]	30	55	90	210	350
peak (yr)	3765 (early 1960s)	47 (1920 - 40)	120 (1945 - 55)	270 (1930s)	350 (1940s, 2001)	

[a] Represents 1963 -1980 only

[b] Represents 1954 - 1980 only

Site 1:

Woodcliff Lake

Hillsdale Bor. (Bergen Co.)

Site Summary:

Woodcliff Lake in northeastern NJ was dammed in 1906. It is currently under the ownership of United Water, a public utility. The lake is known to have good fish populations. The site likely receives urban influences from the nearby metropolitan area. Alum has been added to the lake as a flocculent in recent years to improve water clarity by promoting the settling of suspended particles. This could significantly increase recent sediment accumulation rates. An archived core, collected by Bopp in 1980, had an excellent Cs-137 profile.

Interpretation of Collected Data

Sediment Core WoodB (CN1559). Refer to Figures 2-4.

This is a 32 cm long gravity core taken on August 21, 1980 and archived by Bopp. WoodB was sectioned in 1 cm intervals between 0-6 cm and at 2 cm intervals from 6-32cm. The core was recounted for additional radionuclide data to gain total Pb-210 and xsPb-210 data that had not been obtained with the original Cs-137 counts, but can provide useful supplementary dating information. It appears to contain a continuous record of sediment accumulated from about 1950 to the date of coring (1980234). Sandier sections deposited prior to 1950 (24-32 cm) contain much greater dry mass and much lower Hg concentrations than the dominantly fine-grained material above (see Appendix 4). Since there is a major change in sediment type and little temporal constraint on the deposition of these sandier sections, reliable Hg flux calculations cannot be made prior to 1950.

- A peak in Cs-137 activity is seen in the 14-16 cm section. We assign this peak activity to the 1963-64 global fallout maximum and calculate an average net sedimentation rate of about 1.0 cm/y between 1963 and 1980.

- The smooth decline in Cs-137 activity from the peak to the surface is characteristic of continuous, undisturbed accumulation of fine-grained sediments.

- The deepest detection of Cs-137 occurs at the 22-24 cm section. We associate this horizon with the onset of large-scale atmospheric testing of nuclear weapons around 1954. We calculate an average net sedimentation rate of about 0.9 cm/y between 1954 and 1980.

- A constant mass sedimentation rate of 0.325 g/cm^2/yr was calculated for the WOODB core.

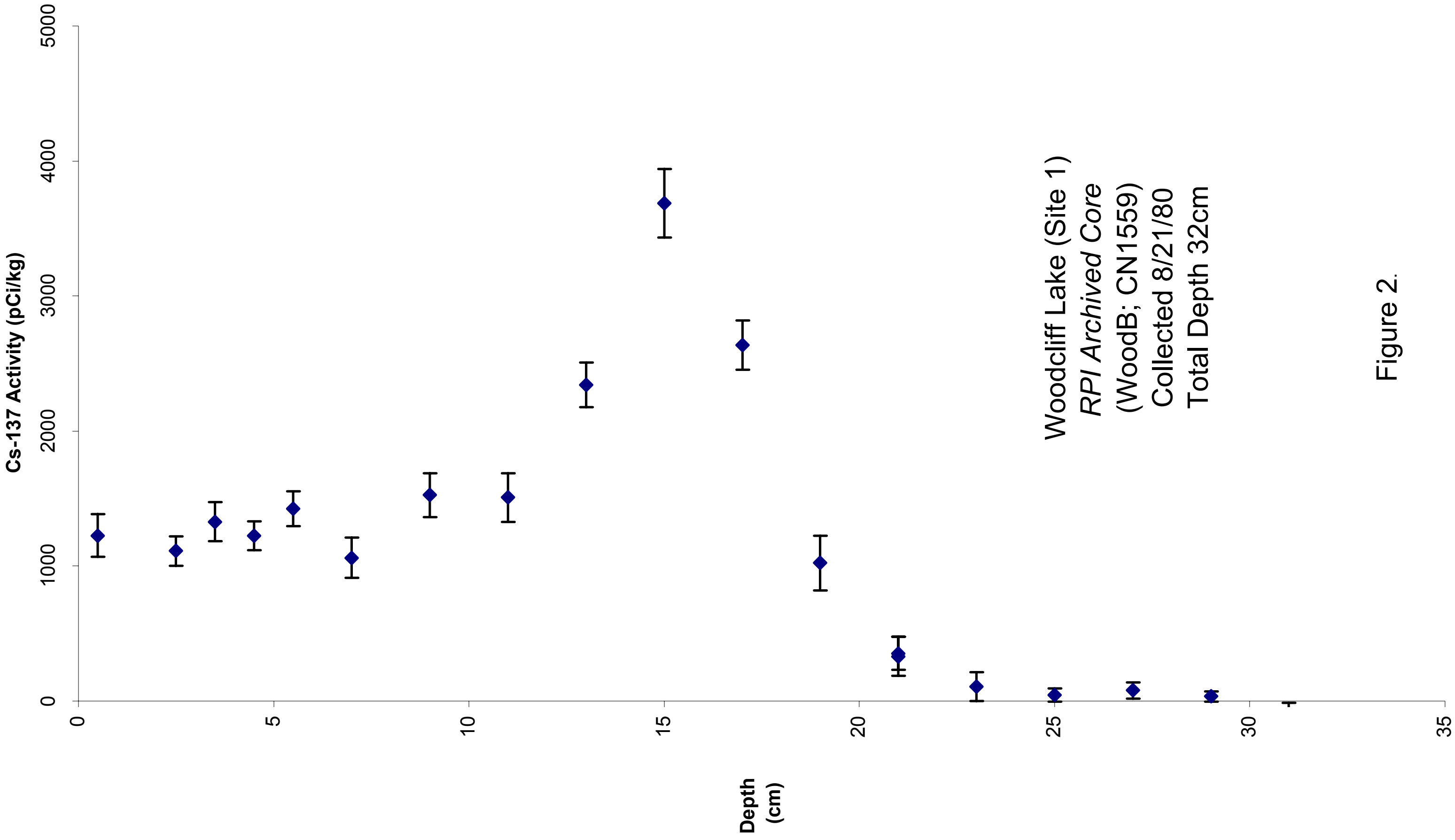

Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm
Cs-137 Activity (pCi/kg)
0
1000
2000
3000
4000
5000
Depth (cm)
0
5
10
15
20
25
30
35

Figure 2.

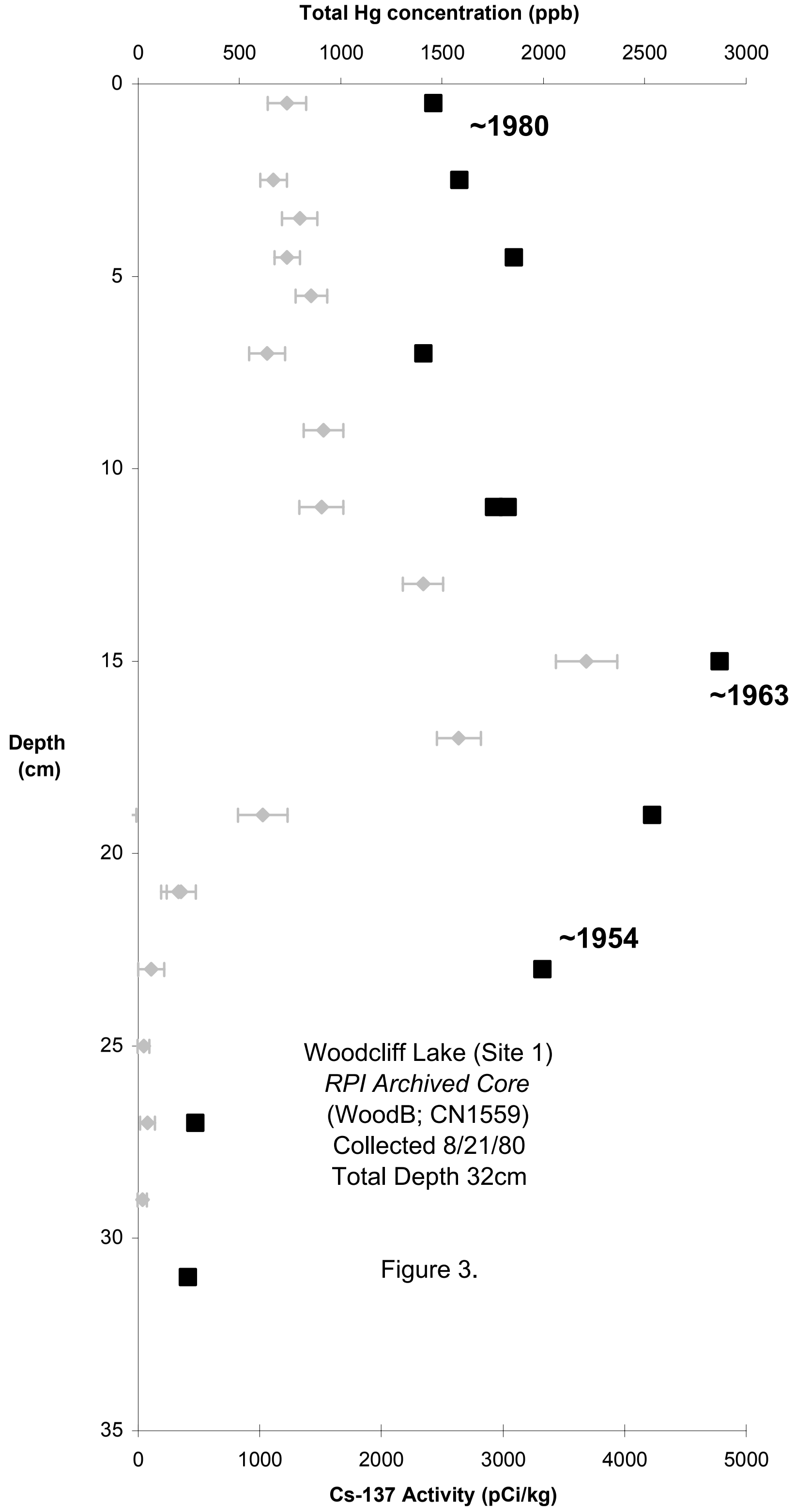
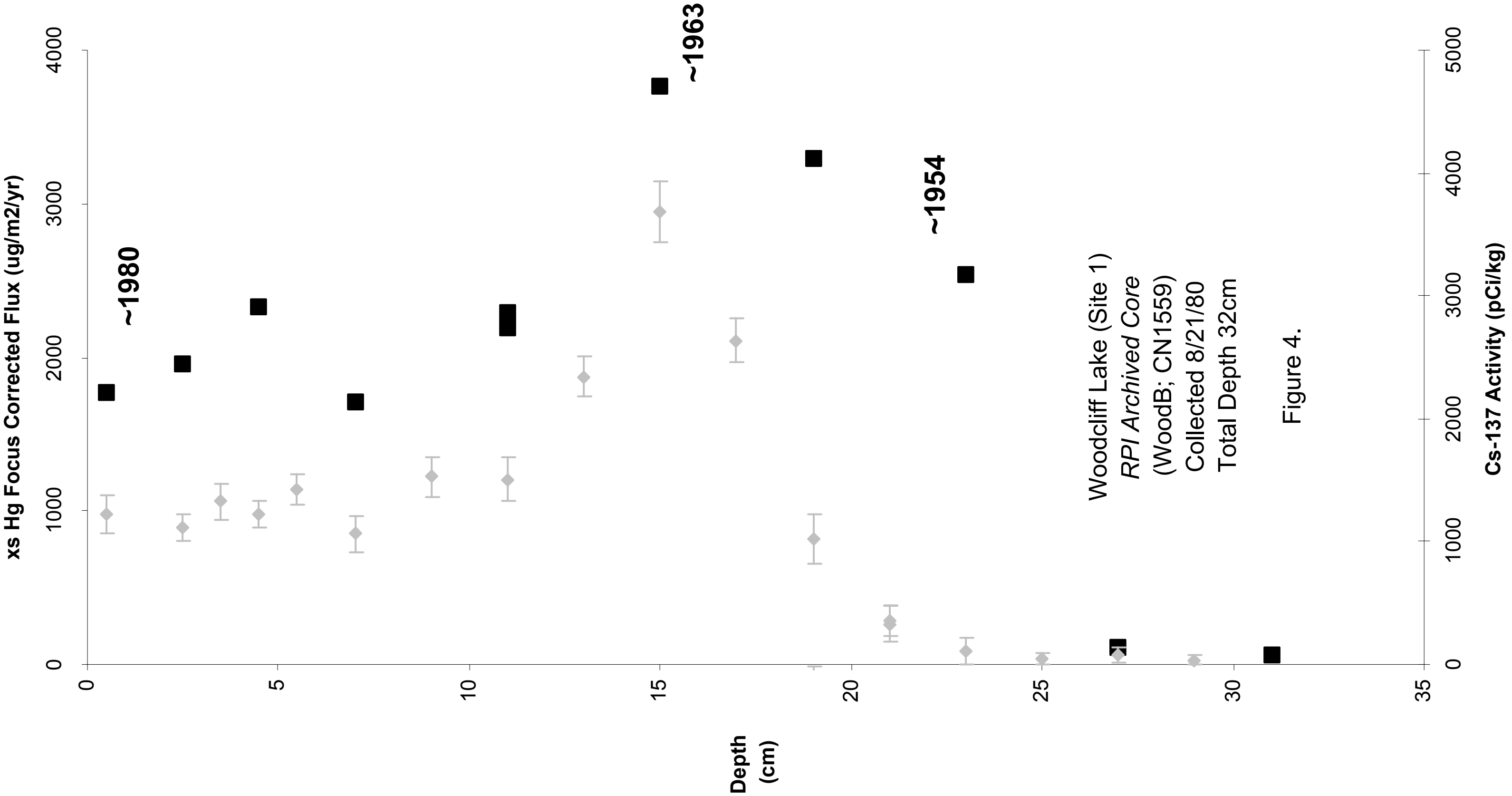

Total Hg concentration (ppb)
0
500
1000
1500
2000
2500
3000
Depth
(cm)
0
5
10
15
20
25
30
35
~1980
~1963
~1954
Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm
0
1000
2000
3000
4000
5000
Cs-137 Activity (pCi/kg)

Figure 3.



Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm

Figure 4.

- Total Hg concentrations range from 245 ppb (sandy sections near the bottom) - 2870 ppb. Peak values occur in the early -1960s. Hg levels throughout the fine grained sediment sections of the core are ~1000-2000 ppb, generally an order of magnitude greater or more than concentrations found in lakes in this study throughout the rest of New Jersey.

- Focusing-normalized Hg fluxes to WoodB fall between 1700 and 3770 $\mu g/m^2/yr$ for the period from about 1950 to 1980. The average flux over these three decades (about 2600 $\mu g/m^2/yr$) is higher than average atmospheric Hg flux to the NY/NJ urban area determined from a Central Park Lake core (about 1800 $\mu g/m^2/yr$).

- Both peak Hg concentration and peak Hg flux occur during the mid-1960s (14-16 cm).

Sediment Core WoodD (R1342). Refer to Figures 5-7.

WoodD is a gravity core collected from Woodcliff Lake on October 13, 2000. The core was taken from the deepest part of the lake (maximum depth ~25 feet) near the site of the WoodB core. The core was 32 cm long and was sectioned into 2 cm sections. Ideally, the core will provide an extension of the chronology from our archived core (WoodB, collected 1980) through the present, 2000.

- Be-7, a short-lived (half-life = 53.4 days) natural radionuclide was detected in the 0-2 cm section. This indicates that the sample contains a significant component of particles deposited within a year of the sample collection date (2000287).

- The core was 32 cm long, but Cs-137 activities increase all the way to the lower section, so we are unable to unequivocally determine how far back in time the lower section of this core dates, although it does appear to post-date the 1963 fallout maximum.

- Sedimentation rates for WoodD are assumed to be higher than for WoodB. This increase in particulate deposition is likely due, at least in part, to the addition of alum to the lake in recent years. For estimated flux calculations a sedimentation rate of 1.6 cm/yr (twice that of WoodB) was used.

- Total Hg concentrations fall between 293 and 359 ppb.

Hg fluxes were normalized using the Cs-137 based focusing factor of 1.1 as well as the xs Pb-210 based focusing factor of 1.7 – 2.3, derived from WoodB radionuclide inventories. Calculated fluxes using the focusing factor of 2.3 range from 195 to 479 $\mu g/m^2/yr$, with lowest fluxes in the most recently deposited sediments.

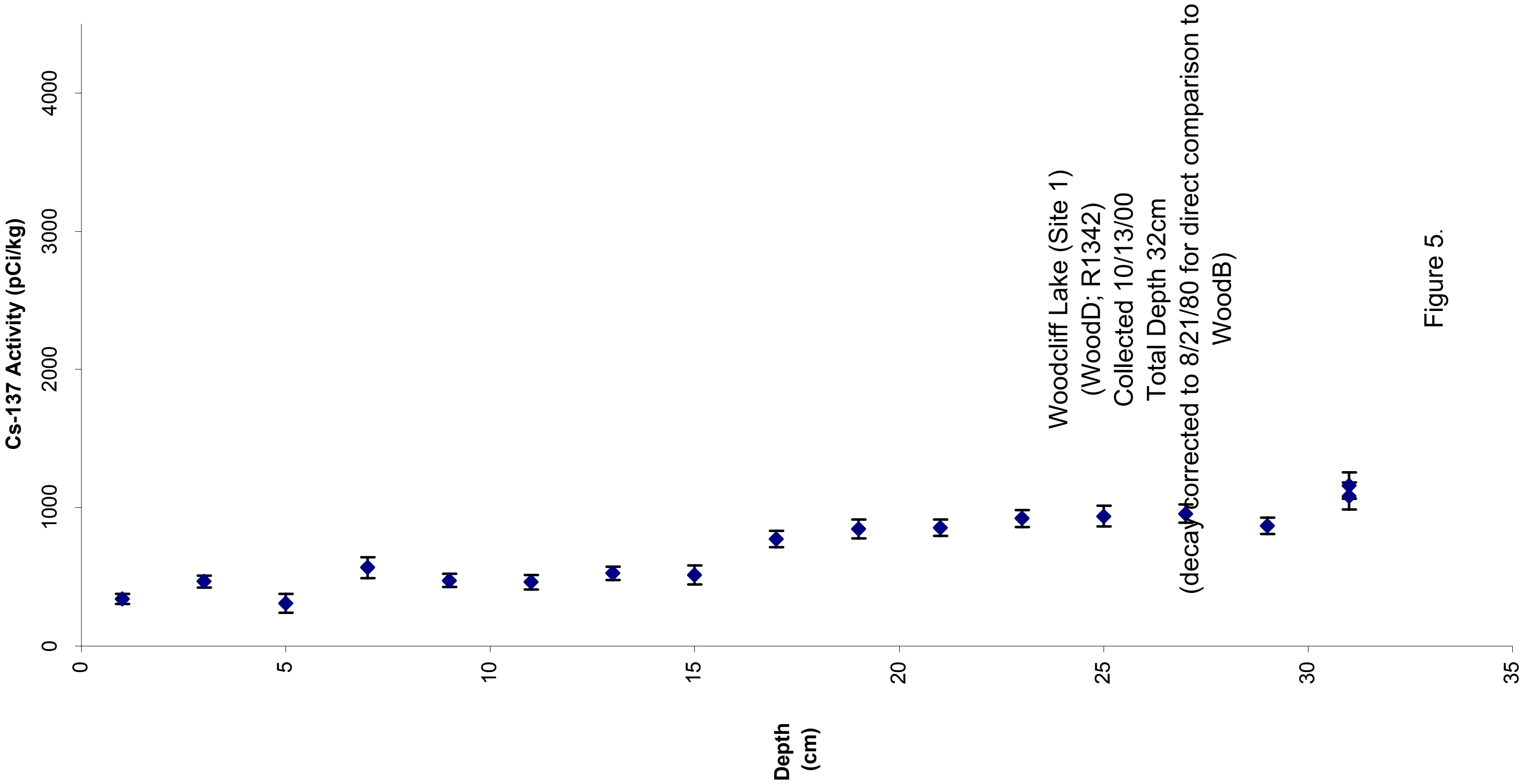
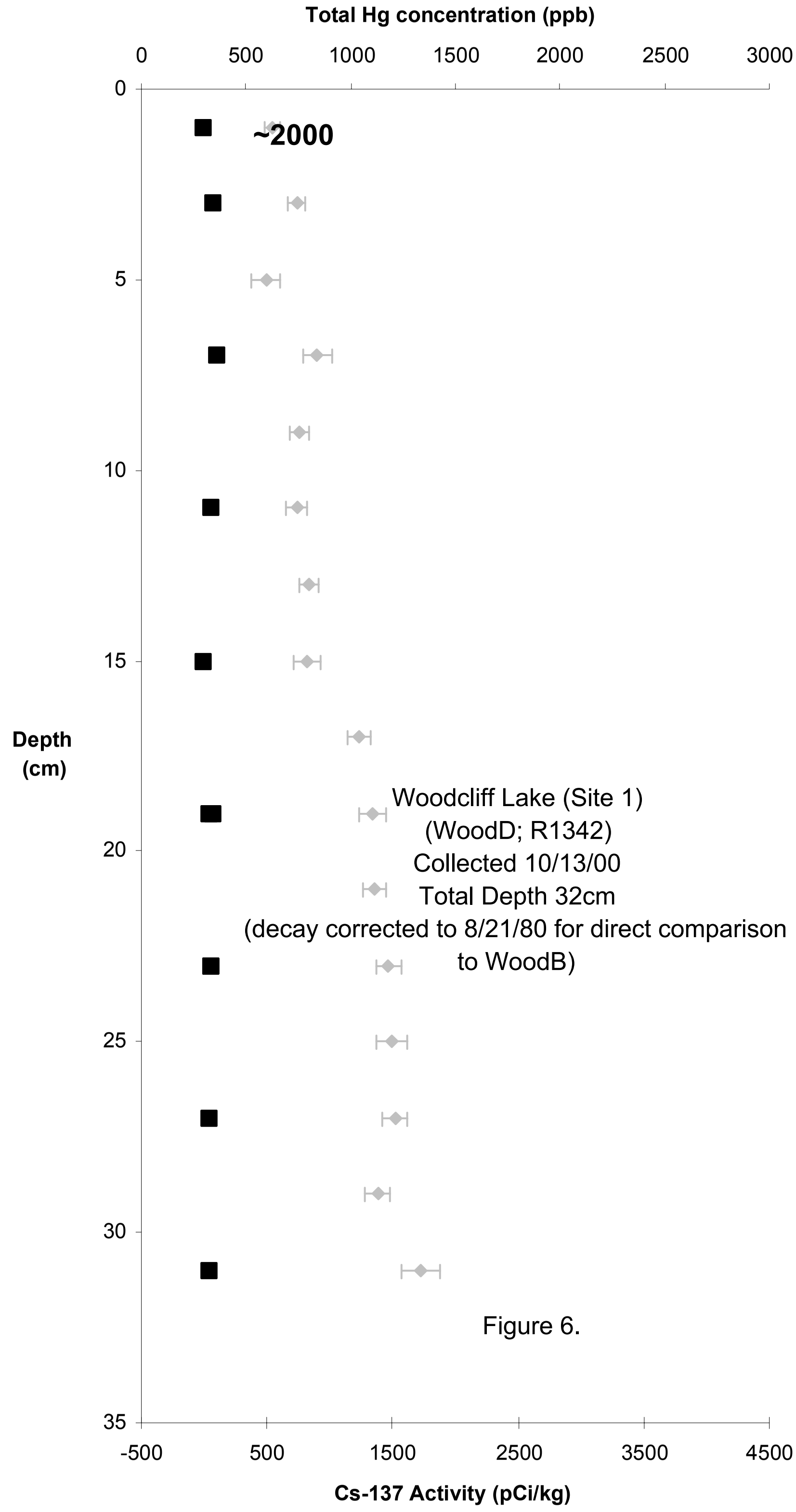

Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
(decay corrected to 8/21/80 for direct comparison to WoodB)
Cs-137 Activity (pCi/kg)
0
1000
2000
3000
4000
Depth (cm)
0
5
10
15
20
25
30
35

Figure 5.



Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
(decay corrected to 8/21/80 for direct comparison to WoodB)

Figure 6.

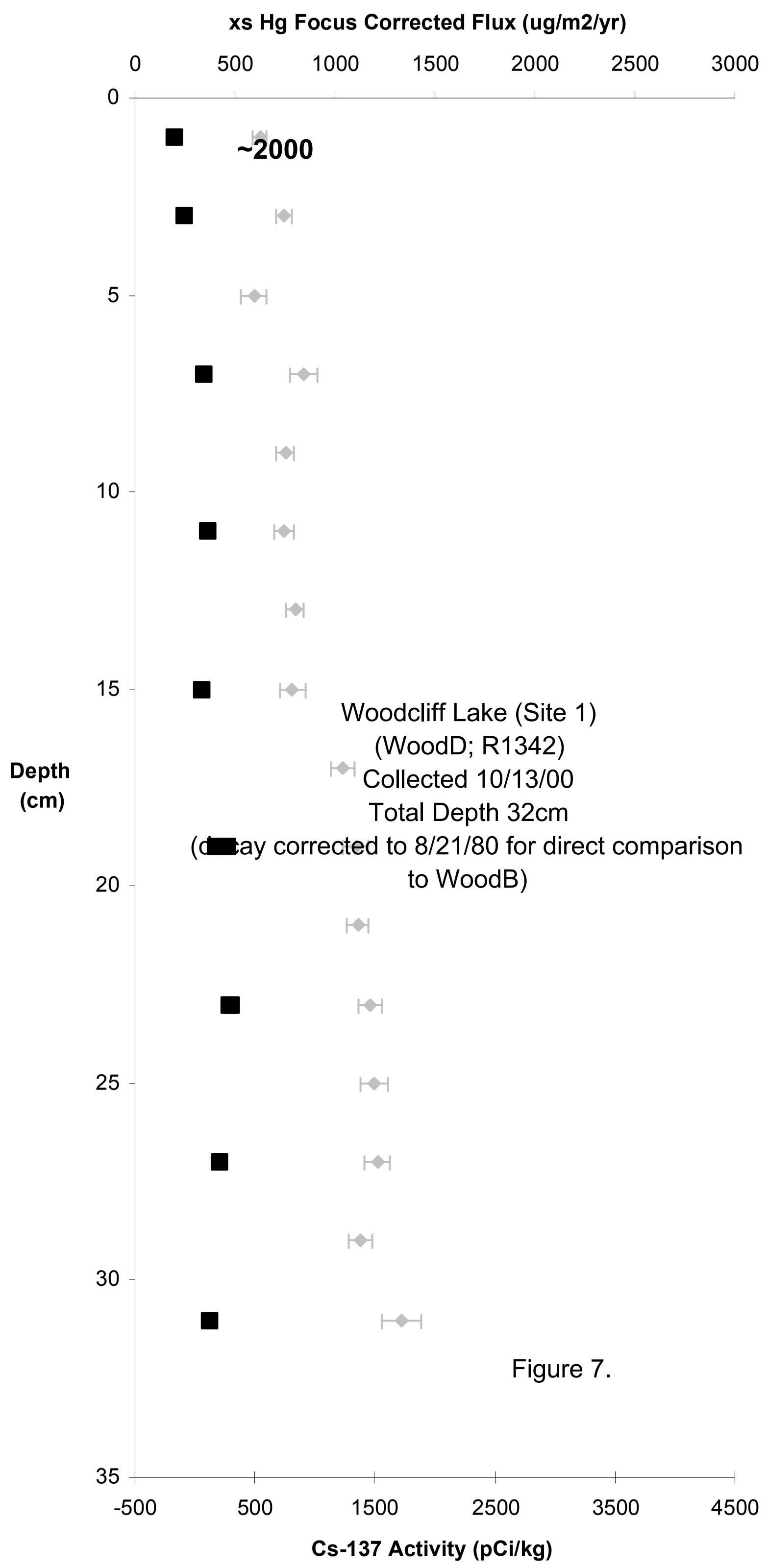

xs Hg Focus Corrected Flux (ug/m2/yr)
0
500
1000
1500
2000
2500
3000
~2000
Depth
(cm)
0
5
10
15
20
25
30
35
Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
(decay corrected to 8/21/80 for direct comparison
to WoodB)
-500
500
1500
2500
3500
4500
Cs-137 Activity (pCi/kg)

Figure 7.

Site 2:
Wawayanda Lake

Wawayanda State Park, Hewitt, Vernon TWP (Sussex Co.)

Site Summary:

Wawayanda Lake is located in northcentral NJ. It was dammed in 1846, creating one large lake from two smaller natural lakes. The lake is owned by NJDEP/DP&F and is reported to have good fish species and few potential impacts.

Interpretation of Collected Data:

Sediment Core WAY1 (R1377). Refer to Figures 8-10.

WAY1, a 33 cm long gravity core, was collected on July 9, 2001. The core was taken from the deepest part of Wawayanda Lake (maximum depth ~61 ft). It was sectioned on-site at 2 cm intervals.

- Cs-137 deposition peaks at in the 2-4 cm section of this core.
- The deepest detection of measurable Cs-137 is found in the 4-6 cm section.
- A constant depth sedimentation rate of 0.1 cm/yr produces core sections with ~20 year intervals which fit with the above Cs-137 dating constraints.
- No detectable Be-7 was found in the top sections of WAY1, indicating that, at most, only a small fraction of the particles in the core top were deposited within a year of core collection. This result was expected, however, due to the very low net sedimentation rate. At 0.1 cm/yr (the Cs-137 derived accumulation rate), only about 5% of the particles in the 0-2 cm section would have been deposited within a year of core collection.
- Measured Total Hg concentrations for the core ranged between 55 and 502 ppb.
- Excess Hg fluxes were normalized using both Cs-137 and xsPb-210 based corrections. Focusing-normalized fluxes of xsHg using the 0.58 xsPb-210 derived focusing factor fall between 1 and 47 $\mu g/m^2/yr$.
- Modern fluxes of Hg (18-20 $\mu g/m^2/yr$) are within a factor of two of the flux ranges reported for remote areas.

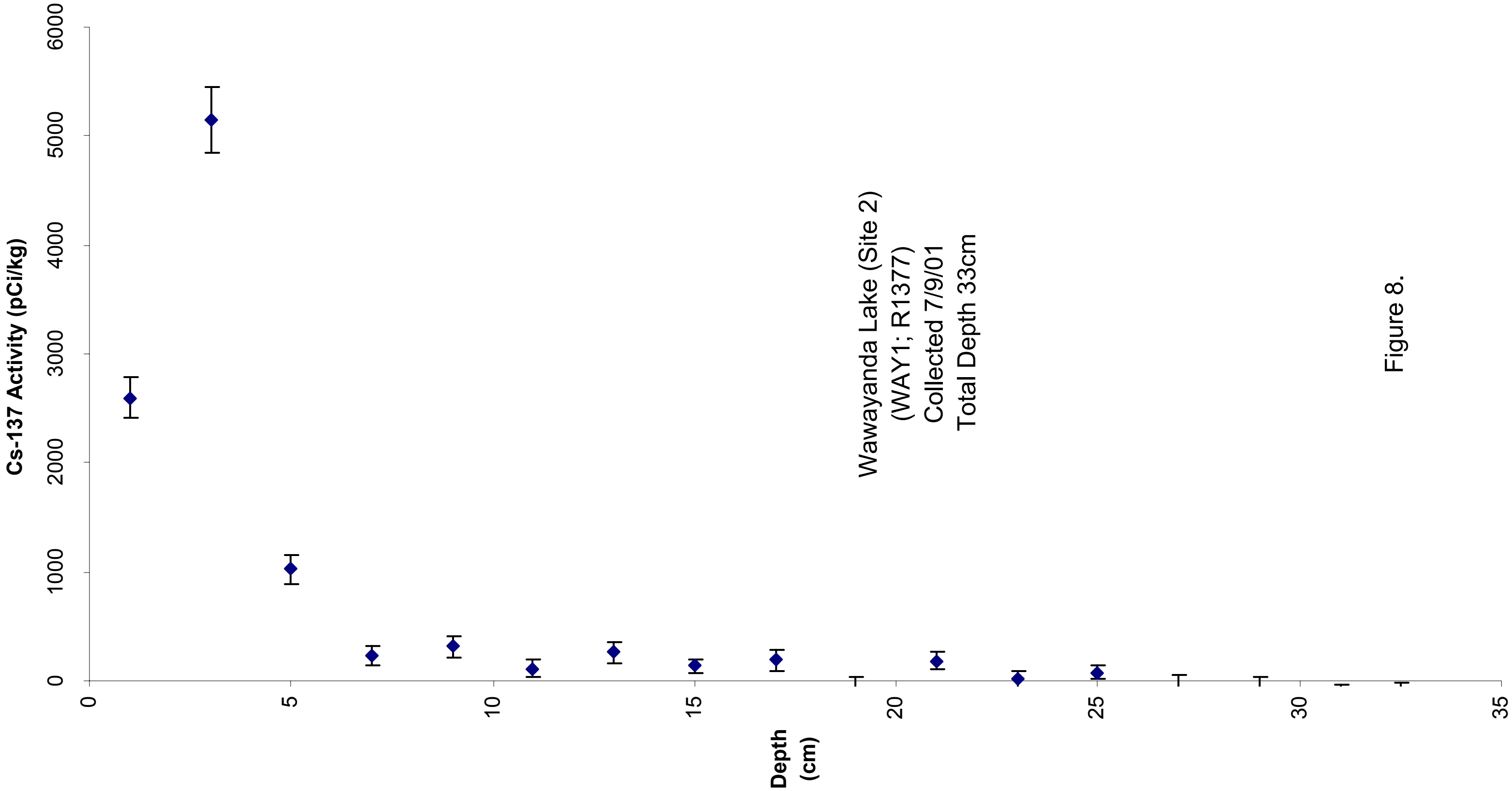

Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm
Cs-137 Activity (pCi/kg)
0
1000
2000
3000
4000
5000
6000
Depth
(cm)
0
5
10
15
20
25
30
35

Figure 8.

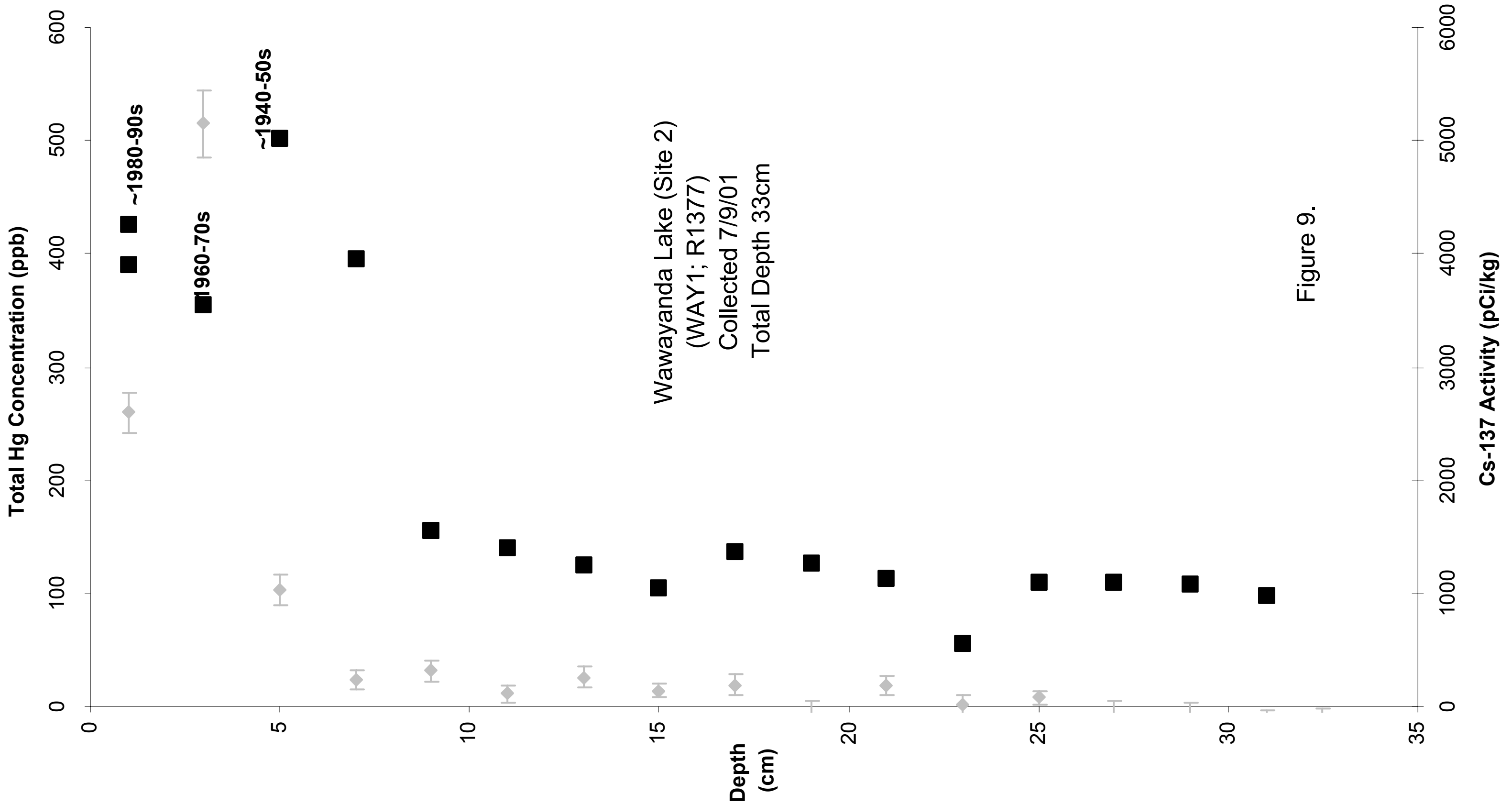
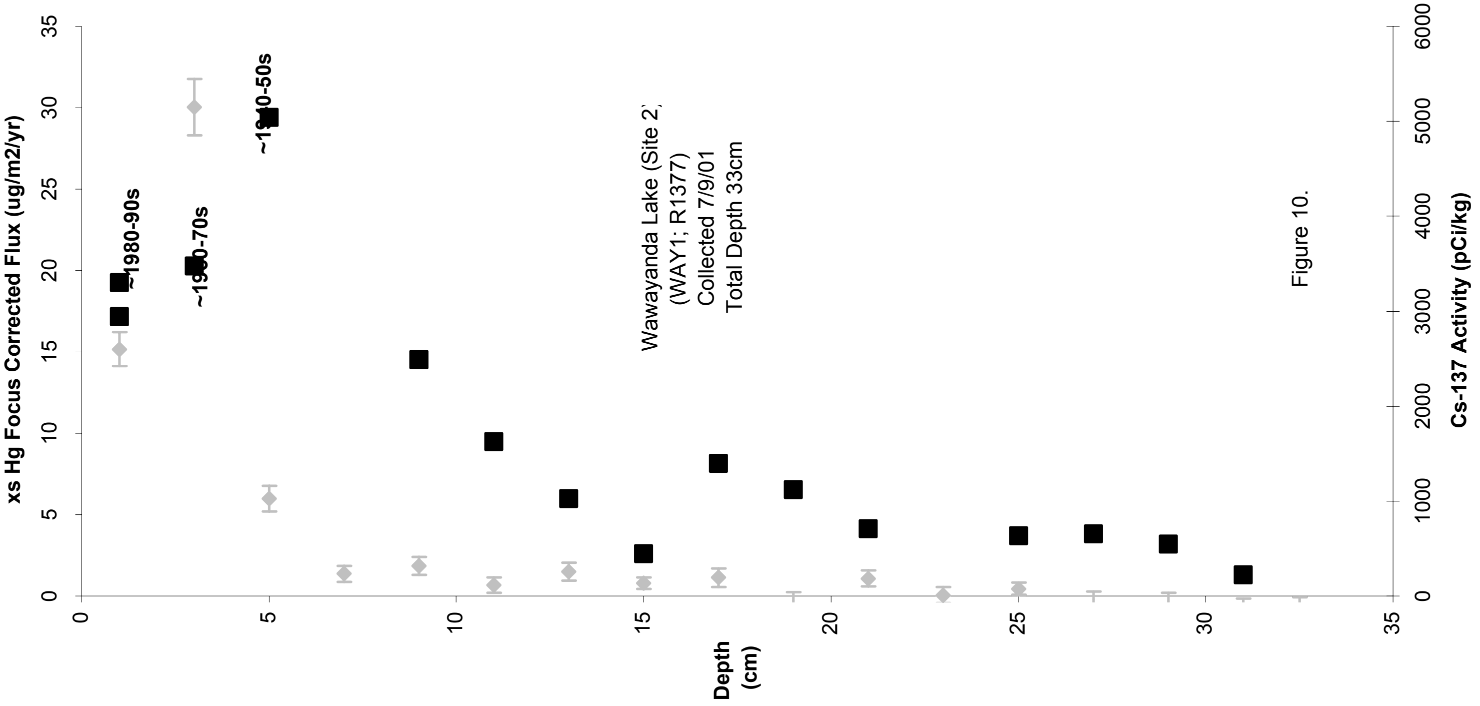

Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm
Total Hg Concentration (ppb)
0
100
200
300
400
500
600
Cs-137 Activity (pCi/kg)
0
1000
2000
3000
4000
5000
6000
Depth (cm)
0
5
10
15
20
25
30
35
~1980-90s
1960-70s
~1940-50s

Figure 9.



Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm

Figure 10.

Site 3:
Mountain Lake

Jenny Jump State Forest, Hope, White TWP (Warren Co.)

Site Summary:

Mountain Lake, located in northwestern NJ, was dammed in 1872. The lake has good fishery and is surrounded by a residential area. Nearby are a municipal waste combustion facility constructed in the mid-1980s, and a coal powered plant, which are possible influences on mercury inputs. This site was used previously in a NJDEP pilot study to assess trace levels of mercury in NJ lakes and precipitation.

Interpretation of Collected Data:

Sediment Core MTN2 (R1340). Refer to Figures 11-13.

A gravity core was collected from the deepest part of Mountain Lake (maximum depth ~35 feet) on September 29, 2000. The core was 28 cm long and was sectioned into 2 cm sections. Overall, MTN2 is a very good core, containing sediment deposited well before 1950 and the date of collection (2000273).

- Be-7 activity in the 0-2 cm section was positive, but less that 2σ greater than zero (984 +/- 516). With this data alone, we are statistically less than 95.5% certain that Be-7 is present in this sample. However, the near ideal Cs-137 profile supports an assumption of continuous sediment accumulation and provides further evidence that the 0-2 cm section does contain particles deposited within a year of core collection.

- A peak Cs-137 activity (1963-64) in the 6-8 cm section, indicating an average net depth sedimentation rate of about 0.19 cm/y in the years between 1963 and 2000.

- Detectable activity (ca. 1954) in the 10-12 cm section gives an average net sedimentation rate of 0.24 for the 1954-2000 period.

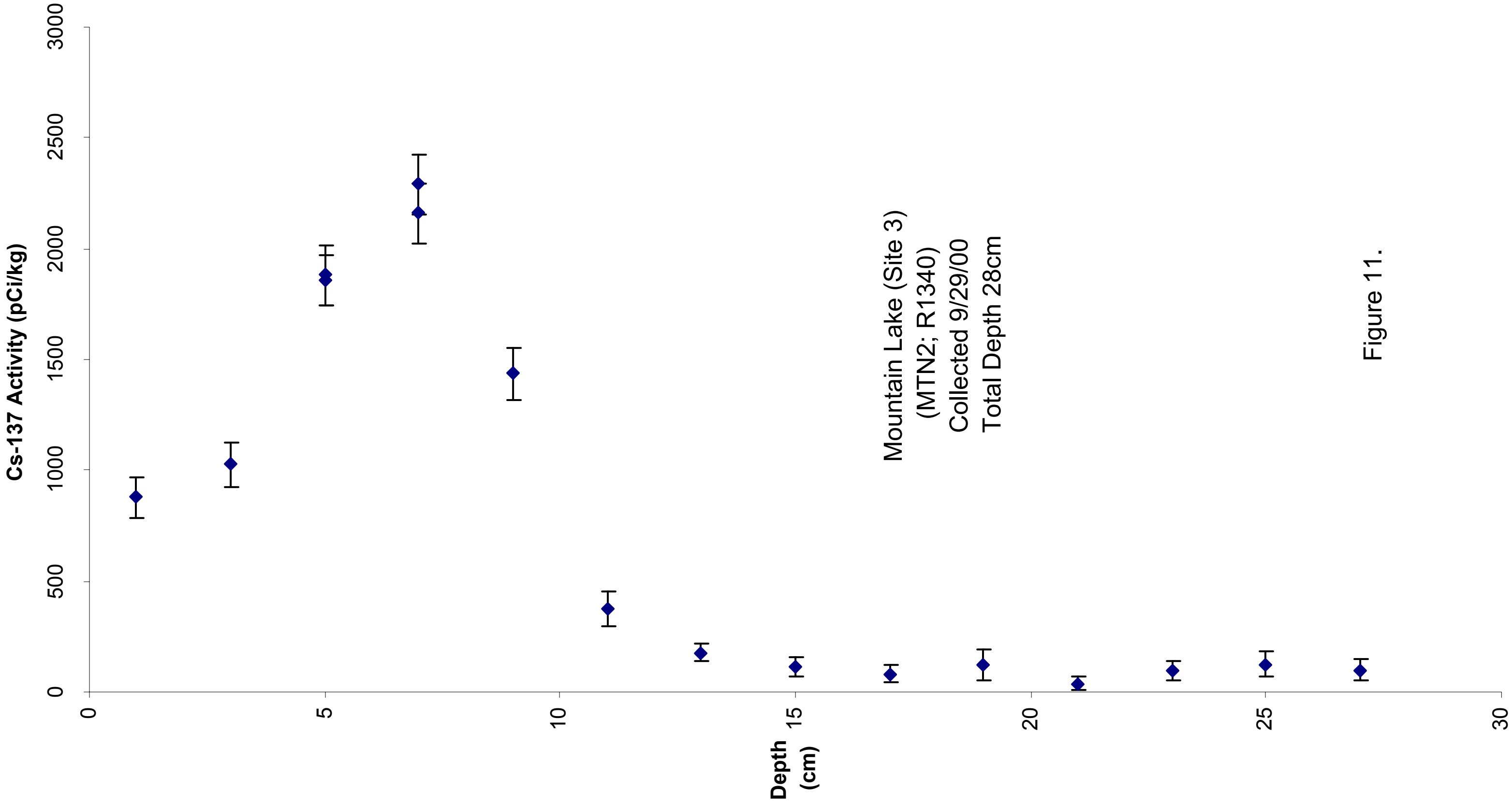
- xsPb-210 (half-life of 22.26 years) activity gives an average net sedimentation rate of about 0.19 cm/y, consistent with the rate of sediment deposition calculated from the Cs-137 peak in 1963.

- Total Hg range is 70 -226 ppm with peak concentrations in the 1960s-70s (4-6 cm). Peak fluxes however are seen earlier in the core around 1950.

- Surface sediment concentrations (217 ppb) are in agreement with average Hg levels found in surface grab sediments in Stevenson, et al. 1995 pilot study (211 ppb).

- Focusing-normalized Hg fluxes range from 70-226 $\mu g/m^2/yr$. Peak fluxes occurred around 1950 (10-12 cm) using a constant depth sedimentation rate model and at 2000 using a constant mass sedimentation rate model. Current fluxes of Hg (20 $\mu g/m^2/yr$, DSR model) are within a factor of two of the flux ranges reported for remote areas.

Insert Figure 11 from file figures.xls



Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm

Figure 11.

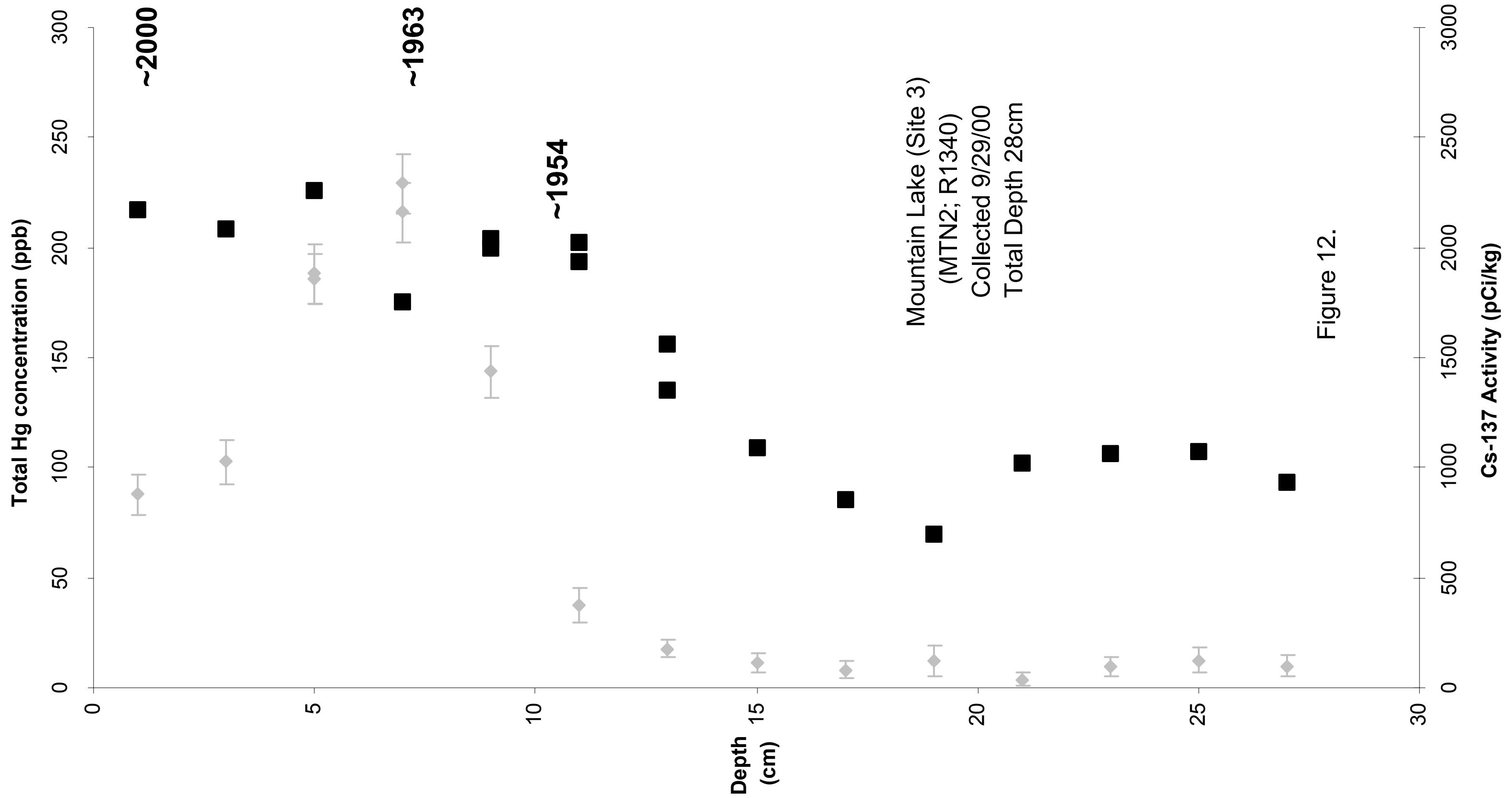
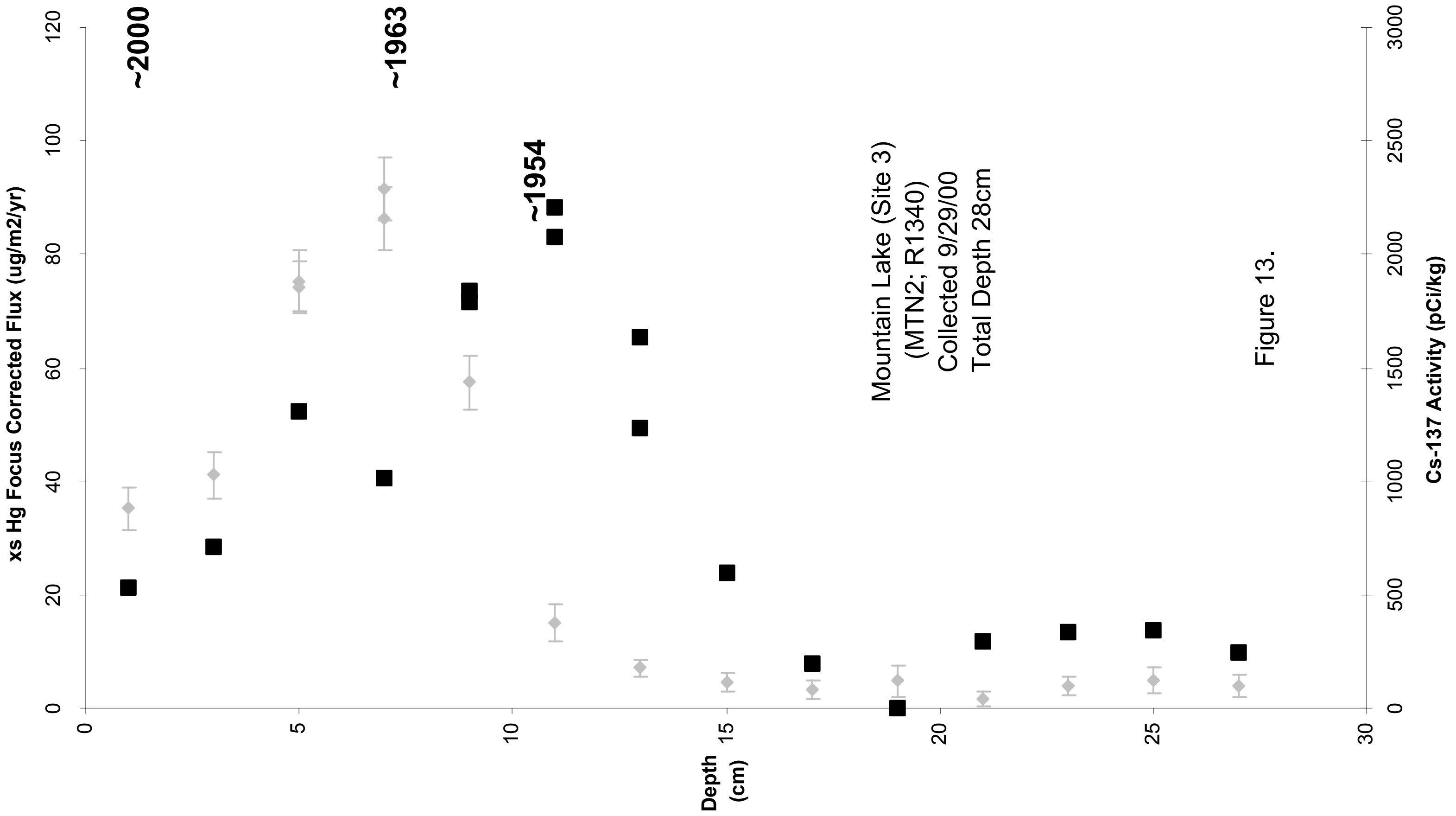

Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm
~2000
~1963
~1954
Total Hg concentration (ppb)
0
50
100
150
200
250
300
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
2500
3000
Depth (cm)
0
5
10
15
20
25
30

Figure 12.



Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm

Figure 13.

Site 4:
Imlaystown Lake
Upper Freehold TWP (Monmouth Co.)

Site Summary:
Imlaystown Lake (central NJ) was built in 1925. It is reported to have been down between ~1985 and 1995. The lake has good fishing and is owned by NJDEP/DF&W.

Interpretation of Collected Data:

Sediment Core IML1 (R1345). Refer to Figures 14-16.
One push core was collected from Imlaystown Lake on November 17, 2000. The core was taken from an area outside the well-defined flow path in about 2 feet of water. IML1 was 58 cm long and was sectioned at 2 cm intervals. This appears to be an excellent core, containing sediment deposited well before 1950.

- Be-7 activity is detectable in the 0-2 cm section of this core, indicating a significant amount of the particles having been deposited in the year 2000.

- A peak Cs-137 activity (1963-64) in the 10-12 cm section, indicating an average net sedimentation rate of about 0.30 cm/y in the years between 1963 and 2000.

- First detectable activity (ca. 1954) in the 12-14 cm section gives an average net sedimentation rate of 0.28 cm/y for the 1954-2000 period.

- Total Hg concentrations lie between 33 ppb (for a sandy bottom section, 46-48 cm) and 320 ppb in sediments deposited ~1930s (18-20 cm).

- Focusing-normalized Hg fluxes range from 6.9 - 270 $\mu g/m^2/yr$. The peak flux seems to have occurred in the 1930s (18-20 cm) and is more than double the flux of any other section from this core. Calculations using a constant depth sedimentation rates gave fluxes that decreased steadily from the peak level through 2000. Use of a constant mass sedimentation model shows another smaller peak flux in the 1960s.

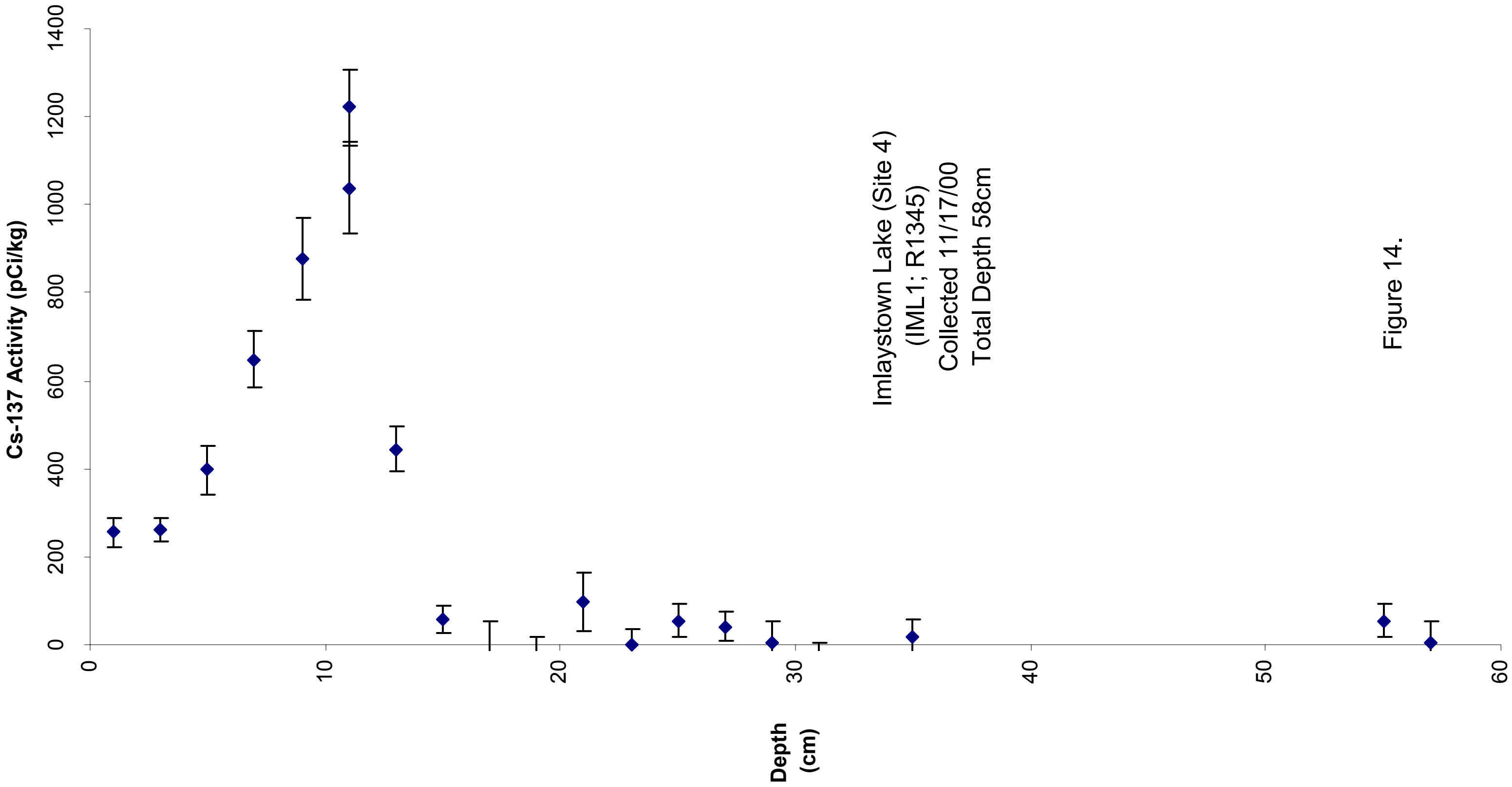
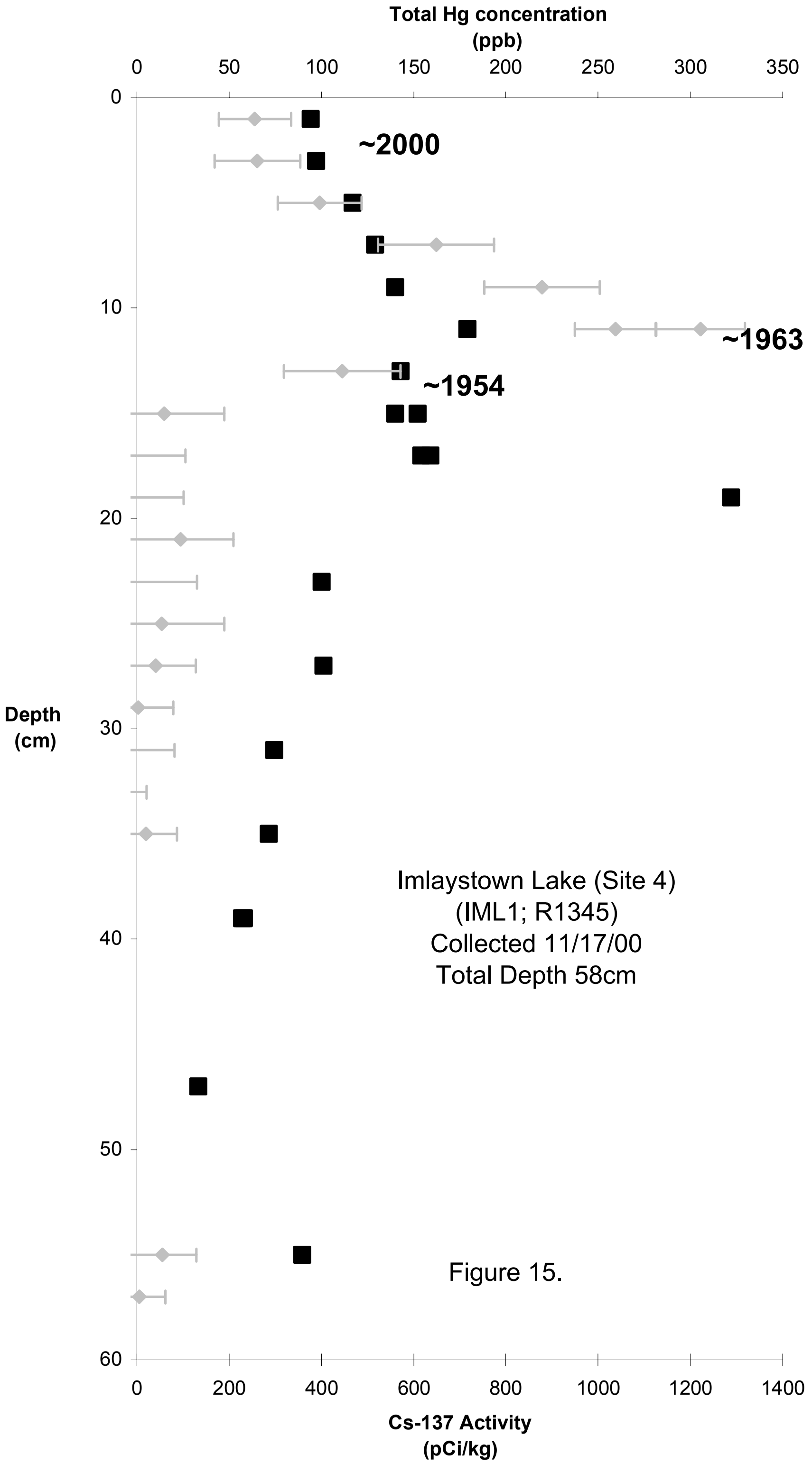

Cs-137 Activity (pCi/kg)
1400
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
Depth
(cm)
Imlaystown Lake (Site 4)
(IML1; R1345)
Collected 11/17/00
Total Depth 58cm

Figure 14.



Imlaystown Lake (Site 4)
(IML1; R1345)
Collected 11/17/00
Total Depth 58cm

Figure 15.

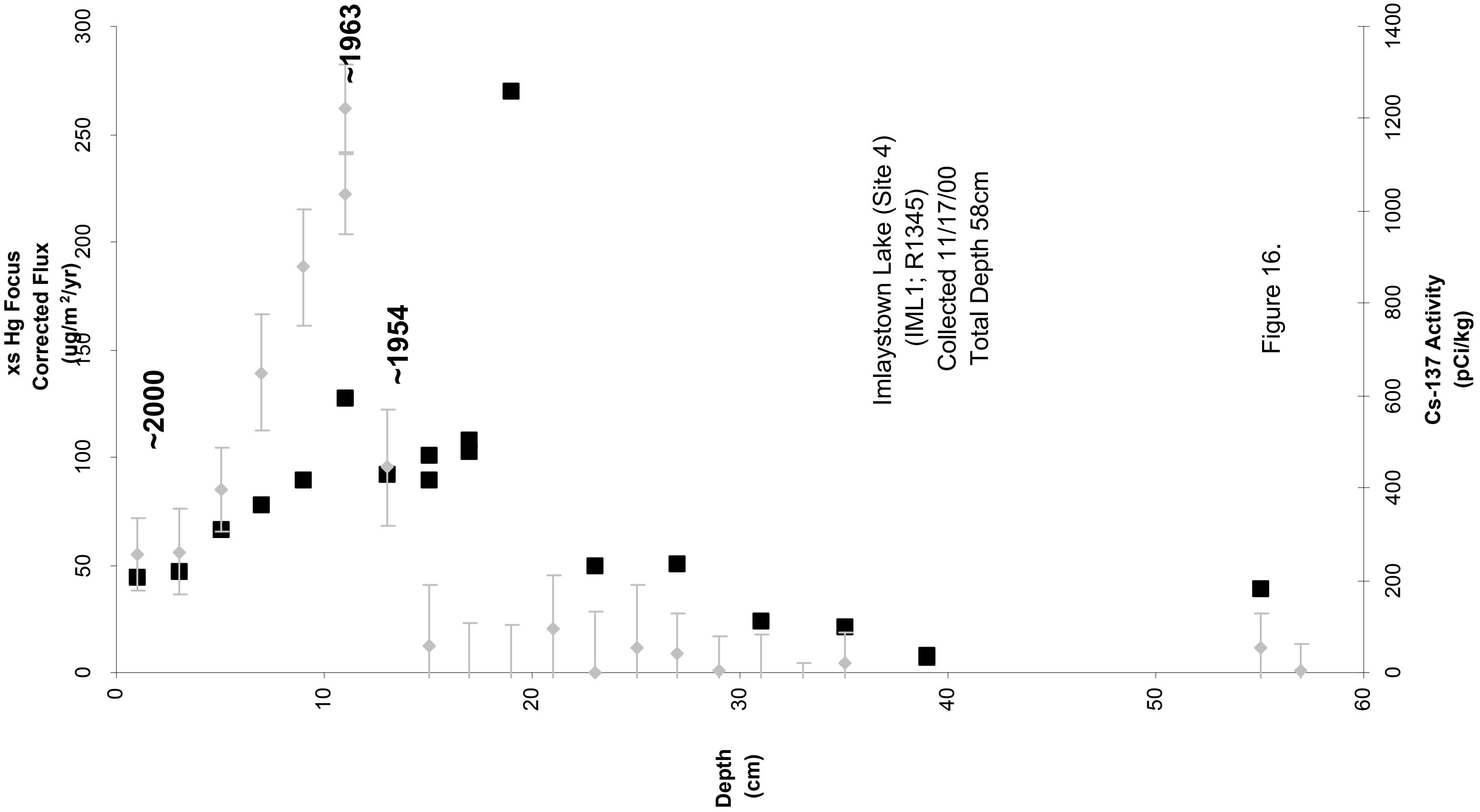

xs Hg Focus
Corrected Flux
(µg/m²/yr)
0
50
100
150
200
250
300
Cs-137 Activity
(pCi/kg)
0
200
400
600
800
1000
1200
1400
Depth
(cm)
0
10
20
30
40
50
60
~2000
~1963
~1954
Imlaystown Lake (Site 4)
(IML1; R1345)
Collected 11/17/00
Total Depth 58cm

Figure 16.

Site 5:
Absegami Lake

Bass River State Park, Bass River TWP (Burlington Co.)

Site Summary:

Absegami Lake was impounded from two streams in 1938. The lake, an old cedar bog, was lowered for a period of time but the Bass River (central stream channel) remained. Current fish species in this southeastern NJ lake include sunfish, pickerel, and catfish .

Interpretation of Collected Data:

Sediment Core ABS1 (R1343). Refer to Figure 17.

ABS1 is a push core collected from Absegami Lake on October 24, 2000, in about 5 ft of water. The ABS1 core was 24 cm long and was sectioned into 2 cm sections.

- Our best interpretation is that a very low net sediment accumulation rate (1 mm/y or less) results in peak Cs-137 activity in the near-surface samples.

- The penetration of detectable Cs-137 activity to a depth of 5 cm is interpreted as a result of mixing in the sediments.

- A composite sample from this core can be used to obtain an estimate of the integrated atmospheric Hg input, similar to a soil core.

- A mass-weighted composite of the 0-16 cm sections of the core showed an average total Hg concentration of 271 ppb

Note: Since a well-dated core was not obtained from Absegami Lake, a marsh core was collected near Tuckerton, a few miles to the east.

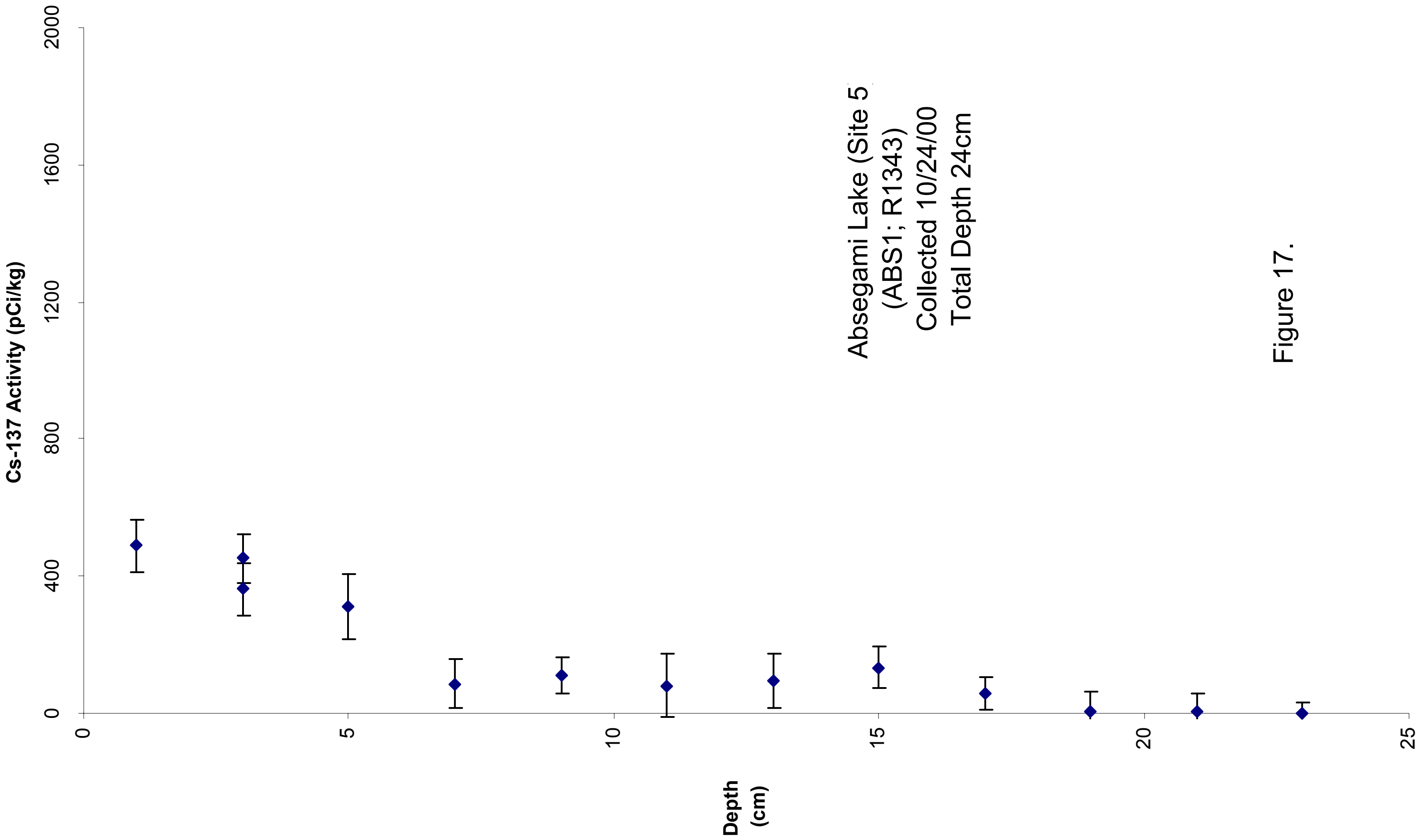

Absegami Lake (Site 5
(ABS1; R1343)
Collected 10/24/00
Total Depth 24cm
Cs-137 Activity (pCi/kg)
0
400
800
1200
1600
2000
Depth
(cm)
0
5
10
15
20
25

Figure 17.

Tuckerton Marsh Core

Edwin B. Forsythe National Wildlife Refuge, near Tuckerton (Ocean Co.)

Site Summary:

This site is a coastal high salt marsh in southeastern NJ. The surrounding area lies within the federally regulated Edwin B. Forsythe National Wildlife Refuge. A good depositional record is expected.

Interpretation of Collected Data:

Marsh Core TUCK2 (R1371). Refer to Figures 18-20.
A marsh core was collected on May 21, 2001 from a short grass area of high salt marsh. This large diameter core was 43 cm long and has been sectioned at ~1.2 cm intervals. The high organic content of the core made precise depth sectioning difficult. Since total mass determinations were more accurate, mass based sedimentation rate models were applied.

- Be-7 activity is detectable in the top section of the core (0-1.2 cm), suggesting that a significant portion of particles in this section was deposited within the year prior to collection.

- A peak in Cs-137 activity is seen in the 18-19.2 cm section. This peak is assumed to be the 1963-64 fallout maximum.

- The deepest detection of Cs-137 occurs at about 30 cm (1954).

- A mass sedimentation rate model for this core employed two separate rates: 0.224 $g/cm^2/yr$ was calculated for the sections within the 0-18.6 cm range, representing dates from 1963-2001 and 0.472 $g/cm^2/yr$ calculated from the 1954 and 1963 dates applied to the core sections below 18.6 cm.

- Total Hg concentrations range between 114 and 406 ppb with the peak value at the core surface.

- Focusing-normalized Hg fluxes to TUCK2 fall between 94 and 350 $\mu g/m^2/yr$. Peak decadal fluxes occurred in the 1940s. The highest flux calculated for an individual core section was at the surface.

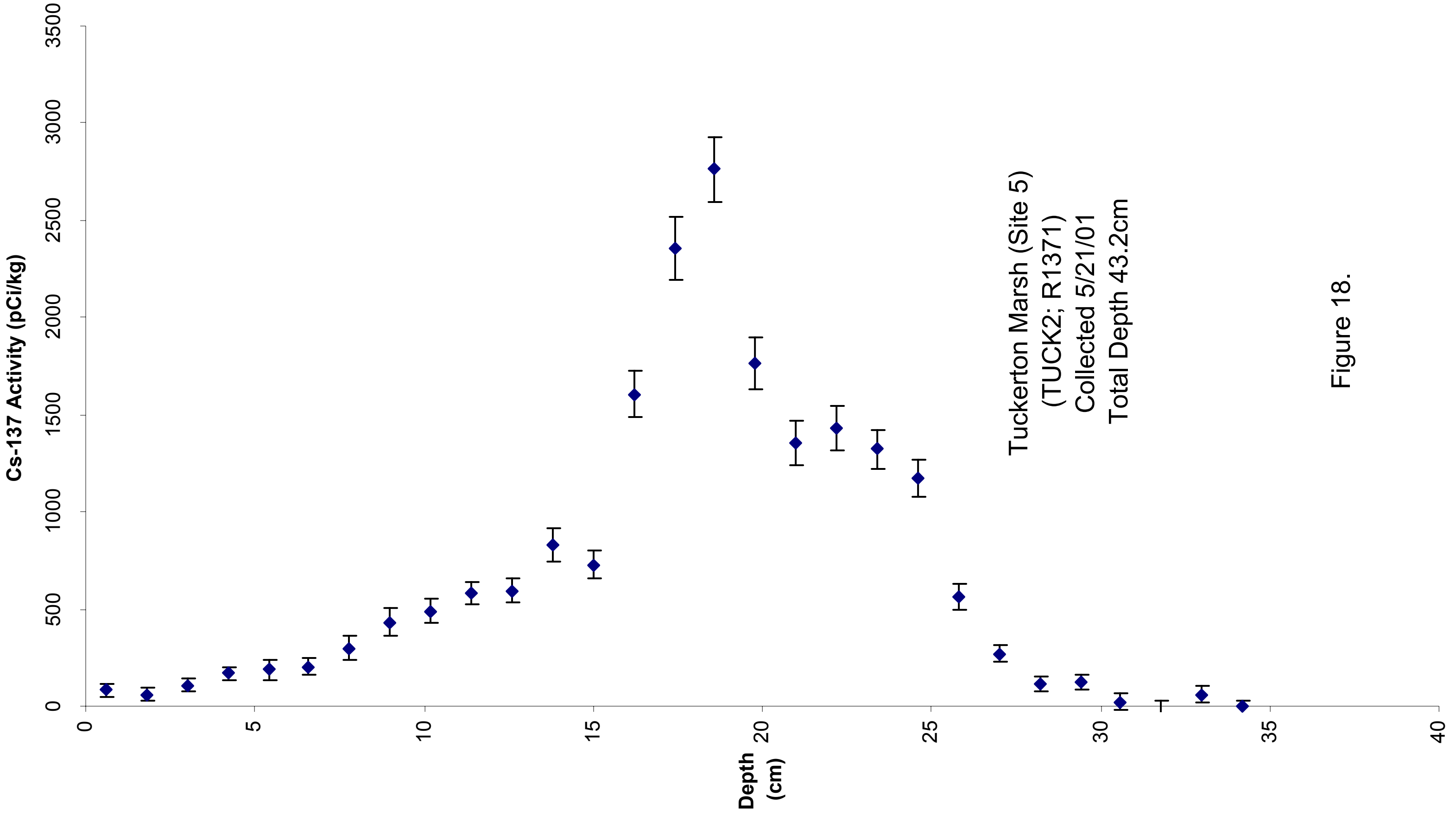
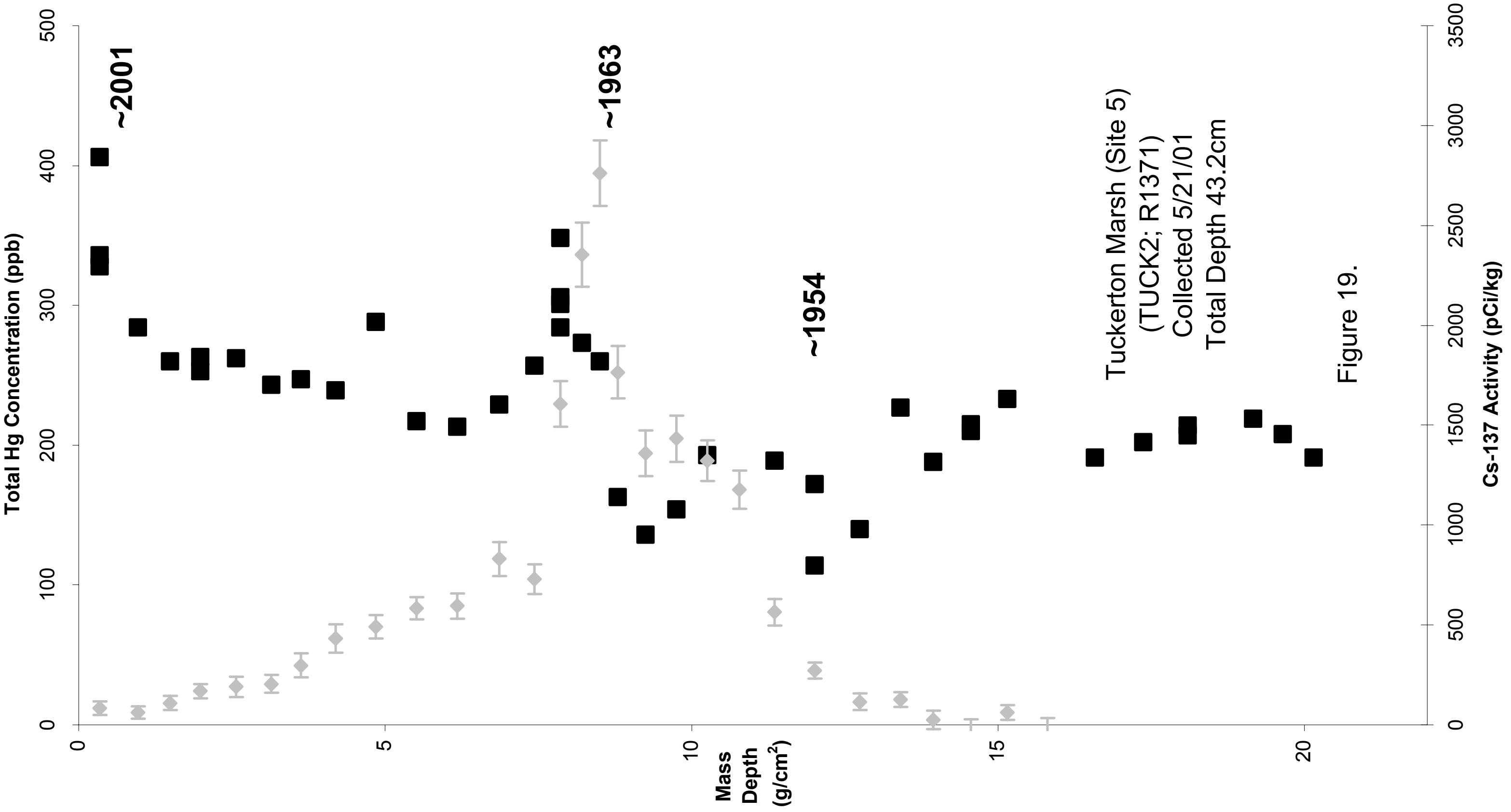

Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
2500
3000
3500
Depth (cm)
0
5
10
15
20
25
30
35
40
Tuckerton Marsh (Site 5)
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm

Figure 18.



Tuckerton Marsh (Site 5)
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm

Figure 19.

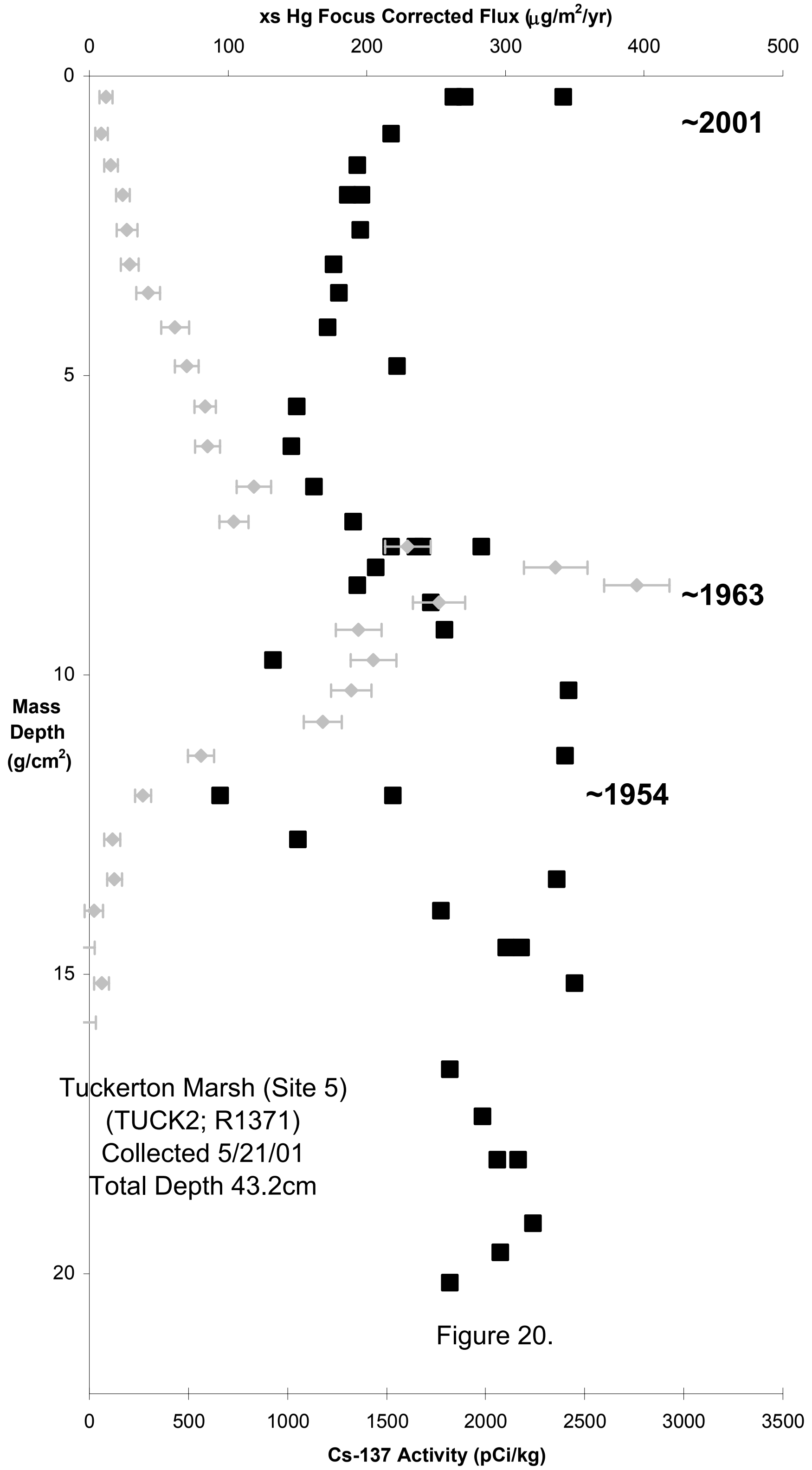

xs Hg Focus Corrected Flux (μg/m^2/yr)
0
100
200
300
400
500
Mass Depth (g/cm^2)
0
5
10
15
20
~2001
~1963
~1954
Tuckerton Marsh (Site 5)
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm
0
500
1000
1500
2000
2500
3000
3500
Cs-137 Activity (pCi/kg)

Figure 20.

Site 6:
Parvin Lake
Parvin State Park, Pittsgrove (Salem Co.)

Site Summary:
Parvin Lake, owned by NJDEP/DP&F, is located in southwestern NJ and was dammed in 1925. The lake has good fishery and motor boat access is allowed. This site was used in a NJDEP pilot study to assess trace levels of mercury in NJ lakes and precipitation.

Interpretation of Collected Data:

Sediment Core PAR1 (R1346). Refer to Figures 21-23.
This push core was collected from Parvin Lake on November 17, 2000. The core was taken from a marshy cove in the lake in about 4 ft of water. The PAR1 core was 50 cm long and was sectioned at 2 cm intervals. Although it appears there is some mixing in the upper sections, it is a good core, containing a continuous record of sediment deposited from prior to 1954 to the date of coring (2000322).

- Be-7 activity is detectable in the 0-2 cm section of this core, indicating a significant amount of the particles having been deposited in the year 2000.

- Cs-137 activity peaks in the 20-22 cm section of this core. Assignment of this peak to the year 1963 gives a calculated net sedimentation rate of 0.57 cm/y.

- First detectable amounts of Cs-137 activity in the core occur in the 34-36 cm section.

- The “leveling off” of Cs-137 activity observed in the top 15 cm of this core indicates that there may be mixing taking place in the upper sediments of Parvin Lake.

- Total Hg concentrations range from 122-415 ppb. Peak concentrations occur in sections dated to the 1970s (12-14 cm). Recent sediments (year 2000) have 400 ppb levels.

- Near surface sediment concentrations 402 ppb are in agreement with average Hg levels found in surface grab sediments in the Stevenson, et al. (1995) pilot study (0.350 ppm).

- Focusing-normalized Hg fluxes are 49-406 $\mu g/m^2/yr$. Peak fluxes occur in the mid-1960s (20-22 cm.) Although the 0-2 cm section flux is elevated over the 2-4 cm section, fluxes generally show a steady decrease between mid-1960s and the present.

- An additional two sediment cores were collected from the deepest areas of Parvin Lake on June 22, 2001. One of these was also be analyzed for radionuclides. The resulting sediment profile was found to be less useful than the somewhat “mixed” profile obtained from PAR1.

Insert Figure 21 from file figures.xls

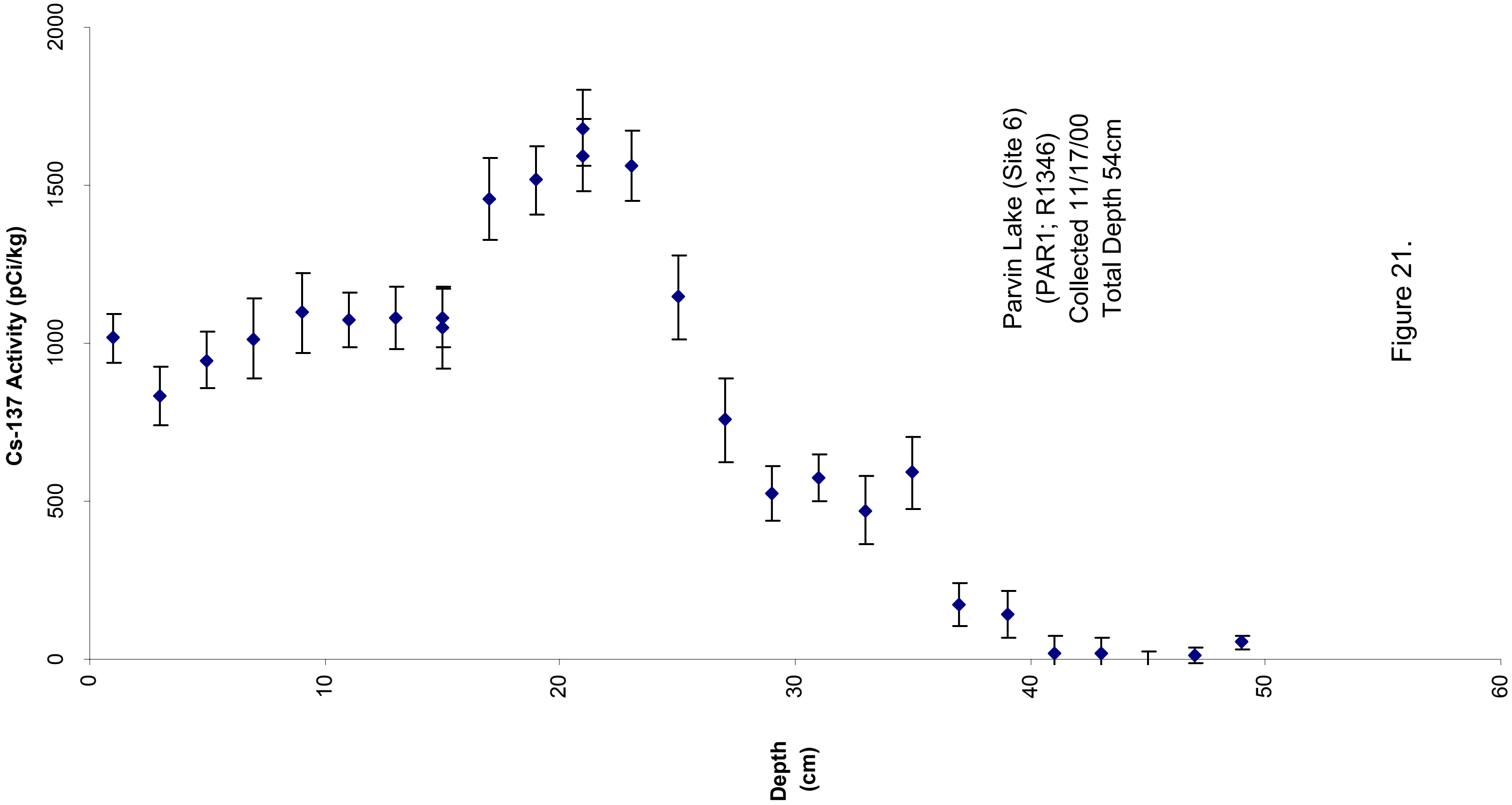
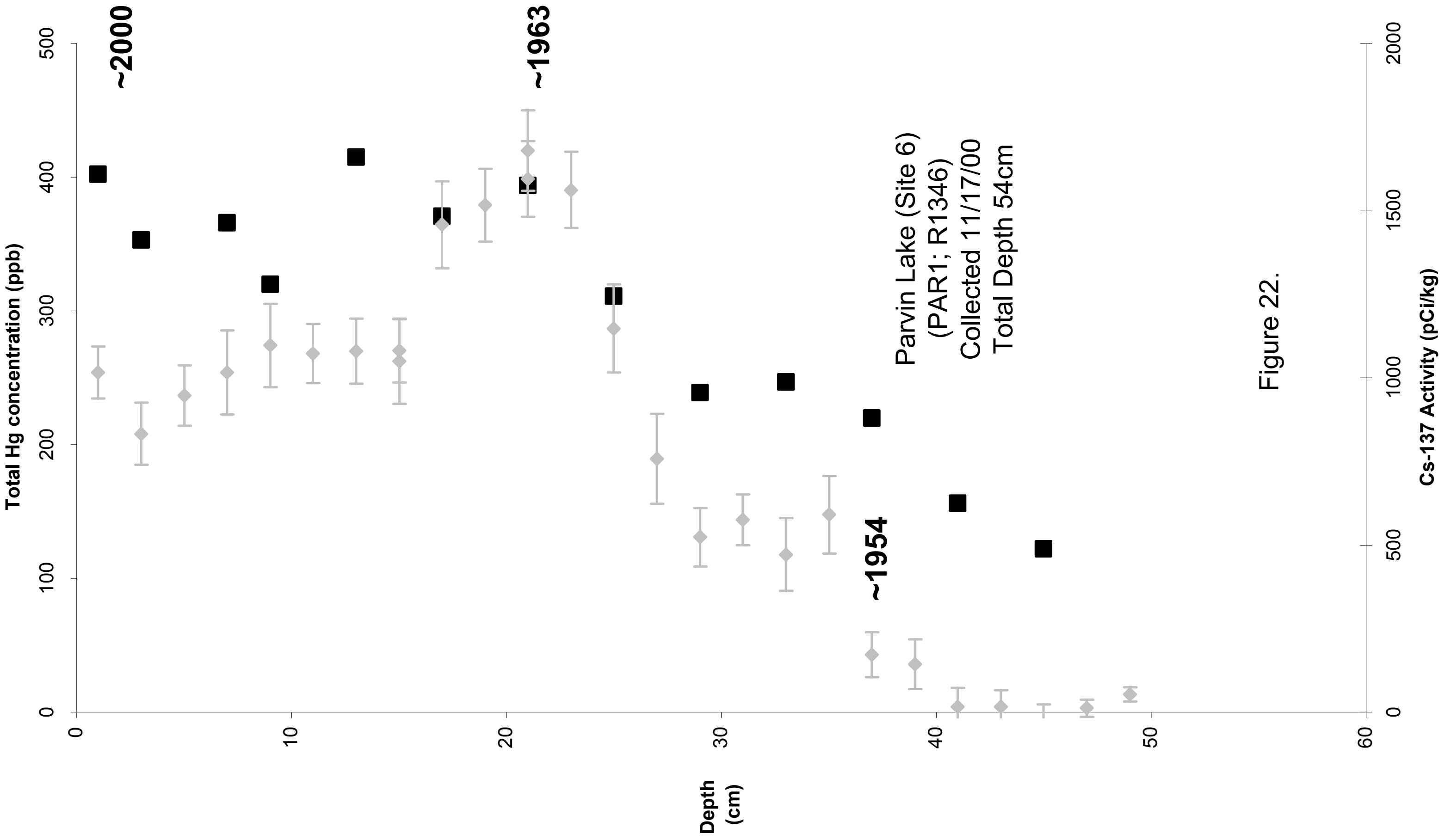
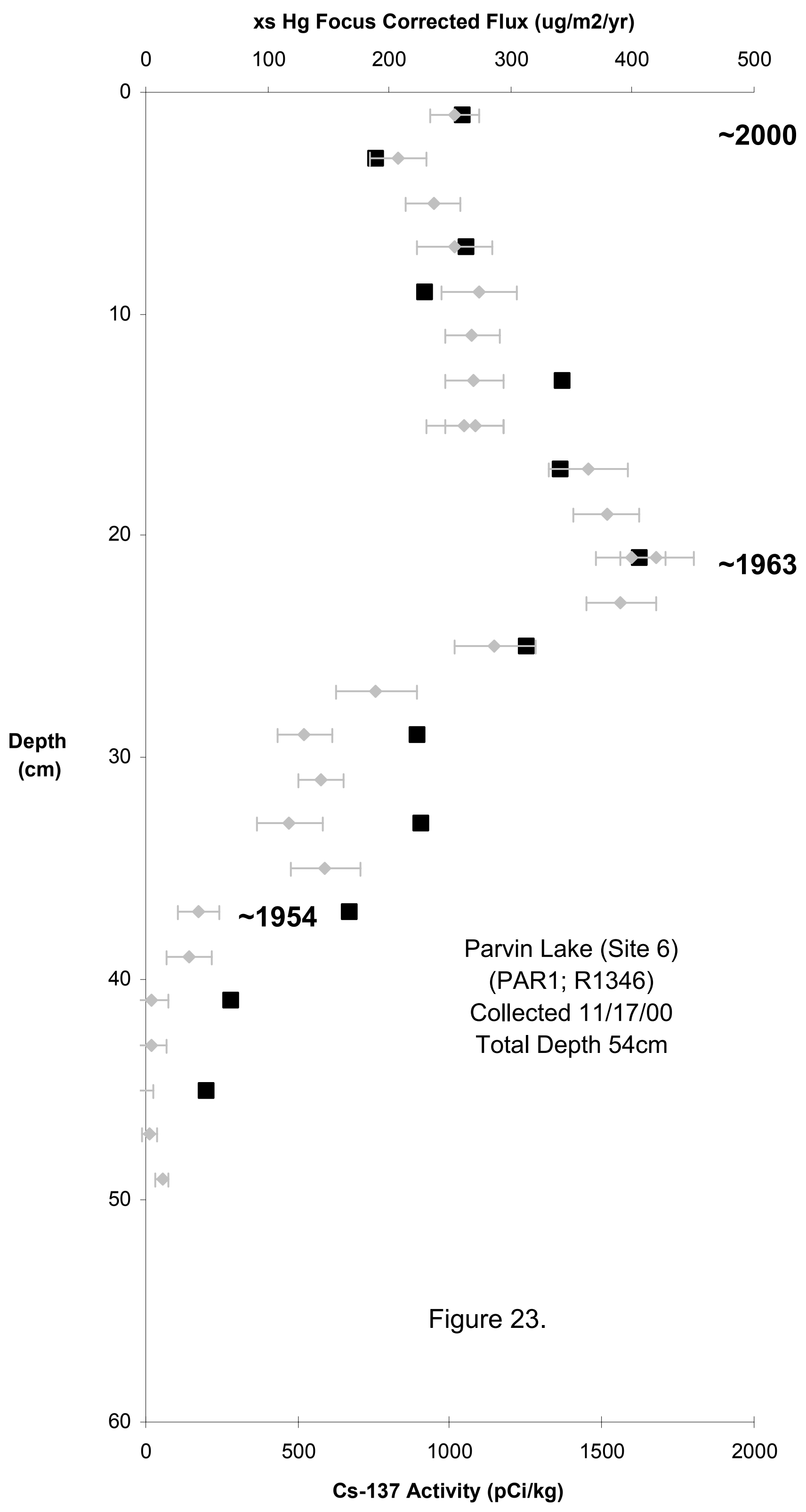

Cs-137 Activity (pCi/kg)
2000
1500
1000
500
0
0
10
20
30
40
50
60
Depth
(cm)
Parvin Lake (Site 6)
(PAR1; R1346)
Collected 11/17/00
Total Depth 54cm

Figure 21.



Parvin Lake (Site 6)
(PAR1; R1346)
Collected 11/17/00
Total Depth 54cm

Figure 22.



Parvin Lake (Site 6)
(PAR1; R1346)
Collected 11/17/00
Total Depth 54cm

Figure 23.

Data Summary and Comparison to Other Studies

Mercury concentrations measured in sediments and soils from Mountain Lake and Parvin Lake in this study were in good agreement with the concentrations reported by Stevenson et al. in 1995 (Table 7). Table 8 gives the range of mercury concentrations and fluxes found at each coring site in this study. Mercury concentrations in New Jersey soil core composites ranged from 13.5 – 188 ppb (Appendix IV). Typical soil backgrounds fall within the 10 – 500 ppb in soils with an average of 60 ppb (Bowen, 1979). Tables 9 and 10 provide ranges of mercury concentrations and fluxes from a variety of other study sites ranging from remote to highly urbanized and industrialized areas. Except for Woodcliff Lake, data collected from the New Jersey sites fall within ranges collected from other areas in North America receiving regional Hg deposition signals, and are similar to regional levels reported by Pirrone, et al. (1998) for the Great Lakes. The Woodcliff Lake site may receive a significant local atmospheric input from the NY/NJ Metropolitan area. Similarly elevated Hg fluxes observed in Central Park Lake, Manhattan, have been related to local atmospheric inputs derived from municipal solid waste and coal combustion (Kroenke et al., 2002). The soil sample from the Woodcliff Lake site had a factor of three higher Hg concentration than any of the other soil samples, consistent with this site receiving the largest atmospheric Hg flux. The total Hg inventory in the soil sample however was significantly lower than the sediment core. This suggests that direct (i.e. non-atmospheric) inputs of Hg to Woodcliff Lake may also be significant. Further study is necessary to characterize the sources of Hg to Woodcliff Lake and to better define the geographical extent of any "local NY/NJ Metropolitan Area" atmospheric signal.

Insert Table 7 from file tables.xls

Table 7. Data Agreement With Data From Previously Sampled NJ Sediments/Soils

	Total Hg (ppb)[1] *surface grab sample* *(~1995)*	**Total Hg (ppb)** *0-2 cm core section* *(~2000)*
Mountain Lake Sediments	211	217
Parvin Lake Sediments	350	402

	Total Hg (ppb)[1] *nearshore soils* *(~1995)*	**Total Hg (ppb)** *nearshore soils* *(composited cores)*
Mountain Lake Soils	5 - 48	67.5
Parvin Lake Soils	18 - 305	26.6

[1] Data from Stevenson et al (1995)

Table 8. Variation in Hg Data Within Sediment Cores

Site	Core	Total Hg (ppb)	Hg flux range within core ($\mu g/m^2/yr$)
1	WOODB	245 - 2867	64 - 3765
1	WOODD	293 - 359	195 - 479
2	WAY1	55 - 502	1 - 47
3	MTN2	70 - 226	0 - 88.3
4	IML1	33.2 - 322	6.9 - 270
5	ABS1	271	59[a]
5	TUCK2	114-406	94 - 350
6	PAR1	122 - 415	49 - 406
NJ soils		13.5 - 188	

[a] ABS Hg measurement was done on one mass weighted composite of the Cs-137 bearing sections
It has not been corrected for sediment focusing (background Hg of 30 ppb is assumed)

Table 9. Measured Total Mercury Concentrations in Sediments

Study Description	Total Hg (ppb)	Reference
Great Lakes	27 - 460	Pirrone et al. (1998)
80 Minnesota Lakes	34 - 753; mean 174	Sorensen et al. (1990)
Western Long Island, NY	1000 - 2000	Wang (1993)
Northeastern NJ Lakes	230 - 5130	Van Metre and Callendar (1997)
North Atlantic States	7 - 500, mean 140	NOAA NS&T (1984-1991)
North Central WI Lakes	90 - 190	Rada et al., (1989)
Adirondacks, NY	80 - 500	Lorey (1999)
Central Park, Manhattan	1000 - 2000	Kroenke et al. (2002)
NJ Lakes and Marshes	33 - 2900	This report

Table 10. Estimated Mercury Deposition Fluxes

Study Description	**Hg flux ($\mu g/m^2/yr$)**	**Reference**
Great Lakes	7 - 2350, 135 mean	Pirrone et al., (1998)
North America	14.3 - 19.8	Pirrone et al., (1998)
United States	2.4 - 20.0; ~10 mean (wet)	NADP/MDN
Western Long Island, NY	200 - 800	Wang (1993)
Little Rock Lake, WI	10	Fitzgerald et al., (1991)
Minnesota peat bog	7.0 preindustrial 24.5 modern	Benoit et al., (1994)
Northern Minnesota	10.4-15.4 (wet deposition)	Sorensen et al., (1990)
Minnesota, Northern WI	3.7 preindustrial 12.5 modern	Engstrom, et al., (1994)
Remote Regions	15	Mason et al., (1994)
Maine peat bog	25 - 30	Norton, et al., (1998)
Chesapeake Bay, MD	10 - 25 (wet deposition)	Mason (1997)
Northern Quebec	35 - 76	Lucotte (1995)
Central & Northern Canada (18 Lakes)	2.1 - 114	Lockhart (1998)
Everglades, FL	53 modern mean	Rood (1995)
NY/NJ Harbor	10,000	Kroenke et al. (2002)
Central Park Lake, Manhattan, NY	1500	Kroenke et al. (2002)
Woodcliff Lake	200 - 5000 (since 1950)	This study
Other NJ Lakes and Marshes	10 - 400 (since 1950)	This study

For each of the six New Jersey sites, the periods of peak Hg flux and annual fluxes averaged over the past four to five decades are reported in Table 6. For comparison of temporal trends, Hg fluxes at the New Jersey sites and Central Park Lake in Manhattan (Kroenke et al., 2002) have been calculated as decadal averages (Table 5). Peak fluxes occur in the cores over a range of years between 1930 and 1960, with the exception of a second peak in the most recent (2001) sediments at the Tuckerton site (Figure 20). The Tuckerton data also shows evidence of an increase in Hg deposition rates over the past two decades. As discussed above, Woodcliff Lake sediments record the highest Hg fluxes of any of our six New Jersey sites. The calculated fluxes were about a factor of two higher than fluxes to Central Park Lake and had a similar temporal trend (Table 5). The next highest fluxes, about and order of magnitude lower than Woodcliff Lake, were calculated for the marsh near Tuckerton and Parvin Lake. The site with the lowest calculated fluxes was Wawayanda Lake. It should be noted however that fluxes reported in Tables 5 and 6 are based on normalization to xsPb-210 inventories. Normalization to the Cs-137 inventory (Table 2) would make the calculated Wawayanda fluxes more similar to those calculated for Mountain Lake.

Sediment Cores taken from three northeastern New Jersey lakes in 1997 as part of the National Water Quality Assessment Program (NAWQA) were dated using Cs-137 and analyzed for trace metals (Van Metre and Callendar, 1997). Mercury results from these cores showed a range of total Hg concentrations from 230-5130 ppb. Orange Reservoir, located in an urbanized watershed, contained the highest concentrations (1300-5130 ppb) with peak Hg levels found in sediments from 1995 among sediments dated back to the 1930s. A steady increase in concentrations in Orange Reservoir is seen between ~1950 and 1995. These levels are comparable with than those found in this study at the Woodcliff Lake Site. Concentrations at Woodcliff Lake, however peaked in the 1960s and have declined with the exception of a slight increase in the 1970s until about 1980 then leveled of at ~ 300 ppb through the present. A second urbanized lake, Packanack Lake, contained concentrations between 230 and 660 ppb, peaking in the 1940s. Clyde Potts Reservoir, located more remotely in a largely forested area contained Hg concentrations ranging between 260-380 ppb with no significant trends over a 30 year period. It would be most interesting to compare the NAWQA lakes to our sites on the basis of calculated Hg fluxes. Unfortunately, at the time of this report, flux estimates were not available for the NAWQA lakes. With the Cs-137 data and some ancillary information about the cores, a direct comparison could be made between Hg fluxes to the NAWQA lakes and our six New Jersey sites.

IV. CONCLUSIONS AND RECOMMENDATIONS

Estimates of mercury depositional fluxes to sediments in this study can vary over about a factor of two depending on the choice of Hg background levels and sediment focusing factors, and complications involving drainage basin holdup or sediment mixing. Despite these uncertainties we are able to conclude:

- Atmospheric fluxes of Hg to our six New Jersey sites have decreased considerably from levels observed three to four decades ago.
- Atmospheric fluxes of Hg to aquatic systems throughout most of the state are higher than fluxes reported for remote areas. At Imlaystown Lake, Tuckerton Marsh, and Parvin Lake, Hg fluxes are similar to those reported for the Great Lakes and about ten times the remote flux. Somewhat lower fluxes were calculated for the northcentral and northwestern New Jersey sites (Wawayanda Lake and Mountain Lake).
- The highest mercury fluxes were found in sediments of northeastern New Jersey. Dated sediment core samples from Woodcliff Lake yielded Hg fluxes comparable to those found

for Central Park Lake and about an order of magnitude higher than at any of our other New Jersey sites. While the Central Park data and Woodcliff Lake soil data suggests enhanced atmospheric Hg deposition at this site, the relative importance of atmospheric and direct inputs has not been determined.

As a continuation of this work, we recommend a renewed focus to obtain a more detailed view of northeastern New Jersey in order to elucidate sources of the elevated local signal to northeastern New Jersey. We suggest two major components for this new study.

- Collection, radionuclide dating, and Hg analysis of sediment cores from three additional lakes in the northeastern New Jersey area. This will help to define the geographical extent of the "local NY/NJ Metropolitan Area" signal. Data analysis will include consideration of our dated Central Park Lake sediment samples, samples from a dated marsh cores from Long Island (Wang 1993), and our samples from dated NYC drinking water reservoir cores in the Hudson basin.

- Analysis of dated sediment core samples for a suite of other trace metals including Pb, Zn, Sn, Sb, Cd, V, and Cr. These analyses will provide tracers of the sources of metals to the aquatic systems. For example, the Hg to Pb ratio associated with municipal solid waste (msw) combustion is much lower than that associated with coal combustion. MSW combustion is also enriched in Cd, Sb, and Sn, and not a significant source of Cr. V is a tracer of oil combustion and in the NY/NJ Metropolitan area, peak V inputs are associated with the mid 1960s.

The “other trace metal” analyses should focus on samples from Woodcliff Lake and the three other lakes to be sampled in northeastern New Jersey. All of the metals mentioned have already been analyzed in our dated Central Park Lake samples and those analyses will provide an important starting point for site to site comparisons. Pb, Zn and Cd fluxes have been reported for dated sediment cores from Long Island marshes (Cochran et al. 1998). Selected samples from the other five sites in our present study (e.g. surface sediment and mid 1960s deposition) should be analyzed to provide a statewide perspective for New Jersey.

V. ACKNOWLEDGEMENTS

Support for this work was provided through a contract between Rensselaer Polytechnic Institute and the State of New Jersey Department of Environmental Protection Division of Science Research and Technology. The authors would like to acknowledge the participation of NJDEP personnel in the planning of this research and discussion of results. Bruce Ruppel and Ed Stevenson helped with site selection. Alan Stern supported and helped to focus our research approach, and Mary Downes Gastrich was a most interested and involved project manager. Mary’s participation in sample collection and her help with site characterization and access are greatly appreciated.

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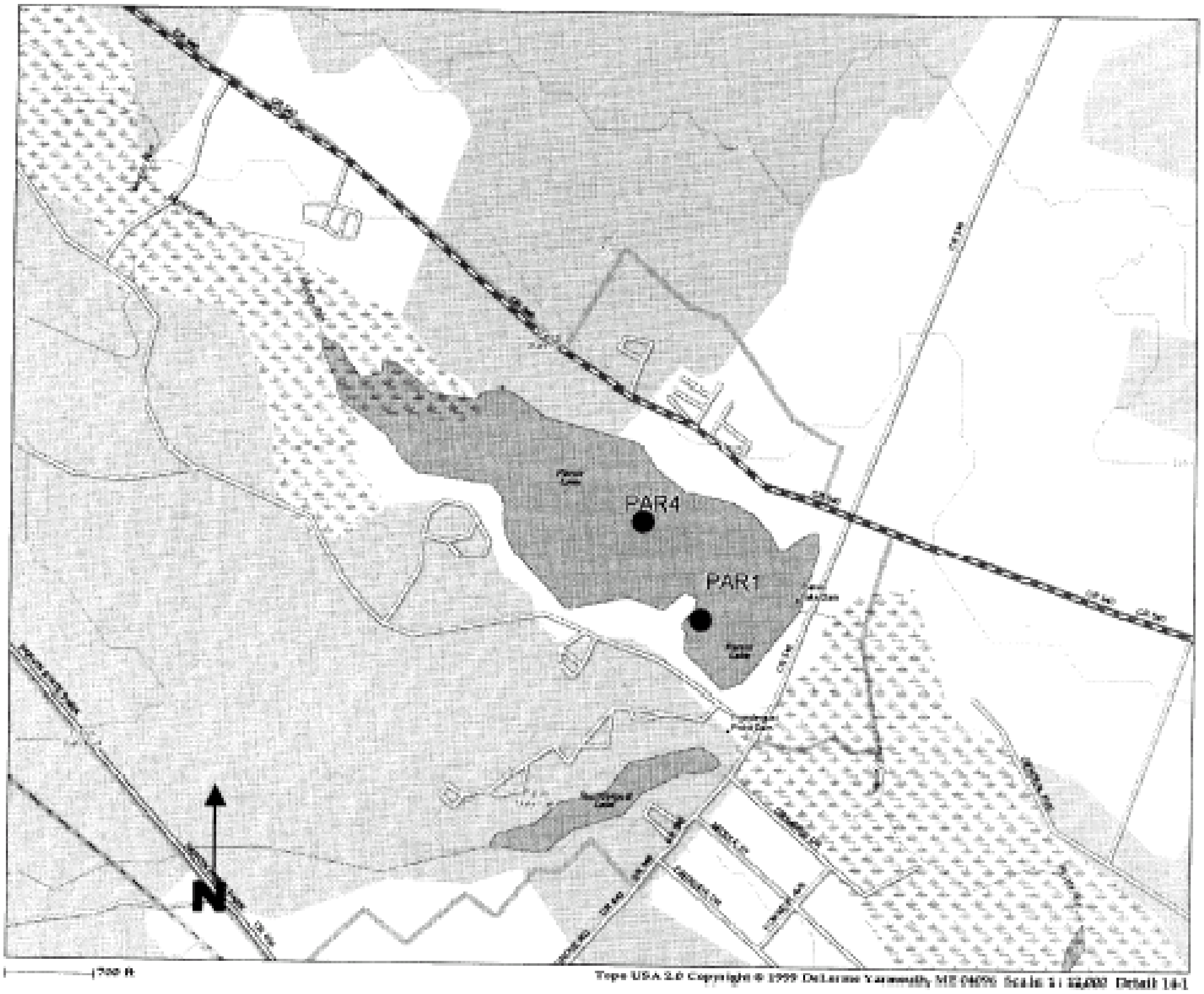
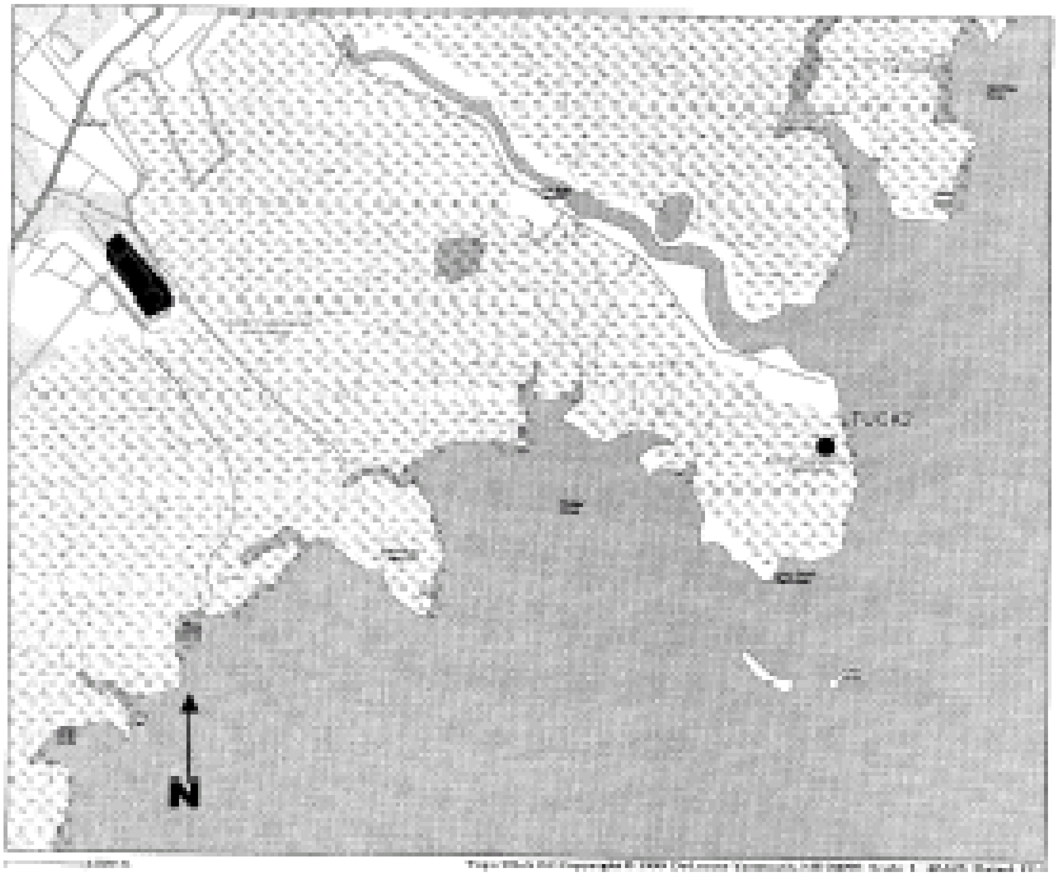
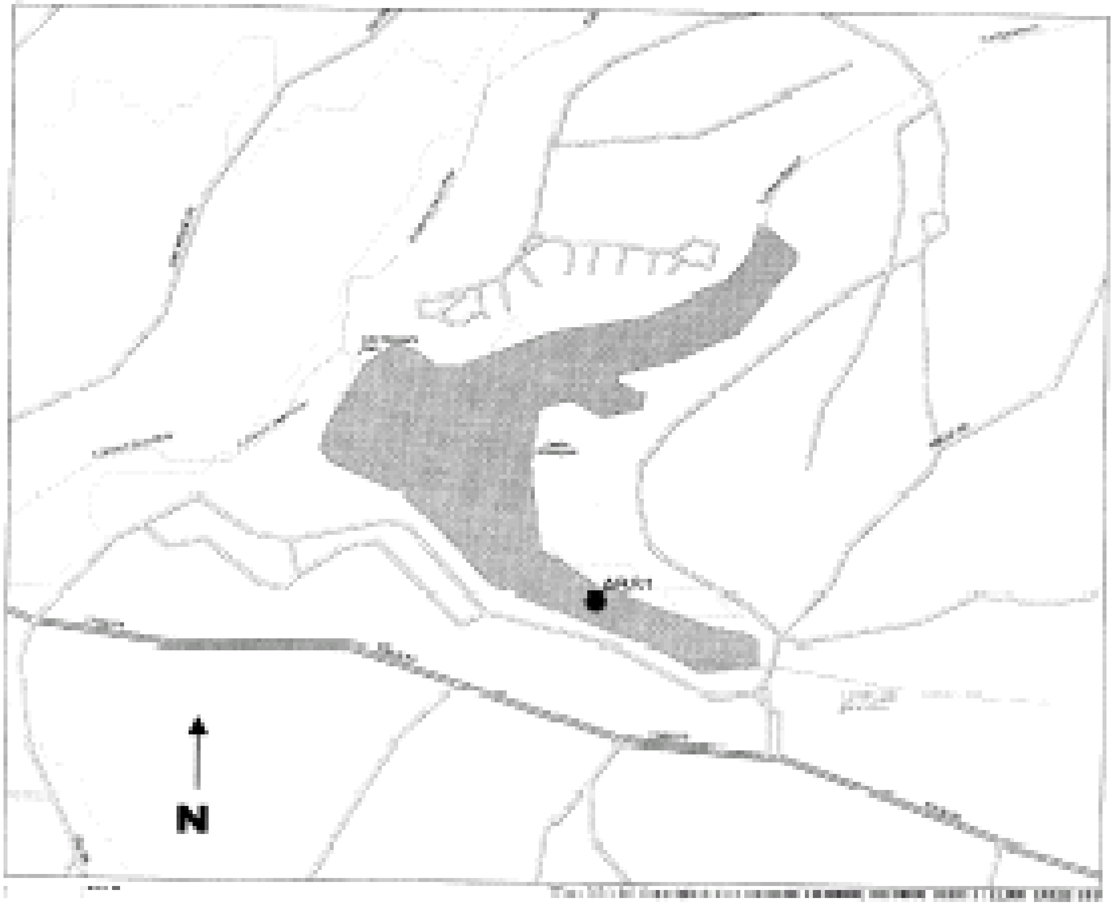
APPENDIX I. Detailed Site Maps


PAR4
PAR1
N
700 ft
Topo USA 2.0 Copyright © 1999 DeLorme Yarmouth, ME 04096 Scale 1:12,800 Detail 14-1

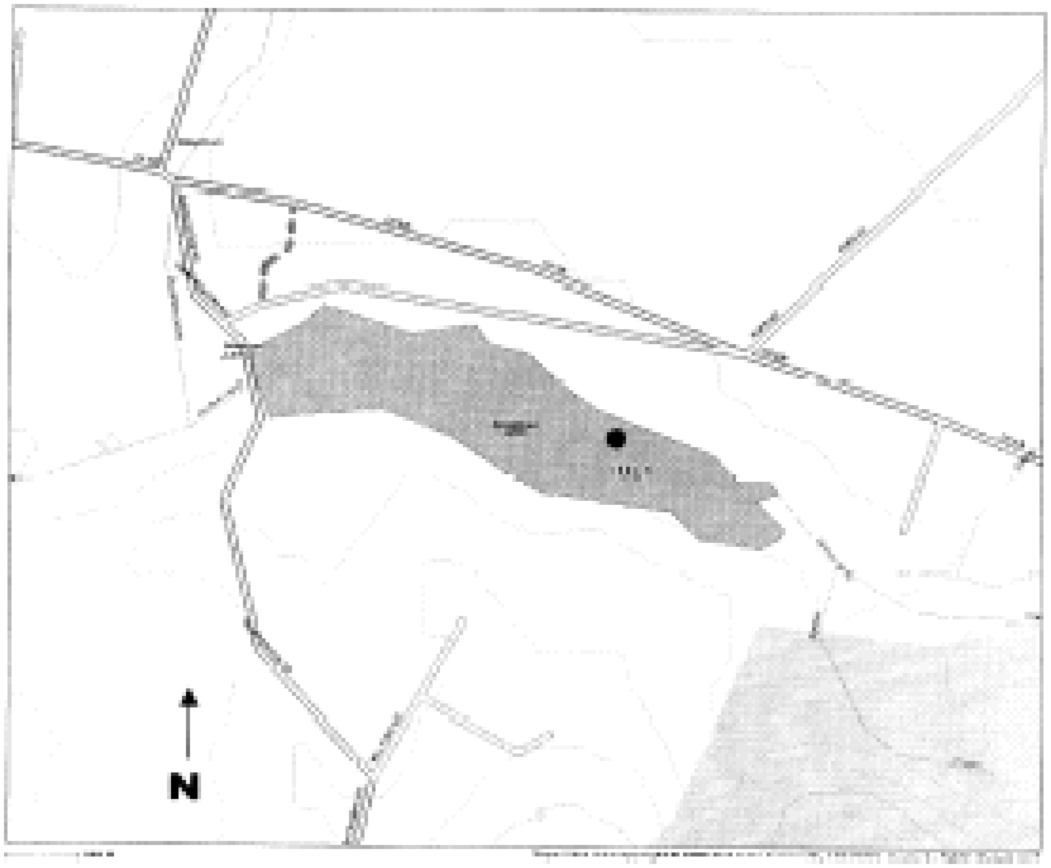
Parvin Lake



Marsh core near Tuckerton, NJ

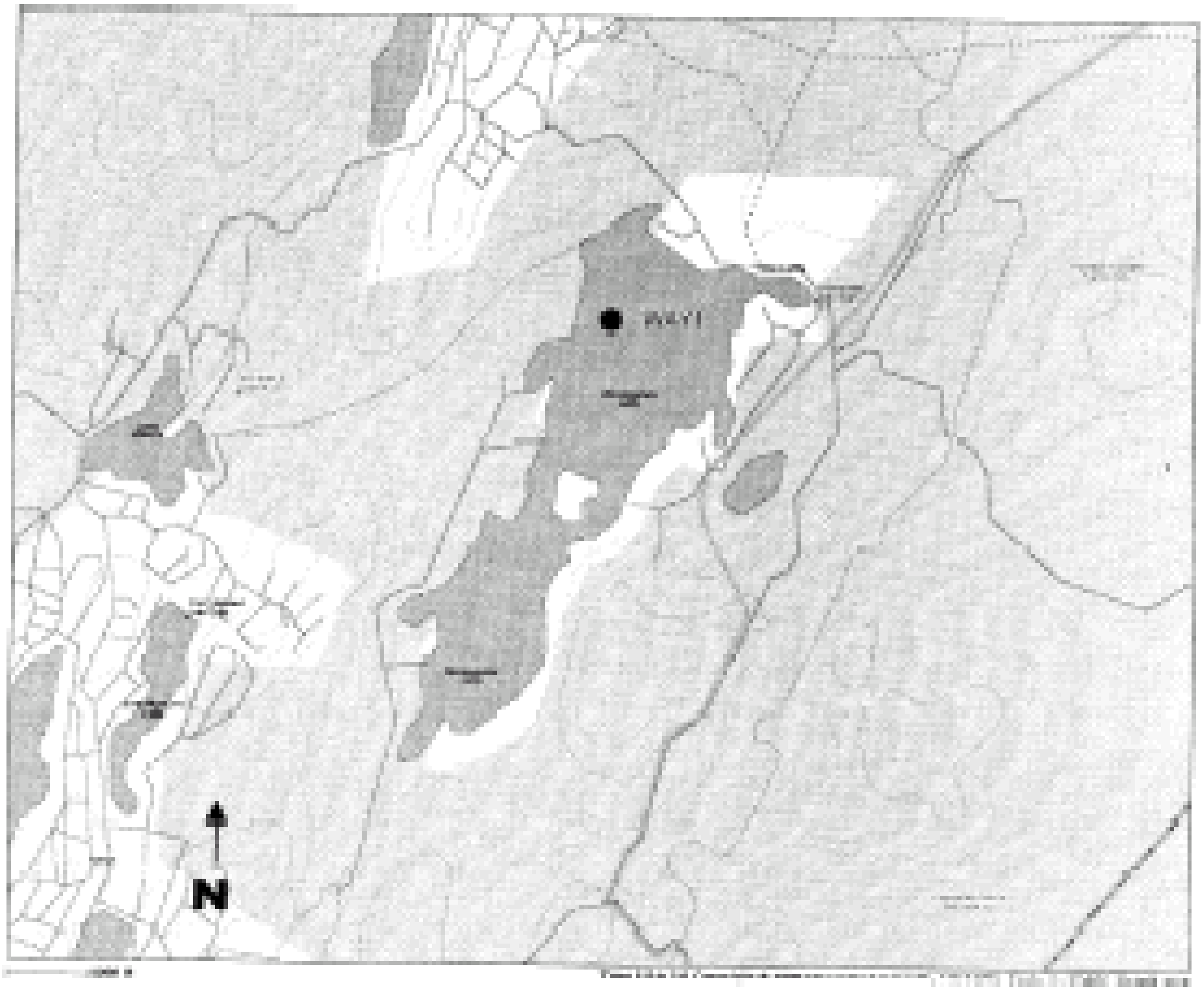


Lake Absegami



Imlaystown Lake

Mountain Lake



Wawayanda Lake

Woodcliff Lake

APPENDIX II. QA/QC Data

Gamma Counting Duplicates

RPI ID	Core	Depth		Julian Count Date	Cs-137 (pCi/kg)	1s	Total Pb-210 (dpm/g)	1s
R1342P	WOOD D	30-32		2000332	1084	98	5.7	1.0
R1342P	WOOD D	30-32	dup	2001122	1161	96	7.7	0.9
R1340C	MTN2	4-6		2000336	1882	135	15.3	1.3
R1340C	MTN2	4-6	dup	2001120	1854	112	14.8	1.0
R1340D	MTN2	6-8		2000333	2160	137	12.2	1.0
R1340D	MTN2	6-8	dup	2001084	2290	137	12.1	0.9
R1345F	IML1	10-12		2001068	1038	105	6.6	1.0
R1345F	IML1	10-12	dup	2001113	1222	87	7.7	0.8
R1343B	ABS1	2-4		2000326	453	71	19.5	1.5
R1343B	ABS1	2-4	dup	2001120	362	75	19.0	1.5
R1346H	PAR1	14-16		2001006	1049	126	18.3	1.8
R1346H	PAR1	14-16	dup	2001122	1081	95	16.7	1.3
R1346K	PAR1	20-22		2001009	1680	121	16.9	1.3
R1346K	PAR1	20-22	dup	2001085	1595	113	16.1	1.2

Gamma Counting D Standards

Standard	Count date	Cs-137 (pCi/kg)	1σ	Pb-210 (dpm/g)	1σ
D std	2000137	933071	46786	2380	120
D std	2000207	942637	47334	2295	117
D std	2000261	943408	47224	2299	115
D std	2000301	941301	47309	2377	121
D std	2000314	941998	47303	2328	118
D std	2000355	946557	47577	2326	119
D std	2000356	906577	45546	2063	105
D std	2000357	942504	47366	2341	119
D std	2001002	946816	47496	2301	117
D std	2001002	990096	49733	2320	118
D std	2001005	914856	45992	2105	107
D std	2001005	937672	47163	2365	121
D std	2001018	978399	49159	2241	114
D std	2001025	937867	47066	2243	114
D std	2001054	938013	47086	2288	116
D std	2001054	987281	49496	2279	115
D std	2001058	1149644	57740	2721	138
D std	2001058	1171091	58820	2708	138
D std	2001063	951799	47880	2290	117
D std	2001085	955233	48008	2382	121
D std	2001096	935700	46907	2329	118
D std	2001110	953794	47781	2311	116
D std	2001120	938368	47135	2238	114
D std	2001123	1002780	50477	2276	117
D std	2001128	940513	47287	2265	116
D std	2001128	949995	47698	2144	109
D std	2001128	941485	47191	2295	116
D std	2001138	937167	47182	2243	115
D std	2001138	956515	48524	2306	122
D std	2001145	961591	48291	2345	119
D std	2001150	969906	48828	2200	113
D std	2001151	946831	47510	2341	119
D std	2001155	949591	47682	2287	116
D std	2001155	954712	48015	2326	119
D std	2001184	988262	49654	2339	119
D std	2001184	933782	46923	2211	113
D std	2001213	936528	47061	2246	114
D std	2001247	936139	46977	2265	115
D std	2001247	963150	48332	2170	110
D std	2001292	913344	45876	2071	106
D std	2001292	922686	46428	2176	112
D std	2001316	950652	47788	2210	113
D std	2001357	965769	48535	2341	119
	Average	958281	48143	2293	117
	Accepted Values	956000	96000	2235	224

Gamma Counting G Standards

Standard	Count date	Cs-137 (pCi/kg)	1σ	Pb-210 (dpm/g)	1σ
G std	2000143	565	56	24.9	1.5
G std	2000261	531	46	23.7	1.3
G std	2000310	490	42	24.2	1.3
G std	2000357	570	57	23.6	1.5
G std	2000361	606	44	24.0	1.3
G std	2000364	484	53	23.7	1.4
G std	2001062	497	54	23.4	1.4
G std	2001064	545	66	22.9	1.5
G std	2001098	514	42	23.5	1.3
G std	2001127	497	38	23.7	1.3
G std	2001129	585	55	24.0	1.4
G std	2001148	523	44	22.5	1.3
G std	2001186	537	43	23.3	1.3
G std	2001201	548	45	23.4	1.3
G std	2001317	565	63	23.3	1.5
	Average	537	50	23.6	1.4
	Accepted Values	509	51	23.9	2.4

Gamma Counting LGP Standards

Standard	Count date	Cs-137 (pCi/kg)	1σ	Pb-210 (dpm/g)	1σ
LGP std	2000227	8514	455	40.2	2.4
LGP std	2000359	8719	455	44.7	2.5
LGP std	2001005	8248	438	41.3	2.3
LGP std	2001063	8685	472	41.8	2.5
LGP std	2001116	8472	450	40.7	2.3
LGP std	2001124	8405	445	39.4	2.2
LGP std	2001149	8211	431	40.0	2.2
LGP std	2001231	8211	422	38.8	2.1
	Average	8433	446	40.9	2.3
	Accepted Values	8400	840	41.2	2.1

Gamma Counting NBS 4350B Standards

Standard	Count date	Cs-137 (pCi/kg)	1σ
NBS 4350B	2000122	771	66
NBS 4350B	2000362	762	67
NBS 4350B	2000363	693	70
NBS 4350B	2001065	800	69
NBS 4350B	2001128	834	70
NBS 4350B	2001135	757	75
NBS 4350B	2001161	816	55
NBS 4350B	2001223	837	65
	Average	784	67
	Accepted Values	784	50

Gamma Counting Duplicates

RPI ID	Core	Depth		Julian Count Date	Cs-137 (pCi/kg)	1s	Total Pb-210 (dpm/g)	1s
R1342P	WOOD D	30-32		2000332	1084	98	5.7	1.0
R1342P	WOOD D	30-32	dup	2001122	1161	96	7.7	0.9
R1340C	MTN2	4-6		2000336	1882	135	15.3	1.3
R1340C	MTN2	4-6	dup	2001120	1854	112	14.8	1.0
R1340D	MTN2	6-8		2000333	2160	137	12.2	1.0
R1340D	MTN2	6-8	dup	2001084	2290	137	12.1	0.9
R1345F	IML1	10-12		2001068	1038	105	6.6	1.0
R1345F	IML1	10-12	dup	2001113	1222	87	7.7	0.8
R1343B	ABS1	2-4		2000326	453	71	19.5	1.5
R1343B	ABS1	2-4	dup	2001120	362	75	19.0	1.5
R1346H	PAR1	14-16		2001006	1049	126	18.3	1.8
R1346H	PAR1	14-16	dup	2001122	1081	95	16.7	1.3
R1346K	PAR1	20-22		2001009	1680	121	16.9	1.3
R1346K	PAR1	20-22	dup	2001085	1595	113	16.1	1.2

Duplicates for Total Hg Analysis

RPI ID	Core	Depth (cm)	Analysis1 Hg (ppb)	Analysis2 Hg (ppb)	Analysis 3 Hg (ppb)	Analysis4 Hg (ppb)	Average (ppm)	%RPD
CN1559I	WOODB	10-12	1754	1825			1790	4.0
R1342J	WOODD	18-20	345	326			336	5.7
R1342L	WOODD	22-24	330	332			331	0.6
R1377A	WAY1	0-2	426	390			408	8.8
R1377E	WAY1	8-10	156	156			156	0.0
R1340E	MTN2	8-10	204	200			202	2.0
R1340F	MTN2	10-12	202	194			198	4.0
R1340G	MTN2	12-14	135	156			146	14.4
R1345H	IML1	14-16	140	152			146	8.2
R1345I	IML1	16-18	154	159			157	3.2
R1345T	IML1	38-40	57.0	58.0			57.5	1.7
R1371A	TUCK2	0.0 - 1.2	328	406	336		357	21.3
R1371D	TUCK2	3.6 - 4.8	263	253			258	3.9
R1371N	TUCK2	15.6 - 16.8	348	284	301	306	310	20.3
R1371W	TUCK2	26.4 - 27.6	114	172			143	40.6
R1371AA	TUCK2	31.2 - 32.4	215	210			213	2.4
R1371FF	TUCK2	37.2 - 38.4	207	214			211	3.3
R1388	PARVS	0-10	26.6	28.4			27.5	6.5
R1388H	PARVS	10-12	13.8	13.5			13.7	2.2

values in shaded boxes are blind duplicates submitted to Brooks-Rand,
others are Brooks-Rand Ltd. Internal laboratory duplicates

APPENDIX III. Radionuclide Data and Plots

APPENDIX III (A) Data Tables

Woodcliff Lake (Site 1)

WOODB (CN1559); *RPI Archived Core*

Collected 8/21/80 (1980234)

RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ	xs Pb-210 (dpm/g) decay corrected to 1980	1σ
CN1559A	0-1	11.20	1225	158			2.73	1.30	-0.43	1.34	-0.80	2.49
CN1559C	2-3	11.36	1112	109			4.88	0.83	2.19	0.86	4.09	1.59
CN1559D	3-4	12.73	1329	145			5.52	0.97	2.85	1.01	5.31	1.87
CN1559E	4-5	10.98	1224	105			5.79	0.72	3.33	0.74	6.20	1.38
CN1559F	5-6	11.13	1424	129			6.32	0.84	3.54	0.87	6.59	1.61
CN1559G	6-8	19.67	1061	148			6.05	1.12	2.89	1.16	5.39	2.16
CN1559H	8-10	21.49	1526	163			9.39	1.17	6.75	1.20	12.56	2.23
CN1559I	10-12	22.22	1507	181			6.05	1.21	2.89	1.26	5.39	2.34
CN1559J	12-14	20.80	2343	164			7.75	0.84	4.61	0.86	8.58	1.60
CN1559K	14-16	17.22	3686	253			6.43	1.04	3.55	1.07	6.60	1.99
CN1559L	16-18	15.59	2636	181			5.80	0.82	2.32	0.85	4.32	1.59
CN1559M	18-20	12.99	1023	204			6.61	2.38	4.05	1.72	7.54	3.21
CN1559N	20-22	12.07	332	144			0.23	1.66	-2.41	2.40	-4.48	4.48
CN1559O	22-24	12.19	106	106			7.21	1.06	4.76	1.09	8.87	2.03
CN1559P	24-26	43.71	44	48			1.11	0.50	-0.38	0.51	-0.70	0.96
CN1559Q	26-28	50.92	78	61			3.10	0.78	1.67	0.80	3.11	1.49
CN1559R	28-30	73.35	34	38			-0.35	0.89	-1.54	0.89	-2.87	1.67
CN1559S	30-32	62.38	-77	62			1.27	0.76	-0.03	0.78	-0.05	1.45

WOODB is an archived sediment core and is too old for Be-7 counts

Woodcliff Lake (Site 1)

WOODD (R1342)

Collected 10/13/00 (2000287)

RPI ID	***Depth Interval (cm)***	***Section Mass (g)***	***Cs-137 (pCi/kg)***	***1σ***	***Be-7 (pCi/kg)***	***1σ***	***Total Pb-210 (dpm/g)***	***1σ***	***Xs Pb-210 (dpm/g)***	***1σ***	***Cs-137 (pCi/kg) decay corrected to 1980***	***1σ***
R1342A	0-2	14.88	343	36	885	226	12.55	0.82	10.65	0.83	545	57
R1342B	2-4	12.34	467	43	-437	218	15.47	0.98	13.50	0.99	742	68
R1342C	4-6	14.03	309	70			14.84	1.36	11.84	1.38	491	111
R1342D	6-8	15.44	568	75			14.92	1.30	12.08	1.32	902	119
R1342E	8-10	15.86	474	47			12.93	0.90	10.01	0.92	754	75
R1342F	10-12	19.69	462	52			10.44	0.88	7.67	0.89	735	83
R1342G	12-14	22.56	526	46			8.33	0.68	5.44	0.70	836	73
R1342H	14-16	25.72	513	68			6.79	0.93	4.35	0.96	815	107
R1342I	16-18	23.77	774	58			8.43	0.70	5.42	0.72	1230	93
R1342J	18-20	22.98	846	67			9.18	0.81	5.96	0.83	1344	107
R1342K	20-22	25.27	855	58			6.73	0.58	3.68	0.60	1359	92
R1342L	22-24	26.09	923	62			7.66	0.63	4.61	0.65	1467	98
R1342M	24-26	23.96	939	75			6.87	0.91	3.77	0.93	1493	119
R1342N	26-28	25.04	956	66			7.45	0.67	4.05	0.69	1519	105
R1342O	28-30	24.01	868	60			7.62	0.65	4.23	0.67	1379	95
R1342P	30-32	21.49	1084	98			5.67	0.98	2.50	1.01	1723	156
R1342P	dup30-32		1161	96			7.73	0.94	4.29	0.97		

Wawayanda Lake (Site 2)

WAY1 (R1377)

Collected 7/9/01 (2001190)

RPI ID	**Depth Interval (cm)**	**Section Mass (g)**	**Cs-137 (pCi/kg)**	**1σ**	**Be-7 (pCi/kg)**	**1σ**	**Total Pb-210 (dpm/g)**	**1σ**	**Xs Pb-210 (dpm/g)**	**1σ**
R1377A	0-2	1.66	2600	180	875	804	73.28	4.15	70.32	4.16
R1377B	2-4	2.22	5151	298	781	732	25.04	1.78	20.93	1.80
R1377C	4-6	2.07	1027	133			27.58	2.32	25.43	2.34
R1377D	6-8	4.45	233	84			12.13	1.55	9.68	1.59
R1377E	8-10	6.39	317	96			4.00	1.29	1.44	1.33
R1377F	10-12	5.39	113	80			4.95	1.28	2.62	1.32
R1377G	12-14	4.95	259	95			3.47	1.29	1.54	1.33
R1377H	14-16	5.02	136	60			3.53	0.85	1.82	0.88
R1377I	16-18	5.04	193	100			3.37	1.38	1.15	1.43
R1377J	18-20	5.13	-45	89			3.11	1.34	1.18	1.38
R1377K	20-22	5.20	184	84			4.40	1.14	2.51	1.18
R1377L	22-24	5.43	10	83			2.91	1.38	1.91	1.42
R1377M	24-26	5.37	77	62			2.43	0.86	0.57	0.89
R1377N	26-28	5.56	-36	82			2.81	1.24	1.81	1.28
R1377O	28-30	5.15	-57	91			2.76	1.34	1.83	1.38
R1377P	30-32	5.22	-89	60			0.76	0.89	-0.54	0.92
R1377Q	32-33	2.65	-99	88			0.06	1.29	-0.93	1.34

Mountain Lake (Site 3)

MTN2 (R1340)

Collected 9/29/00 (2000273)

RPI ID	***Depth Interval (cm)***	***Section Mass (g)***	***Cs-137 (pCi/kg)***	***1σ***	***Be-7 (pCi/kg)***	***1σ***	***Total Pb-210 (dpm/g)***	***1σ***	***Xs Pb-210 (dpm/g)***	***1σ***
R1340A	0-2	2.04	879	90	984	516	30.34	1.98	27.14	1.99
R1340B	2-4	2.92	1026	102	-1322	499	24.44	1.79	20.90	1.81
R1340C	4-6	4.74	1882	135			15.33	1.28	11.41	1.31
R1340C	dup4-6		1854	112			14.84	1.01	11.11	1.02
R1340D	6-8	5.44	2160	137			12.18	1.03	8.49	1.05
R1340D	dup6-8		2290	137			12.05	0.94	7.84	0.96
R1340E	8-10	7.76	1435	121			9.62	1.16	5.17	1.20
R1340F	10-12	9.44	375	79			8.05	1.22	4.21	1.26
R1340G	12-14	10.74	176	39			7.23	0.69	3.24	0.72
R1340H	14-16	8.60	114	44			6.35	0.77	2.54	0.80
R1340I	16-18	7.34	83	40			4.02	0.64	-0.05	0.67
R1340J	18-20	5.34	121	68			4.19	1.03	0.05	1.07
R1340K	20-22	5.26	38	33			3.49	0.54	0.52	0.57
R1340L	22-24	5.29	97	40			4.69	0.66	0.85	0.70
R1340M	24-26	5.24	124	58			4.93	0.95	1.43	0.98
R1340N	26-28	6.08	99	48			4.41	0.82	1.19	0.85

Imlaystown Lake (Site 4)

IML1 (R1345)

Collected 11/17/00 (2000322)

RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ
R1345A	0-2	6.83	256	33	947	394	7.62	0.60	5.10	0.61
R1345B	2-4	14.72	261	28	326	325	5.63	0.47	2.64	0.48
R1345C	4-6	10.75	397	57			6.03	0.79	2.58	0.81
R1345D	6-8	11.63	649	63			8.56	0.84	3.10	0.88
R1345E	8-10	13.54	878	94			7.08	1.04	1.73	1.09
R1345F	10-12	11.68	1038	105			6.62	1.03	2.04	1.07
R1345F	dup10-12		1222	87			7.69	0.83	3.16	0.86
R1345G	12-14	18.01	445	51			4.47	0.65	0.43	0.68
R1345H	14-16	22.90	59	31			6.08	0.63	1.59	0.66
R1345I	16-18	22.18	-3	56			5.25	1.01	0.96	1.05
R1345J	18-20	21.21	-19	37			6.35	0.72	1.73	0.75
R1345K	20-22	15.58	95	66			7.89	1.21	2.78	1.26
R1345L	22-24	18.37	-1	37			4.63	0.69	0.58	0.72
R1345M	24-26	19.56	55	39			4.73	0.75	0.49	0.79
R1345N	26-28	18.82	41	34			6.78	0.73	1.46	0.76
R1345O	28-30	20.99	2	51			4.30	0.90	-1.31	0.94
R1345P	30-32	20.62	-27	29			5.23	0.64	0.04	0.67
R1435Q	32-34	22.41	-95	39			4.06	0.84	-0.97	0.87
R1345R	34-36	18.81	19	39			5.30	0.79	1.15	0.82
R1345S	36-38	18.79								
R1345T	38-40	19.91								
R1345U	40-42	20.51								
R1345V	42-44	26.19								
R1345W	44-46	32.16								
R1345X	46-48	34.86								
R1345Y	48-50	29.14								
R1345Z	50-52	19.25								
R1345AA	52-54	20.63								
R1345BB	54-56	18.57	55	36			5.93	0.68	0.55	0.72
R1345CC	56-58	13.96	6	49			5.59	0.98	0.86	1.02

Tuckerton Marsh (Site 5)

TUCK2 (R1371)

Collected 5/21/01 (2001141)

RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ
R1371A	0.0 - 1.2	43.96	84	34	956	521	9.62	0.86	8.69	0.87
R1371B	1.2 - 2.4	34.76	61	31	691	456	8.42	0.76	7.42	0.77
R1371C	2.4 - 3.6	31.80	109	35			7.64	0.73	6.71	0.74
R1371D	3.6 - 4.8	31.45	169	34			8.49	0.75	7.31	0.76
R1371E	4.8 - 6.0	43.25	190	52			8.32	0.96	7.44	0.98
R1371F	6.0 - 7.2	29.74	204	44			6.47	0.83	5.10	0.84
R1371G	7.2 - 8.4	30.96	297	61			8.18	0.99	6.88	1.01
R1371H	8.4 - 9.6	41.44	433	70			5.11	0.95	4.12	0.97
R1371I	9.6 - 10.8	41.32	491	59			4.21	0.77	2.90	0.79
R1371J	10.8 - 12.0	43.51	584	55			3.63	0.65	2.60	0.66
R1371K	12.0 - 13.2	41.52	596	63			4.71	0.74	3.82	0.76
R1371L	13.2 - 14.4	44.66	830	86			2.93	0.86	1.62	0.89
R1371M	14.4 - 15.6	29.26	729	73			4.55	0.84	3.55	0.85
R1371N	15.6 - 16.8	24.09	1607	115			6.29	0.86	5.38	0.87
R1371O	16.8 - 18.0	20.38	2353	161			4.27	0.96	3.49	0.98
R1371P	18.0 - 19.2	16.72	2762	164			2.13	0.64	1.47	0.66
R1371Q	19.2 - 20.4	20.62	1765	132			1.54	0.84	0.62	0.86
R1371R	20.4 - 21.6	37.28	1359	114			1.71	0.78	1.07	0.80
R1371S	21.6 - 22.8	27.36	1433	116			2.11	0.83	1.18	0.85
R1371T	22.8 - 24.0	35.81	1322	101			2.48	0.77	1.52	0.78
R1371U	24.0 - 25.2	31.15	1177	95			4.43	0.78	3.54	0.80
R1371V	25.2 - 26.4	41.80	565	66			3.32	0.81	2.39	0.82
R1371W	26.4 - 27.6	41.62	271	40			1.87	0.55	0.38	0.56
R1371X	27.6 - 28.8	52.50	115	42			2.03	0.75	1.10	0.76
R1371Y	28.8 - 30.0	31.68	126	37			2.87	0.58	1.94	0.59
R1371Z	30.0 - 31.2	35.80	23	47			2.09	0.80	1.08	0.82
R1371AA	31.2 - 32.4	42.11	-13	41			2.72	0.75	1.80	0.77
R1371BB	32.4 - 33.6	33.83	62	38			2.91	0.74	2.07	0.76
R1371CC	33.6 - 34.8	49.28	-4	37			1.56	0.69	0.37	0.71
R1371DD	34.8 - 36.0	50.05								
R1371EE	36.0 - 37.2	50.10								
R1371FF	37.2 - 38.4	42.20								
R1371GG	38.4 - 39.6	29.04								
R1371HH	39.6 - 40.8	34.80								
R1371II	40.8 - 42.0	26.35								
R1371JJ	42.0 - 43.2	37.86								

Absegami Lake (Site 5)

ABS1 (R1343)

Collected 10/24/00 (2000298)

RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ
R1343A	0-2	2.58	489	77	241	543	18.40	1.47	8.57	1.53
R1343B	2-4	3.46	453	71	498	563	19.54	1.54	6.25	1.62
R1343B	dup2-4		362	75			19.01	1.53	1.81	1.65
R1343C	4-6	3.75	312	96			24.74	2.11	5.35	2.24
R1343D	6-8	4.12	87	73			21.78	1.78	-2.73	1.98
R1343E	8-10	4.09	109	52			25.15	1.63	-0.26	1.82
R1343F	10-12	4.15	81	93			31.06	2.50	-3.41	2.78
R1343G	12-14	4.40	95	77			32.30	2.37	1.46	2.59
R1343H	14-16	4.19	134	61			29.39	1.99	0.56	2.20
R1343I	16-18	7.00	59	47			31.76	1.92	-0.64	2.17
R1343J	18-20	10.61	6	55			34.77	2.15	-1.12	2.42
R1343K	20-22	13.95	3	57			22.01	1.67	-1.48	1.85
R1343L	22-24	29.98	0	29			9.93	0.83	0.08	0.90

Parvin Lake (Site 6)

PAR1 (R1346)

Collected 11/17/00 (2000322)

RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ
R1346A	0-2	4.85	1016	78	1982	436	19.39	1.29	2.65	1.40
R1346B	2-4	4.22	832	93	368	574	19.87	2.40	2.43	2.48
R1346C	4-6	4.99	946	90			19.08	1.48	-1.59	1.63
R1346D	6-8	5.59	1015	126			14.64	1.81	-6.57	1.99
R1346E	8-10	5.90	1097	125			17.87	1.82	-2.83	1.99
R1346F	10-12	6.36	1073	88			17.25	1.28	-2.72	1.44
R1346G	12-14	6.12	1080	97			20.33	1.53	-0.37	1.68
R1346H	14-16	6.39	1049	126			18.31	1.82	-1.23	1.97
R1346H	dup14-16		1081	95			16.7	1.3	-3.26	1.50
R1346I	16-18	7.10	1458	130			15.35	1.51	-2.91	1.66
R1346J	18-20	7.37	1516	109			16.26	1.25	-1.29	1.38
R1346K	20-22	7.79	1680	121			16.87	1.31	0.39	1.44
R1346K	dup20-22		1595	113			16.1	1.2	0.061	1.35
R1346L	22-24	7.99	1562	114			14.50	1.21	-0.88	1.33
R1346M	24-26	8.38	1148	132			11.77	1.60	-2.78	1.73
R1346N	26-28	8.61	757	134			16.73	1.99	3.33	2.11
R1346O	28-30	9.04	523	87			11.90	1.28	1.22	1.37
R1346P	30-32	8.48	575	76			10.73	1.13	-0.36	1.22
R1346Q	32-34	8.69	471	109			11.31	1.66	1.16	1.75
R1346R	34-36	8.54	591	116			8.10	1.54	-0.70	1.63
R1346S	36-38	7.86	171	67			11.32	1.17	1.86	1.24
R1346T	38-40	7.13	144	74			7.31	1.15	-0.92	1.22
R1346U	40-42	7.05	17	56			6.04	0.98	-0.46	1.04
R1346V	42-44	8.54	16	49			5.17	0.87	0.14	0.92
R1346W	44-46	12.68	-11	34			4.78	0.62	1.06	0.65
R1346X	46-48	26.78	12	26			1.75	0.47	-1.02	0.49
R1346Y	48-50	38.82	54	21			2.06	0.39	0.49	0.40
R1346Z	50-52	52.53								
R1346AA	52-54	48.25								

Parvin Lake (Site 6)

PAR4 (R1383)

Collected 6/22/01 (2001173)

RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ
R1383A	0-2	6.59	936	81	48	694	18.78	1.34	2.76	1.45
R1383B	2-4	6.78	1293	104	766	794	16.68	1.33	1.43	1.44
R1383C	4-6	8.05	1167	119			13.23	1.54	-1.58	1.65
R1383D	6-8	8.62	816	106			10.94	1.46	-0.43	1.55
R1383E	8-10	9.91	772	52			12.35	0.78	0.75	0.87
R1383F	10-12	9.71	589	98			11.41	1.54	0.35	1.63
R1383G	12-14	10.85	380	59			8.58	0.91	0.75	0.97
R1383H	14-16	12.66	374	70			6.95	1.07	-0.94	1.14
R1383I	16-18	12.70	370	51			6.71	0.76	-1.15	0.82
R1383J	18-20	12.54	308	73			6.89	1.14	-0.48	1.20
R1383K	20-22	8.58	234	52			7.47	0.86	-0.27	0.92
R1383L	22-24	8.51	310	92			8.50	1.58	1.72	1.64
R1383M	24-26	9.32								
R1383N	26-28	8.66								
R1383O	28-30	45.40								

PARVS

Core	*RPI ID*	*Depth Interval (cm)*	*Section Mass (g)*	*Cs-137 (pCi/kg)*	*1s*	*Total Pb-210 (dpm/g)*	*1s*	*Xs Pb-210 (dpm/g)*	*1s*
PARVS	**R1388**	**0-10**	**286.14**	**125**	**19**	**2.49**	**0.41**	**2.05**	**0.41**
PARVS	R1388A	0-1	18.60	247	26	5.03	0.49		
PARVS	R1388B	1-2	21.72	179	27	4.13	0.50		
PARVS	R1388C	2-3	25.78	267	37	5.39	0.72		
PARVS	R1388D	3-4	24.29	192	62	6.90	1.55		
PARVS	R1388E	4-6	57.42	110	37	3.23	0.92		
PARVS	R1388F	6-8	67.64	109	22	1.05	0.49		
PARVS	R1388G	8-10	70.69	152	58	0.42	1.01		
PARVS	R1388H	10-12	77.73	8	32	0.97	0.91		

WAYS

Core	*RPI ID*	*Depth Interval (cm)*	*Section Mass (g)*	*Cs-137 (pCi/kg)*	*1σ*	*Total Pb-210 (dpm/g)*	*1σ*	*Xs Pb-210 (dpm/g)*	*1σ*
WAYS	**R1385**	**0-12**	**332.39**	**239**	**27**	**3.73**	**0.50**	**1.76**	**0.51**
WAYS	R1385A	0-1	20.65	285	35	5.27	0.61		
WAYS	R1385B	1-2	24.85	302	43	6.03	0.82		
WAYS	R1385C	2-3	23.77	274	33	4.29	0.61		
WAYS	R1385D	3-4	31.79	178	55	3.88	1.16		
WAYS	R1385E	4-6	51.10	188	47	4.44	1.01		
WAYS	R1385F	6-8	57.41						
WAYS	R1385G	8-10	60.85						
WAYS	R1385H	10-12	61.97	126	75	4.42	1.45		

ASSS

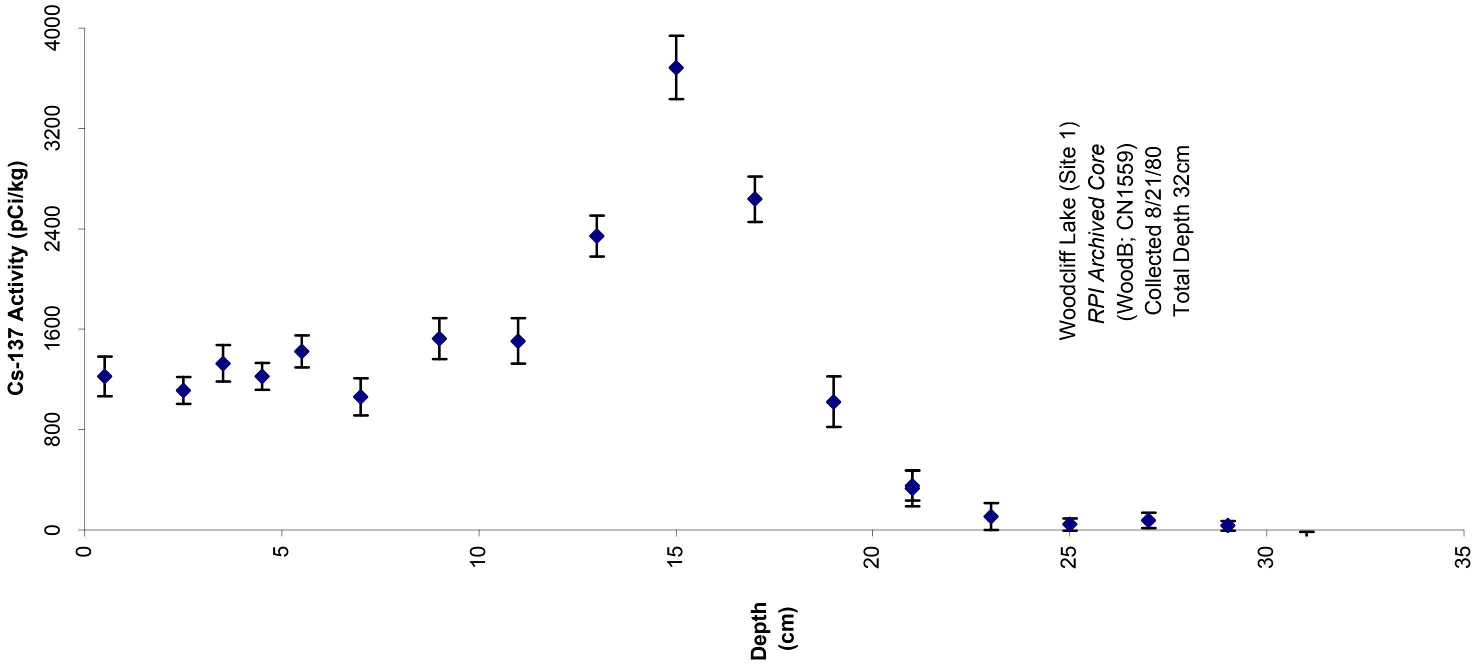
Core	RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ
ASSS	**R1386**	**0-12**	**315.24**	**327**	**26**	**4.23**	**0.45**	**3.33**	**0.46**
ASSS	R1386A	0-1	22.42	243	33	7.32	0.68		
ASSS	R1386B	1-2	16.62	226	34	7.62	0.81		
ASSS	R1386C	2-3	22.27	290	38	6.27	0.76		
ASSS	R1386D	3-4	22.75	116	63	6.91	1.35		
ASSS	R1386E	4-6	50.47	449	45	4.65	0.61		
ASSS	R1386F	6-8	60.23						
ASSS	R1386G	8-10	59.65						
ASSS	R1386H	10-12	60.83	291	66	1.51	1.10		

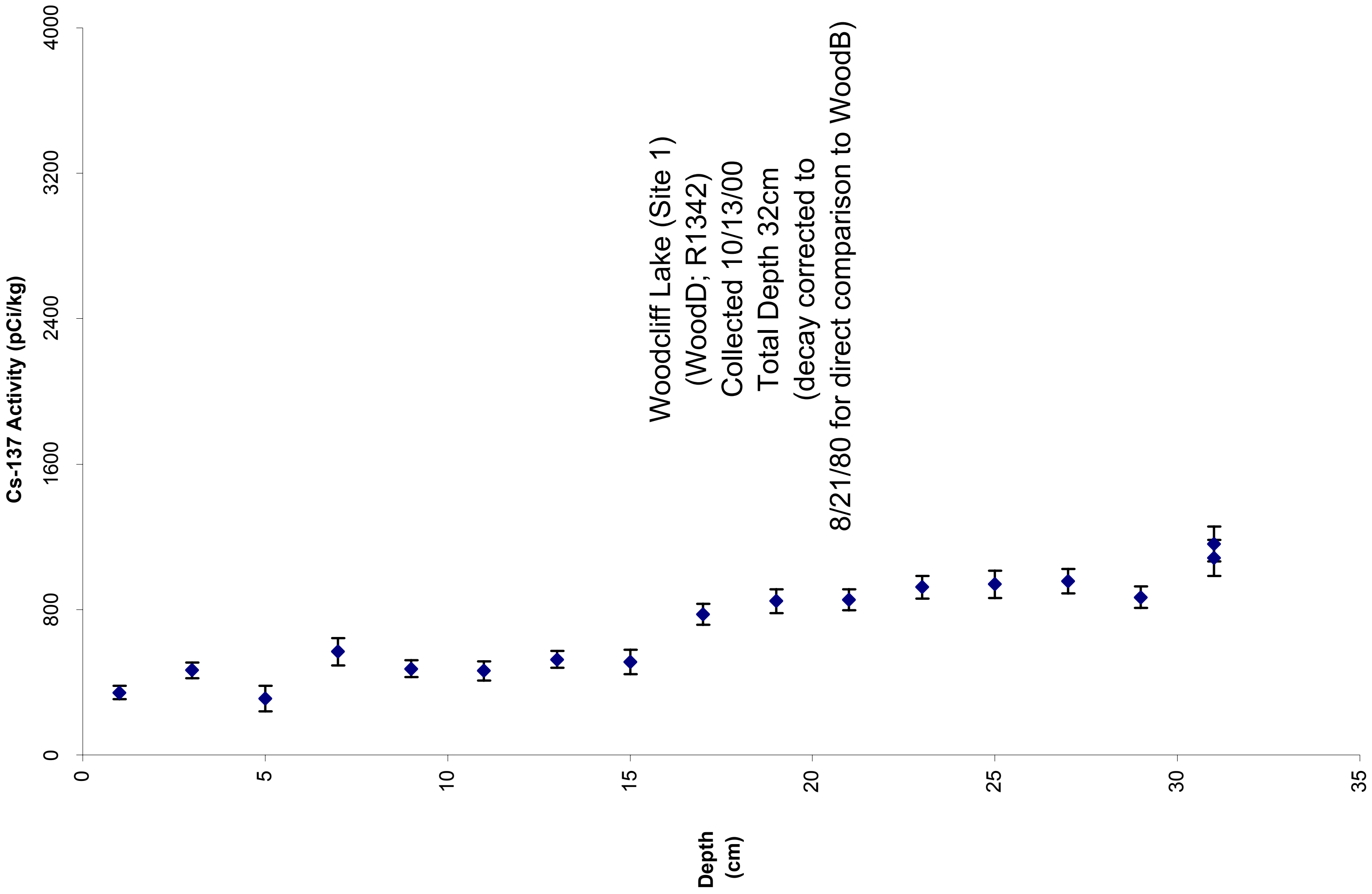
MTNS

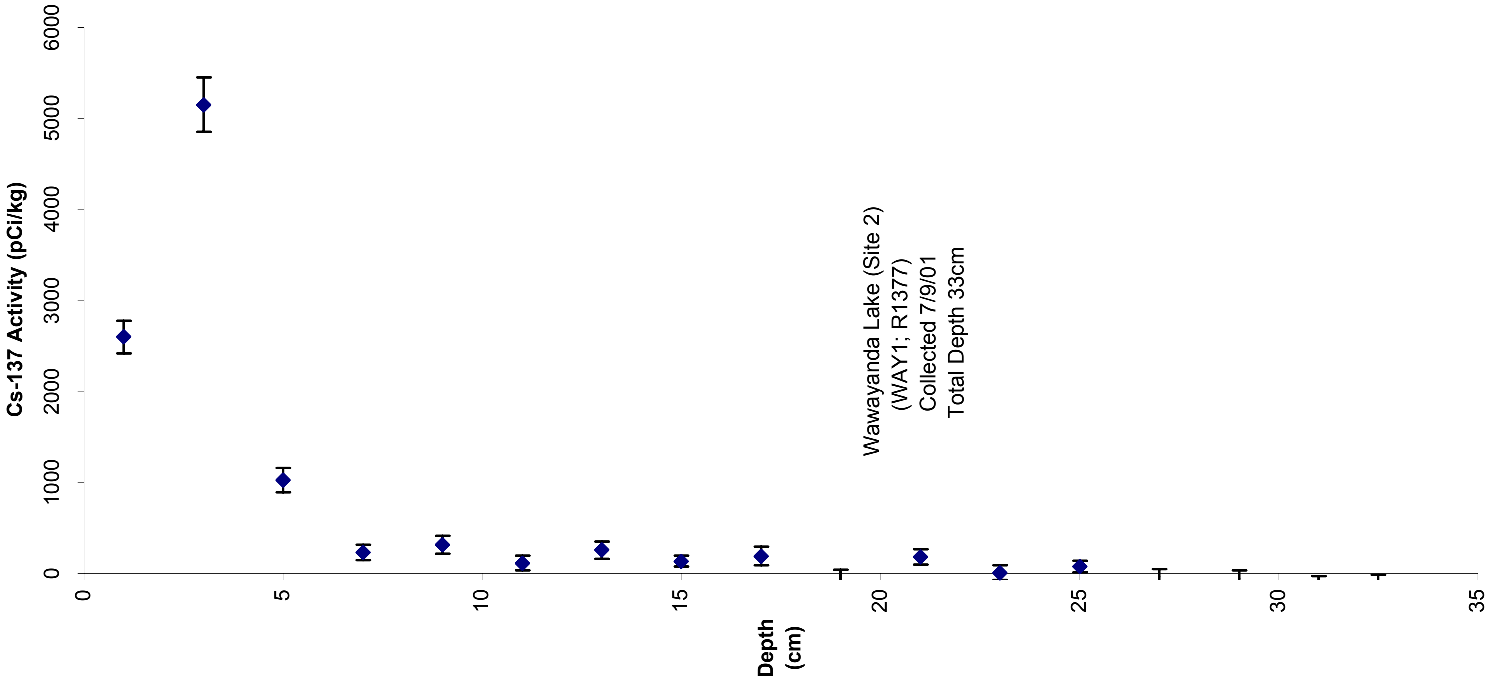
Core	RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ
MTNS	**R1387**	**0-12**	**316.59**	**347**	**32**	**4.60**	**0.52**	**2.46**	**0.53**
MTNS	R1387A	0-1	23.83	405	45	5.11	0.67		
MTNS	R1387B	1-2	20.03	409	56	5.49	1.07		
MTNS	R1387C	2-3	24.39	433	42	3.91	0.61		
MTNS	R1387D	3-4	25.49	368	67	6.74	1.18		
MTNS	R1387E	4-6	52.80	355	40	4.58	0.71		
MTNS	R1387F	6-8	53.07						
MTNS	R1387G	8-10	53.17						
MTNS	R1387H	10-12	63.81	217	34	3.22	0.64		

WOODS

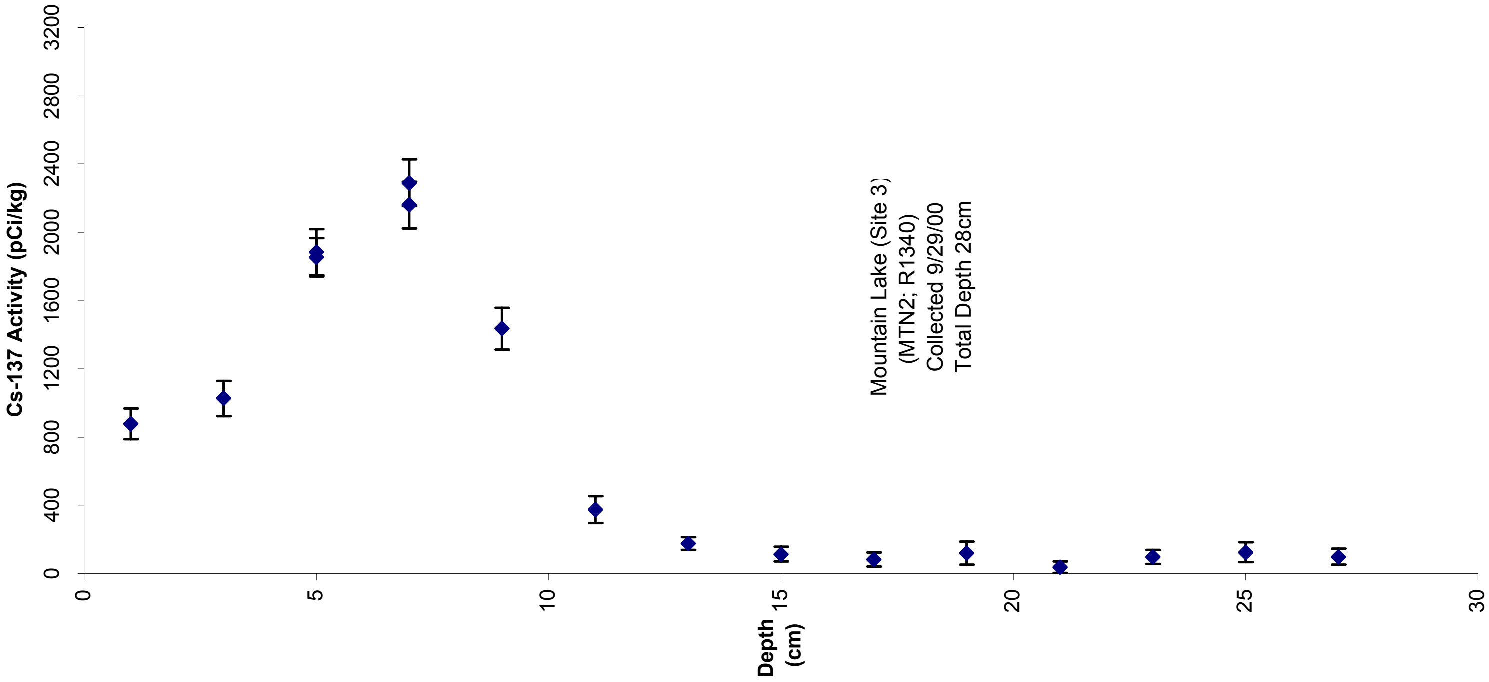
Core	RPI ID	Depth Interval (cm)	Section Mass (g)	Cs-137 (pCi/kg)	1σ	Total Pb-210 (dpm/g)	1σ	Xs Pb-210 (dpm/g)	1σ
WOODS	**R1389**	**0-10**	**223.92**	**766**	**50**	**5.50**	**0.56**	**3.93**	**0.57**
WOODS	R1389A	0-1	11.53	635	59	12.49	0.94		
WOODS	R1389B	1-2	15.71	838	79	8.98	1.02		
WOODS	R1389C	2-3	16.48	1009	72	8.03	0.76		
WOODS	R1389D	3-4	24.63	928	112	8.27	1.82		
WOODS	R1389E	4-6	45.25						
WOODS	R1389F	6-8	61.19						
WOODS	R1389G	8-10	49.13	424	57	4.19	1.04		

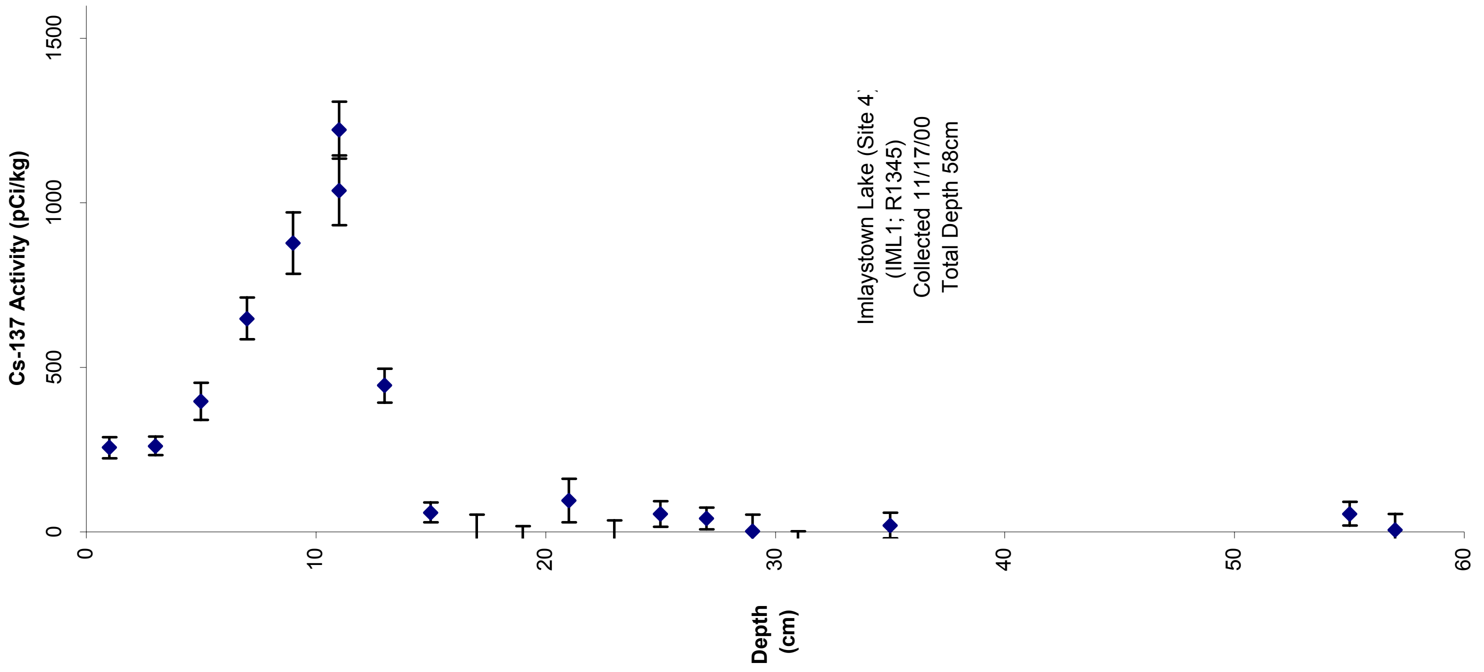

Cs-137 Activity (pCi/kg)
0
800
1600
2400
3200
4000
Depth (cm)
0
5
10
15
20
25
30
35
Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm

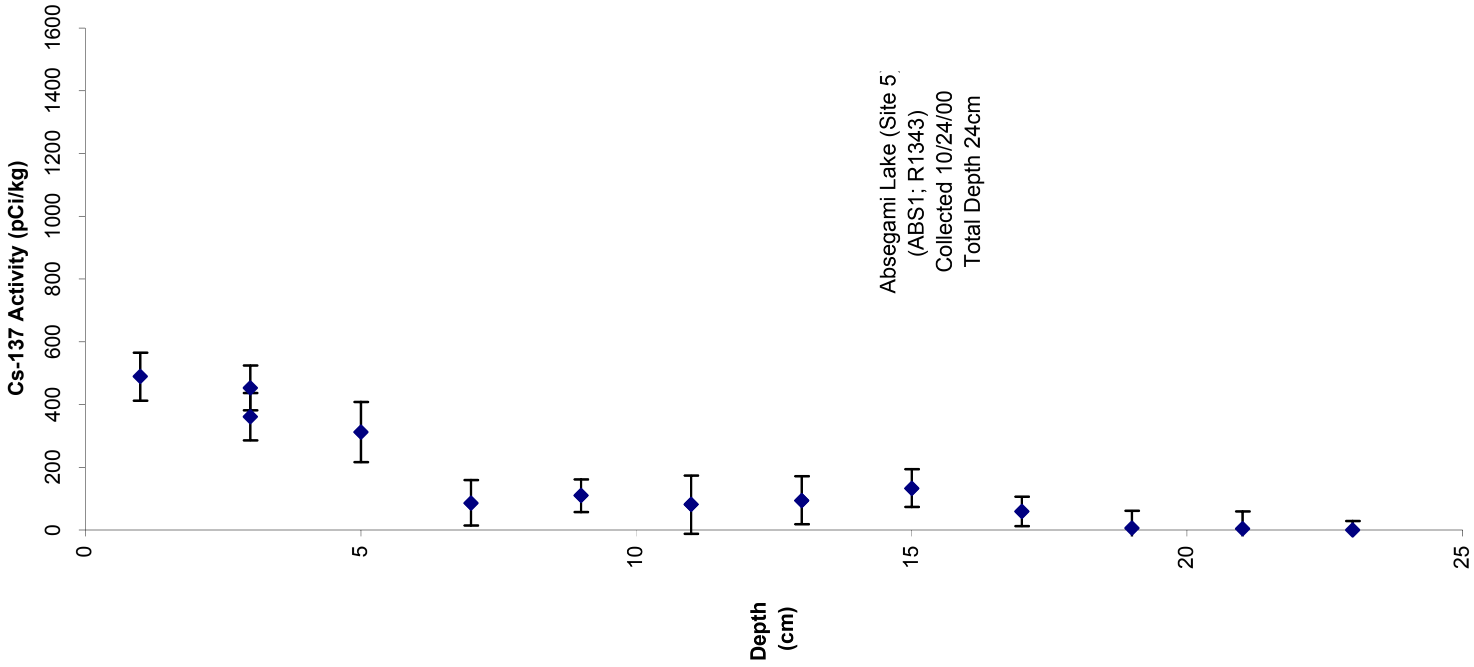

Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
(decay corrected to
8/21/80 for direct comparison to WoodB)
Cs-137 Activity (pCi/kg)
0
800
1600
2400
3200
4000
Depth
(cm)
0
5
10
15
20
25
30
35

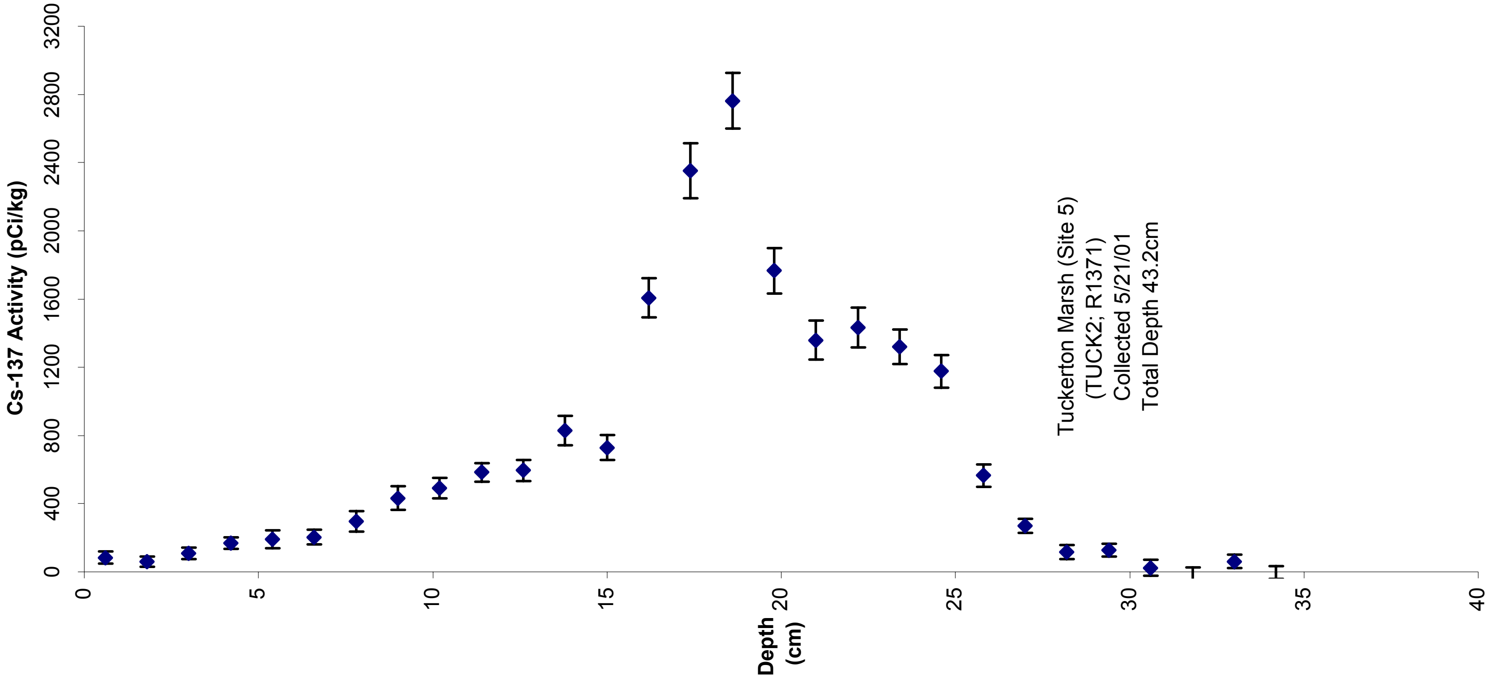


Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm

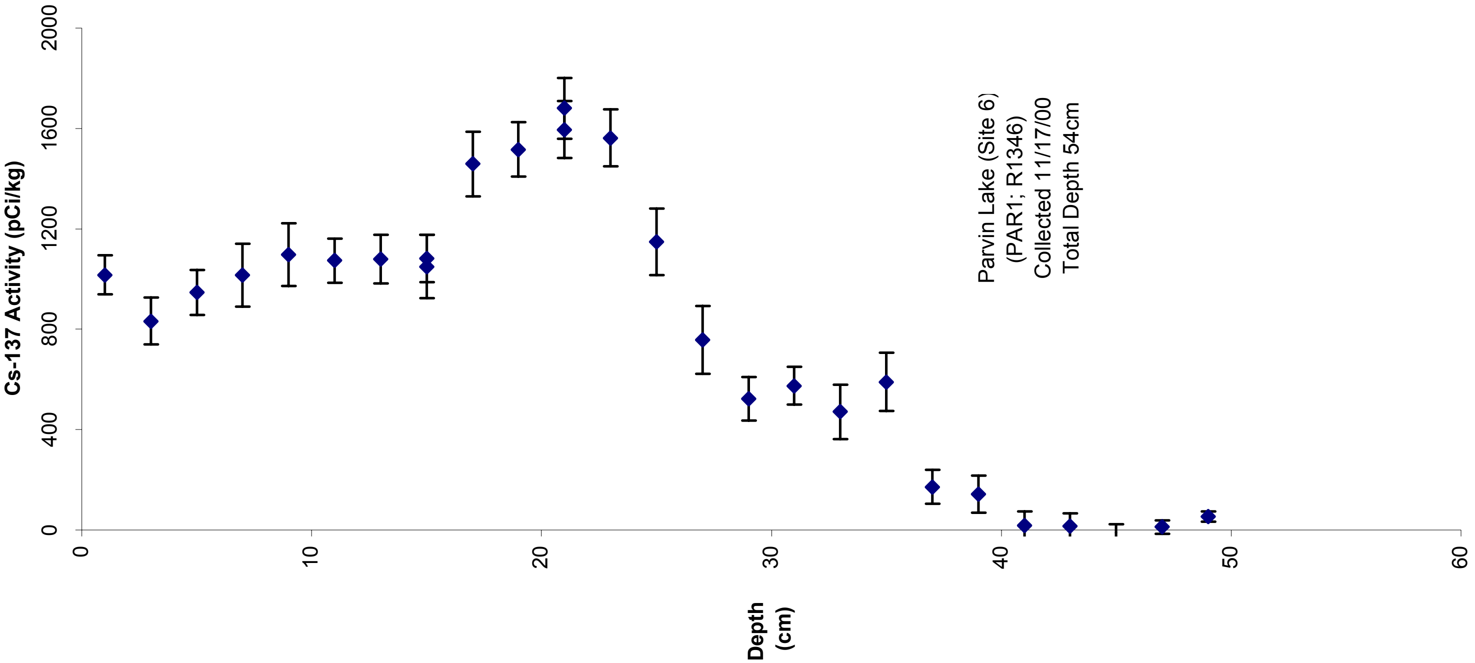

Cs-137 Activity (pCi/kg)
0
400
800
1200
1600
2000
2400
2800
3200
Depth (cm)
0
5
10
15
20
25
30
Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm

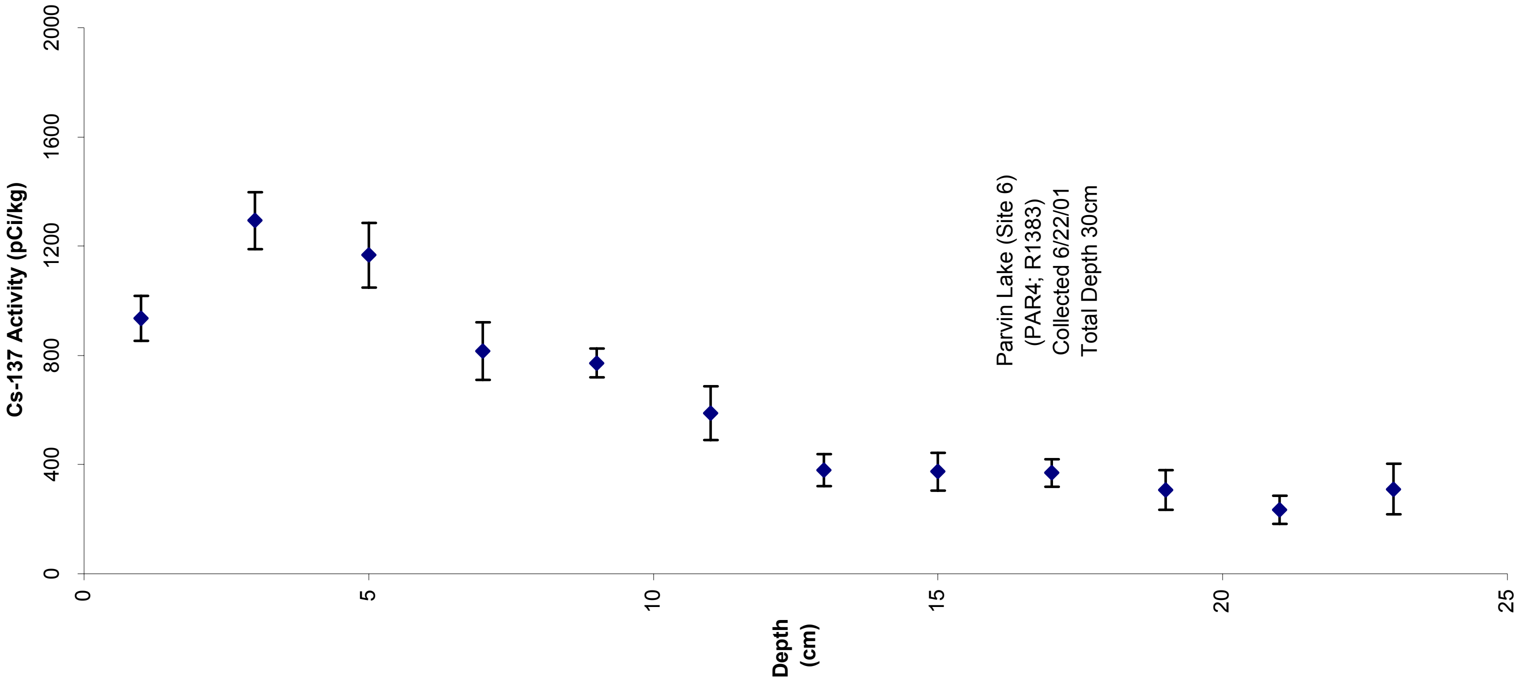

Imlaystown Lake (Site 4
(IML1; R1345)
Collected 11/17/00
Total Depth 58cm
Cs-137 Activity (pCi/kg)
0
500
1000
1500
Depth
(cm)
0
10
20
30
40
50
60


Cs-137 Activity (pCi/kg)
0
200
400
600
800
1000
1200
1400
1600
Depth
(cm)
0
5
10
15
20
25
Absegami Lake (Site 5
(ABS1; R1343)
Collected 10/24/00
Total Depth 24cm

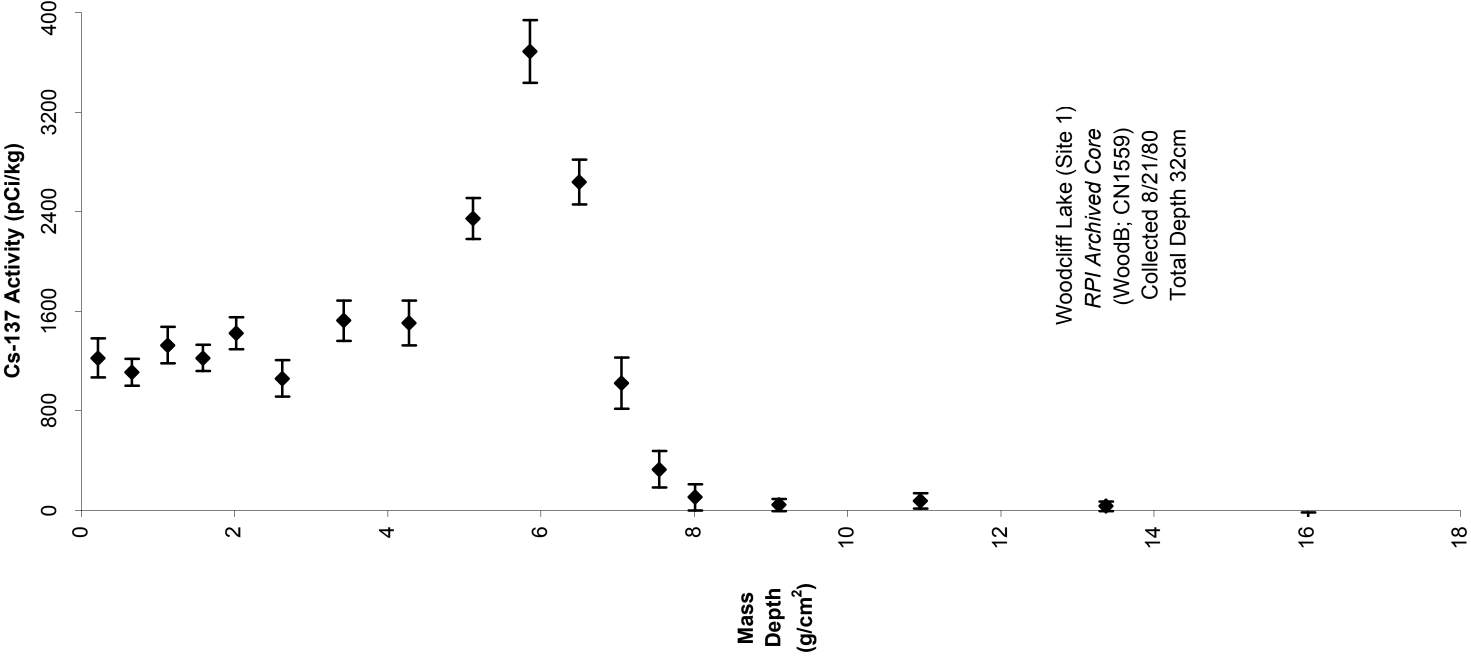


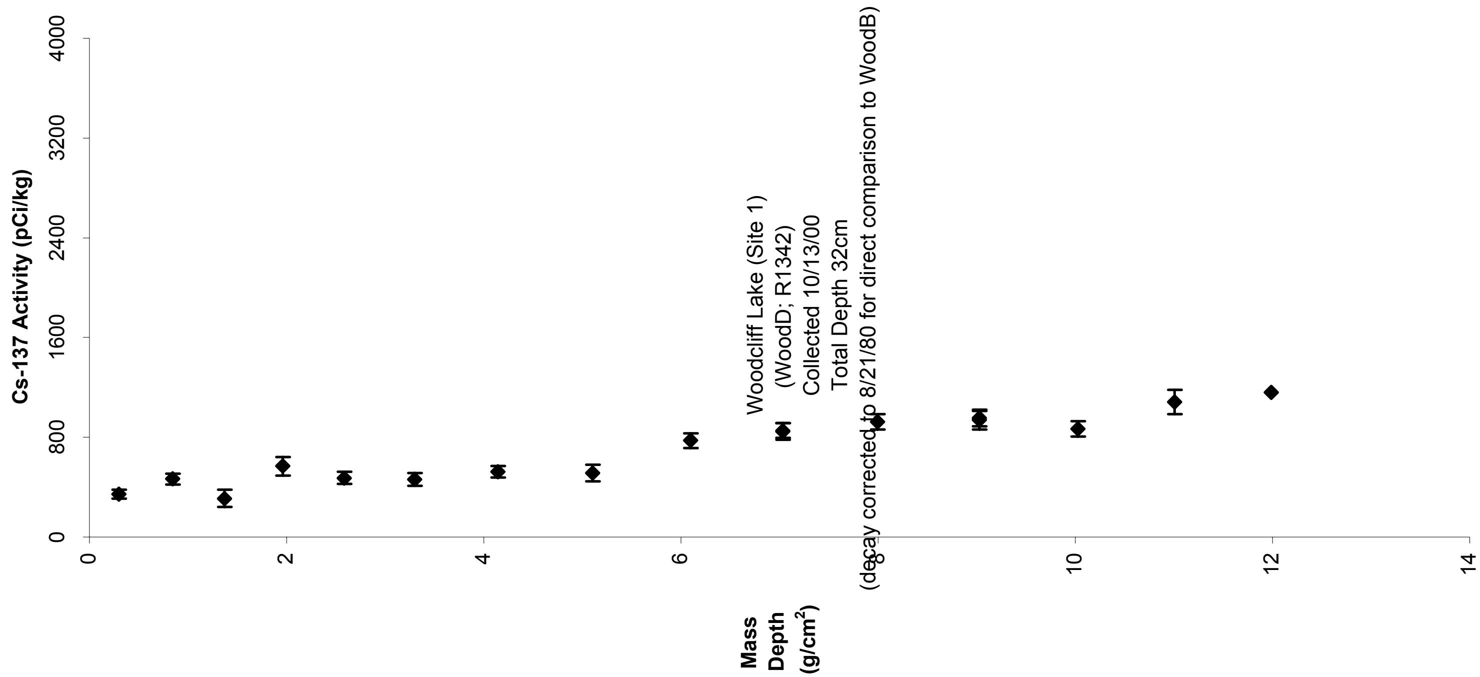
Tuckerton Marsh (Site 5)
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm

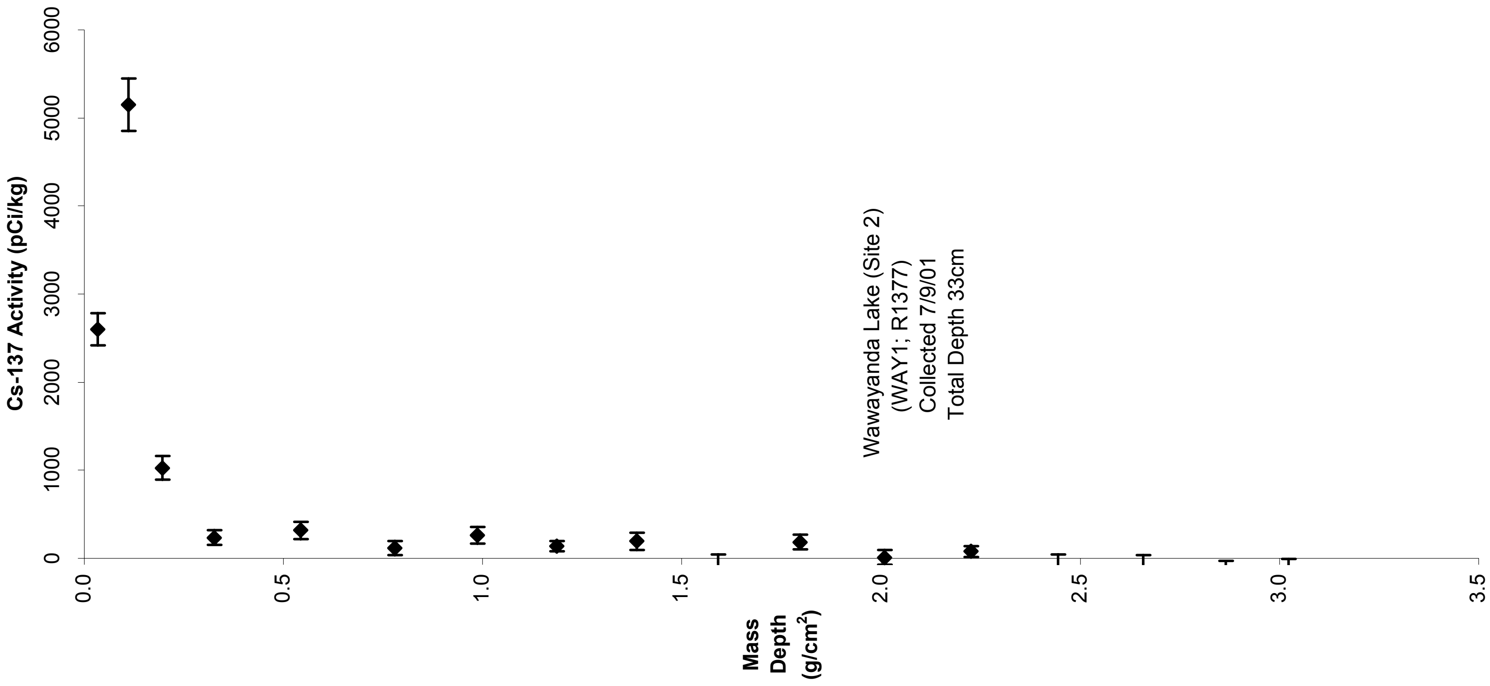

Cs-137 Activity (pCi/kg)
0
400
800
1200
1600
2000
Depth
(cm)
0
10
20
30
40
50
60
Parvin Lake (Site 6)
(PAR1; R1346)
Collected 11/17/00
Total Depth 54cm

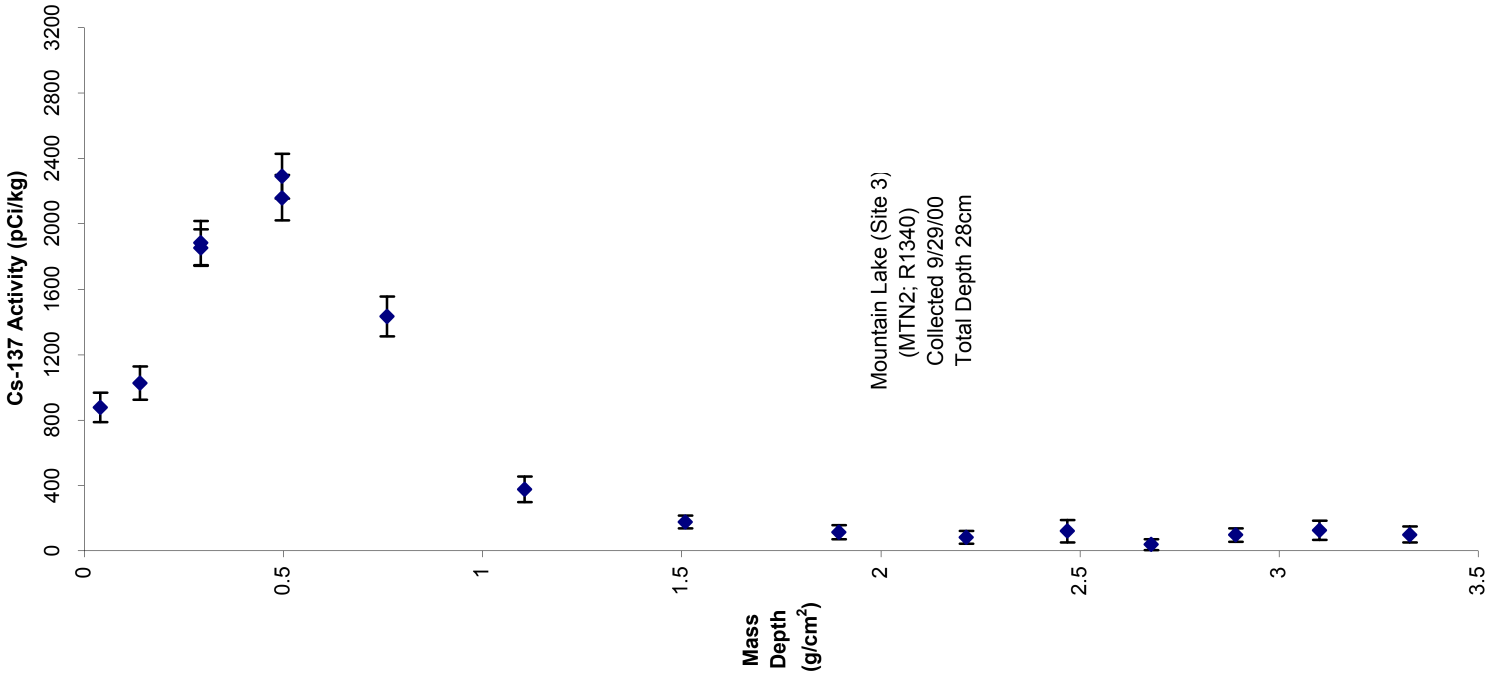

Cs-137 Activity (pCi/kg)
2000
1600
1200
800
400
0
Depth
(cm)
0
5
10
15
20
25
Parvin Lake (Site 6)
(PAR4; R1383)
Collected 6/22/01
Total Depth 30cm

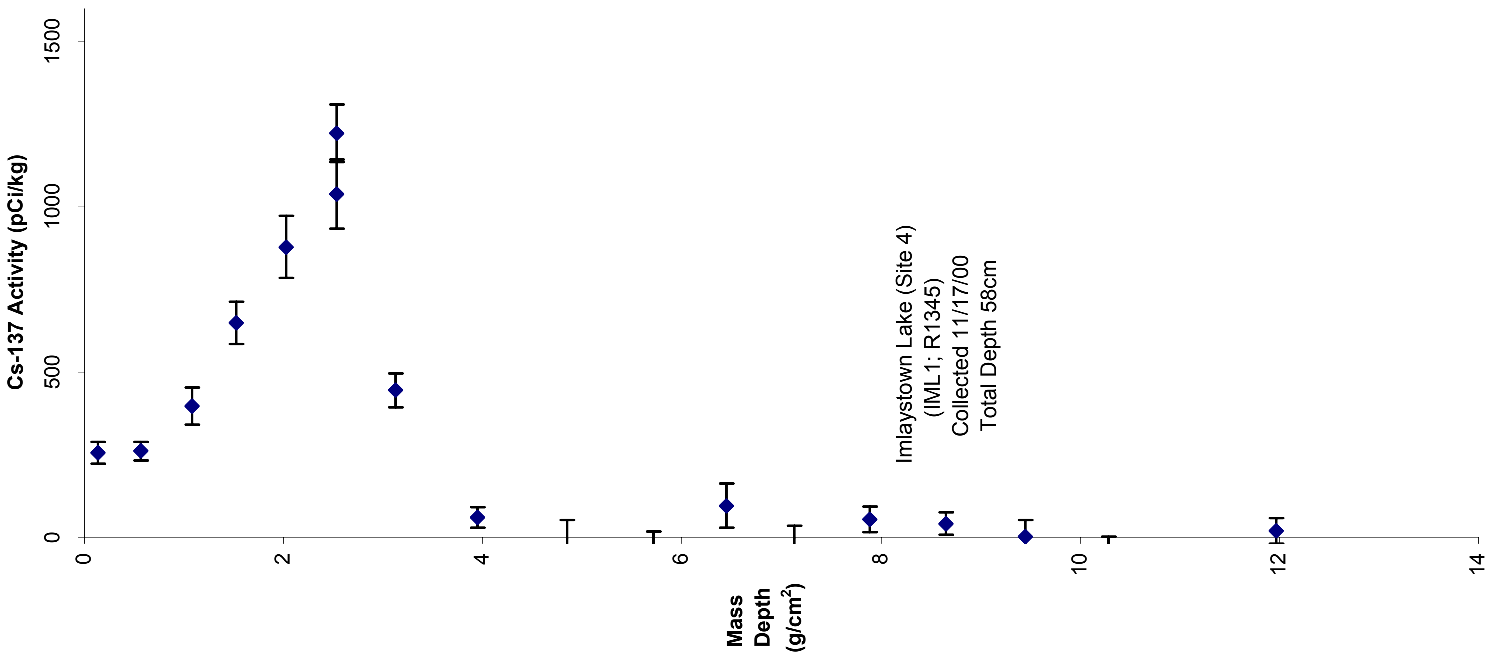
APPENDIX III © Cs-137 Activity vs Mass Depth

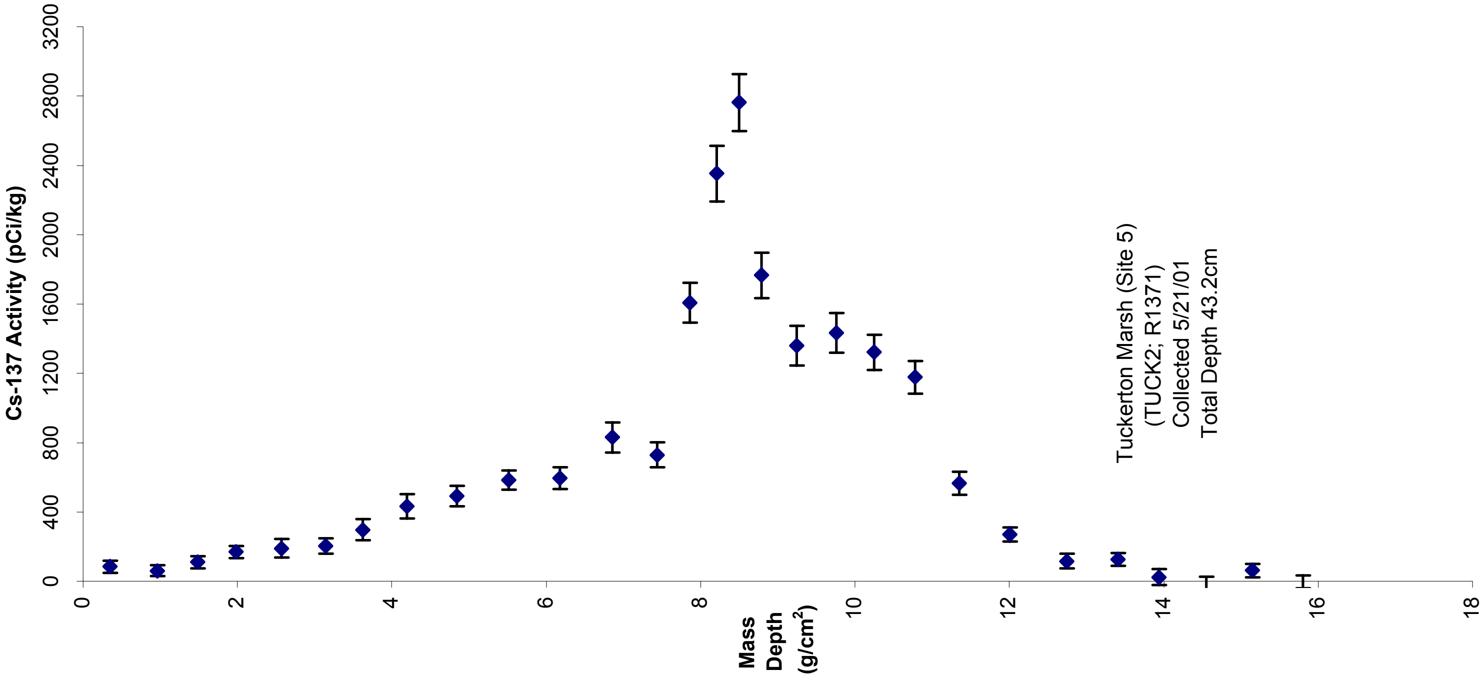

Cs-137 Activity (pCi/kg)
0
800
1600
2400
3200
4000
0
2
4
6
8
10
12
14
16
18
Mass Depth (g/cm^2)
Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm

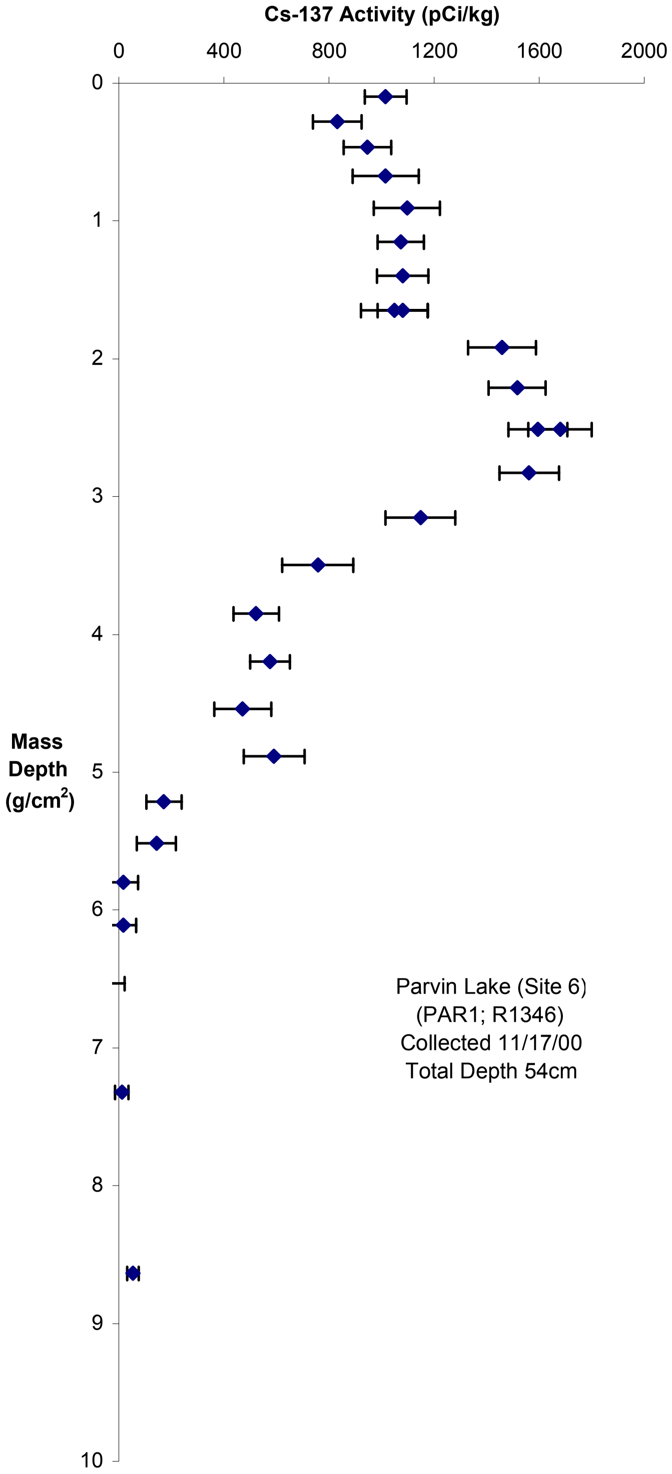

Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
(decay corrected to 8/21/80 for direct comparison to WoodB)


Cs-137 Activity (pCi/kg)
6000
5000
4000
3000
2000
1000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Mass Depth (g/cm^2)
Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm

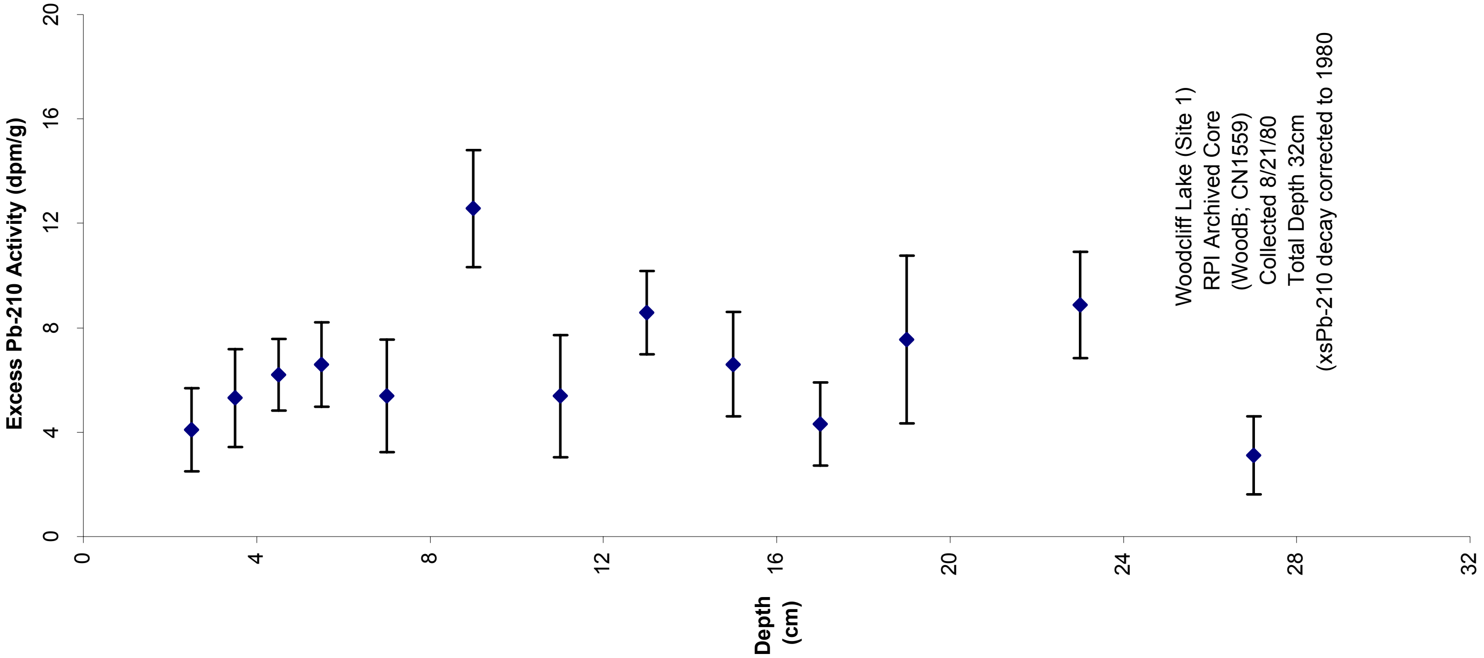

Cs-137 Activity (pCi/kg)
0
400
800
1200
1600
2000
2400
2800
3200
Mass Depth (g/cm^2)
0
0.5
1
1.5
2
2.5
3
3.5
Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm

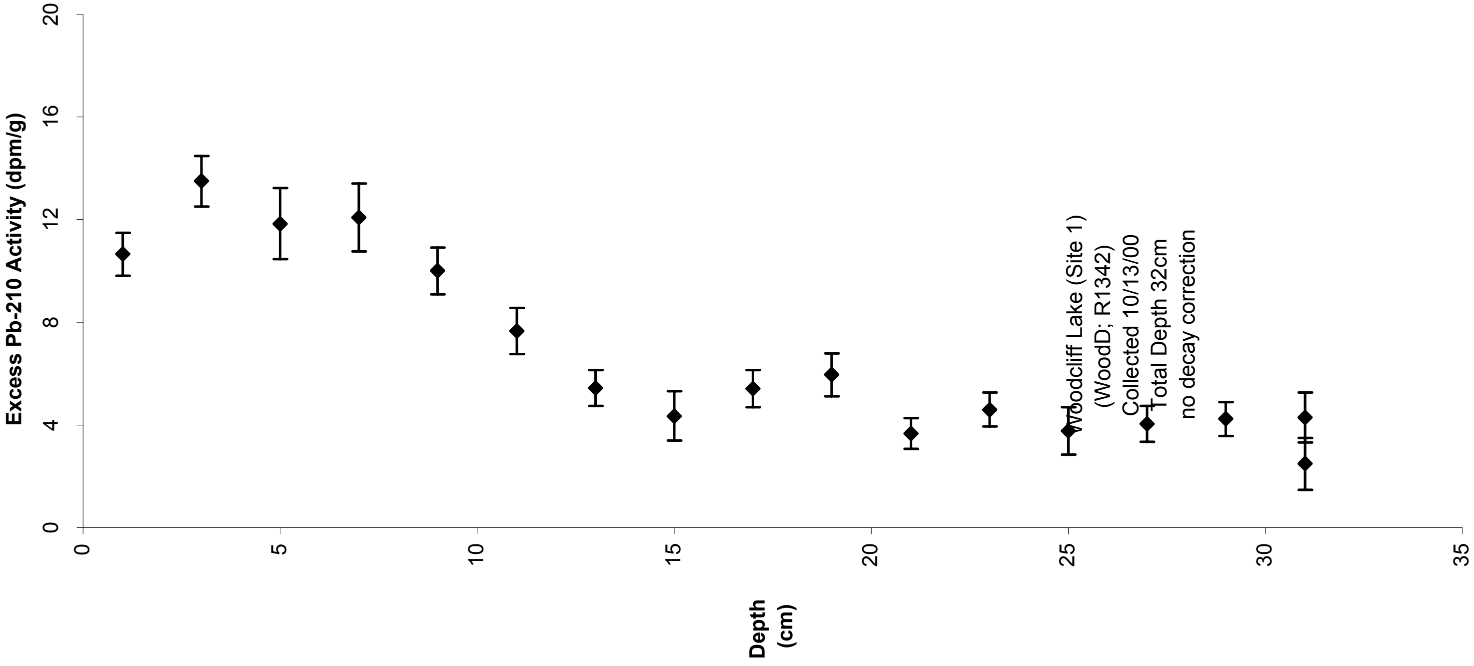

Cs-137 Activity (pCi/kg)
0
500
1000
1500
Mass Depth (g/cm^2)
0
2
4
6
8
10
12
14
Imlaystown Lake (Site 4)
(IML1; R1345)
Collected 11/17/00
Total Depth 58cm

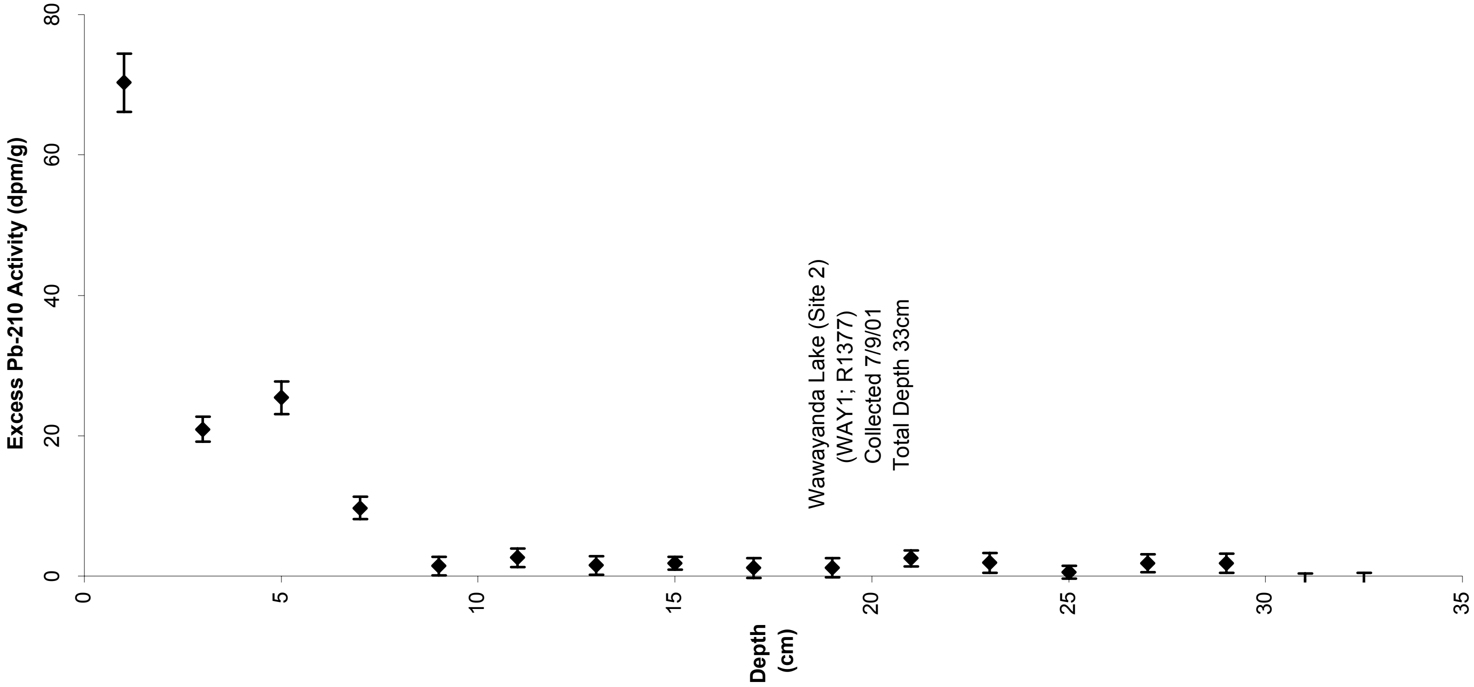

Cs-137 Activity (pCi/kg)
0
400
800
1200
1600
2000
2400
2800
3200
0
2
4
6
8
10
12
14
16
18
Mass Depth (g/cm^2)
Tuckerton Marsh (Site 5)
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm

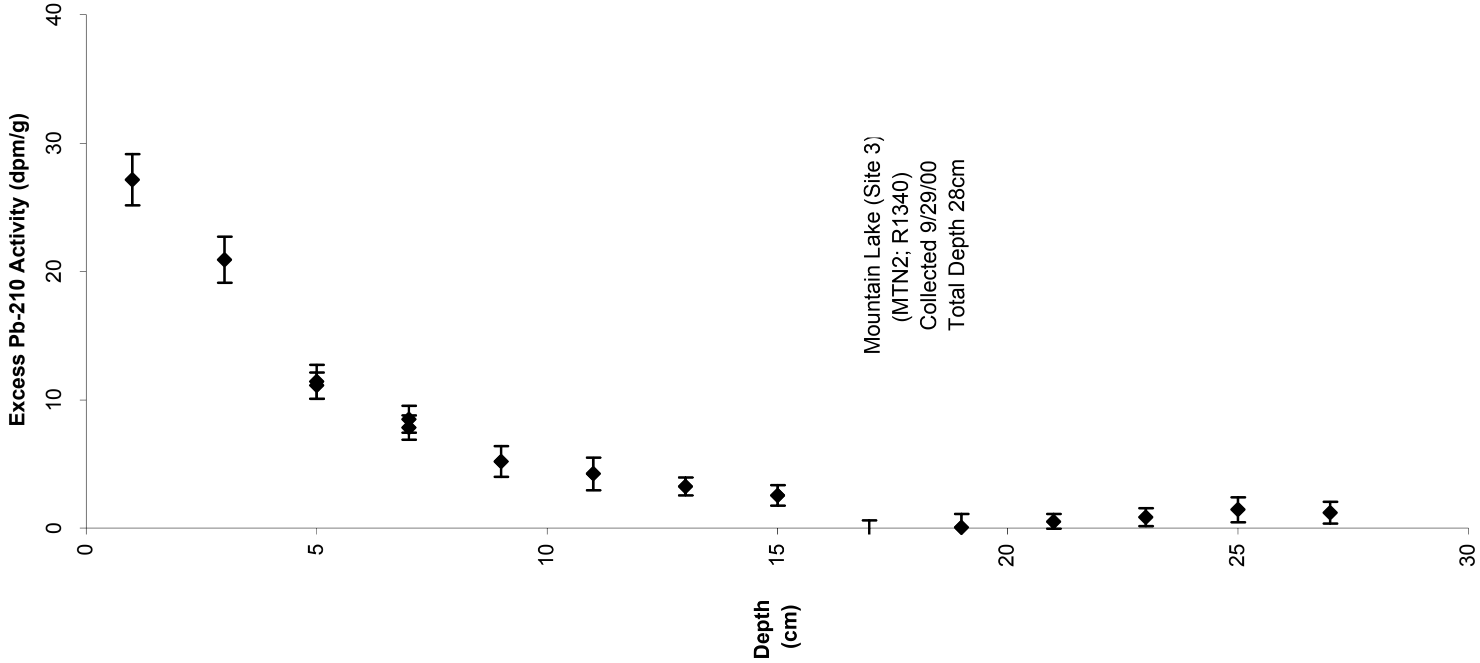

Cs-137 Activity (pCi/kg)
0
400
800
1200
1600
2000
Mass Depth (g/cm^2)
0
1
2
3
4
5
6
7
8
9
10
Parvin Lake (Site 6)
(PAR1; R1346)
Collected 11/17/00
Total Depth 54cm

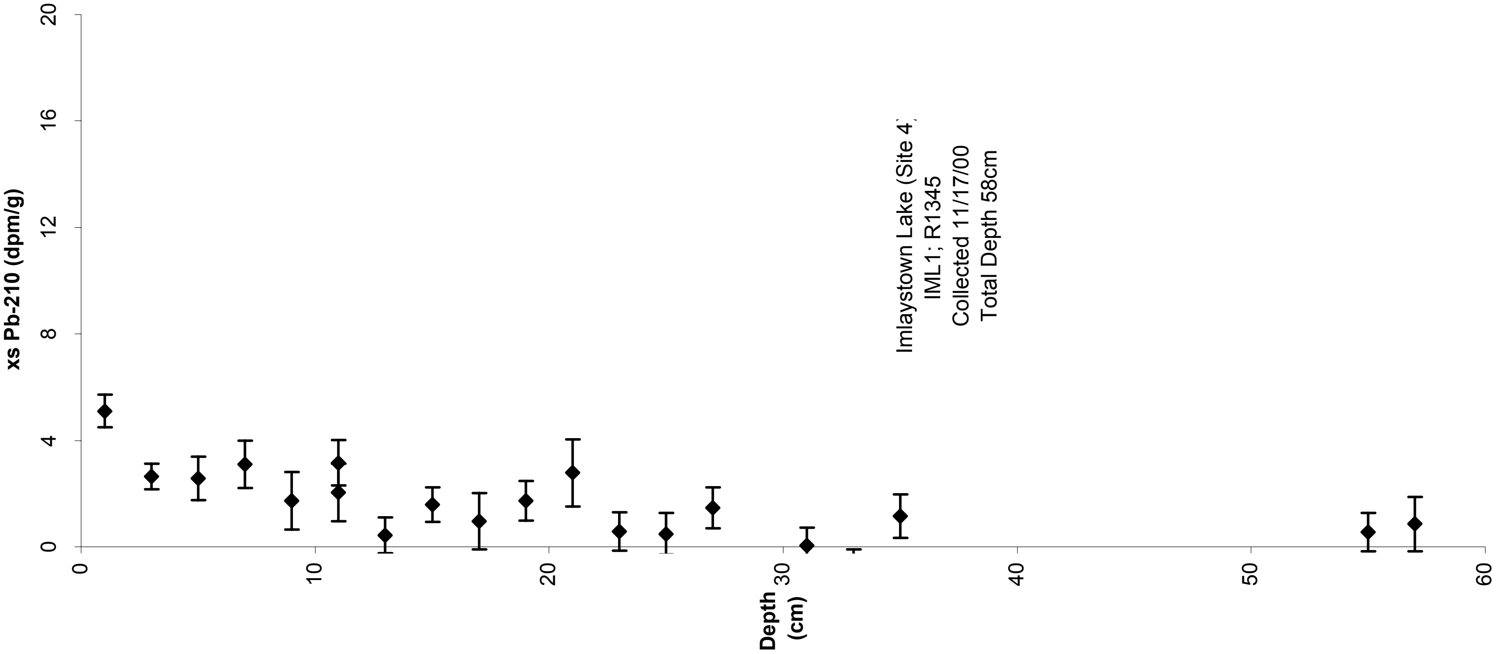
APPENDIX III (D) Excess Pb 210 Activity vs. Depth

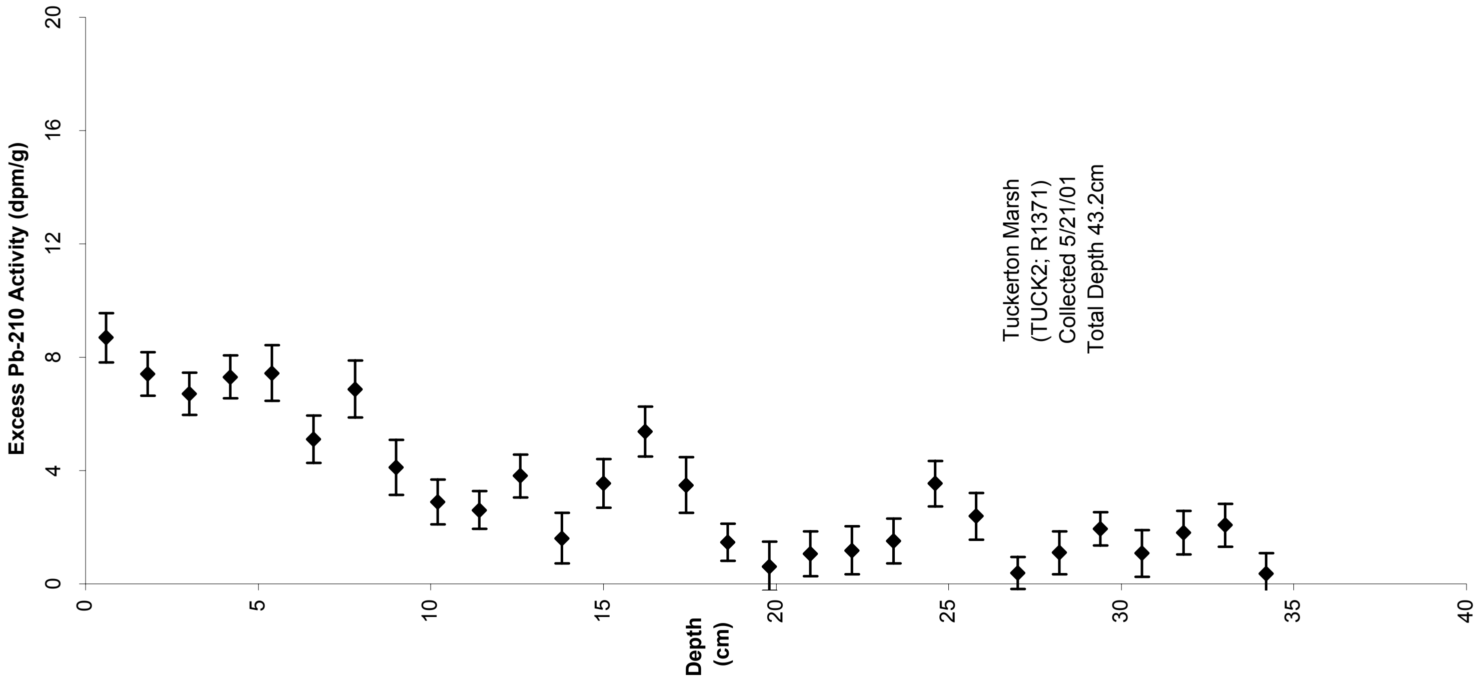

Excess Pb-210 Activity (dpm/g)
0
4
8
12
16
20
0
4
8
12
16
20
24
28
32
Depth
(cm)
Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm
(xsPb-210 decay corrected to 1980


Excess Pb-210 Activity (dpm/g)
0
4
8
12
16
20
Depth (cm)
0
5
10
15
20
25
30
35
Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
no decay correction

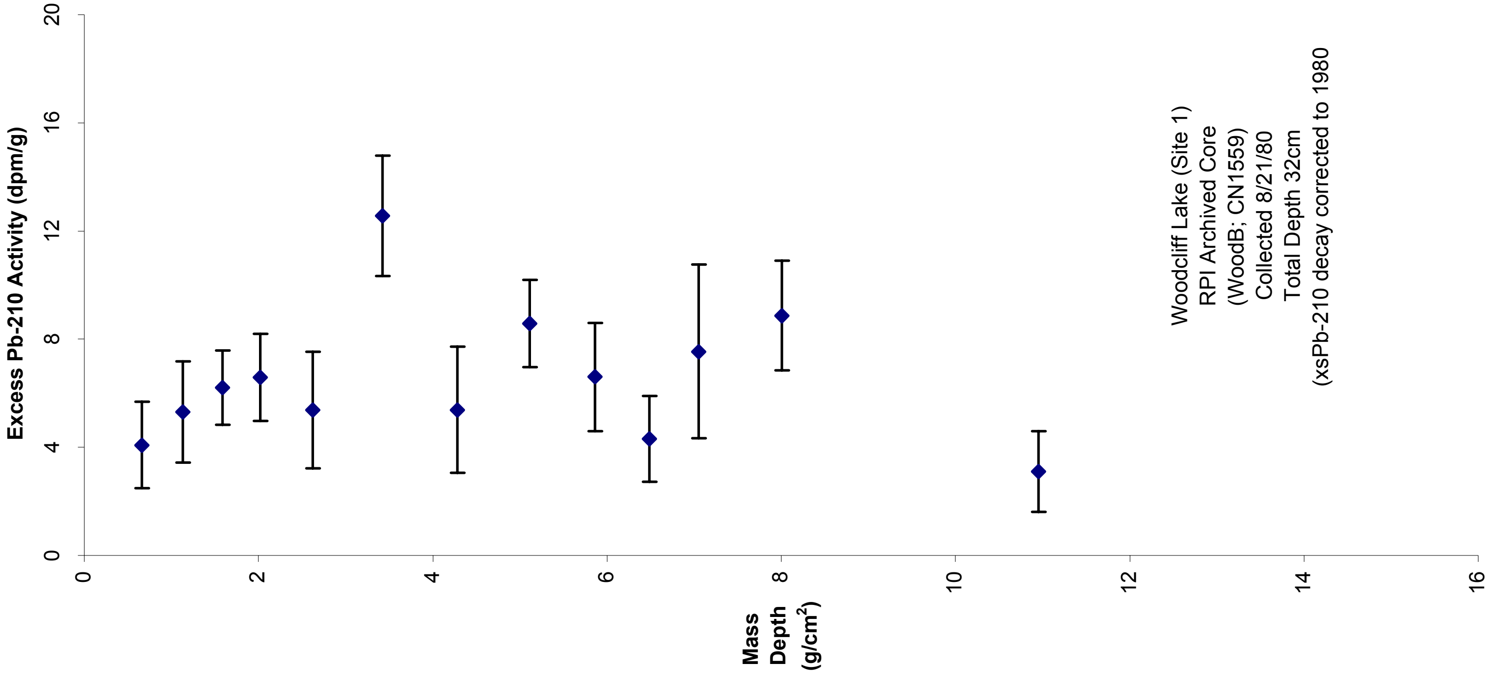

Excess Pb-210 Activity (dpm/g)
0
20
40
60
80
Depth (cm)
0
5
10
15
20
25
30
35
Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm

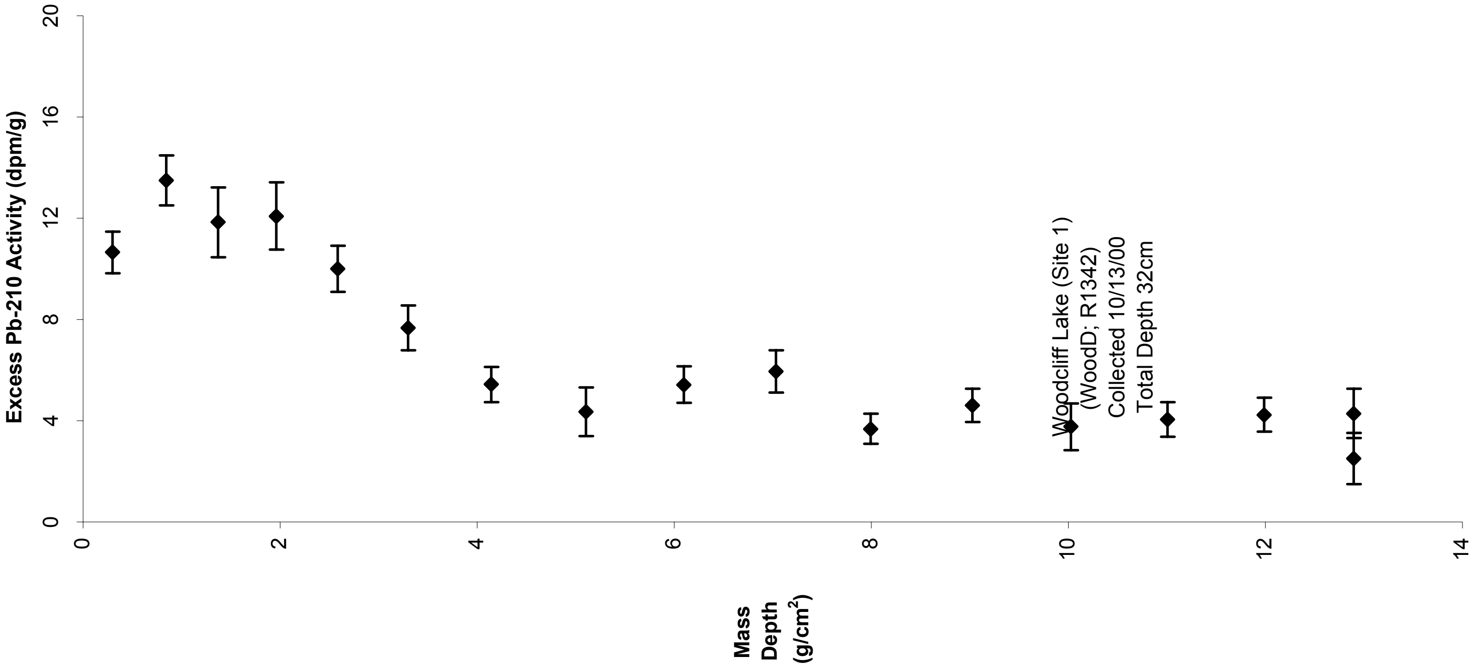

Excess Pb-210 Activity (dpm/g)
0
10
20
30
40
Depth
(cm)
0
5
10
15
20
25
30
Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm

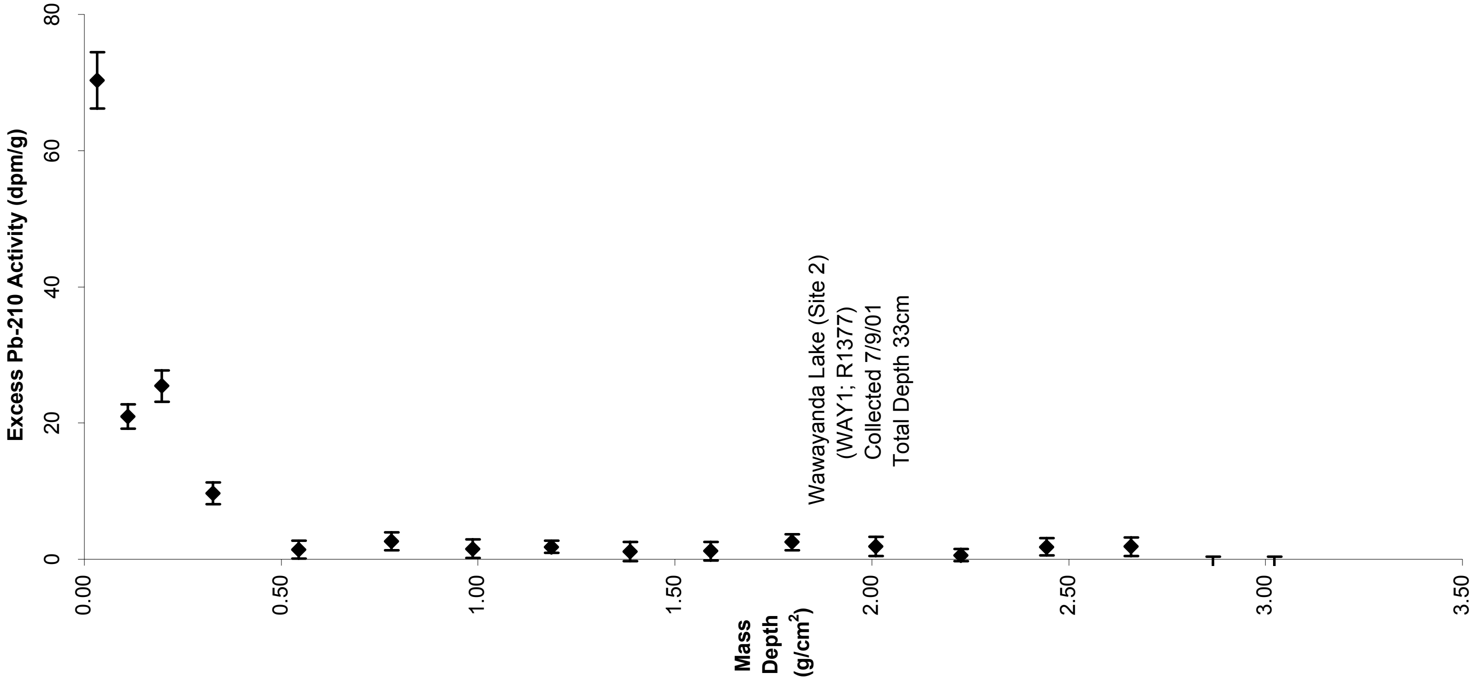

xs Pb-210 (dpm/g)
0
4
8
12
16
20
0
10
20
30
40
50
60
Depth (cm)
Imlaystown Lake (Site 4
IML1; R1345
Collected 11/17/00
Total Depth 58cm

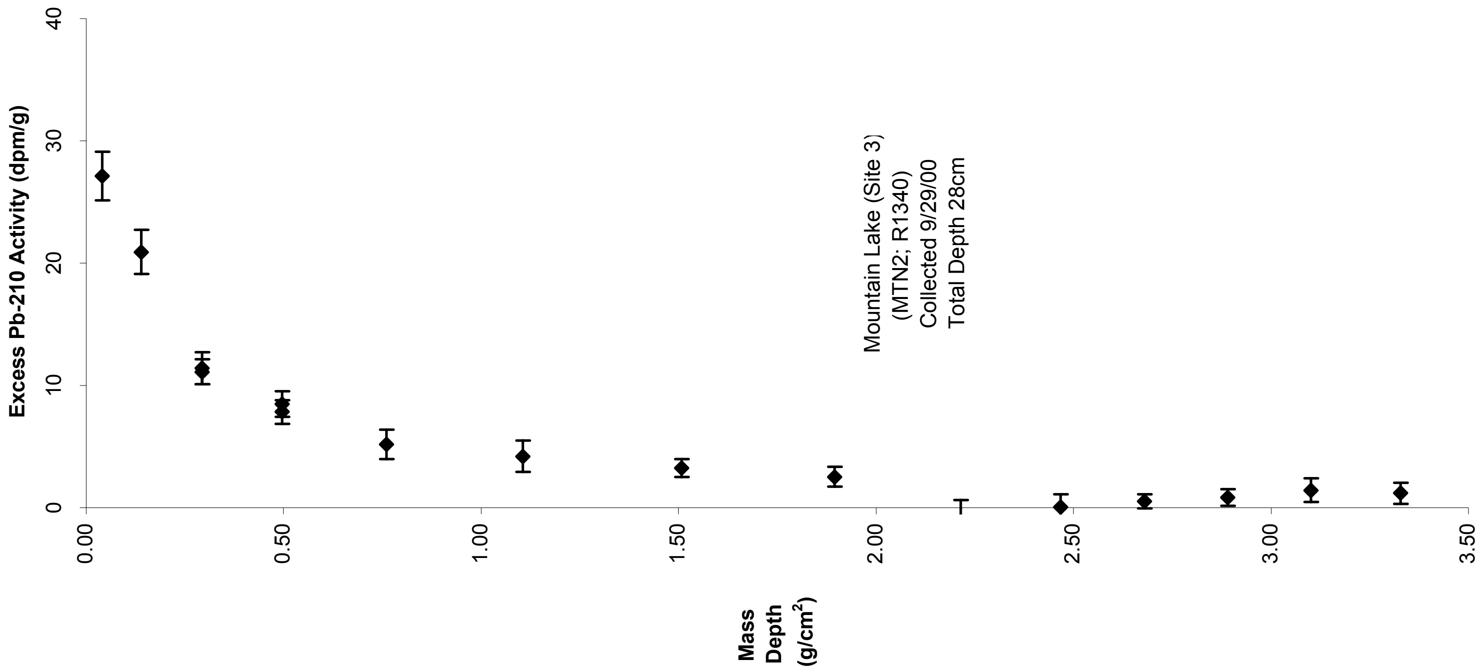

Excess Pb-210 Activity (dpm/g)
0
4
8
12
16
20
Depth (cm)
0
5
10
15
20
25
30
35
40
Tuckerton Marsh
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm

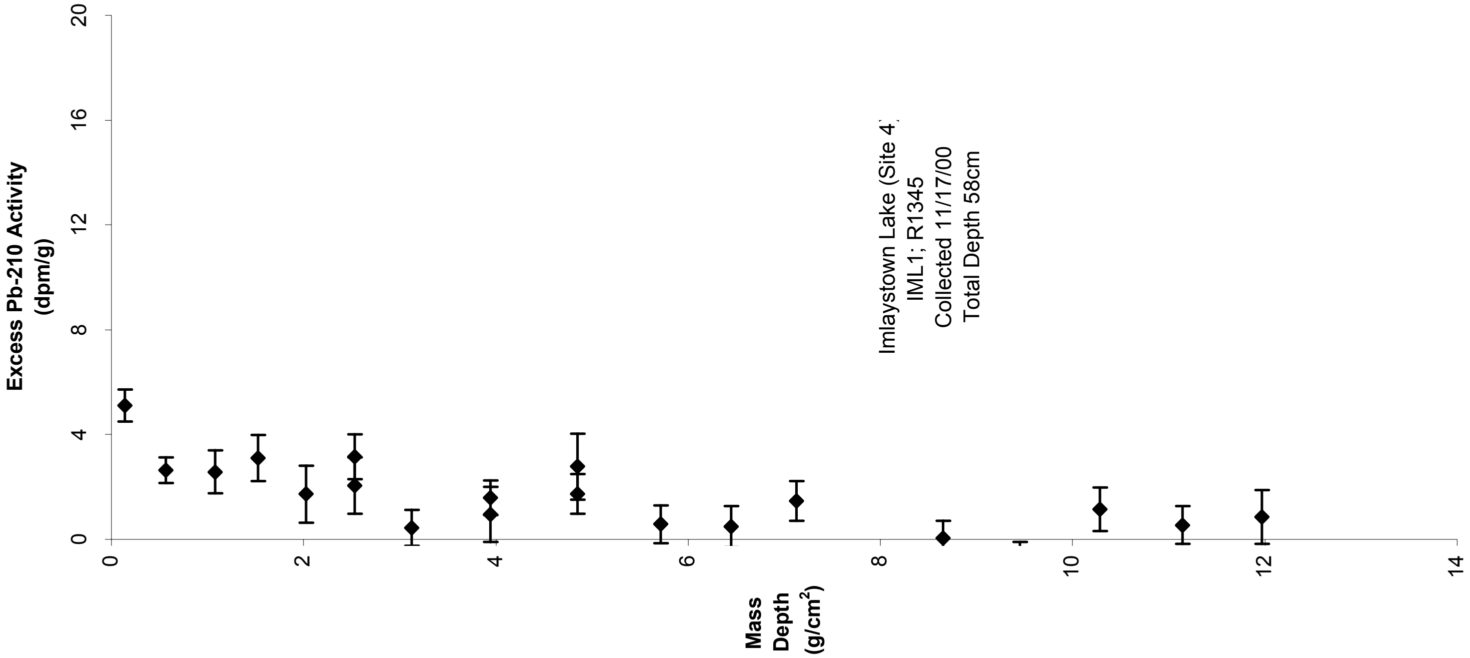
APPENDIX III (E) Excess Pb-210 Activity vs Mass Depth

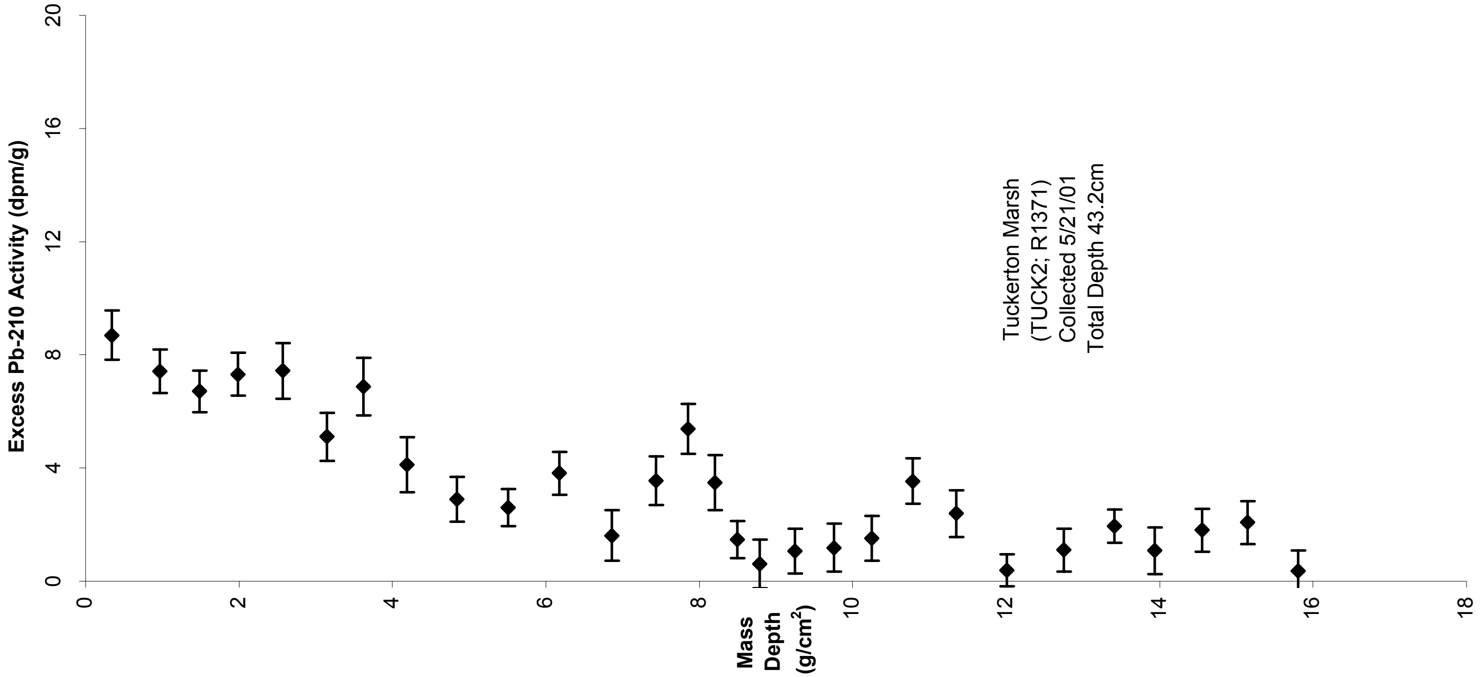

Excess Pb-210 Activity (dpm/g)
0
4
8
12
16
20
Mass Depth (g/cm^2)
0
2
4
6
8
10
12
14
16
Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm
(xsPb-210 decay corrected to 1980


Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
Excess Pb-210 Activity (dpm/g)
0
4
8
12
16
20
0
2
4
6
8
10
12
14
Mass Depth (g/cm^2)


Excess Pb-210 Activity (dpm/g)
0
20
40
60
80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Mass Depth (g/cm^2)
Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm


Excess Pb-210 Activity (dpm/g)
0
10
20
30
40
Mass Depth (g/cm^2)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm


Excess Pb-210 Activity (dpm/g)
0
4
8
12
16
20
Mass Depth (g/cm^2)
0
2
4
6
8
10
12
14
Imlaystown Lake (Site 4
IML1; R1345
Collected 11/17/00
Total Depth 58cm


Excess Pb-210 Activity (dpm/g)
0
4
8
12
16
20
0
2
4
6
8
10
12
14
16
18
Mass Depth (g/cm^2)
Tuckerton Marsh
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm

APPENDIX IV. Mercury Data and Plots

APPENDIX IV (A) Data Tables

Woodcliff Lake (Site 1)

WoodB (CN1559); *RPI Archived Core*

Collected 8/21/80 (1980234)

RPI ID	**Depth Interval (cm)**	**Section mass (g)**	**Total Hg (ppb)**	**xs Hg (ppb) assumes 200ppb bkgd**	**xs Hg flux (Constant MSR years) (μg/m^2/yr)**	**Cs-137 normalized flux (MSR based) (μg/m^2/yr)**	**xsPb210 normalized (MSR based) flux range (μg/m^2/yr)**	
CN1559A	0-1	11.2	1456	1256	4078	3708	1773	2399
CN1559C	2-3	11.36	1585	1385	4497	4088	1955	2645
CN1559D	3-4	12.73						
CN1559E	4-5	10.98	1853	1653	5367	4879	2334	3157
CN1559F	5-6	11.13						
CN1559G	6-8	19.67	1407	1207	3919	3563	1704	2305
CN1559H	8-10	21.49						
CN1559I	10-12	22.22	1754	1554	5046	4587	2194	2968
CN1559I	dup10-12	22.22	1824	1624	5273	4794	2293	3102
CN1559J	12-14	20.8						
CN1559K	14-16	17.22	2867	2667	8660	7873	3765	5094
CN1559L	16-18	15.59						
CN1559M	18-20	12.99	2536	2336	7585	6896	3298	4462
CN1559N	20-22	12.07						
CN1559O	22-24	12.19	1994	1794	5825	5296	2533	3427
CN1559P	24-26	43.71						
CN1559Q	26-28	50.92	282	82	266	242	116	157
CN1559R	28-30	73.35						
CN1559S	30-32	62.38	245	45	146	133	64	86

Woodcliff Lake (Site 1)

WoodD (R1342)

Collected 10/13/00 (2000287)

RPI ID	Depth Interval (cm)	Section mass (g)	Total Hg (ppb)	xs Hg (ppb) assumes 200ppb bkgd	xs Hg flux (Constant DSR years) (μg/m²/yr)	Cs-137 normalized flux (DSR based) (μg/m²/yr)	xsPb210 normalized (DSR based) flux range (μg/m²/yr)	
R1342A	0-2	14.88	294	94	448	407	195	263
R1342B	2-4	12.34	340	140	553	503	240	325
R1342C	4-6	14.03						
R1342D	6-8	15.44	359	159	786	714	342	462
R1342E	8-10	15.86						
R1342F	10-12	19.69	331	131	825	750	359	486
R1342G	12-14	22.56						
R1342H	14-16	25.72	293	93	765	696	333	450
R1342I	16-18	23.77						
R1342J	18-20	22.98	345	145	1066	969	464	627
R1342J	dup18-20	22.98	326	126	927	842	403	545
R1342K	20-22	25.27						
R1342L	22-24	26.09	330	130	1085	987	472	638
R1342L	dup22-24	26.09	332	132	1102	1002	479	648
R1342M	24-26	23.96						
R1342N	26-28	25.04	321	121	970	881	422	570
R1342O	28-30	24.01						
R1342P	30-32	21.49	324	124	853	775	371	502

Wawayanda Lake (Site 2)

WAY1 (R1377)

Collected 7/9/01 (2001190)

RPI ID	Depth Interval (cm)	Section mass (g)	Total Hg (ppb)	xs Hg (ppb) assumes 90ppb bkgd	xs Hg flux (Constant DSR years) ($\mu g/m^2/yr$)	Cs-137 normalized flux (DSR based) ($\mu g/m^2/yr$)	xsPb210 normalized (DSR based) flux range ($\mu g/m^2/yr$)	
R1377A	0-2	1.66	426	336	11	80	19	27
R1377A	dup 0-2	1.66	390	300	10	71	17	24
R1377B	2-4	2.22	355	265	12	84	20	28
R1377C	4-6	2.07	502	412	17	122	29	41
R1377D	6-8	4.45	396	306	27	195	47	65
R1377E	8-10	6.39	156	66	8.4	60	15	20
R1377E	dup 8-10	6.39	156	66	8.4	60	15	20
R1377F	10-12	5.39	141	51	5.5	39	9.5	13
R1377G	12-14	4.95	125	35	3.5	25	6.0	8.3
R1377H	14-16	5.02	105	15	1.5	11	2.6	3.6
R1377I	16-18	5.04	137	47	4.7	34	8.2	11.3
R1377J	18-20	5.13	127	37	3.8	27	6.5	9.0
R1377K	20-22	5.20	113	23	2.4	17	4.1	5.7
R1377L	22-24	5.43	55[a]					
R1377M	24-26	5.37	110	20	2.1	15	3.7	5.1
R1377N	26-28	5.56	110	20	2.2	16	3.8	5.3
R1377O	28-30	5.15	108	18	1.9	13	3.2	4.4
R1377P	30-32	5.22	97.2	7	0.8	5	1.3	1.8
R1377Q	32-33	2.65						

[a] Sample bottle was broken during shipment prior to analysis

Mountain Lake (Site 3)

MTN2 (R1340)

Collected 9/29/00 (2000273)

RPI ID	Depth Interval (cm)	Section mass (g)	Total Hg (ppb)	xs Hg (ppb) assumes 70ppb bkgd	xs Hg flux (Constant DSR years) (μg/m^2/yr)	Cs-137 normalized flux (DSR based) (μg/m^2/yr)	xsPb210 normalized (DSR based) flux range (μg/m^2/yr)	
R1340A	0-2	2.04	217	147	13.0	54.0	21.3	29.5
R1340B	2-4	2.92	208	138	17.4	72.6	28.6	39.6
R1340C	4-6	4.74	226	156	32.0	133	52.4	72.7
R1340D	6-8	5.44	175	105	24.7	103	40.5	56.1
R1340E	8-10	7.76	204	134	45.0	187	73.7	102
R1340E	dup 8-10	7.76	200	130	43.6	182	71.5	99.1
R1340F	10-12	9.44	202	132	53.9	225	88.3	122
R1340F	dup 10-12	9.44	194	124	50.6	211	83.0	115
R1340G	12-14	10.74	135	65	30.2	126	49.5	68.6
R1340G	dup 12-14	10.74	156	86	39.9	166	65.5	90.8
R1340H	14-16	8.60	109	39	14.5	60.4	23.8	33.0
R1340I	16-18	7.34	85.3	15	4.9	20.2	8.0	11.0
R1340J	18-20	5.34	70	0	0	0	0	0
R1340K	20-22	5.26	102	32	7.3	30.3	11.9	16.5
R1340L	22-24	5.29	106	36	8.2	34.3	13.5	18.7
R1340M	24-26	5.24	107	37	8.4	34.9	13.7	19.1
R1340N	26-28	6.08	93.1	23	6.1	25.3	10.0	13.8

Imlaystown Lake (Site 4)

IML1 (R1345)

Collected 11/17/00 (2000322)

RPI ID	***Depth Interval (cm)***	***Section mass (g)***	***Total Hg (ppb)***	***xs Hg (ppb) assumes 50ppb bkgd***	***xs Hg flux (Constant MSR years) (μg/m^2/yr)***	***Cs-137 normalized flux (MSR based) (μg/m^2/yr)***	***xsPb210 normalized (MSR based) flux range (μg/m^2/yr)***	
R1345A	0-2	6.83	94.3[a]	44.3	30.3	112	44	61
R1345B	2-4	14.72	97.1[a]	47.1	32.2	119	47	64
R1345C	4-6	10.75	117[a]	67.0	45.8	170	66	92
R1345D	6-8	11.63	129	79.0	54.0	200	78	108
R1345E	8-10	13.54	140	90.0	61.5	228	89	123
R1345F	10-12	11.68	179	129	88.2	327	128	176
R1345G	12-14	18.01	143	93.0	63.6	236	92	127
R1345H	14-16	22.90	140	90.0	61.5	228	89	123
R1345H	dup14-16	22.90	152	102	69.7	258	101	139
R1345I	16-18	22.18	154	104	71.1	263	103	142
R1345I	dup16-18	22.18	159	109	74.5	276	108	149
R1345J	18-20	21.21	322	272	186	689	270	372
R1345K	20-22	15.58						
R1345L	22-24	18.37	100	50.0	34.2	127	49.5	68.4
R1345M	24-26	19.56						
R1345N	26-28	18.82	101	51.0	34.9	129	50.5	69.7
R1345O	28-30	20.99						
R1345P	30-32	20.62	74.3	24.3	16.6	61.5	24.1	33.2
R1435Q	32-34	22.41						
R1345R	34-36	18.81	71.6	21.6	14.8	54.7	21.4	29.5
R1345S	36-38	18.79						
R1345T	38-40	19.91	57.0	7.0	4.8	17.7	6.9	9.6
R1345T	dup38-40	19.91	58.0	8.0	5.5	20.3	7.9	10.9
R1345U	40-42	20.51						
R1345V	42-44	26.19						
R1345W	44-46	32.16						
R1345X	46-48	34.86	33.2[b]					
R1345Y	48-50	29.14						

R1345Z	50-52	19.25						
R1345AA	52-54	20.63						
R1345BB	54-56	18.57	89.7	39.7	27.1	101	39.3	54.3
R1345CC	56-58	13.96						

[a]Samples reported as "Detected by instrument, above MDL but less that the PQL. Measured result is reported and considered an estimate"

[b]Sediment section R1345X was recorded in the core lab record as particularly sandy compared to other IML sections. As a result we do not believe this section is representative of the whole-core "background" level of Hg.

Tuckerton Marsh (Site 5)

TUCK2 (R1371)

Collected 5/21/01 (2001141)

RPI ID	***Depth Interval (cm)***	***Section mass (g)***	***Total Hg (ppb)***	***xs Hg (ppb) assumes 70ppb bkgd***	***xs Hg flux (MSR years) ($\mu g/m^2/yr$)***	***Cs-137 normalized flux (MSR based) ($\mu g/m^2/yr$)***	***xsPb210 normalized (MSR based) flux range ($\mu g/m^2/yr$)***	
R1371A	0.0 - 1.2	43.96	328	258	577	444	262	361
R1371A	dup0.0 - 1.2	43.96	406	336	752	578	342	470
R1371A	dup0.0 - 1.2	43.96	336	266	595	458	270	372
R1371B	1.2 - 2.4	34.76	284	214	479	368	218	299
R1371C	2.4 - 3.6	31.80	260	190	425	327	193	266
R1371D	3.6 - 4.8	31.45	263	193	432	332	196	270
R1371D	3.6 - 4.8	31.45	253	183	409	315	186	256
R1371E	4.8 - 6.0	43.25	262	192	429	330	195	268
R1371F	6.0 - 7.2	29.74	243	173	387	298	176	242
R1371G	7.2 - 8.4	30.96	247	177	396	305	180	247
R1371H	8.4 - 9.6	41.44	239	169	378	291	172	236
R1371I	9.6 - 10.8	41.32	288	218	488	375	222	305
R1371J	10.8 - 12.0	43.51	217	147	329	253	149	206
R1371K	12.0 - 13.2	41.52	213	143	320	246	145	200
R1371L	13.2 - 14.4	44.66	229	159	356	274	162	222
R1371M	14.4 - 15.6	29.26	257	187	418	322	190	261
R1371N	15.6 - 16.8	24.09	348	278	622	478	283	389
R1371N	dup15.6 - 16.8	24.09	284	214	479	368	218	299
R1371N	dup15.6 - 16.8	24.09	301	231	517	397	235	323
R1371N	dup15.6 - 16.8	24.09	306	236	528	406	240	330
R1371O	16.8 - 18.0	20.38	273	203	454	349	206	284
R1371P	18.0 - 19.2	16.72	260	190	425	327	193	266
R1371Q	19.2 - 20.4	20.62	163	93	542	417	246	339
R1371R	20.4 - 21.6	37.28	136	66	563	433	256	352
R1371S	21.6 - 22.8	27.36	154	84	291	224	132	182

R1371T	22.8 - 24.0	35.81	193	123	760	585	346	475
R1371U	24.0 - 25.2	31.15						
R1371V	25.2 - 26.4	41.80	189	119	754	580	343	471
R1371W	26.4 - 27.6	41.62	114	44	207	159	94	129
R1371W	dup26.4 - 27.6	41.62	172	102	482	371	219	301
R1371X	27.6 - 28.8	52.50	140	70	331	254	150	207
R1371Y	28.8 - 30.0	31.68	227	157	741	570	337	463
R1371Z	30.0 - 31.2	35.80	188	118	557	429	253	348
R1371AA	31.2 - 32.4	42.11	215	145	685	527	311	428
R1371AA	dup31.2 - 32.4	42.11	210	140	661	509	301	413
R1371BB	32.4 - 33.6	33.83	233	163	770	592	350	481
R1371CC	33.6 - 34.8	49.28						
R1371DD	34.8 - 36.0	50.05	191	121	571	440	260	357
R1371EE	36.0 - 37.2	50.10	202	132	623	479	283	390
R1371FF	37.2 - 38.4	42.20	207	137	647	498	294	404
R1371FF	dup37.2 - 38.4	42.20	214	144	680	523	309	425
R1371GG	38.4 - 39.6	29.04						
R1371HH	39.6 - 40.8	34.80	219	149	704	541	320	440
R1371II	40.8 - 42.0	26.35	208	138	652	501	296	407
R1371JJ	42.0 - 43.2	37.86	191	121	571	440	260	357

Parvin Lake (Site 6)

PAR1 (R1346)

Collected 11/17/00 (2000322)

RPI ID	***Depth Interval (cm)***	***Section mass (g)***	***Total Hg (ppb)***	***xs Hg (ppb) assumes 100ppb bkgd***	***xs Hg flux (Constant DSR years) ($\mu g/m^2/yr$)***	***Cs-137 normalized flux (DSR based) ($\mu g/m^2/yr$)***
R1346A	0-2	4.85	402	302	184	259
R1346B	2-4	4.22	353	253	134	189
R1346C	4-6	4.99				
R1346D	6-8	5.59	366	266	187	263
R1346E	8-10	5.9	320	220	163	230
R1346F	10-12	6.36				
R1346G	12-14	6.12	415	315	242	341
R1346H	14-16	6.39				
R1346I	16-18	7.1	371	271	242	341
R1346J	18-20	7.37				
R1346K	20-22	7.79	394	294	288	406
R1346L	22-24	7.99				
R1346M	24-26	8.38	311	211	222	313
R1346N	26-28	8.61				
R1346O	28-30	9.04	239	139	158	222
R1346P	30-32	8.48				
R1346Q	32-34	8.69	247	147	161	226
R1346R	34-36	8.54				
R1346S	36-38	7.86	220	120	119	167
R1346T	38-40	7.13				
R1346U	40-42	7.05	156	56	50	70
R1346V	42-44	8.54				
R1346W	44-46	12.68	122	22	35	49
R1346X	46-48	26.78				
R1346Y	48-50	38.82				
R1346Z	50-52	52.53				
R1346AA	52-54	48.25				

Absegami Lake (Site 5)

ABS1 (R1343)

Collected 10/24/00 (2000298)

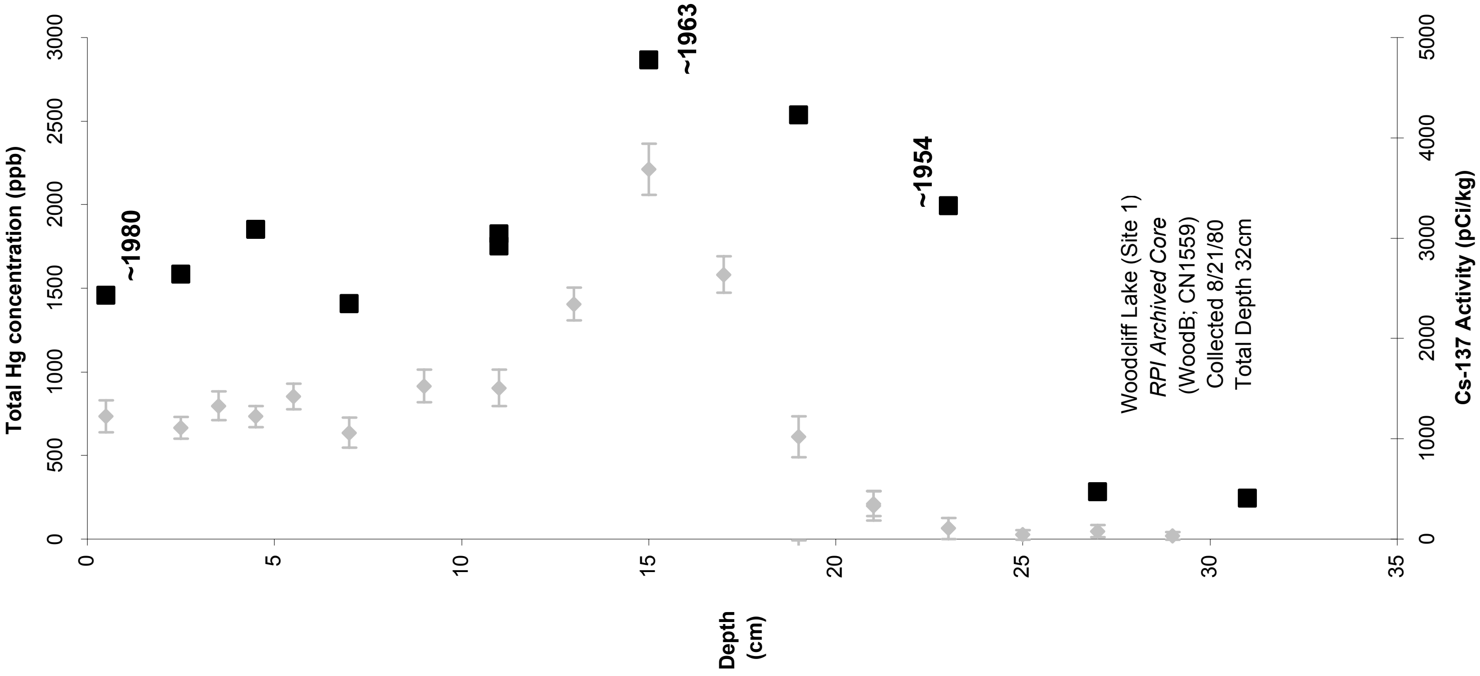
RPI ID	***Depth Interval (cm)***	***Section mass (g)***	***Total Hg concentration (ppb)***
R1343A-H	0-16	30.74	271

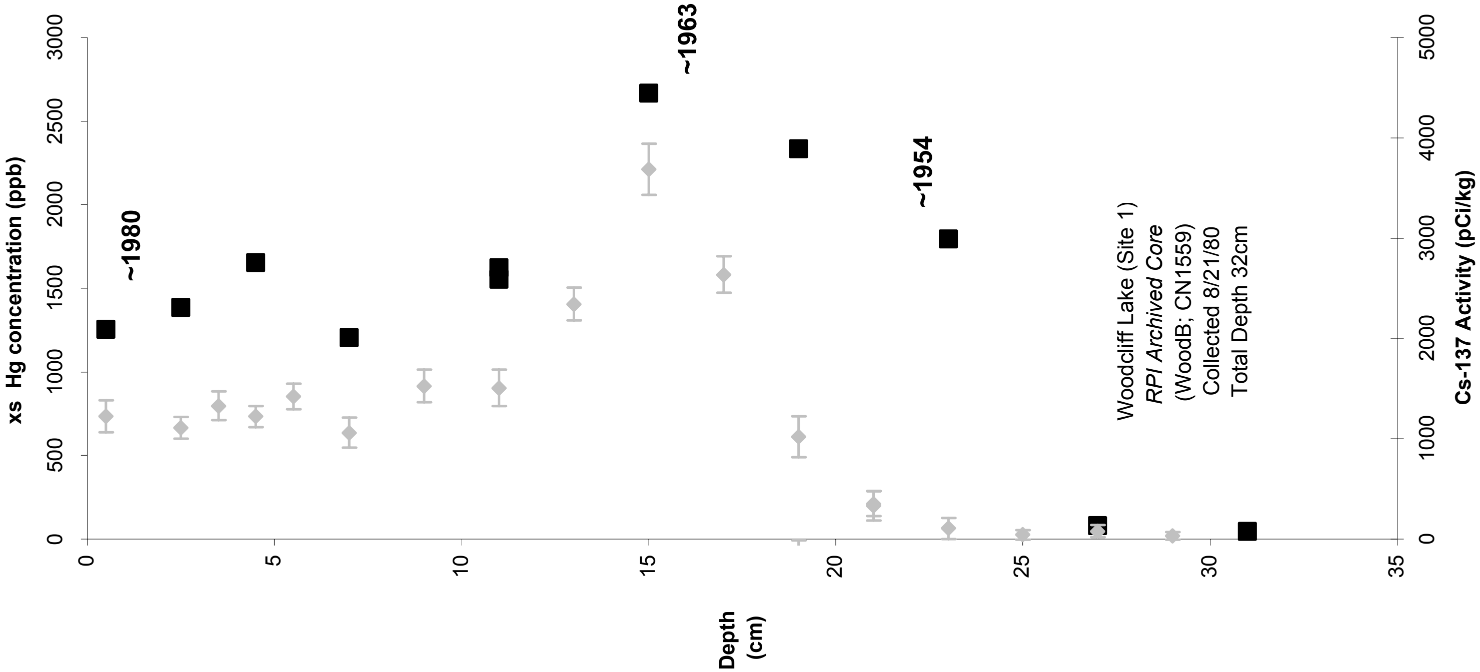
Soil Cores

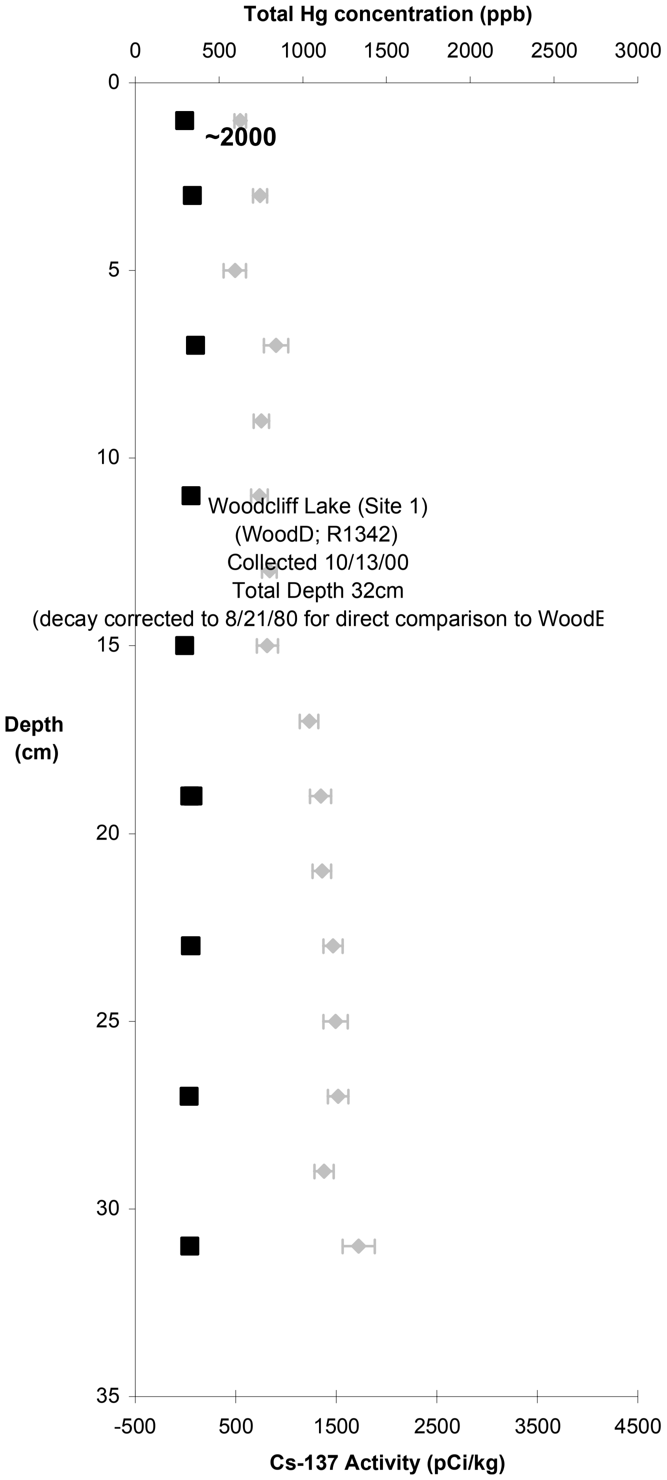
RPI ID	***Core***	***Depth Interval (cm)***	***Excess Pb-210 section inventory (dpm/cm2)***	***Cs-137 section inventory (mCi/km2)***	***Section mass (g)***	***Total Hg concentration (ppb)***
R1385A-H	WAYS	0-12	23.4	31.8	332.39	52.6
R1386A-H	ASSS	0-12	42.0	41.2	315.24	50.2
R1387A-H	MTNS	0-12	31.2	43.9	316.59	67.5
R1388A-G	PARVS	0-10	29.9	18.2	363.87	26.6
R1388A-G	PARVS	dup0-10			363.87	28.4
R1388H	PARVS	10-12			77.73	13.8
R1388H	PARVS	dup10-12			77.73	13.5
R1389A-G	WOODS	0-10	35.2	68.6	223.92	188

Note: Cs-137 inventories for all soil cores except PARVS continued below the bottom section collected

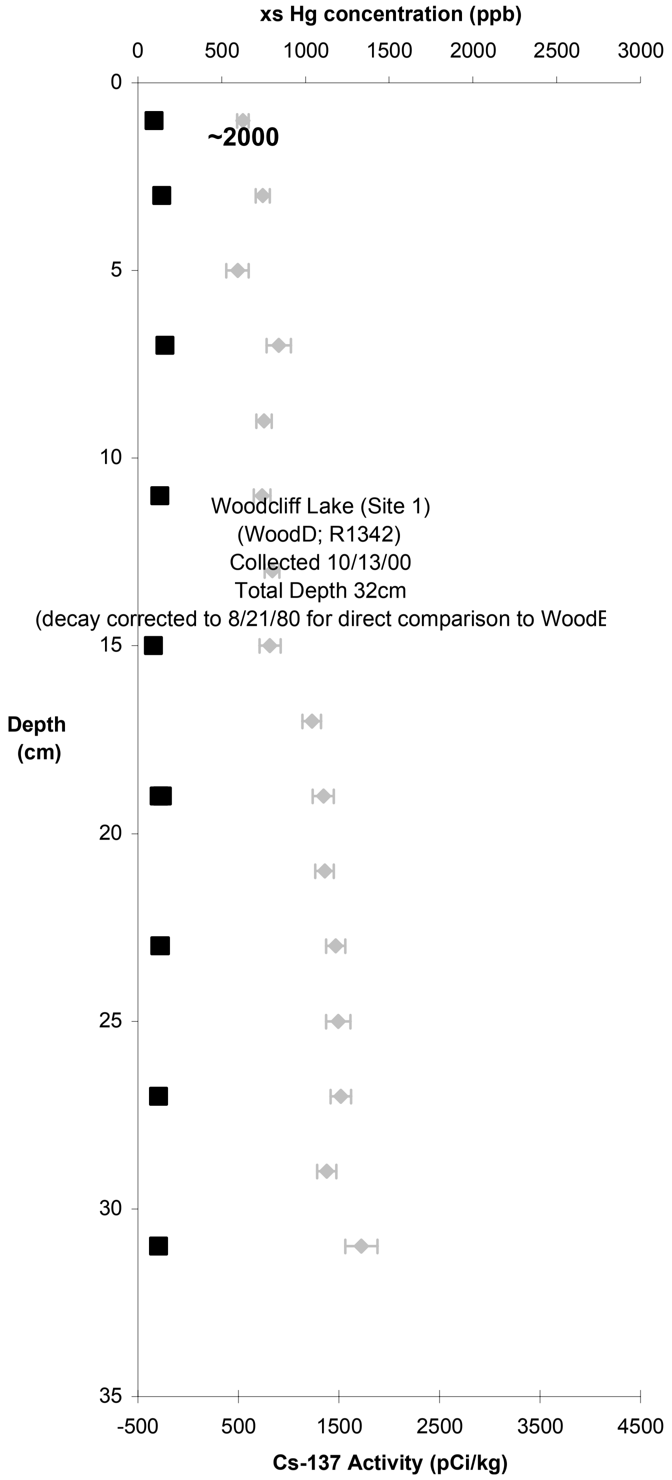
APPENDIX IV (B) Hg Concentration vs Depth

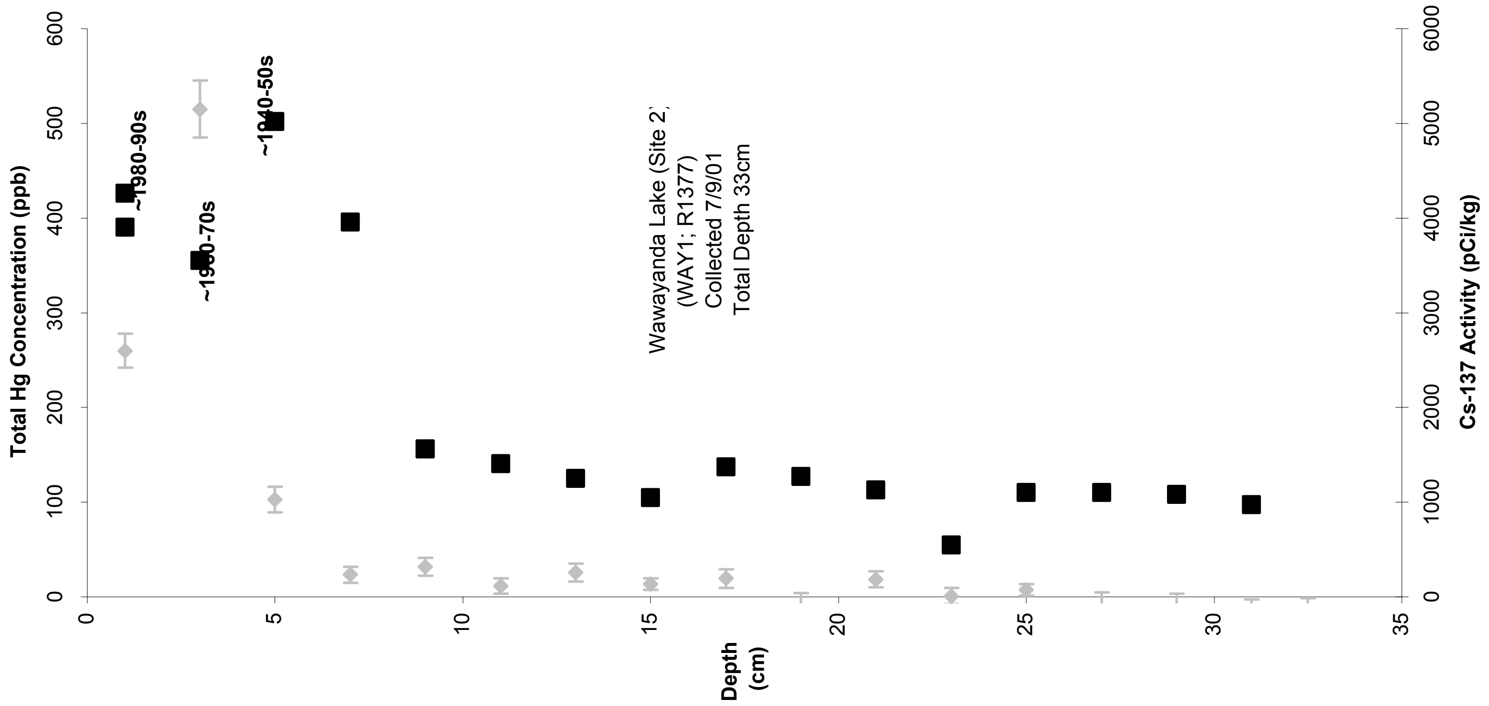

Total Hg concentration (ppb)
0
500
1000
1500
2000
2500
3000
Cs-137 Activity (pCi/kg)
0
1000
2000
3000
4000
5000
Depth (cm)
0
5
10
15
20
25
30
35
~1980
~1963
~1954
Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm

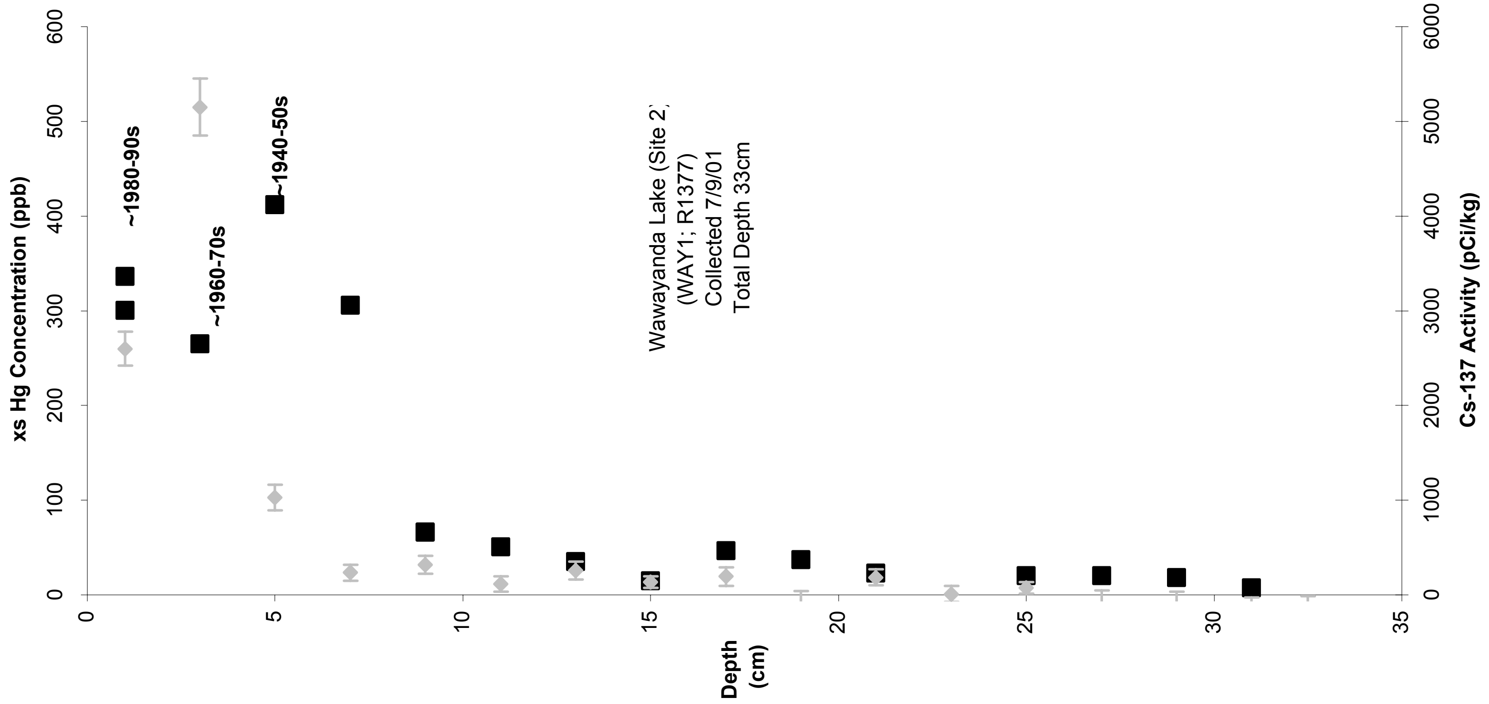

xs Hg concentration (ppb)
0
500
1000
1500
2000
2500
3000
Cs-137 Activity (pCi/kg)
0
1000
2000
3000
4000
5000
Depth (cm)
0
5
10
15
20
25
30
35
~1980
~1963
~1954
Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm

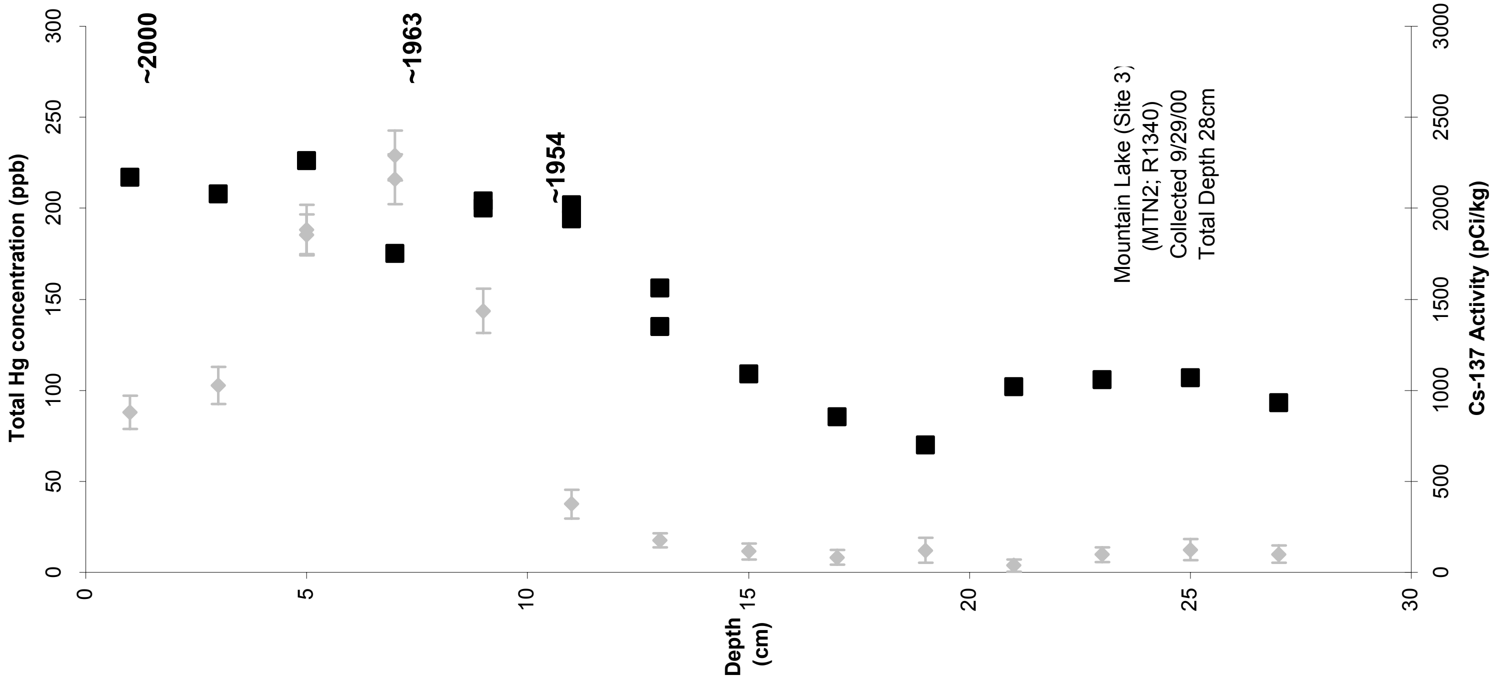


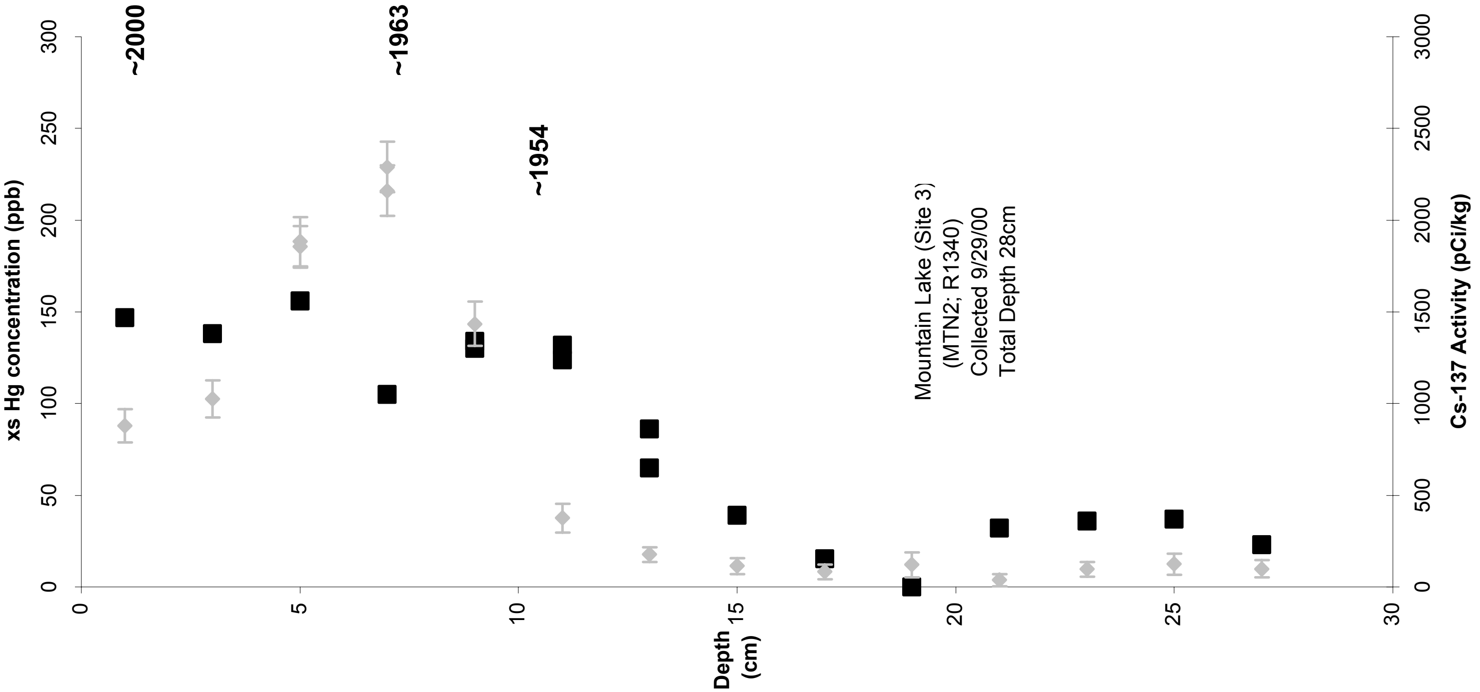
Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
(decay corrected to 8/21/80 for direct comparison to WoodE

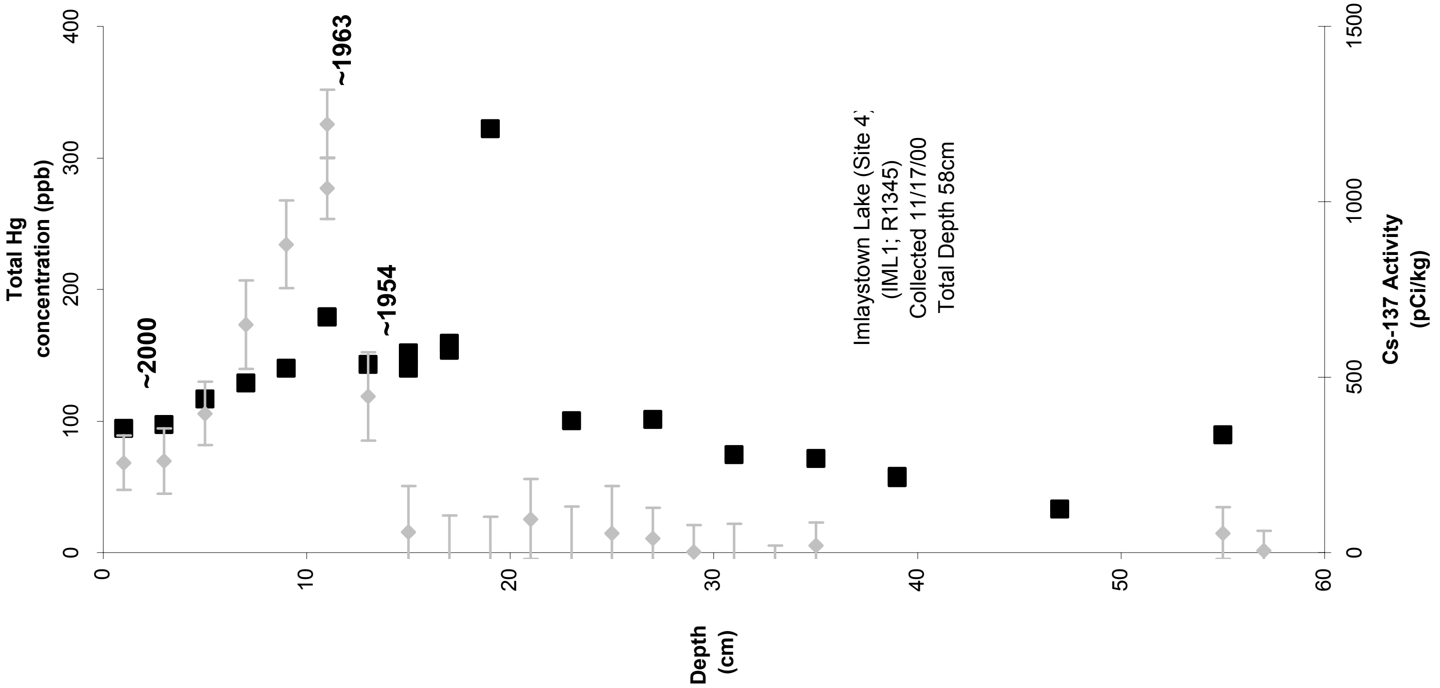

xs Hg concentration (ppb)
0
500
1000
1500
2000
2500
3000
~2000
Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
(decay corrected to 8/21/80 for direct comparison to WoodE
Depth
(cm)
0
5
10
15
20
25
30
35
-500
500
1500
2500
3500
4500
Cs-137 Activity (pCi/kg)

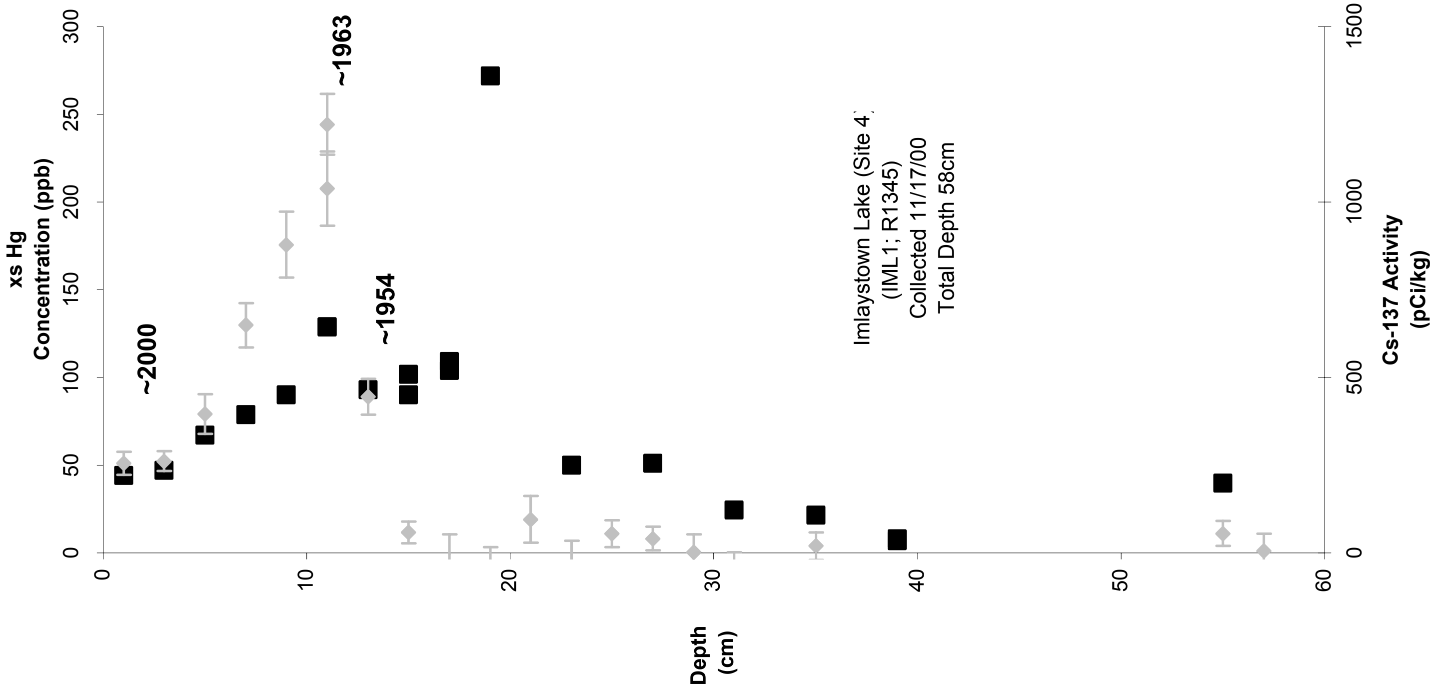

Total Hg Concentration (ppb)
Cs-137 Activity (pCi/kg)
Depth (cm)
Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm
~1980-90s
~1960-70s
~1940-50s
0
100
200
300
400
500
600
0
1000
2000
3000
4000
5000
6000
0
5
10
15
20
25
30
35

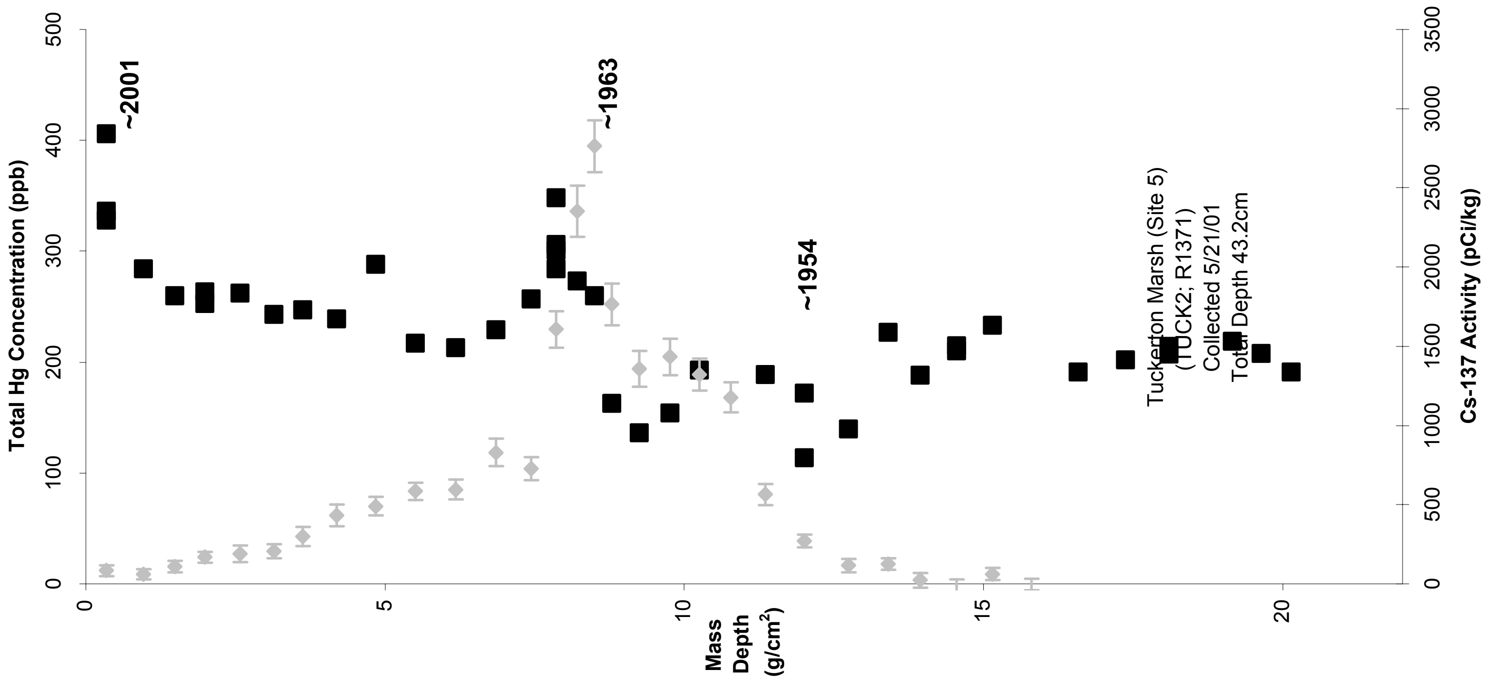

xs Hg Concentration (ppb)
0
100
200
300
400
500
600
Cs-137 Activity (pCi/kg)
0
1000
2000
3000
4000
5000
6000
Depth (cm)
0
5
10
15
20
25
30
35
~1980-90s
~1960-70s
~1940-50s
Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm

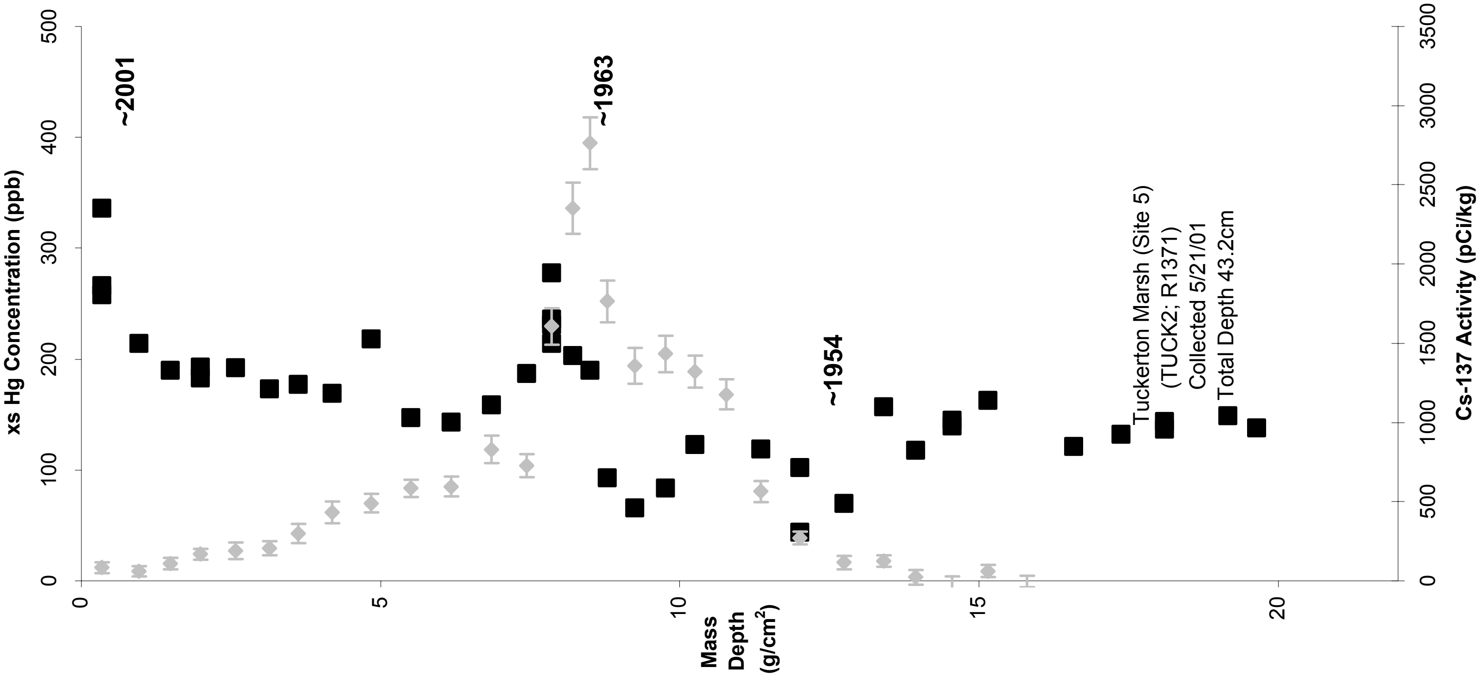

~2000
~1963
~1954
Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm
Total Hg concentration (ppb)
0
50
100
150
200
250
300
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
2500
3000
Depth
(cm)
0
5
10
15
20
25
30

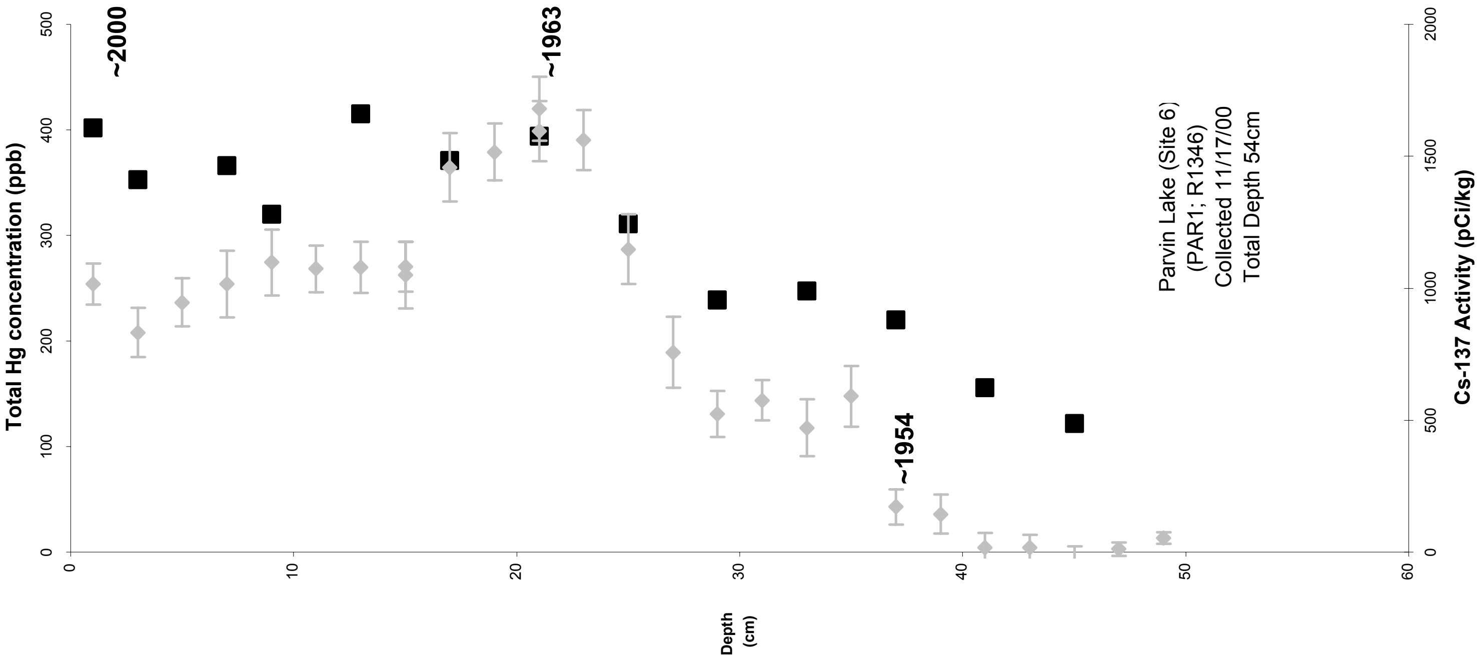

~2000
~1963
~1954
Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm
xs Hg concentration (ppb)
0
50
100
150
200
250
300
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
2500
3000
Depth (cm)
0
5
10
15
20
25
30

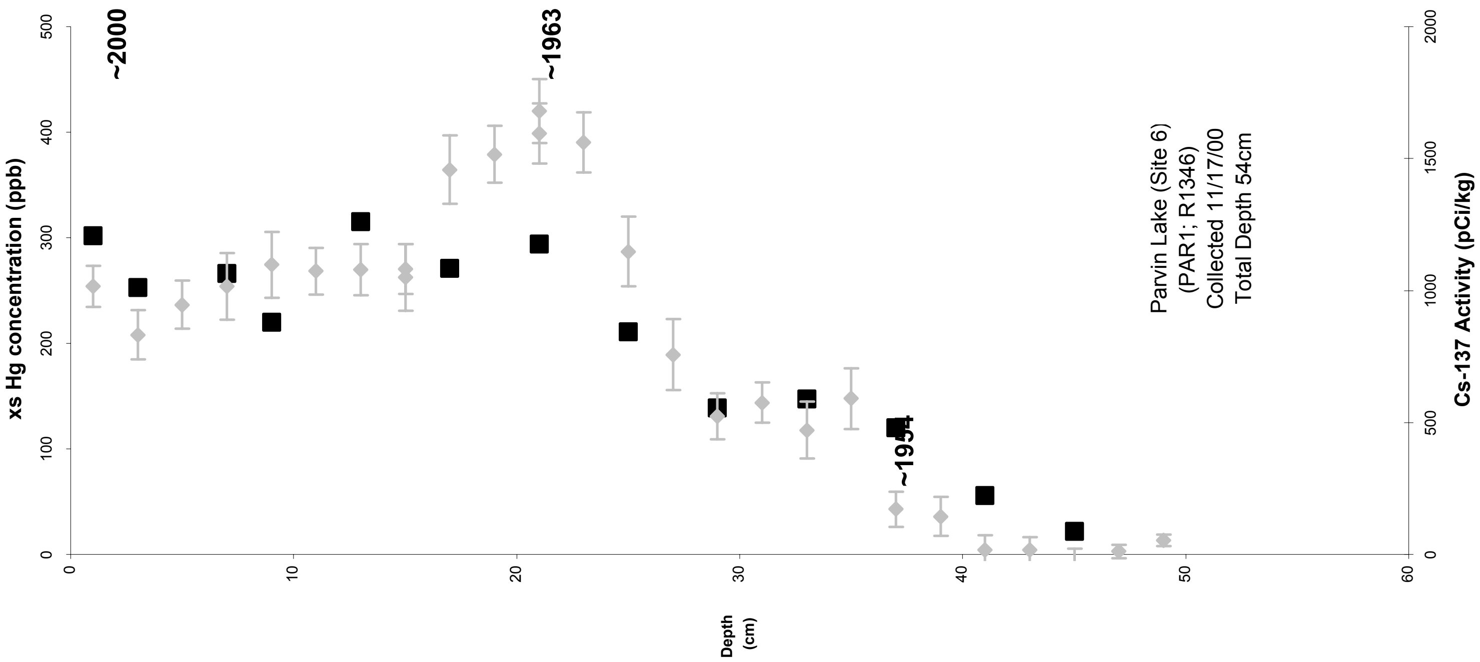

Total Hg concentration (ppb)
0
100
200
300
400
Cs-137 Activity (pCi/kg)
0
500
1000
1500
Depth (cm)
0
10
20
30
40
50
60
~2000
~1963
~1954
Imlaystown Lake (Site 4)
(IML1; R1345)
Collected 11/17/00
Total Depth 58cm


xs Hg
Concentration (ppb)
0
50
100
150
200
250
300
Cs-137 Activity
(pCi/kg)
0
500
1000
1500
Depth
(cm)
0
10
20
30
40
50
60
~2000
~1963
~1954
Imlaystown Lake (Site 4)
(IML1; R1345)
Collected 11/17/00
Total Depth 58cm

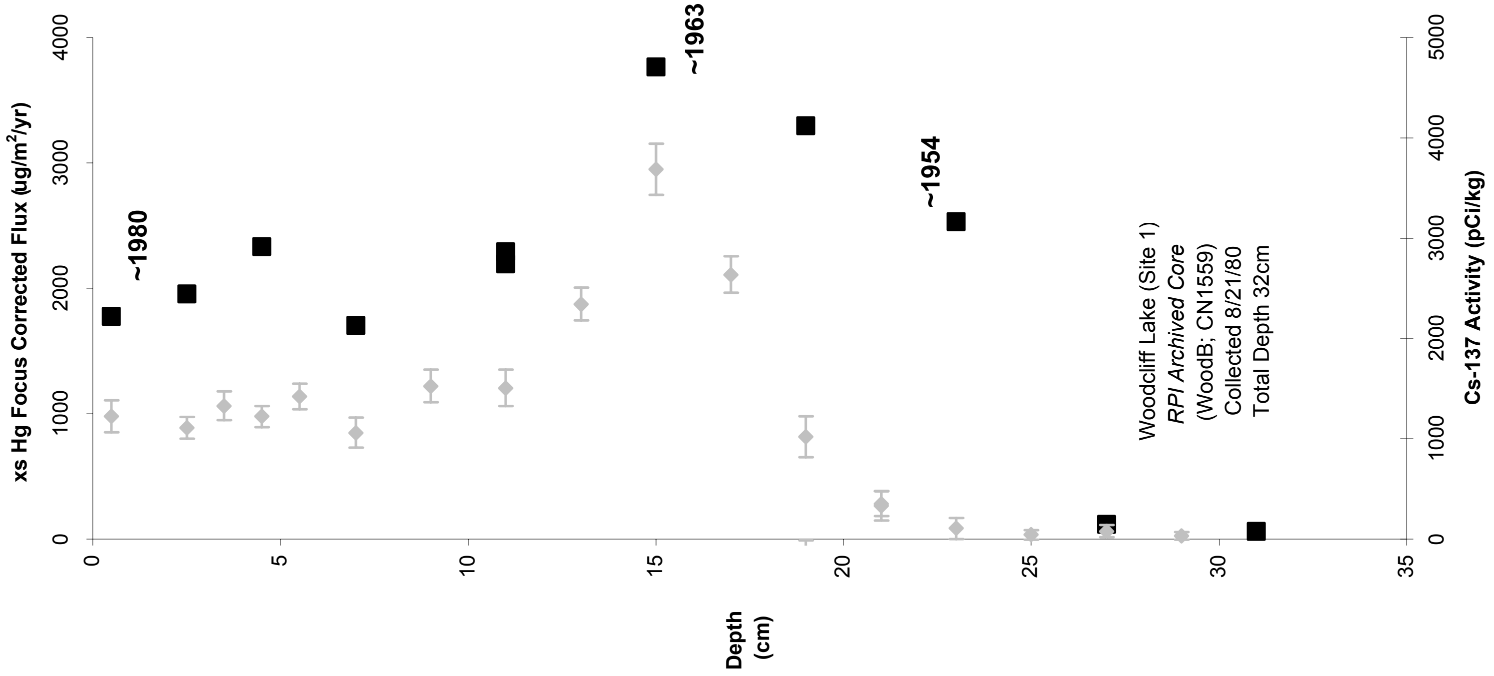

Total Hg Concentration (ppb)
0
100
200
300
400
500
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
2500
3000
3500
Mass Depth (g/cm^2)
0
5
10
15
20
~2001
~1963
~1954
Tuckerton Marsh (Site 5)
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm

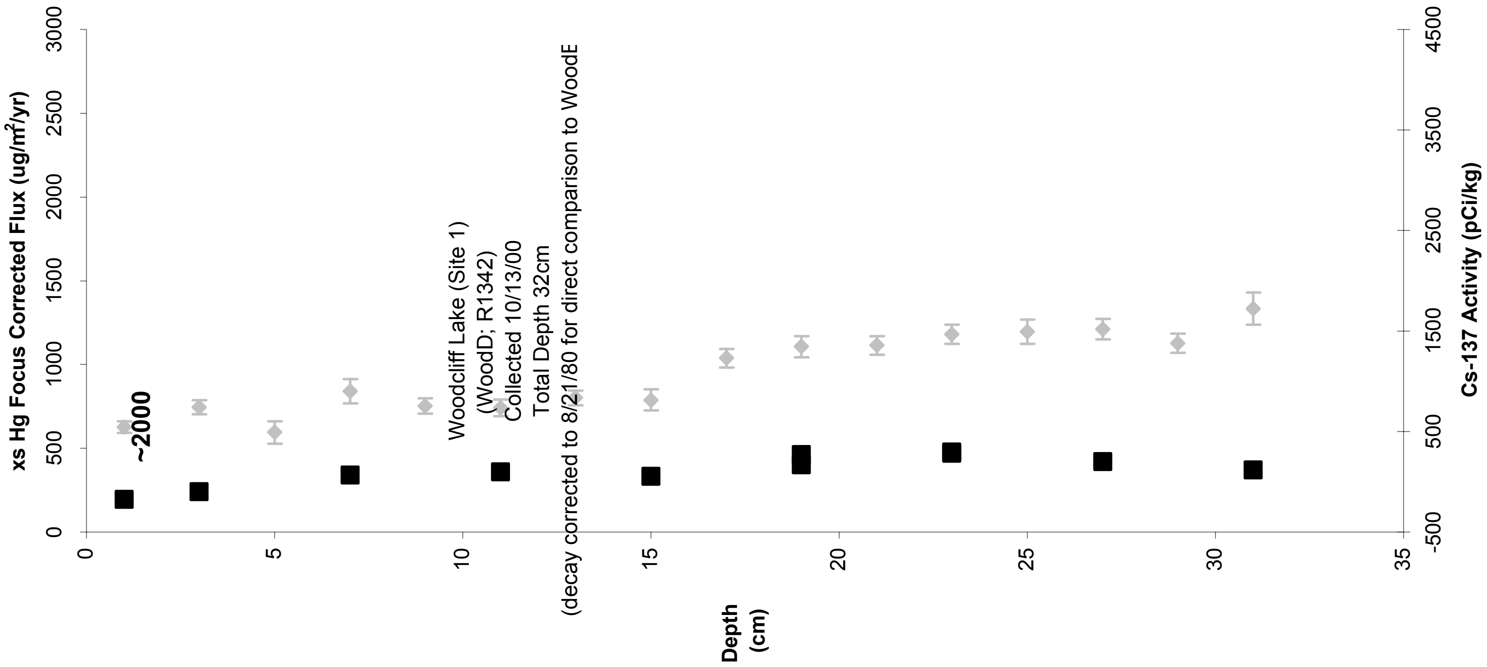

xs Hg Concentration (ppb)
0
100
200
300
400
500
~2001
~1963
~1954
Tuckerton Marsh (Site 5)
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
2500
3000
3500
0
5
10
15
20
Mass Depth (g/cm^2)

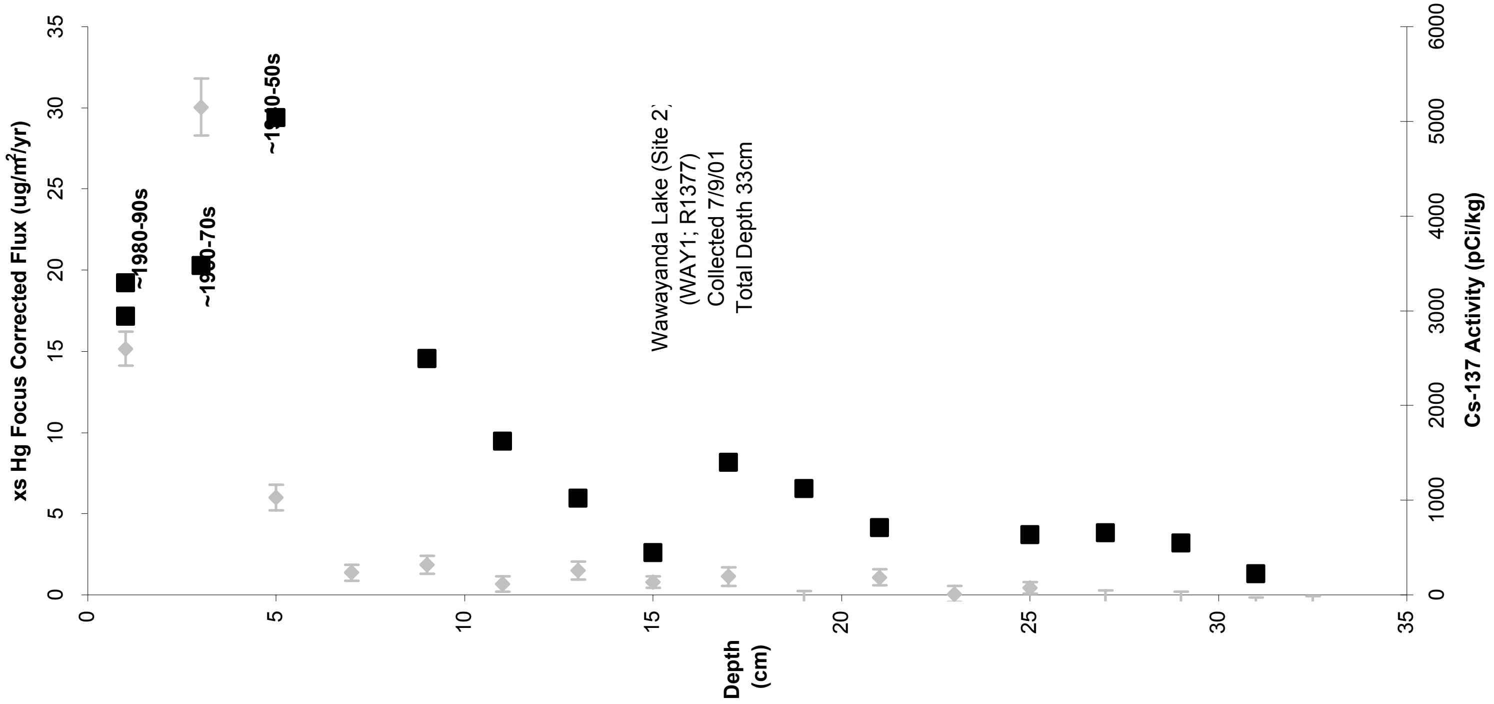

Total Hg concentration (ppb)
0
100
200
300
400
500
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
Depth (cm)
0
10
20
30
40
50
60
~2000
~1963
~1954
Parvin Lake (Site 6)
(PAR1; R1346)
Collected 11/17/00
Total Depth 54cm

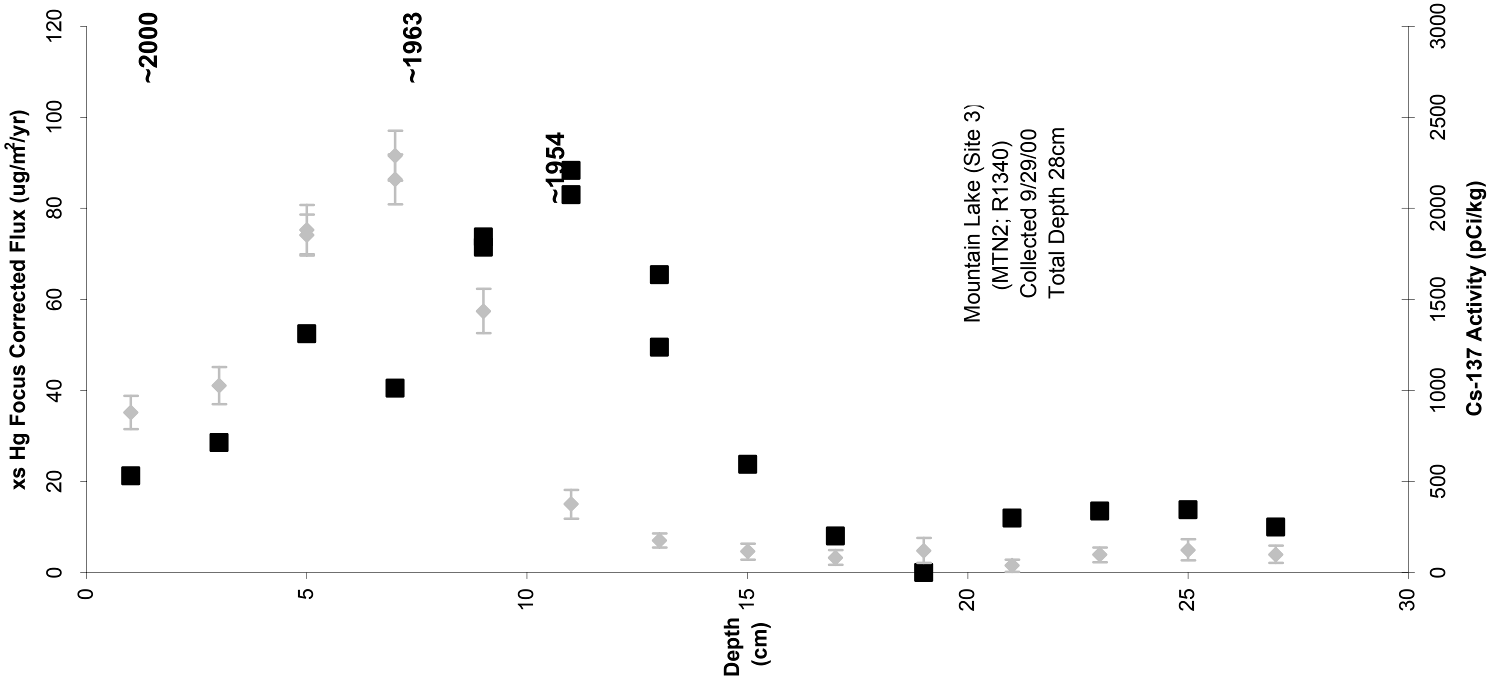

xs Hg concentration (ppb)
0
100
200
300
400
500
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
Depth (cm)
0
10
20
30
40
50
60
~2000
~1963
~1954
Parvin Lake (Site 6)
(PAR1; R1346)
Collected 11/17/00
Total Depth 54cm

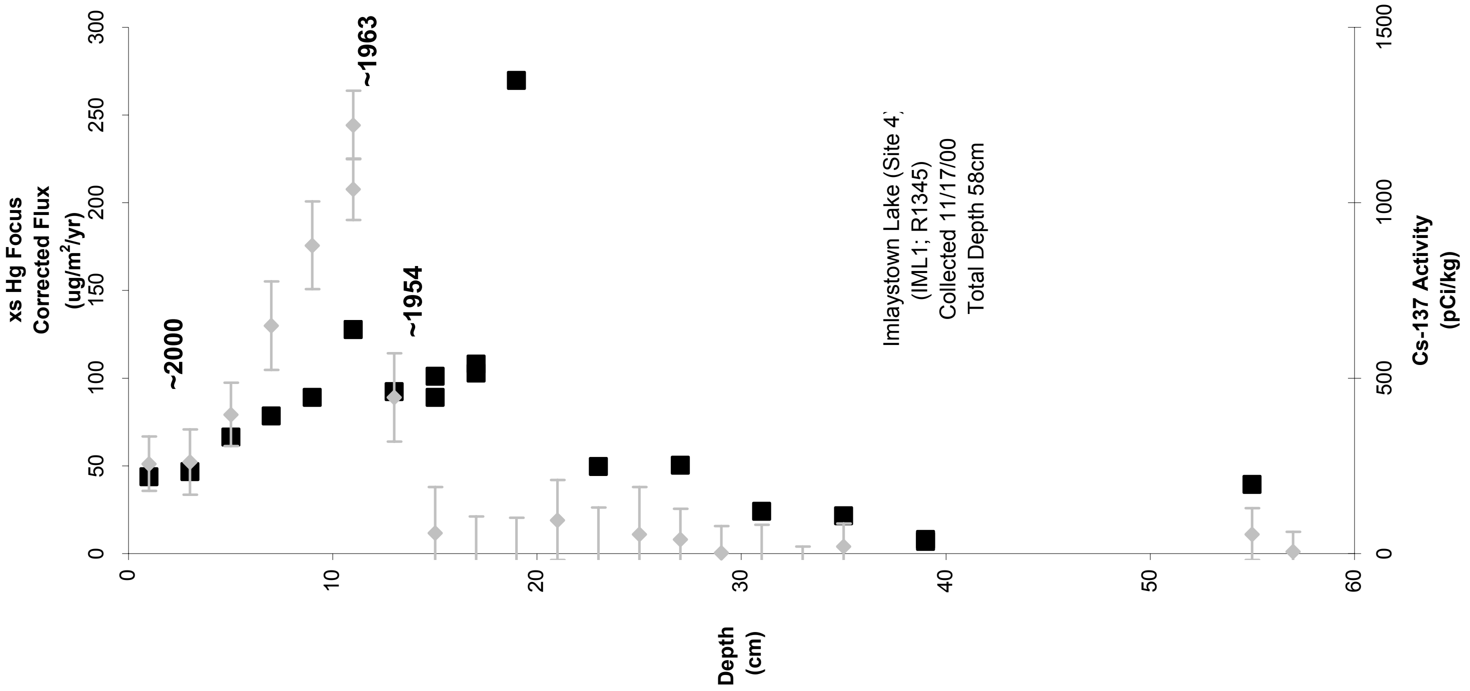
APPENDIX IV (C) Hg Flux vs Depth

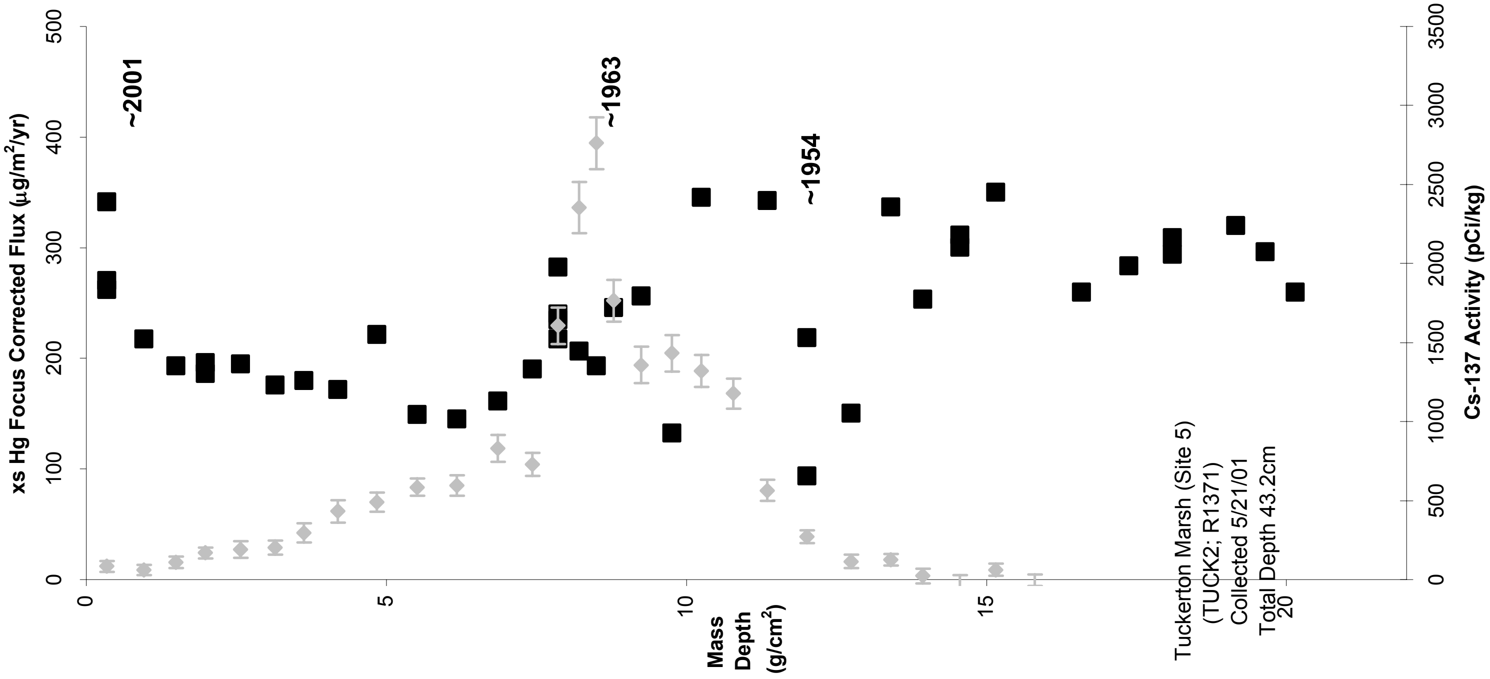

xs Hg Focus Corrected Flux (ug/m2/yr)
0
1000
2000
3000
4000
Depth (cm)
0
5
10
15
20
25
30
35
Cs-137 Activity (pCi/kg)
0
1000
2000
3000
4000
5000
~1980
~1963
~1954
Woodcliff Lake (Site 1)
RPI Archived Core
(WoodB; CN1559)
Collected 8/21/80
Total Depth 32cm

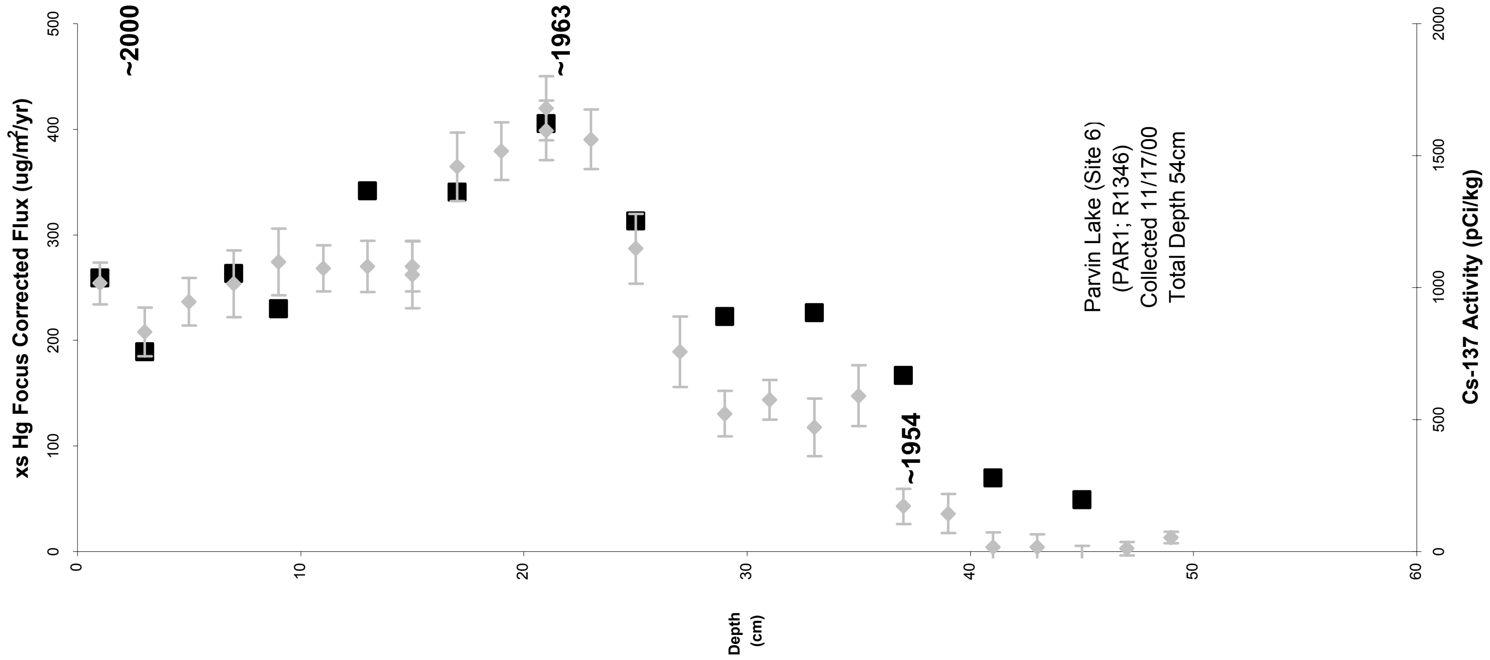

Woodcliff Lake (Site 1)
(WoodD; R1342)
Collected 10/13/00
Total Depth 32cm
(decay corrected to 8/21/80 for direct comparison to WoodE
~2000
xs Hg Focus Corrected Flux (ug/m^2/yr)
0
500
1000
1500
2000
2500
3000
Cs-137 Activity (pCi/kg)
-500
500
1500
2500
3500
4500
Depth
(cm)
0
5
10
15
20
25
30
35

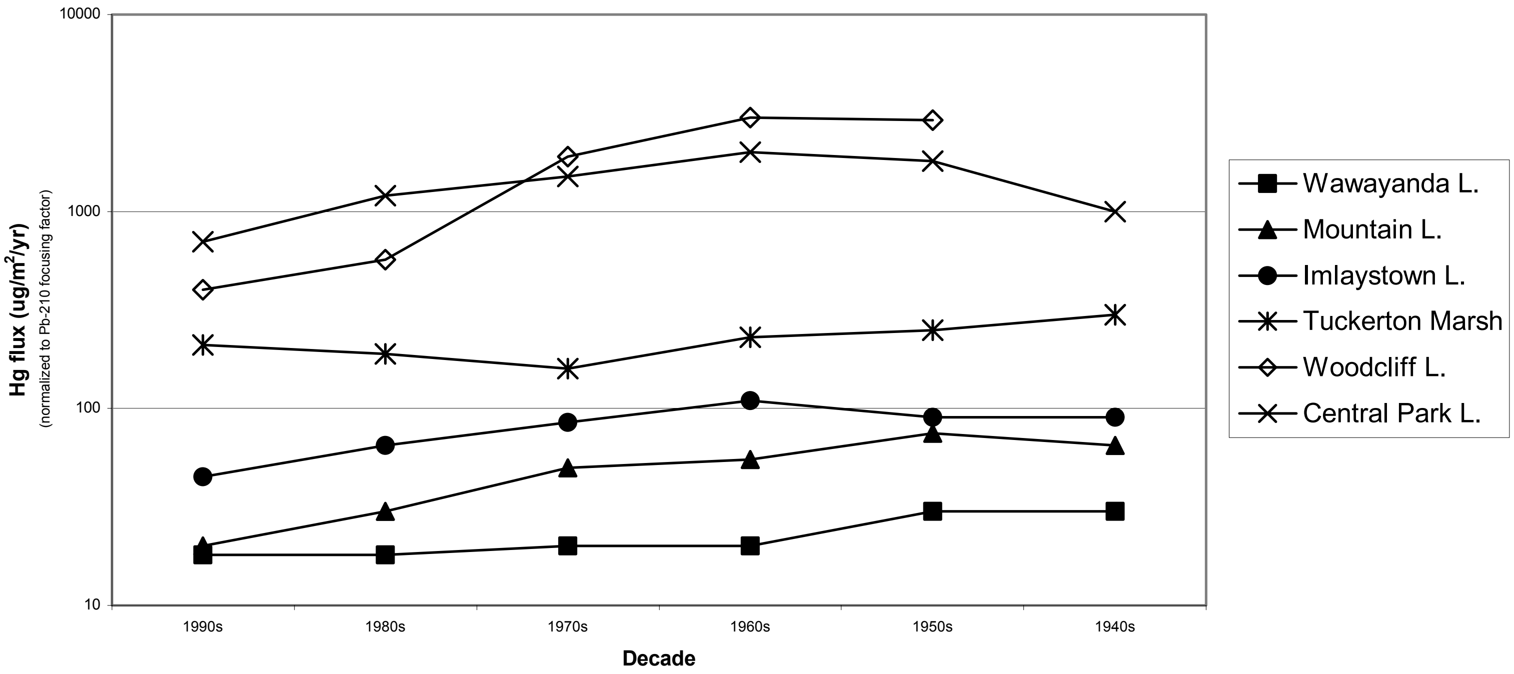

Wawayanda Lake (Site 2)
(WAY1; R1377)
Collected 7/9/01
Total Depth 33cm
xs Hg Focus Corrected Flux (ug/m^2/yr)
Cs-137 Activity (pCi/kg)
Depth (cm)
~1980-90s
~19[illegible]0-70s
~1[illegible]0-50s
0
5
10
15
20
25
30
35
0
1000
2000
3000
4000
5000
6000


~2000
~1963
~1954
Mountain Lake (Site 3)
(MTN2; R1340)
Collected 9/29/00
Total Depth 28cm
xs Hg Focus Corrected Flux (ug/m^2/yr)
0
20
40
60
80
100
120
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
2500
3000
Depth
(cm)
0
5
10
15
20
25
30


~2000
~1963
~1954
Imlaystown Lake (Site 4)
(IML1; R1345)
Collected 11/17/00
Total Depth 58cm
xs Hg Focus Corrected Flux (ug/m^2/yr)
0
50
100
150
200
250
300
Cs-137 Activity (pCi/kg)
0
500
1000
1500
Depth (cm)
0
10
20
30
40
50
60


xs Hg Focus Corrected Flux (µg/m²/yr)
0
100
200
300
400
500
Cs-137 Activity (pCi/kg)
0
500
1000
1500
2000
2500
3000
3500
Mass Depth (g/cm²)
0
5
10
15
20
~2001
~1963
~1954
Tuckerton Marsh (Site 5)
(TUCK2; R1371)
Collected 5/21/01
Total Depth 43.2cm


~2000
~1963
~1954
Parvin Lake (Site 6)
(PAR1; R1346)
Collected 11/17/00
Total Depth 54cm
xs Hg Focus Corrected Flux (ug/m²/yr)
Cs-137 Activity (pCi/kg)
Depth
(cm)
0
100
200
300
400
500
0
500
1000
1500
2000
0
10
20
30
40
50
60


10000
1000
100
10
Hg flux (ug/m2/yr)
(normalized to Pb-210 focusing factor)
1990s
1980s
1970s
1960s
1950s
1940s
Decade
Wawayanda L.
Mountain L.
Imlaystown L.
Tuckerton Marsh
Woodcliff L.
Central Park L.