Additional Results

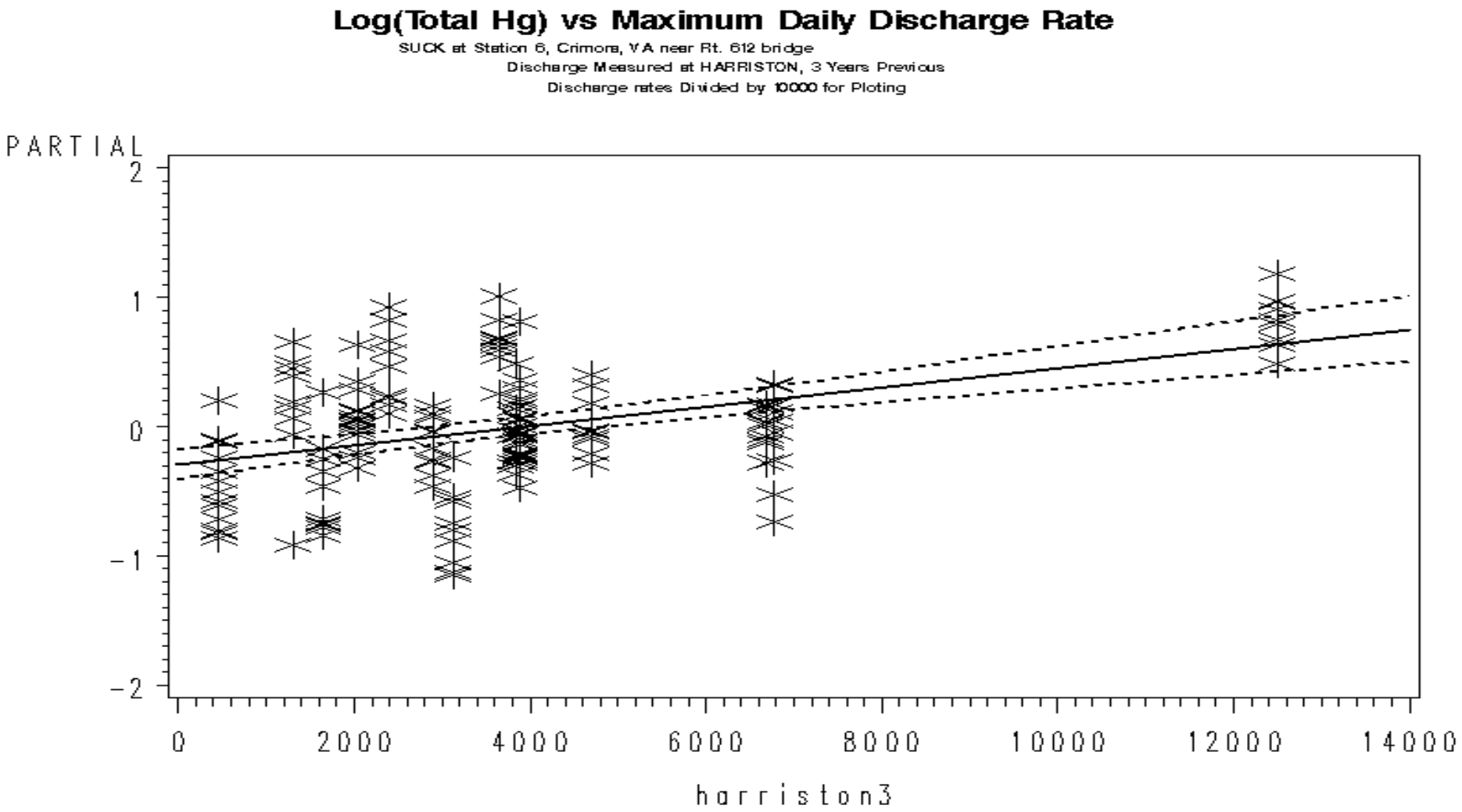
- **Additional, similar slides are provided for the other species (Sunfish, Redbreast, more sucker)**

- **An appendix is given indicating how the assumptions underlying the modeling were done and what the results were**

Regression of Log(Adjusted Hg) vs Year
SUCK at Station 6, Crimora, VA near Rt. 612 bridge

model	rsquare	ratio/rsqr	Source	DF	FValue	ProbF
Year	.	.	Model	14	29.15	<.0001
Year	.	.	Error	153	_	_
Year	.	.	Corrected Total	167	_	_
Year	0.727317	.	R-Square	.	.	.
Hydro	.	.	Model	4	15.58	<.0001
Hydro	.	.	Error	154	_	_
Hydro	.	.	Corrected Total	158	_	_
Hydro	0.288152	40	R-Square	.	.	.
Hydro	.	.	harriston0	1	7.81	0.0058
Hydro	.	.	harriston1	1	0.01	0.9195
Hydro	.	.	harriston2	1	3.56	0.0609
Hydro	.	.	harriston3	1	39.65	<.0001

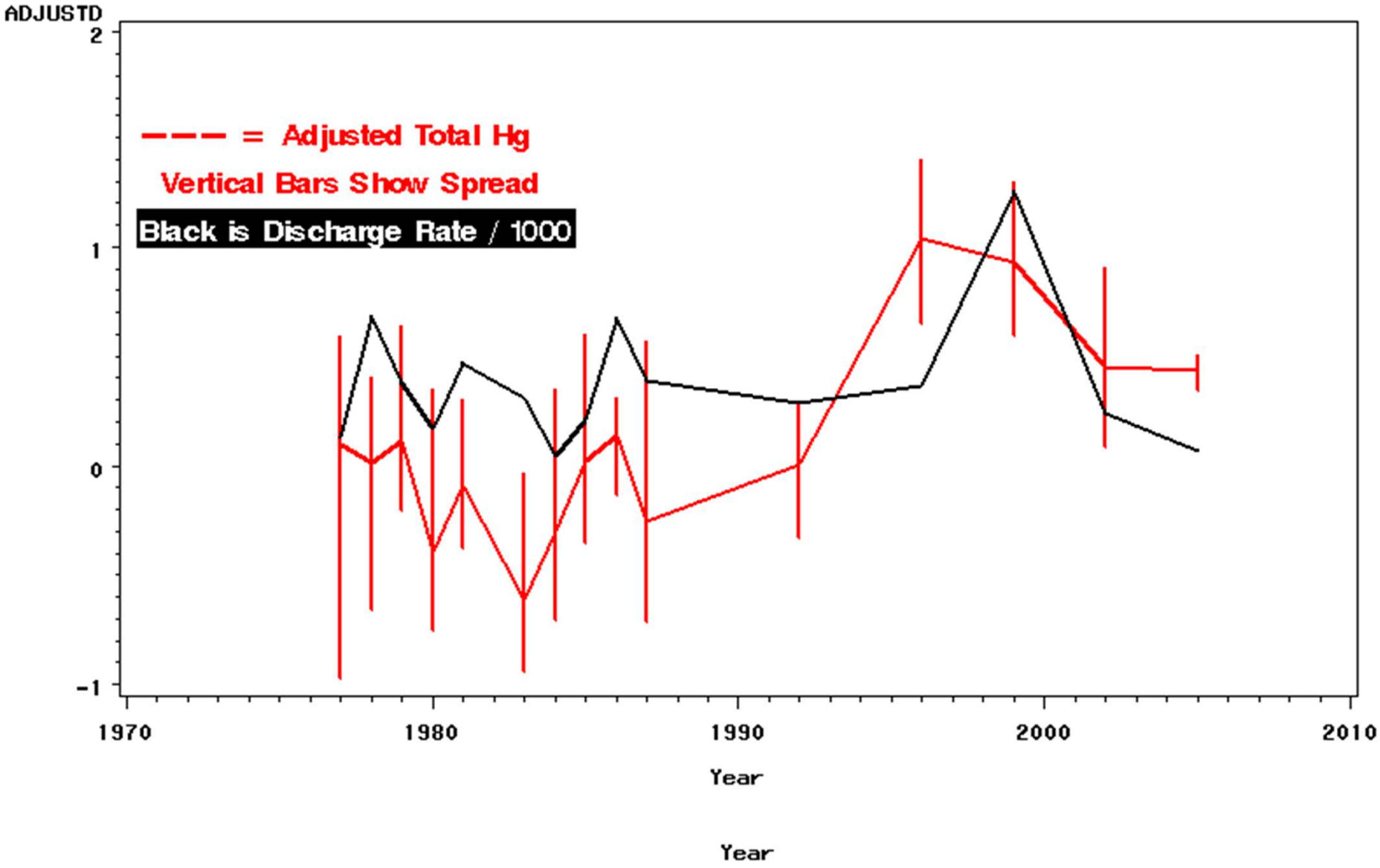
Parameter	Estimate	StdErr	tValue	Probt
Intercept	-.3072999791	0.11654677	-2.64	0.0092
harriston0	0.0000366278	0.00001310	2.80	0.0058
harriston1	0.0000010174	0.00001005	0.10	0.9195
harriston2	-.0000155019	0.00000821	-1.89	0.0609
harriston3	0.0000793659	0.00001260	6.30	<.0001



Partial regression plot showing relationship of THg vs Lag 3 discharge rate after correcting for lags 0, 1, and 2. This corresponds to ANOVA table on previous slide. Upward trend not entirely driven by high 1996 discharge rate.

Log(Adjusted Hg) vs Maximum Daily Discharge Rate

SUCK at Station 6, Crimora, VA near Rt. 612 bridge
Discharge Measured at Harriston, 3 Years Previous
Discharge rates Divided by 10000 for Ploting

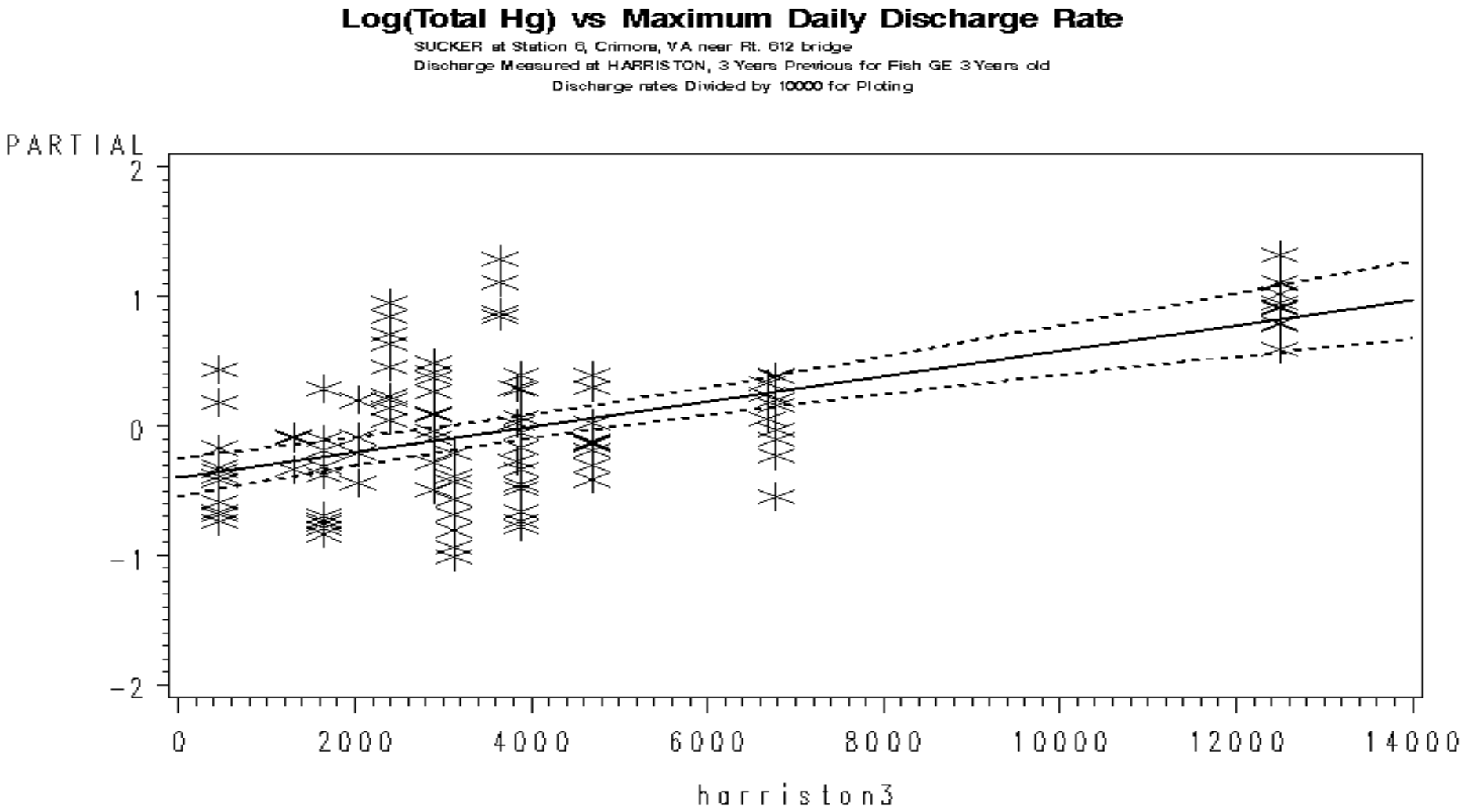


Year

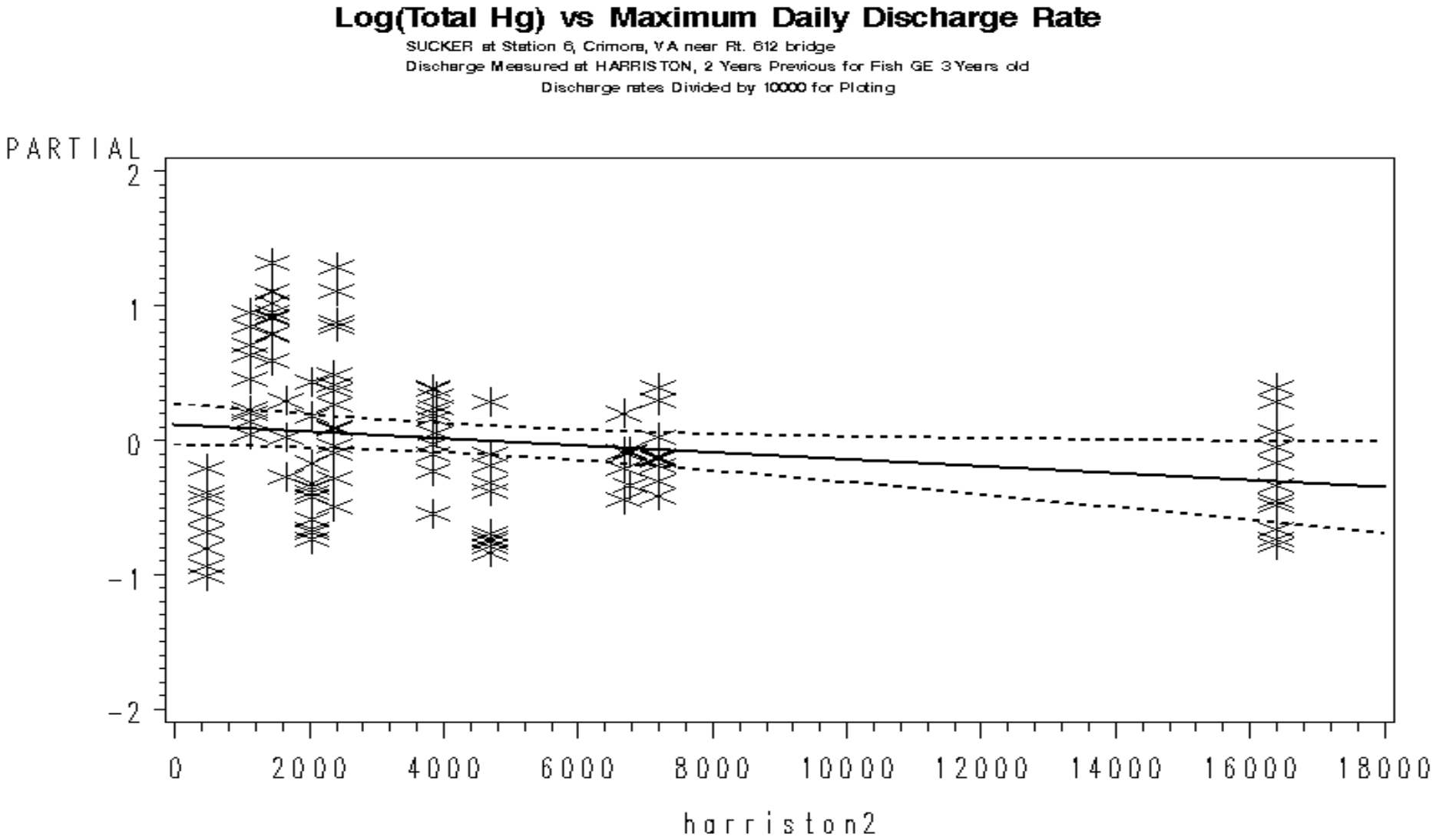
Regression of Log(Total Hg) vs Year for Fish GE 3 Years old SUCKER at Station 6, Crimora, VA near Rt. 612 bridge

model	rsquare	ratio/rsqr	Source	DF	FValue	ProbF
Year	.	.	Model	13	19.23	<.0001
Year	.	.	Error	91	_	_
Year	.	.	Corrected Total	104	_	_
Year	0.733087	.	R-Square	.	.	.
Hydro	.	.	Model	4	12.89	<.0001
Hydro	.	.	Error	100	_	_
Hydro	.	.	Corrected Total	104	_	_
Hydro	0.34018	46	R-Square	.	.	.
Hydro	.	.	harriston0	1	0.12	0.7320
Hydro	.	.	harriston1	1	0.06	0.8064
Hydro	.	.	harriston2	1	3.84	0.0527
Hydro	.	.	harriston3	1	43.46	<.0001

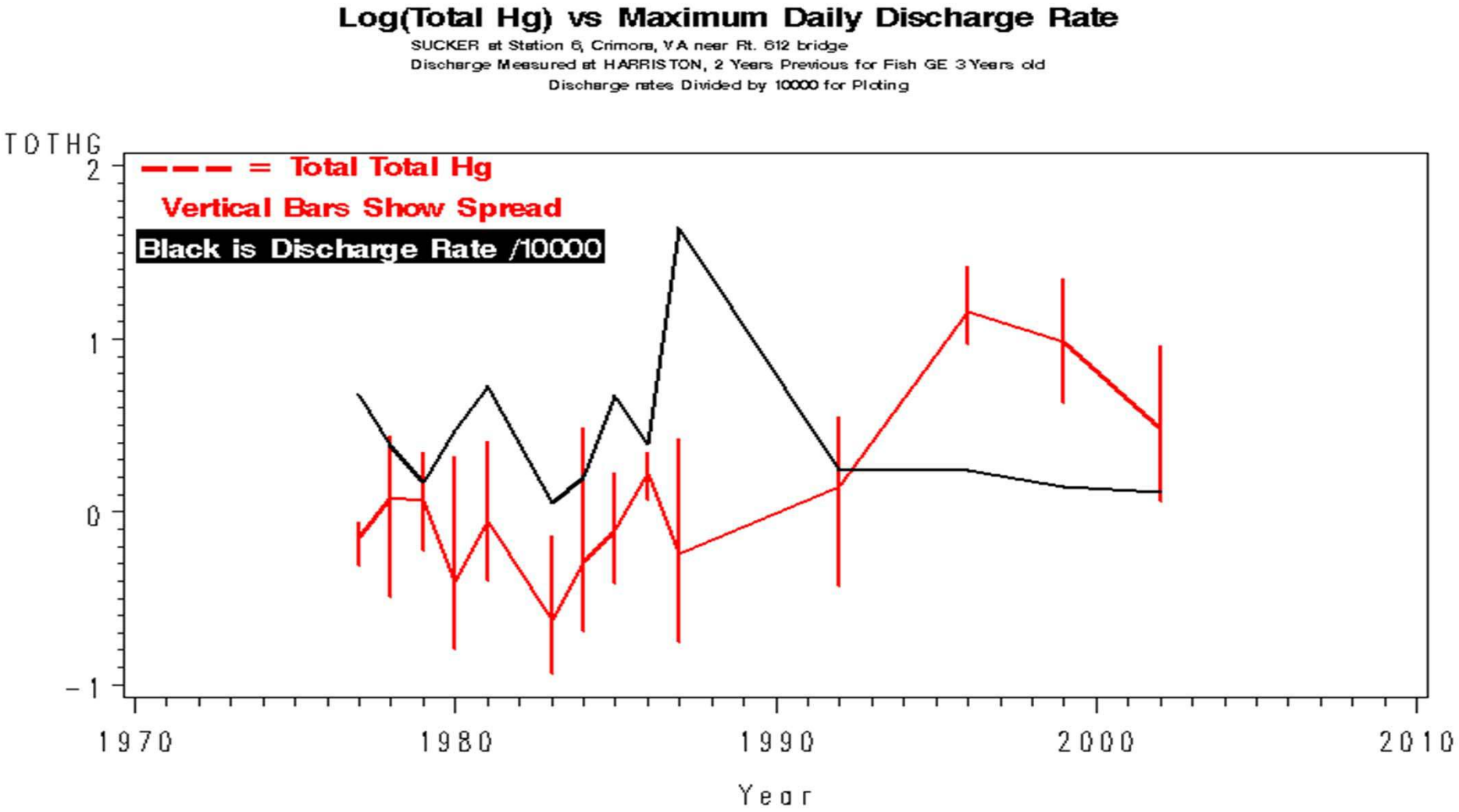
Parameter	Estimate	StdErr	tValue	Probt
Intercept	-.2553185602	0.15528895	-1.64	0.1033
harriston0	0.0000065001	0.00001893	0.34	0.7320
harriston1	-.0000039737	0.00001618	-0.25	0.8064
harriston2	-.0000224507	0.00001145	-1.96	0.0527
harriston3	0.0000958463	0.00001454	6.59	<.0001



Partial regression plot showing relationship of THg vs Lag 3 discharge rate after correcting for lags 0, 1, and 2. This corresponds to ANOVA table on previous slide. Upward trend clear, not entirely driven by high 1996 discharge rate.



Partial regression plot showing relationship of THg vs Lag 2 discharge rate after correcting for lags 0, 1, and 3. This corresponds to ANOVA table on previous slide. Downward trend entirely driven by high 1985 discharge rate. See next slide for further detail.

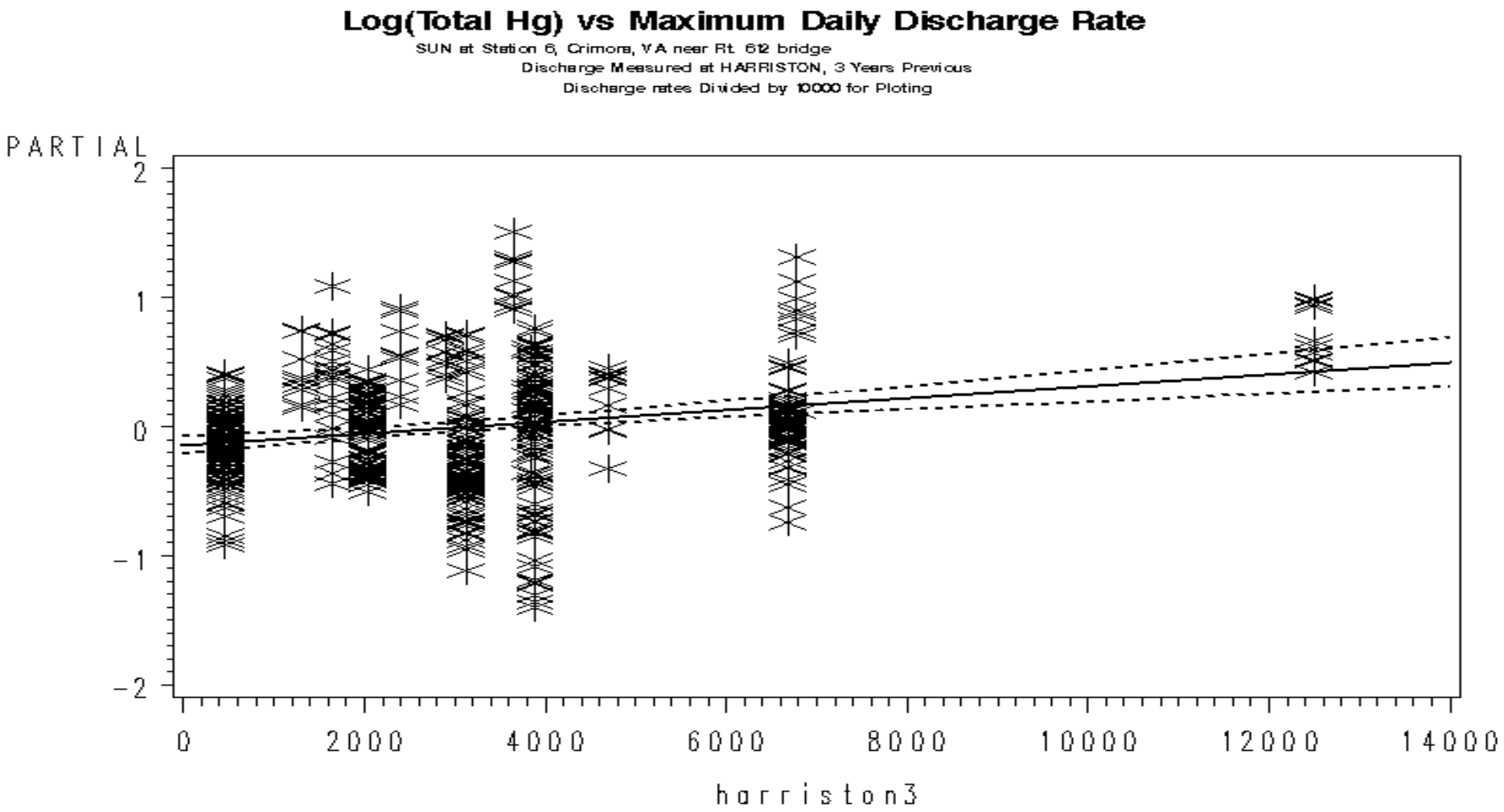


Almost significant negative correlation in 2-yr lag due in large part to 1985 inverse patterns in discharge rate and fish tissue Hg.

Regression of Log(Adjusted Hg) vs Year
SUN at Station 6, Crimora, VA near Rt. 612 bridge

model	rsquare	ratio/rsqr	Source	DF	FValue	ProbF
Year	.	.	Model	15	34.34	<.0001
Year	.	.	Error	505	_	_
Year	.	.	Corrected Total	520	_	_
Year	0.504942	.	R-Square	.	.	.
Hydro	.	.	Model	4	22.67	<.0001
Hydro	.	.	Error	507	_	_
Hydro	.	.	Corrected Total	511	_	_
Hydro	0.151711	30	R-Square	.	.	.
Hydro	.	.	harriston0	1	0.01	0.9375
Hydro	.	.	harriston1	1	14.74	0.0001
Hydro	.	.	harriston2	1	1.63	0.2018
Hydro	.	.	harriston3	1	33.28	<.0001

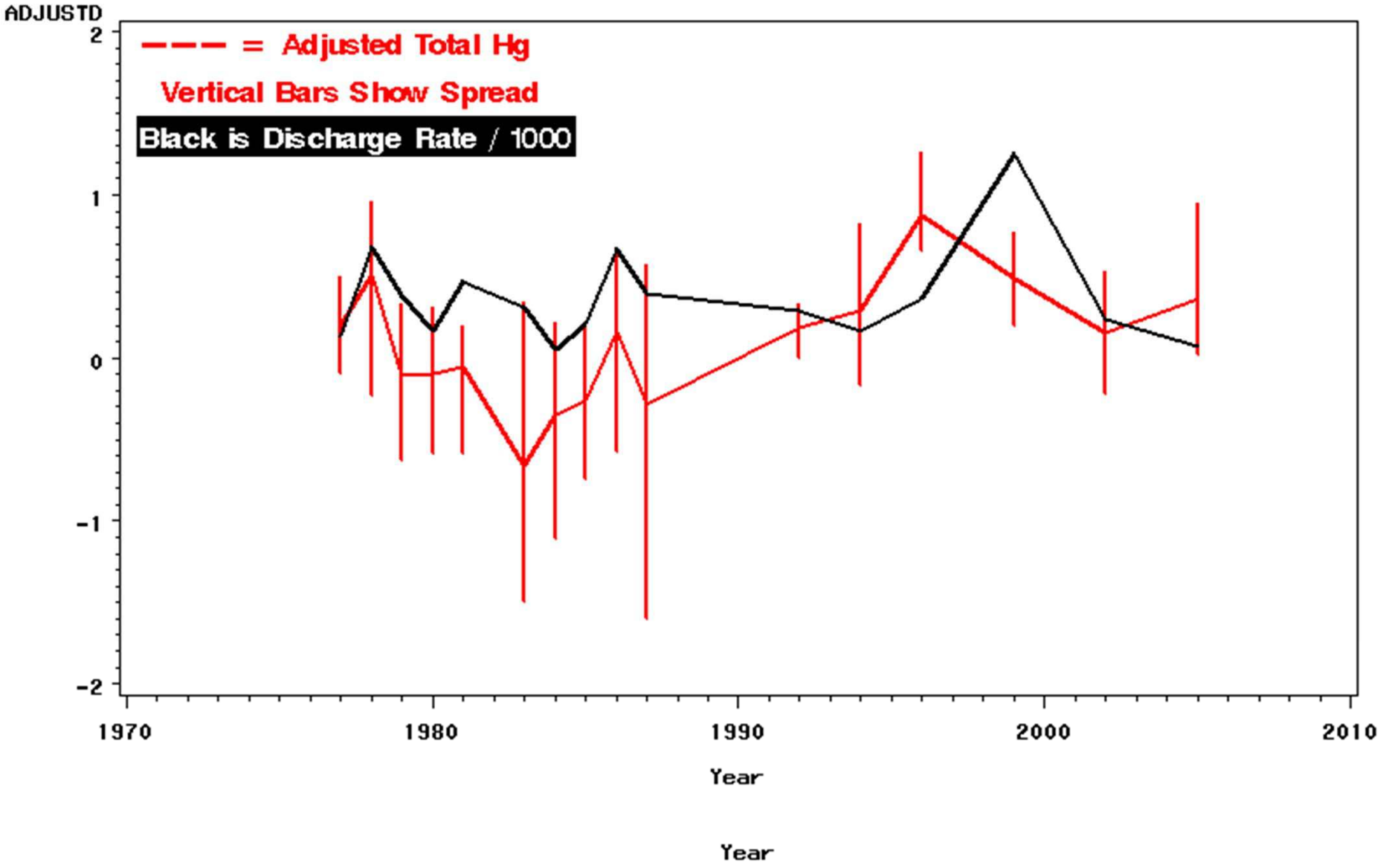
Parameter	Estimate	StdErr	tValue	Probt
Intercept	-.5391484713	0.09000146	-5.99	<.0001
harriston0	-.0000009513	0.00001213	-0.08	0.9375
harriston1	0.0000243803	0.00000635	3.84	0.0001
harriston2	0.0000070985	0.00000555	1.28	0.2018
harriston3	0.0000535933	0.00000929	5.77	<.0001



Partial regression plot showing relationship of THg vs Lag3 discharge rate after correcting for lags 0, 1, and 2. This corresponds to ANOVA table on previous slide. Upward trend not entirely driven by storm event in 1996.

Log(Adjusted Hg) vs Maximum Daily Discharge Rate

SUN at Station 6, Crimora, VA near Rt. 612 bridge
Discharge Measured at Harriston, 3 Years Previous
Discharge rates Divided by 10000 for Ploting

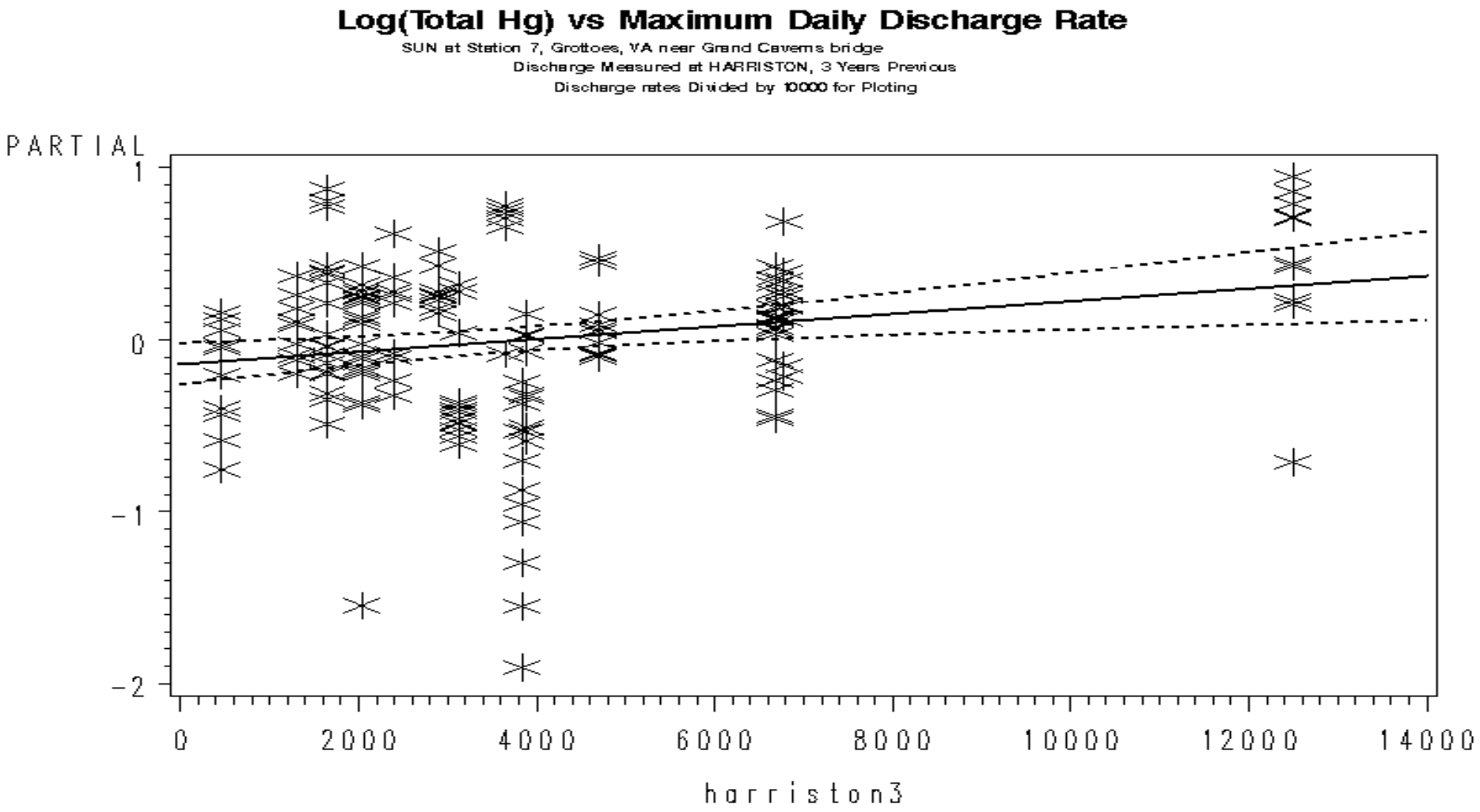


Year

Regression of Log(Adjusted Hg) vs Year
SUN at Station 7, Grottoes, VA near Grand Caverns bridge

model	rsquare	ratio/rsqr	Source	DF	FValue	ProbF
Year	.	.	Model	15	15.72	<.0001
Year	.	.	Error	156	_	_
Year	.	.	Corrected Total	171	_	_
Year	0.601895	.	R-Square	.	.	.
Hydro	.	.	Model	4	4.72	0.0013
Hydro	.	.	Error	158	_	_
Hydro	.	.	Corrected Total	162	_	_
Hydro	0.106737	18	R-Square	.	.	.
Hydro	.	.	harriston0	1	0.22	0.6420
Hydro	.	.	harriston1	1	2.95	0.0880
Hydro	.	.	harriston2	1	4.24	0.0412
Hydro	.	.	harriston3	1	9.49	0.0024

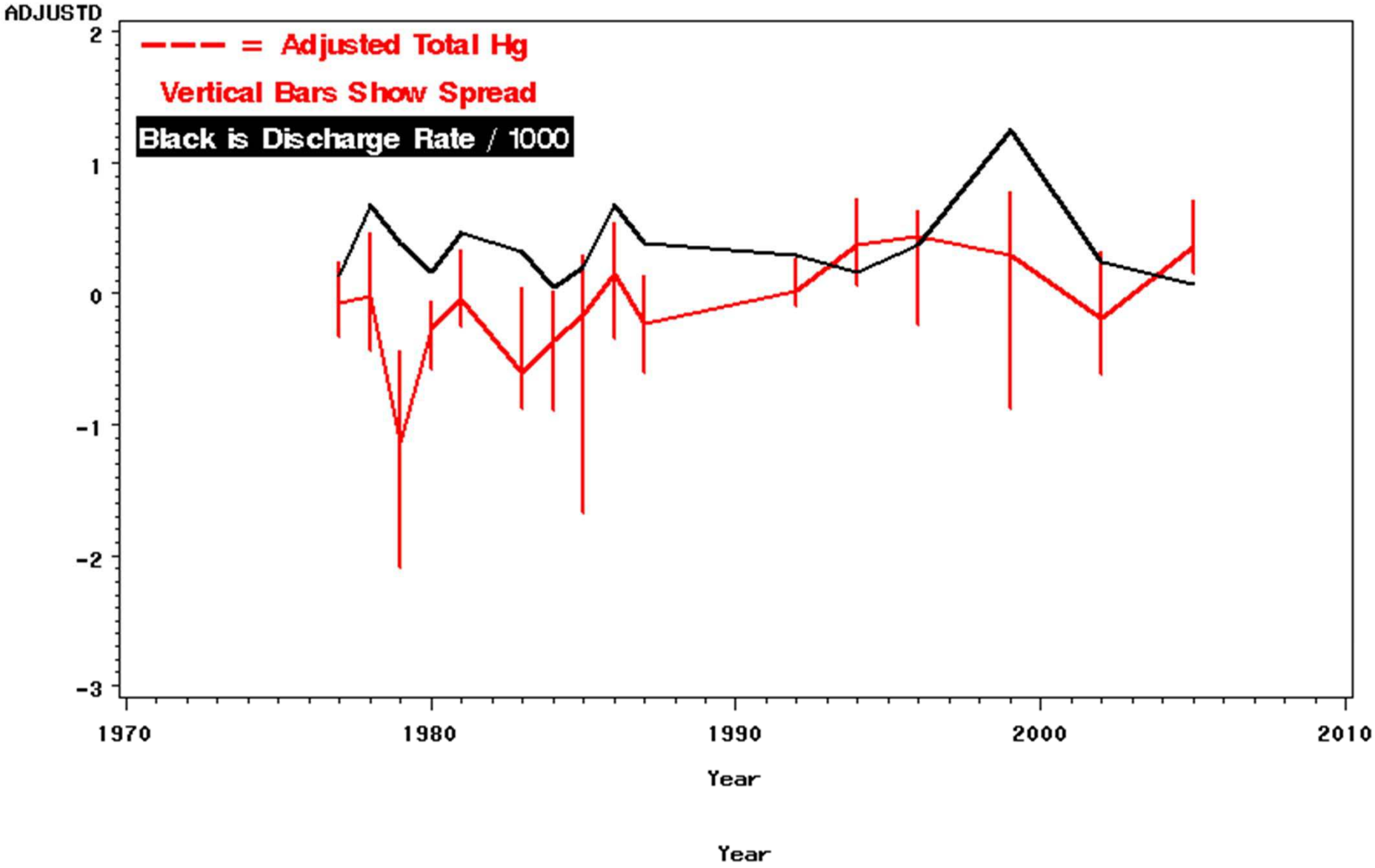
Parameter	Estimate	StdErr	tValue	Probt
Intercept	-.5109349778	0.12714318	-4.02	<.0001
harriston0	0.0000074135	0.00001592	0.47	0.6420
harriston1	0.0000165712	0.00000965	1.72	0.0880
harriston2	0.0000227651	0.00001106	2.06	0.0412
harriston3	0.0000408708	0.00001327	3.08	0.0024



Partial regression plot showing relationship of THg vs Lag 3 discharge rate after correcting for lags 0, 1, and 2. This corresponds to ANOVA table on previous slide.

Log(Adjusted Hg) vs Maximum Daily Discharge Rate

SUN at Station 7, Grottoes, VA near Grand Caverns bridge
Discharge Measured at Harriston, 3 Years Previous
Discharge rates Divided by 10000 for Ploting

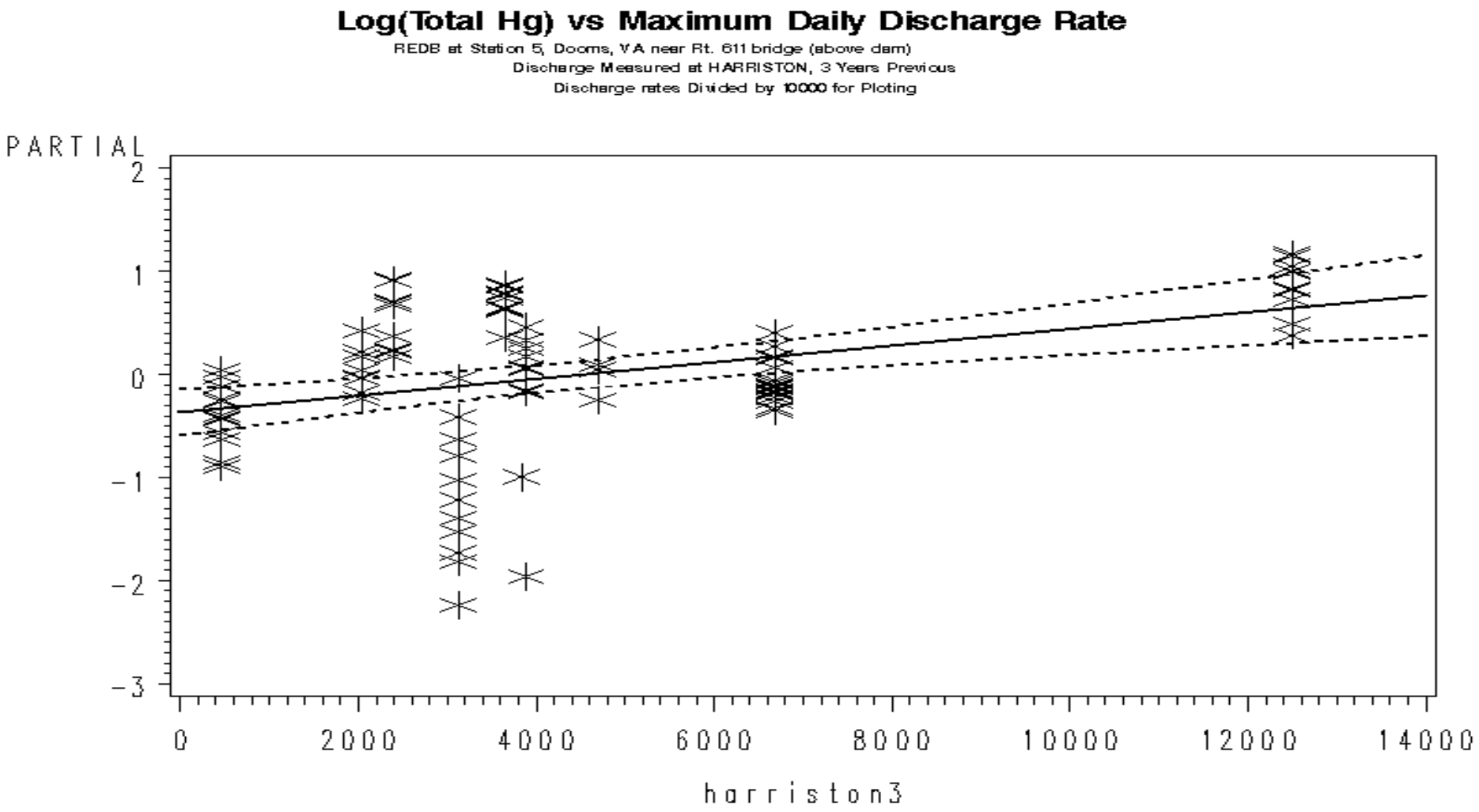


Year

Regression of Log(Adjusted Hg) vs Year
REDB at Station 5, Dooms, VA near Rt. 611 bridge (above dam)

model	rsquare	ratio/rsqr	Source	DF	FValue	ProbF
Year	.	.	Model	10	27.55	<.0001
Year	.	.	Error	93	_	_
Year	.	.	Corrected Total	103	_	_
Year	0.747618	.	R-Square	.	.	.
Hydro	.	.	Model	4	6.23	0.0002
Hydro	.	.	Error	90	_	_
Hydro	.	.	Corrected Total	94	_	_
Hydro	0.216826	29	R-Square	.	.	.
Hydro	.	.	harriston0	1	5.43	0.0220
Hydro	.	.	harriston1	1	0.08	0.7831
Hydro	.	.	harriston2	1	0.17	0.6789
Hydro	.	.	harriston3	1	19.85	<.0001

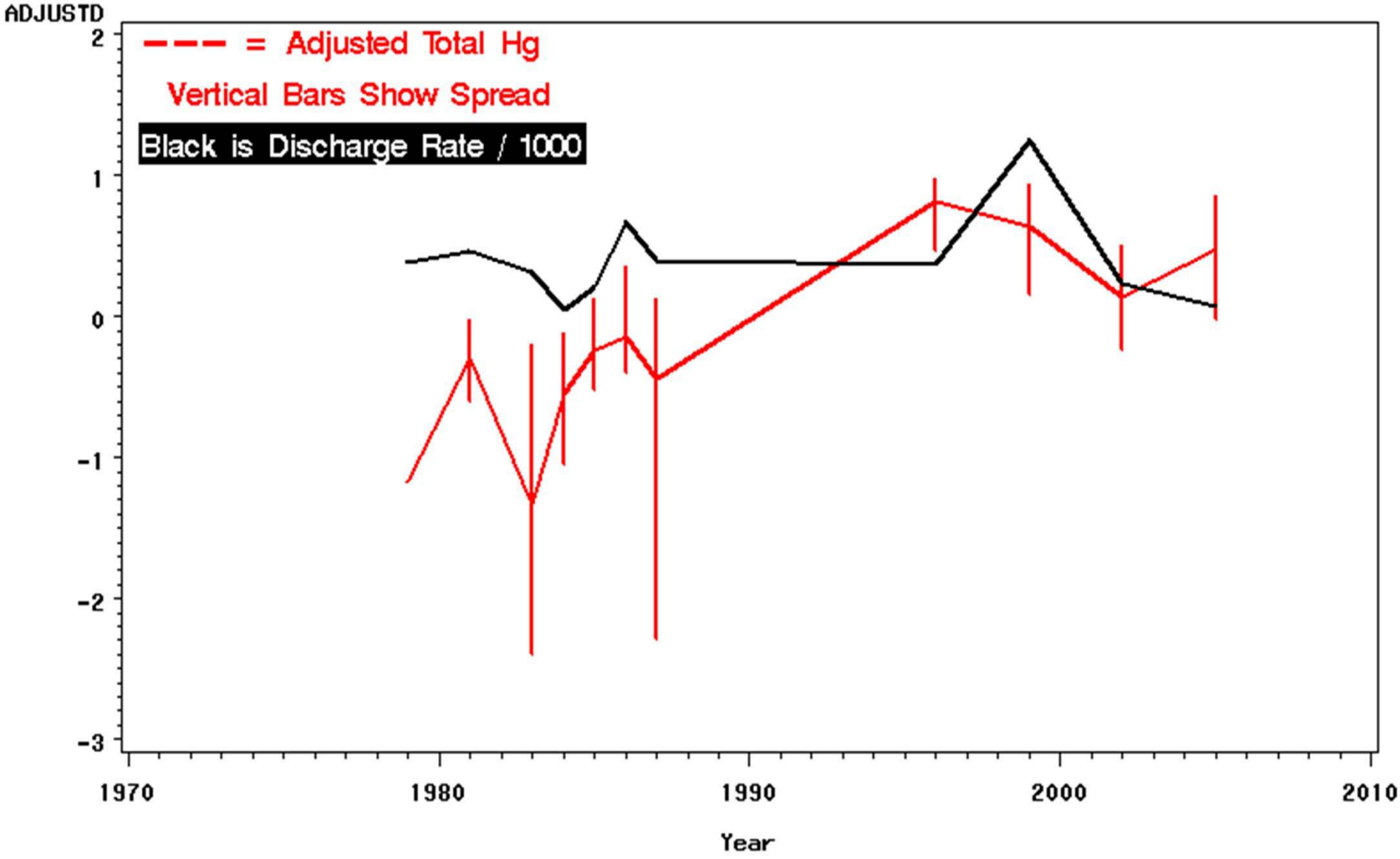
Parameter	Estimate	StdErr	tValue	Probt
Intercept	-.8359939275	0.19997890	-4.18	<.0001
harriston0	0.0000478323	0.00002052	2.33	0.0220
harriston1	0.0000038913	0.00001410	0.28	0.7831
harriston2	0.0000068096	0.00001639	0.42	0.6789
harriston3	0.0000965877	0.00002168	4.46	<.0001



Partial regression plot showing relationship of THg vs Lag3 discharge rate after correcting for lags 0, 1, and 2. This corresponds to ANOVA table on previous slide.

Log(Adjusted Hg) vs Maximum Daily Discharge Rate

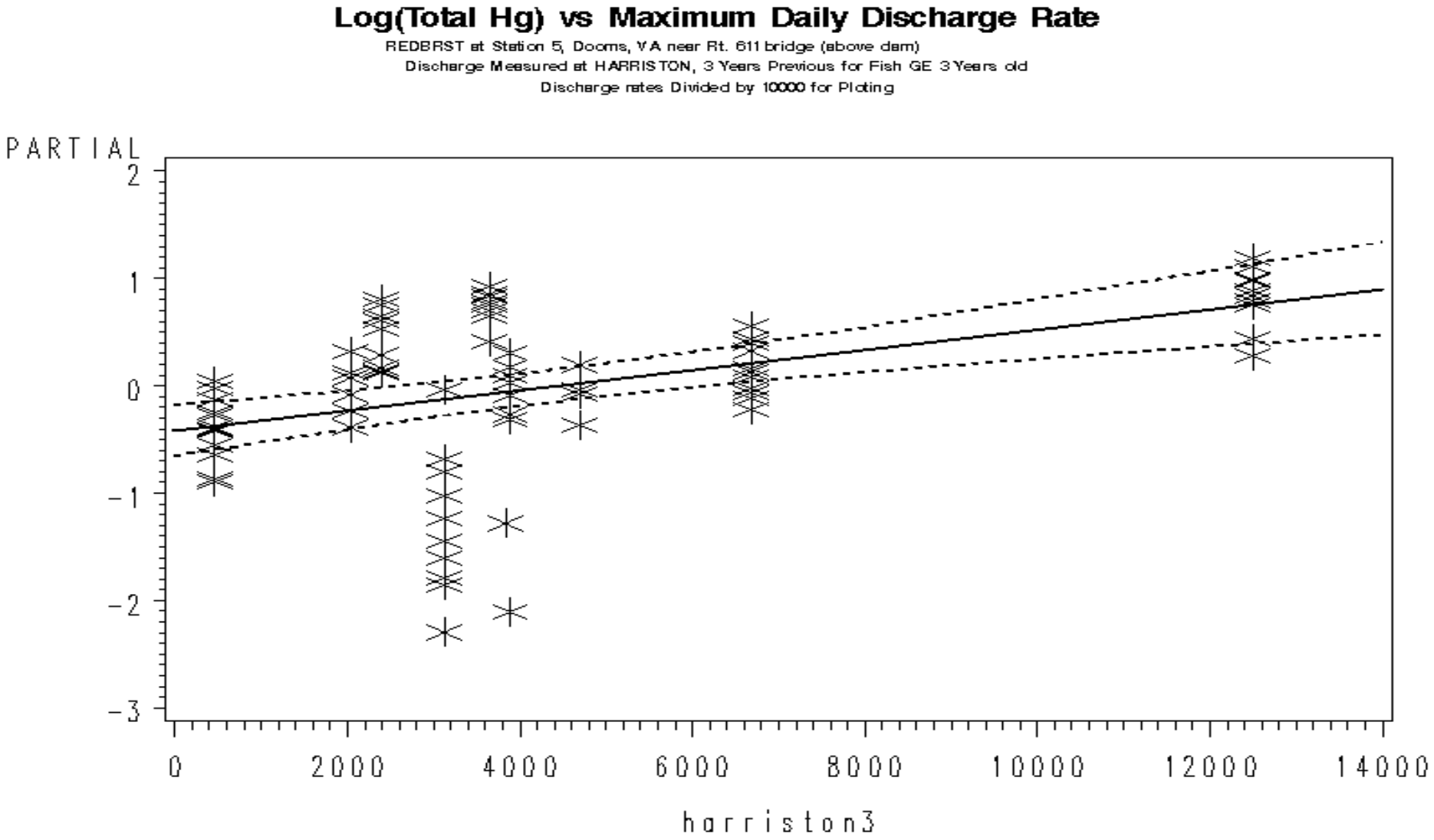
REDB at Station 5, Dooms, VA near Rt. 611 bridge (above dam)
Discharge Measured at Harriston, 3 Years Previous
Discharge rates Divided by 10000 for Ploting



Regression of Log(Total Hg) vs Year for Fish GE 3 Years old REDBRST at Station 5, Dooms, VA near Rt. 611 bridge (above dam)

model	rsquare	ratio/rsqr	Source	DF	FValue	ProbF
Year	.	.	Model	9	24.64	<.0001
Year	.	.	Error	74	_	_
Year	.	.	Corrected Total	83	_	_
Year	0.749808	.	R-Square	.	.	.
Hydro	.	.	Model	4	5.14	0.0010
Hydro	.	.	Error	79	_	_
Hydro	.	.	Corrected Total	83	_	_
Hydro	0.206608	28	R-Square	.	.	.
Hydro	.	.	harriston0	1	2.66	0.1068
Hydro	.	.	harriston1	1	0.22	0.6425
Hydro	.	.	harriston2	1	0.02	0.8930
Hydro	.	.	harriston3	1	16.75	0.0001

Parameter	Estimate	StdErr	tValue	Probt
Intercept	-.7700637989	0.21743114	-3.54	0.0007
harriston0	0.0000357330	0.00002191	1.63	0.1068
harriston1	0.0000082466	0.00001769	0.47	0.6425
harriston2	0.0000023717	0.00001758	0.13	0.8930
harriston3	0.0000947703	0.00002315	4.09	0.0001



Partial regression plot showing relationship of THg vs Lag 3 discharge rate after correcting for lags 0, 1, and 2. This corresponds to ANOVA table on previous slide. Positive trend evident, due only in part to high discharge rate in 1996.

Appendix

- **The following slides indicate the process followed to check the models for statistical appropriateness.**

Check of Assumptions Underlying ANCOVA, Regression

- **Normality checked by**
  - **Shapiro-Wilk test**
  - **QQ-plot**
  - **histogram with fitted normal pdf**
- **Variance homogeneity checked by**
  - **Levene test (in the so-called "W50" form)**
  - **Box plots**
- **Outliers (in total Hg) checked by**
  - **Tukey outlier rule**
  - **Re-analysis with outliers omitted**

Example Assumption Check

SUN at Station 7 Transform=LOG

EXPLANATORY VARIABLE IS YEAR

TESTS OF NORMALITY OF ADJUSTD: FULL DATA SET

Test	Label	Stat	pType	Sign	pValue
Shapiro-Wilk	W	0.939295	Pr < W	<	0.0001
Kolmogorov-Smirnov	D	0.070765	Pr > D		0.0346
Cramer-von Mises	W-Sq	0.138101	Pr > W-Sq		0.0358
Anderson-Darling	A-Sq	1.167841	Pr > A-Sq	<	0.0050

POSSIBLE OUTLIERS FROM ANOVA ON ADJUSTD

Obs	year	ADJUSTD	Pred	Resid	LB	UB
1	1979	-2.10215	-1.14665	-0.95551	-0.72261	0.76721
2	1985	-1.68159	-0.15912	-1.52247	-0.72261	0.76721
3	1999	-0.88512	0.28657	-1.17169	-0.72261	0.76721

LEVENE TEST FOR ADJUSTD

Effect	DF	LEVENE	P_VALUE
year	15	1.45033	0.13063

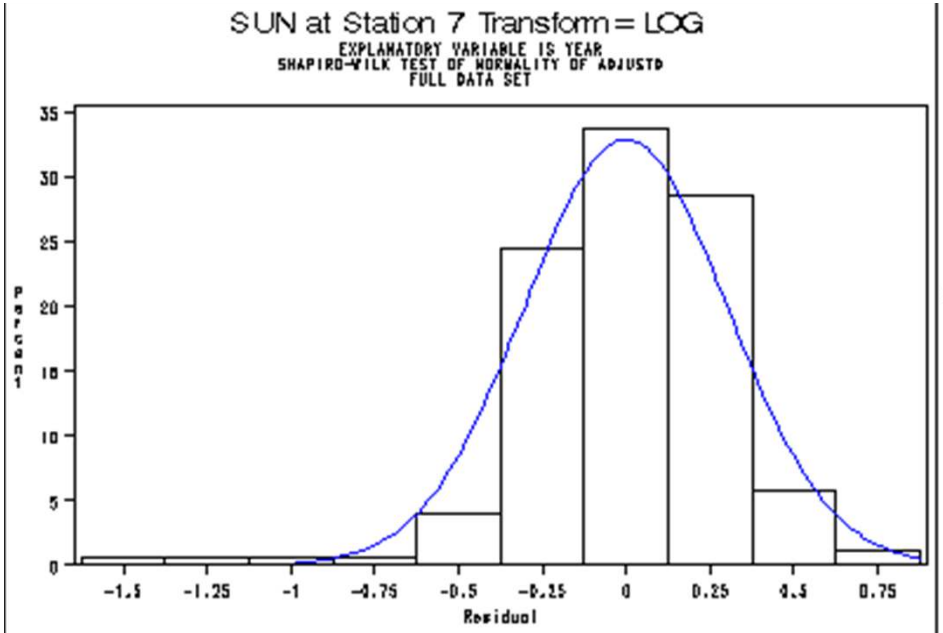
SUN at Station 7 Transform=LOG
EXPLANATORY VARIABLE IS YEAR
TESTS OF NORMALITY OF ADJUSTD: Outlier Omitted DATA SET

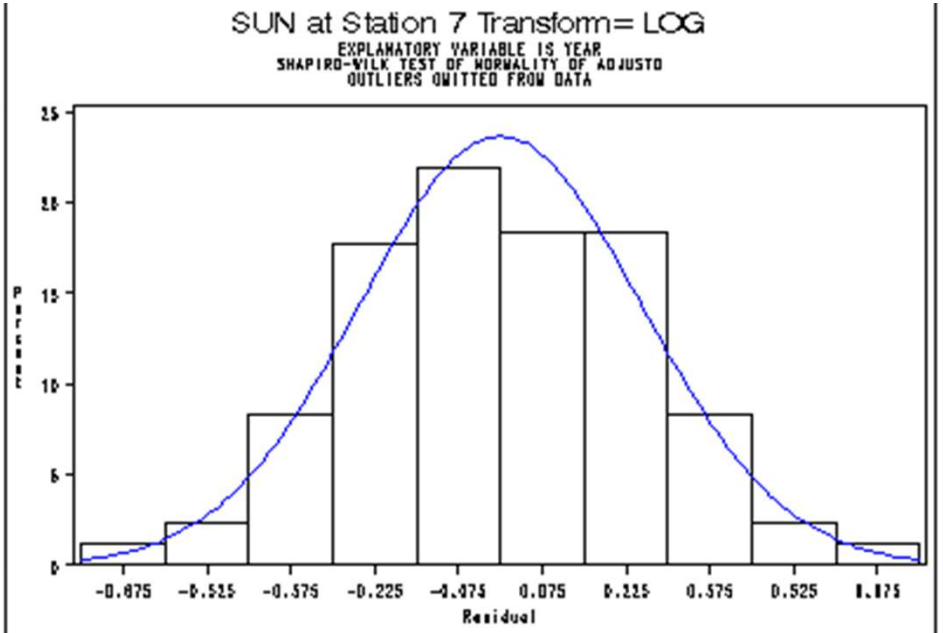
Test	Label	Stat	pType	Sign	pValue
Shapiro-Wilk	W	0.995791	Pr < W		0.9184
Kolmogorov-Smirnov	D	0.039848	Pr > D	>	0.1500
Cramer-von Mises	W-Sq	0.035728	Pr > W-Sq	>	0.2500
Anderson-Darling	A-Sq	0.217891	Pr > A-Sq	>	0.2500

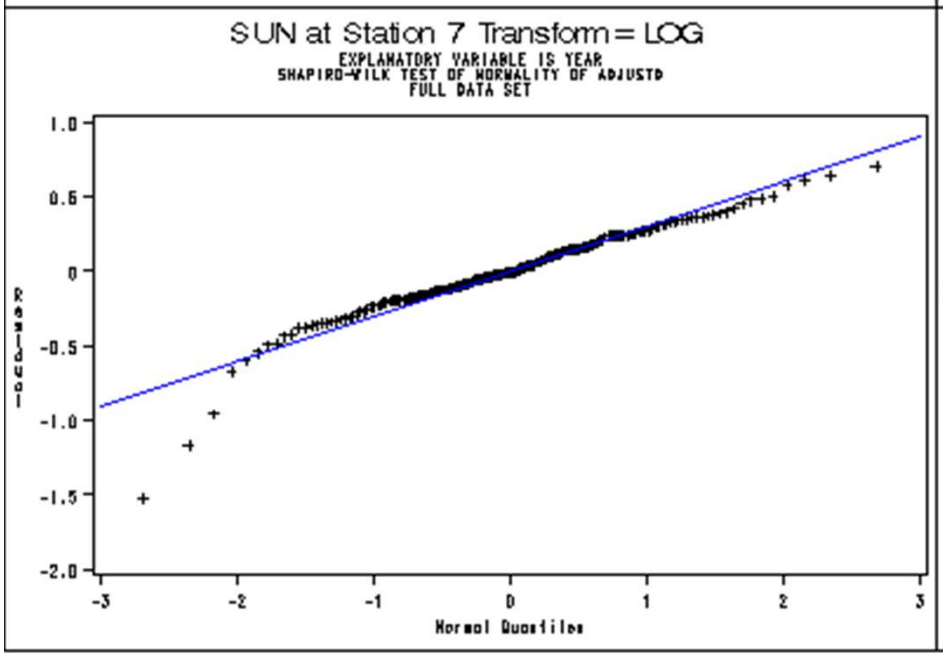
LEVENE TEST FOR ADJUSTD

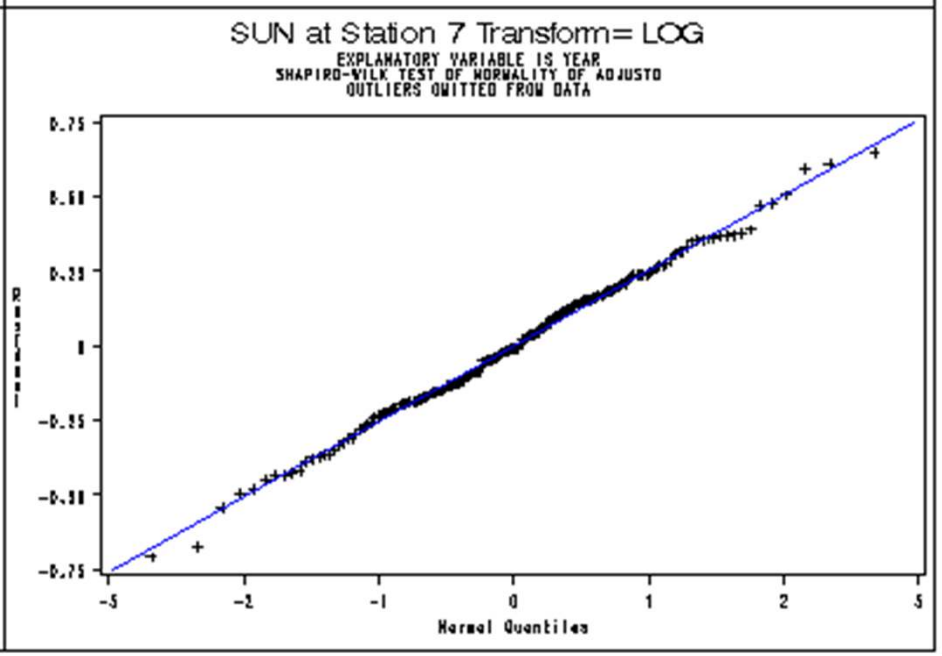
Effect	DF	LEVENE	P_VALUE
year	15	1.20951	0.27009

Omission of three low values eliminates the significant formal tests for normality.
The QQ-plot makes clear that the data are normally distributed.









Normal Quantiles

Tukey Outlier Summary

Number of Outliers Found

	species				
	LMB	REDB	SMB	SUCK	SUN
station					
3	0	1	1	8	3
5	1	4	4	3	13
6	1	8	6	3	16
7	1	2	2	3	3
8	0	5	1	4	7

Summary of Shapiro-Wilk Tests

Shapiro-Wilk Tests on Full Dataset

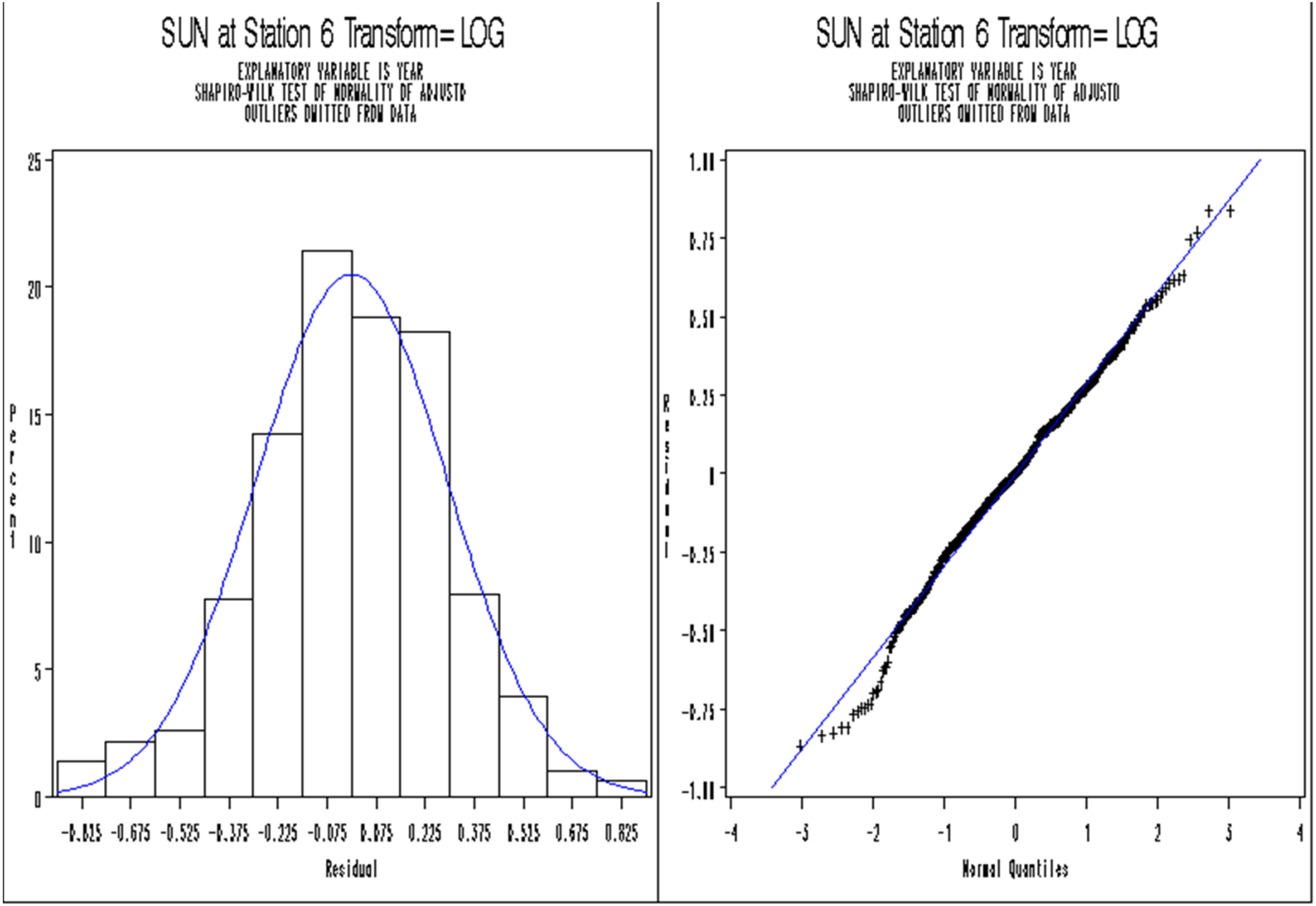
station	species LMB	REDB	SMB	SUCK	SUN
3	1.000	0.116	0.000	0.008	0.000
5	0.311	0.000	0.002	0.000	0.000
6	0.381	0.001	0.043	0.009	0.000
7	0.878	0.000	0.000	0.000	0.000
8	0.496	0.071	0.007	0.000	0.004

Shapiro-Wilk w/ Outliers Omitted

station	species LMB	REDB	SMB	SUCK	SUN
3	1.000	0.222	0.135	0.784	0.069
5	0.414	0.697	0.196	0.451	0.757
6	0.111	0.089	0.653	0.572	0.007
7	0.996	0.348	0.621	0.070	0.918
8	0.496	0.977	0.278	0.965	0.340

So all but one dataset tests as normal after removal of a small number of outliers (ranging from 0 to 8, plus one each of 13 or 16).

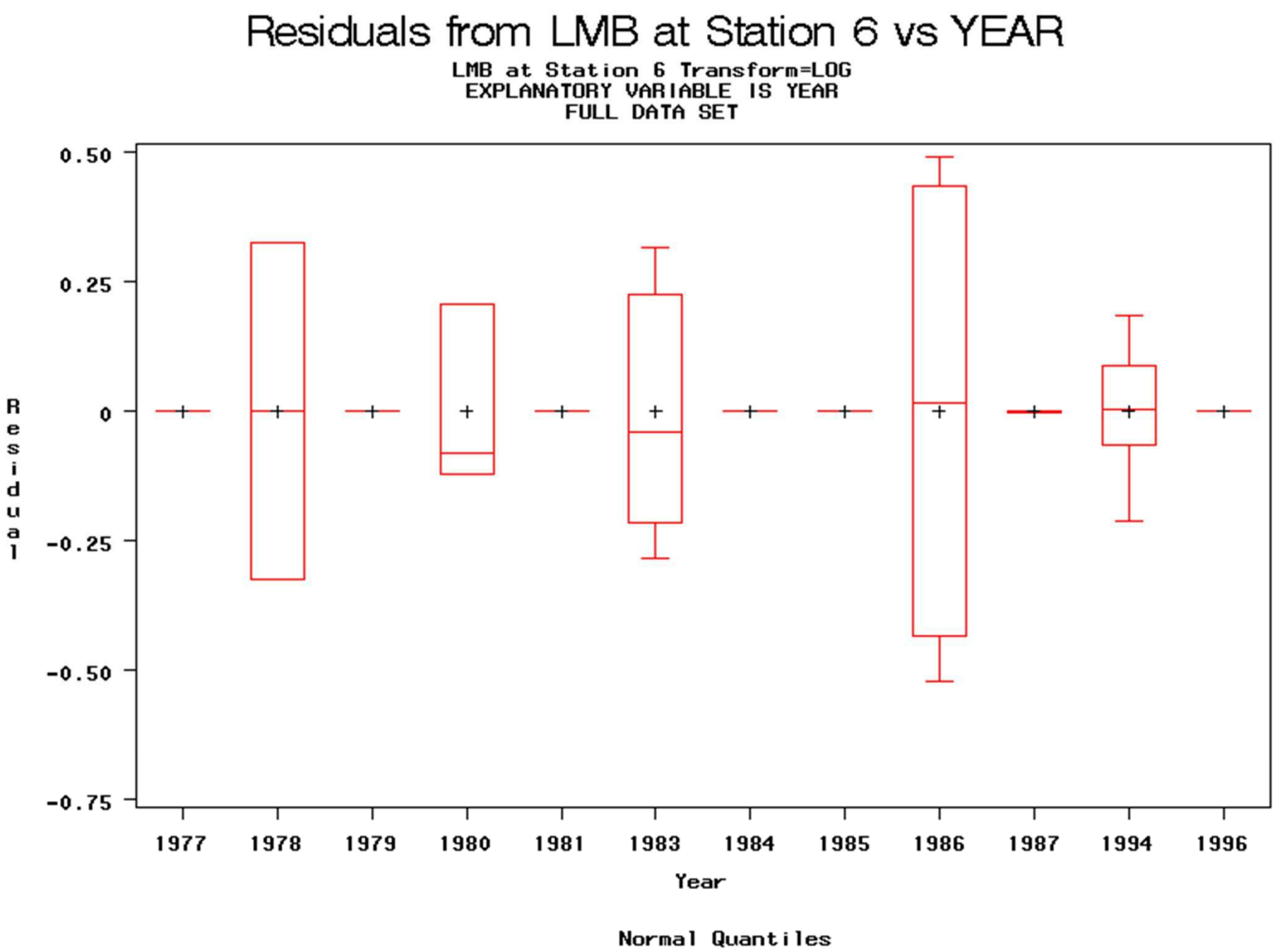
The plots following for the sole exception show a slight skewness, but little reason to question the applicability of normal-based methods.


SUN at Station 6 Transform= LOG
EXPLANATORY VARIABLE IS YEAR
SHAPIRO-WILK TEST OF NORMALITY OF ADJUSTD
OUTLIERS OMITTED FROM DATA
Percent
Residual
SUN at Station 6 Transform= LOG
EXPLANATORY VARIABLE IS YEAR
SHAPIRO-WILK TEST OF NORMALITY OF ADJUSTD
OUTLIERS OMITTED FROM DATA
Residual
Normal Quantiles

Residual

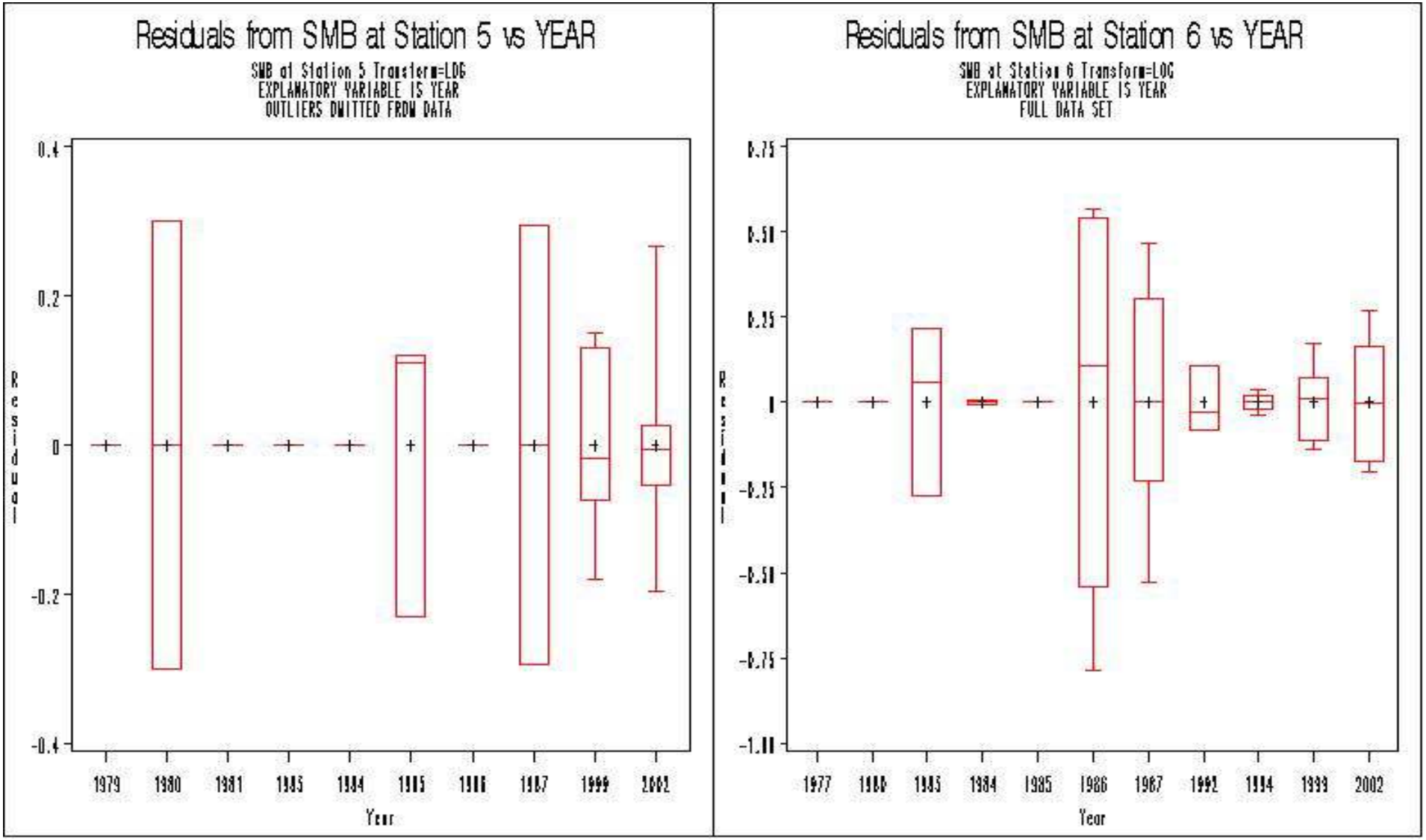
Example of Significant Levene Test for Variance Homogeneity

- **The next example makes clear that formal tests for variance homogeneity should not be taken as "true" without further examination.**
- **The Levene test is highly significant, indicating variance heterogeneity. The box plot makes clear the problem is several years with a single observation.**
  - **There is no meaningful variance heterogeneity in these data**

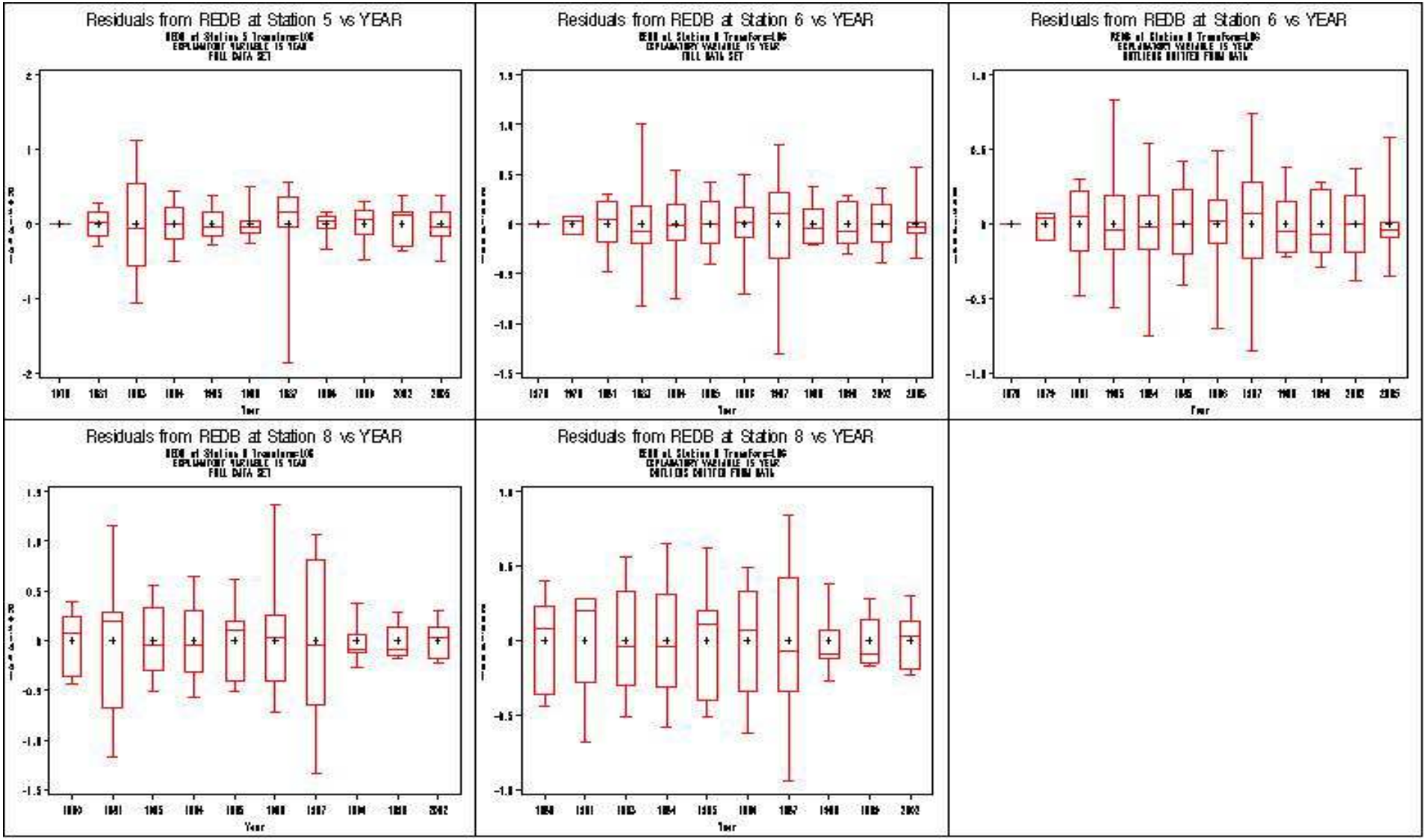

Residuals from LMB at Station 6 vs YEAR
LMB at Station 6 Transform=LOG
EXPLANATORY VARIABLE IS YEAR
FULL DATA SET
Residual
0.50
0.25
0
-0.25
-0.50
-0.75
1977
1978
1979
1980
1981
1983
1984
1985
1986
1987
1994
1996
Year
Normal Quantiles

Variance Boxplots

- **Boxplot drawn only where a significant Levene test reported**
  - **If outlier-omitted data had non-significant Levene test, boxplot not given for that**
- **If only an outlier-omitted boxplot is given then Levene test on full dataset was not significant and outlier-omitted analysis not needed**

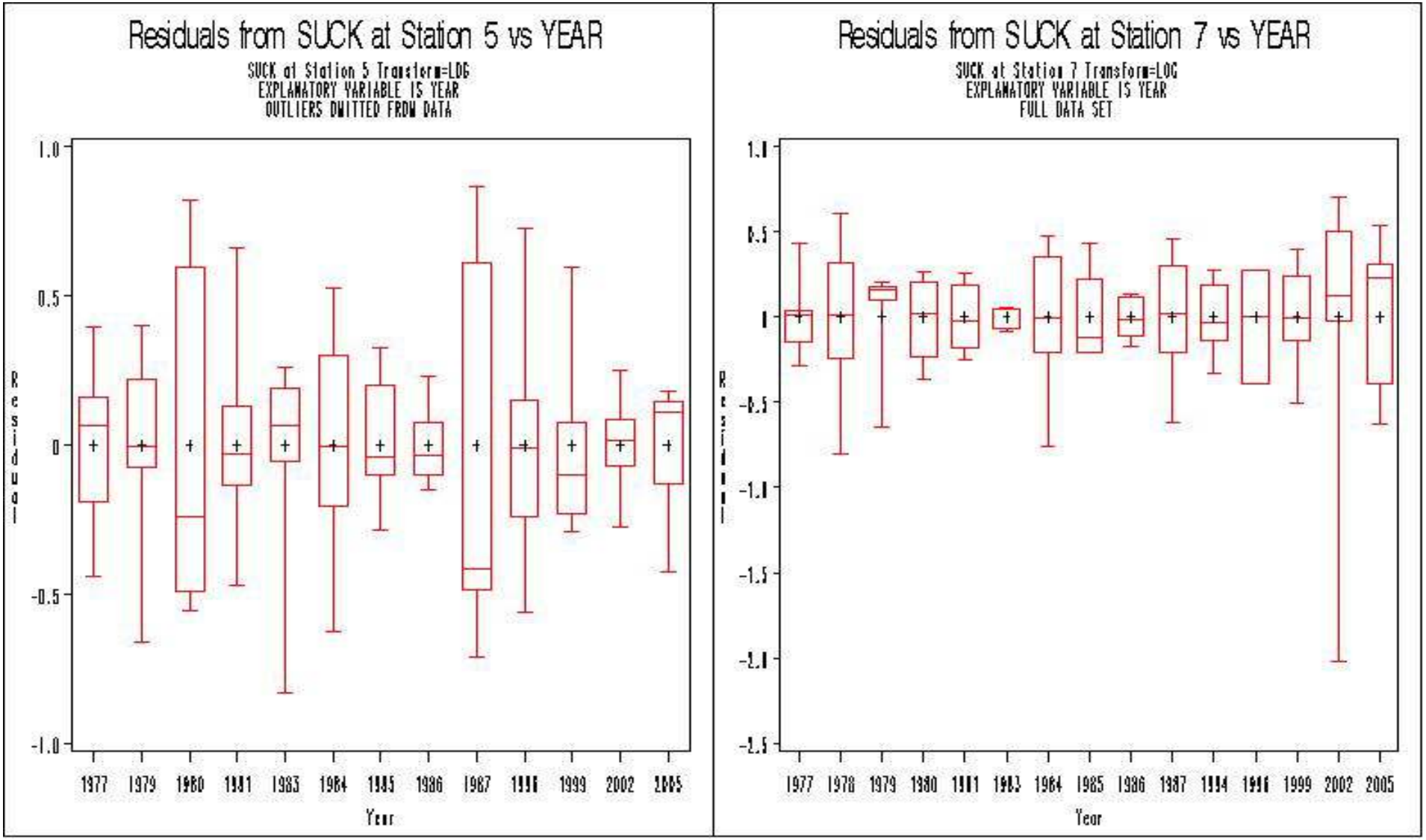


Significant Levene tests arise from years with only 1 or 2 observations



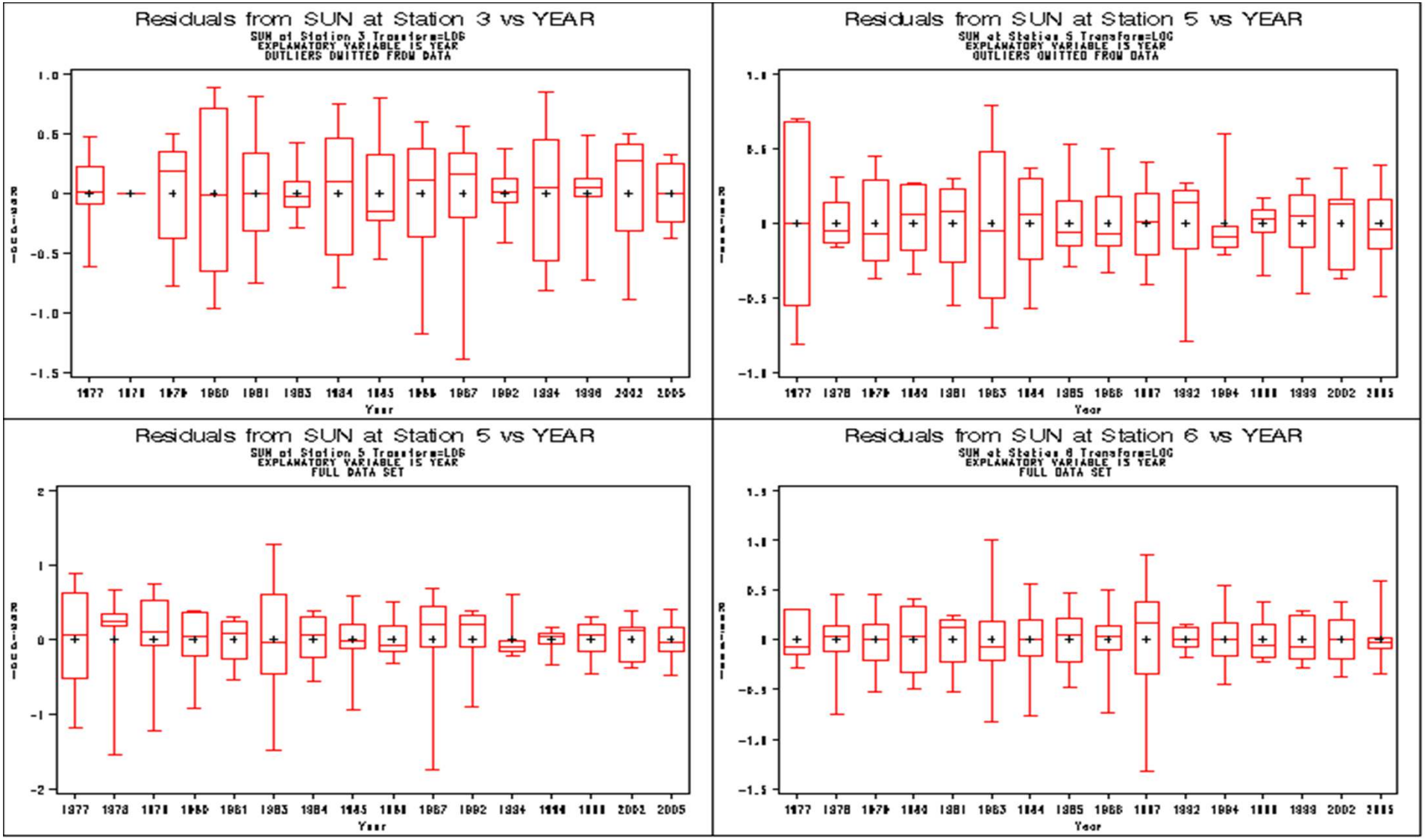
Significant Levene tests at stations 5 and 6 (top row) arise from year with only 1 observation.

Significant Levene test at station 8 is result of reduced variability in latest 3 years. ANOVA and regression results likely little affected.



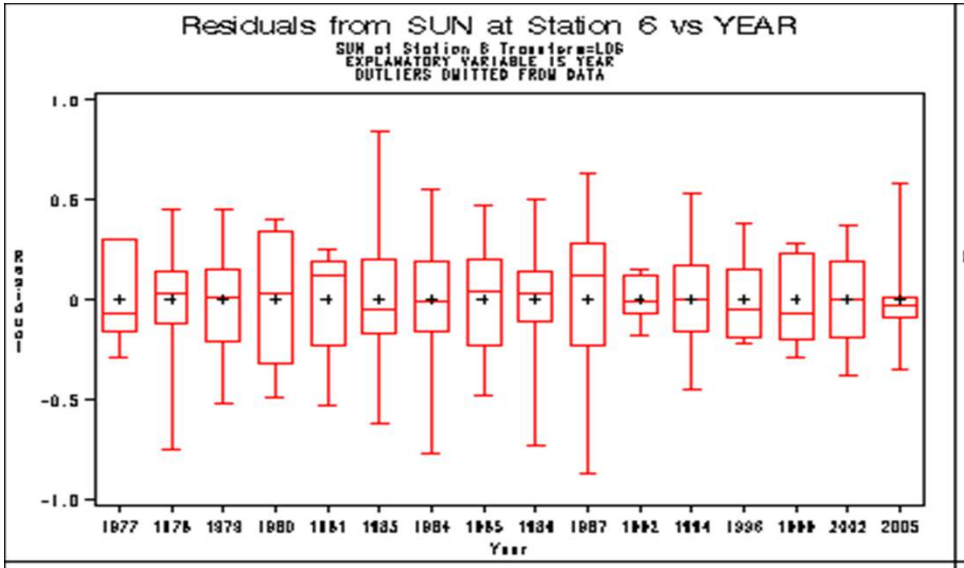
Significant Levene test for station 5 appears only in outlier-omitted analysis, so not relevant

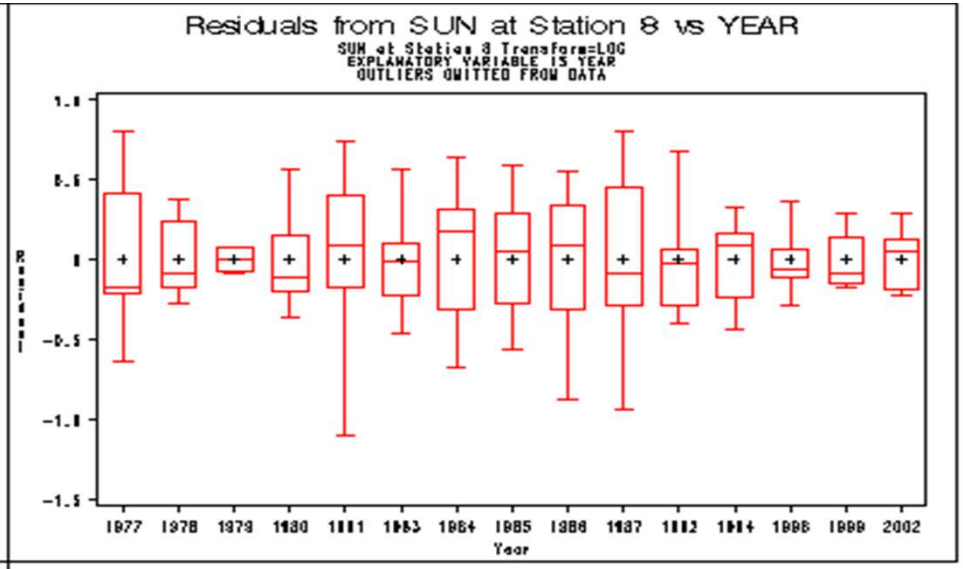
Significant Levene test for station 7 disappears in outlier-omitted analysis

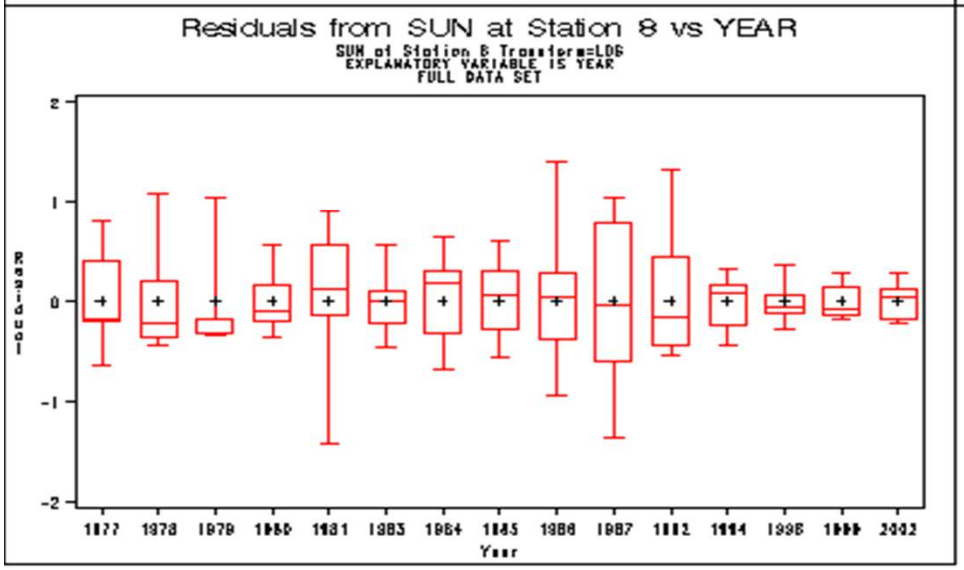


Significant Levene test for station 3 only occurs in outlier-omitted analysis, so irrelevant.

Significant Levene test for station 5 is cause for concern. Square-root transform eliminates problem, has very little effect on regression.

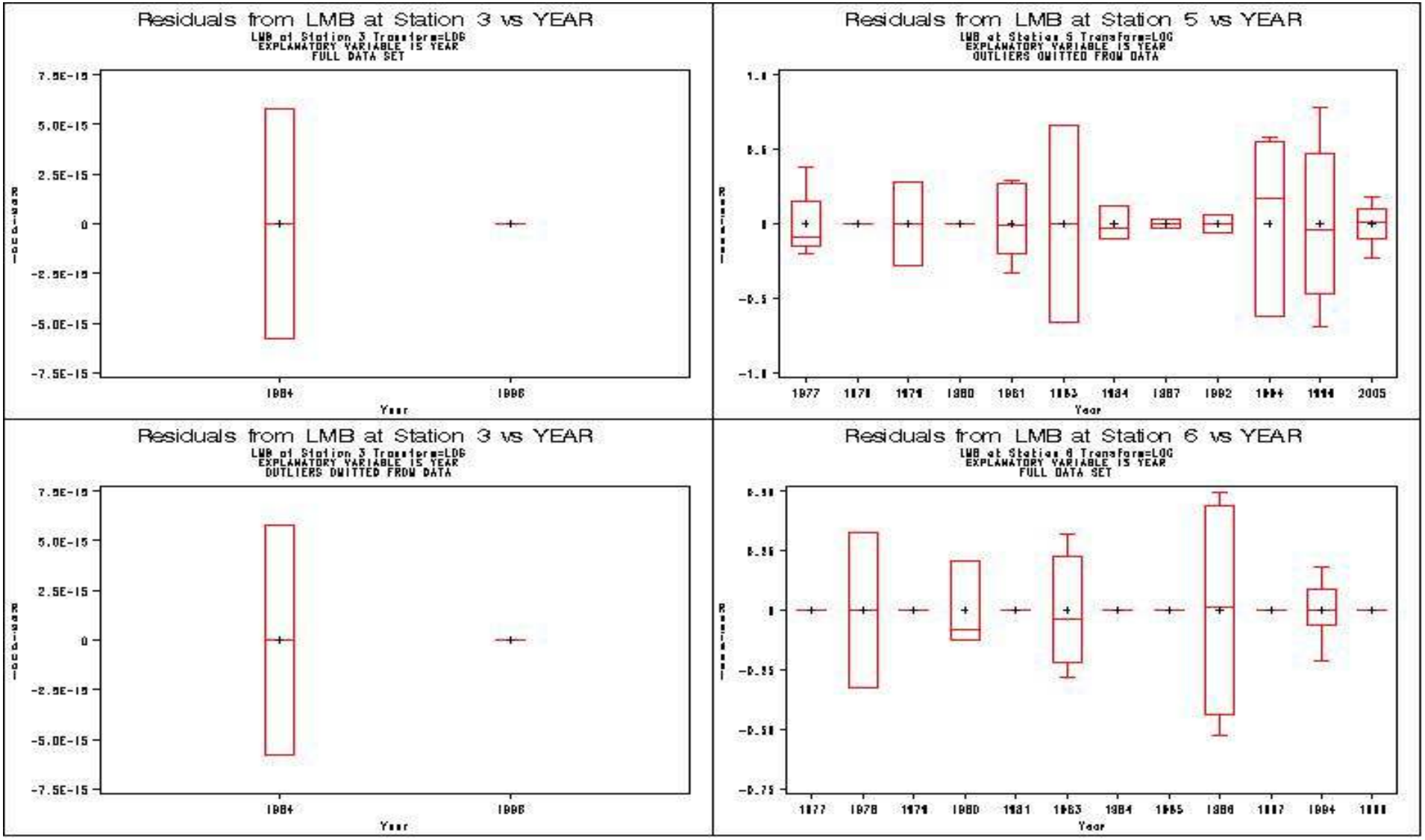






Significant Levene test for station 6 due to low variance in one year, 2005. Should not have much effect on results.

Significant Levene test for station 8 due primarily to low variance in one year, 1979. Should not have much effect on results.



All significant Levene tests arise from years with only 1 or 2 observations

Summary for Assumptions Check

- **Log-transform normalizes results (with a few outliers omitted), and stabilizes variances except for one species and station. Square-root transform eliminates that concern and has only trivial affect on regression results**
- **Virtue of common approach to all species and stations outweighs technical issue**