

**Terramin Australia Limited**

**Angas Zinc Mine**

**Regional Topsoil Annual Monitoring**

**Data Processing, Charting and Statistical Analysis**



*Previously trading as Natural Resource Services Pty Ltd*

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Document code: COOE\_TER.RWS.4.110215

Version: DRAFT 1

Date of this version: 15<sup>th</sup> February 2011

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**DOCUMENT CONTROL**

Date	Document Code	Reason for change	Author	Check
15-2-2011	TER.RWS.4	Draft 1	Joe Mifsud	

# 1 INTRODUCTION

Terramin Australia operates that Angas Zinc Mine three kilometres north of the South Australian town of Strathalbyn. The Environmental Management System developed by Angas Zinc Mine to address their commitments in the Mining and Rehabilitation Program (MARP) and to comply with the Mining Lease Conditions, include a regional topsoil monitoring program intended to demonstrate that mining activities do not adversely affect soils within a radius of 4.5 kilometres of the Mining Operations.

This report presents that results of the 2010 survey and compares the data to background levels collected in 2006 and 2007.

## 2 2010 Results

Appendix A presents all of this year's regional topsoil data. Descriptive statistics to summarise the regional soil data are shown in Table 1. Quality control duplicates were not included in statistical analysis to reduce bias.

**Table 1: Angas Zinc Mine Regional Soil Sampling - Descriptive Statistics**

Parameter	<DL	Minimum	10%	median	90%	max	Average	Std Dev	CoV
pH Value	0	6.7	7.2	8.1	8.35	36	8.63	0.49	0.06
EC @ 25°C	0	29	49	115	273.5	1900	186.49	305.21	1.64
M.C. @103°C	0	12.2	14.2	21.2	26.55	36	20.53	4.87	0.24
Arsenic	10	5	6	12	30.5	83	17.26	16.13	0.93
Cadmium	36	0		0		0	0.00		
Chromium	0	4	10.5	23	37	44	23.41	9.76	0.42
Copper	5	5	8	16.5	43	133	22.91	25.26	1.10
Iron	0	2610	7095	14600	25750	54200	16069	9282.72	0.58
Lead	2	6	8.3	14	57.8	108	23.54	23.16	0.98
Manganese		.	.	.	.	.	.	.	.
Nickel	2	2	4.6	8	18	34	10.60	5.18	0.49
Selenium	36								
Silver	36								
Zinc	0	14	23.5	56	126	156	65.65	39.79	0.61
Sulphate (SO <sub>4</sub> <sup>2-</sup> )	0	180	240	530	1265	2280	657.19	466.71	0.71
Nitrite + Nitrate (N)	8	0.8	1.49	4	13.32	33.2	7.11	6.71	0.94
Total Kjeldahl Nitrogen	0	870	2155	4220	8885	12200	4886.65	2792.91	0.57
Total Nitrogen (N)	0	870	2155	4230	8895	12200	4890.70	2794.32	0.57
Total Phosphorus (P)	0	158	277.5	640	1385	2490	748.76	523.21	0.70

\* units in mg/kg except for pH which is unit less and electrical conductivity (EC) which is in µ/cm.

<DL is less than detection limit, 10% = 10 percentile, 90% = ninety percentile, max = maximum, Std Dev is standard deviation and CoV is coefficient of variation.

### 2.1 Quality control

The laboratory results came with NATA certification indicating that all data is accurate and precise within NATA standards. Field duplicates also show good field quality control. For this work the upper level of acceptable relative percent difference (RPD) for quality control was 50% or less than 2x the detection limit. All parameters were within acceptable field quality control standards, Table 2.

**Table 2: Field Quality Control**

Rep 1	BL8	BL22	BL30
Rep 2	BL52	BL51	BL 50
pH	3.9%	-5.3%	5.5%
EC	8.5%	-82.4%	-6.8%
M.C	-22.9%	13.0%	23.1%
As	BDL	26.7%	-78.3%
Cd	BDL	BDL	BDL
Cr	0.0%	12.5%	-9.5%
Cu	BDL	BDL	-15.7%
Fe	3.5%	21.3%	-21.4%
Pb	<2xDL	BDL	-12.8%
Mn			
Ni	BDL	0.0%	-22.2%
Se	BDL	BDL	BDL
Ag	BDL	BDL	BDL
Zn	37.5%	-13.3%	0.0%
SO4	-28.6%	18.2%	-3.8%
NOx	<2xDL	57.1%	8.3%
TKN	-47.6%	-6.2%	2.1%
TN	-47.6%	-6.2%	2.1%
TP	-50.9%	12.3%	38.9%

## 2.2 Results

No soil sample had any parameter exceeding the relevant National Environmental Protection Measure (NEPM), for health-based investigation level criteria (HIL).

Eight samples had elevated arsenic and one has elevated copper values that exceeded the ecological investigation level (EIL); these are highlighted in pink in Appendix A.

For ease of interpreting data, values that were not highlighted in pink (for exceeding the EIL) were highlighted in tan if they were the maximum value for that parameter and in yellow if they exceeded the 90 percentile value for 2011.

Prior to 2010 three composite samples were collected at 1m, 3m and 5m from the marker post at each site these were labelled with a suffix of .1, .2 and .3 respectively. The data for 2010 did not include distance sub-samples and the exact location with respect to the markers were not recorded; therefore caution must be taken in comparing between year results.

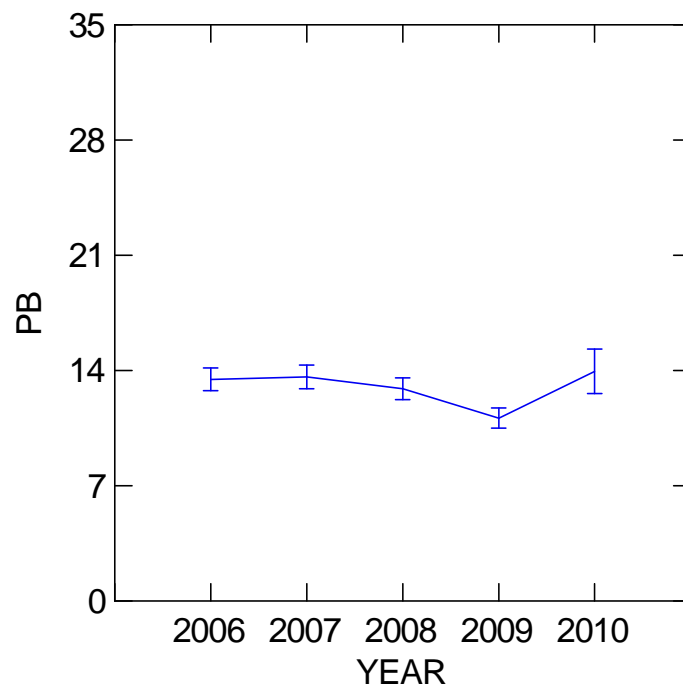
## 2.3 Graphs and statistics for selected parameters

Raw data plots for all soil parameter tested are presented in Appendix B followed by the regional annual averages in Appendix C. All graphs show values below the method limit of detection at the detection limit for ease of visualisation and to demonstrate the extent of the dataset.

This section presents graphs and statistical analysis for selected parameters. They show linear graphs of the annual regional average for each parameter combining all soil samples collected from within 4.5 kilometres of the Angas Zinc Mine followed by the results of analysis of variance (ANOVA). The second graph for each parameters present the annual site averages (only one sample per site for 2010).

Analysis of variance (ANOVA) was used to test the null hypothesis that the annual regional averages for selected parameters are not the same, i.e.  $H_0: \text{Average } 2006 \neq 2007 \neq 2008 \neq 2009 \neq 2010$ . The analysis found that all null hypothesis tested were rejected at the set probability level ( $p=0.001$ ). That is the difference between annual regional averages for the parameters tested was not statistically significant. The pooled data did not include duplicate quality control values, for interest these were included and retested with the ensuing probability is reported after the main ANOVA results table.

## 2.4 Lead

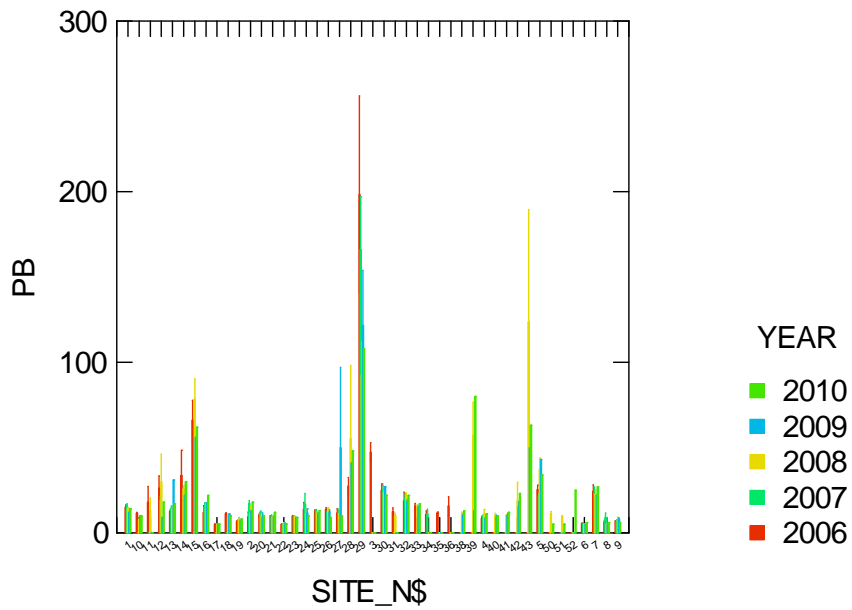


No significant trends in soil lead concentrations were observed.

Dep Var: **Lead** N: 412 Multiple R: 0.051 Squared multiple R: 0.003

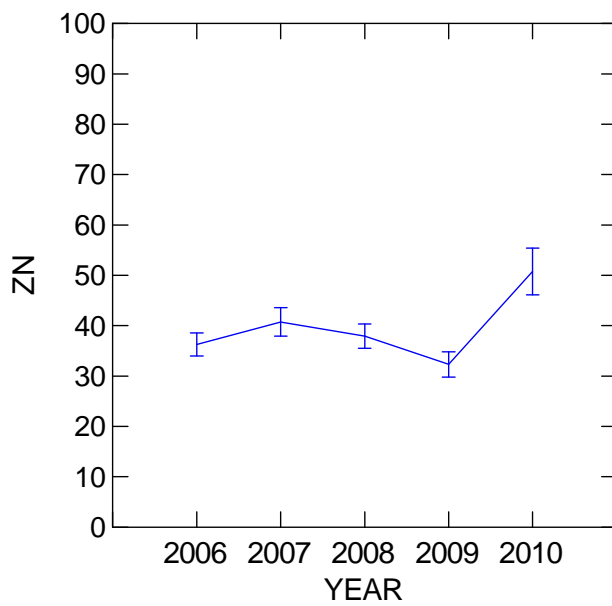
Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	987.924	4	246.981	0.268	0.898
Error	374405.795	407	919.916		

Duplicates added P=0.932



Graph showing annual soil lead concentration at each site. Note Sites 15, 28, 29 39 and 43 have higher values than the other sites and that Site 29 near the greyhound training track has constantly higher lead values.

## 2.5 Zinc

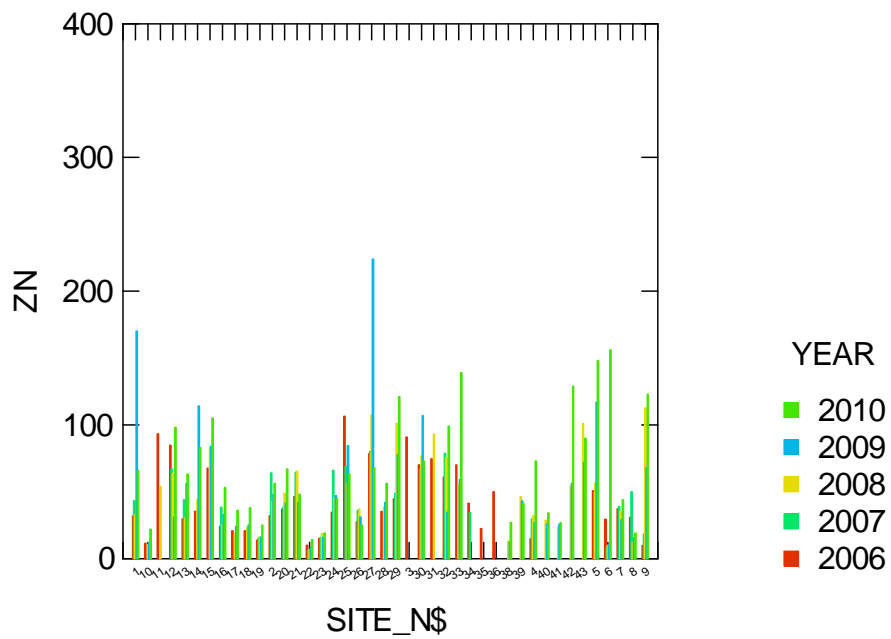


No significant trends in soil zinc concentrations were observed.

Dep Var: **Zinc** N: 410 Multiple R: 0.146 Squared multiple R: 0.021

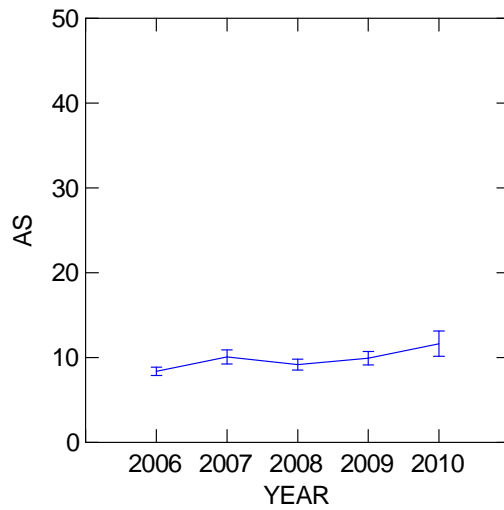
Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	15600.886	4	3900.221	2.20	0.068
Error	717856.736	405	1772.486		

Duplicates included P=0.111



Graph showing annual (average) zinc concentration at each site.

## 2.6 Arsenic

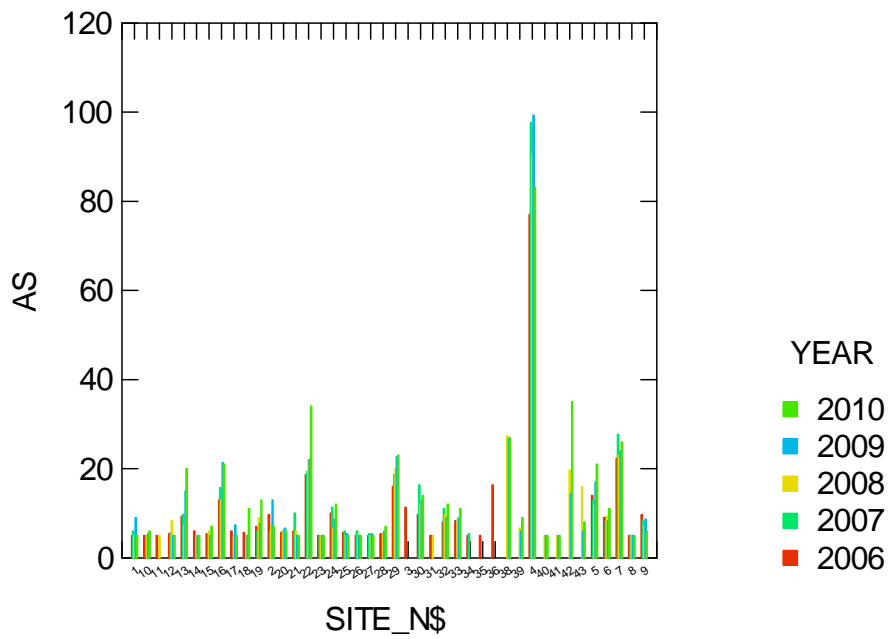


No significant trends in soil arsenic concentrations were observed.

Dep Var: **Arsenic** N: 412 Multiple R: 0.088 Squared multiple R: 0.008

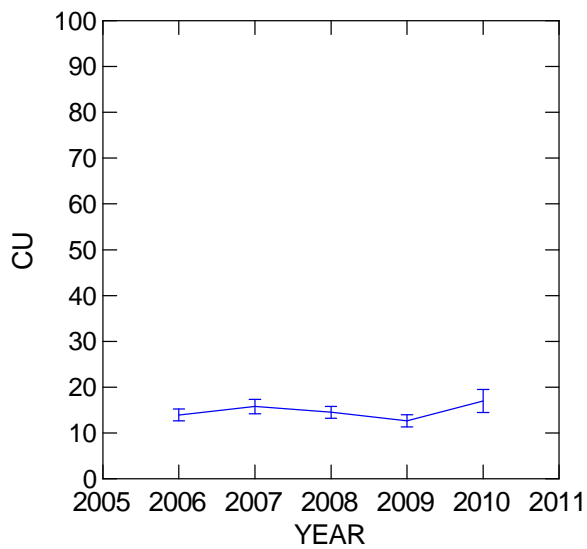
Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	796.614	4	199.154	0.795	0.529
Error	101895.840	407	250.358		

Duplicates included P=0.437



Sit 4 has consistently high arsenic levels compared to the other locations sampled.

## 2.7 Copper

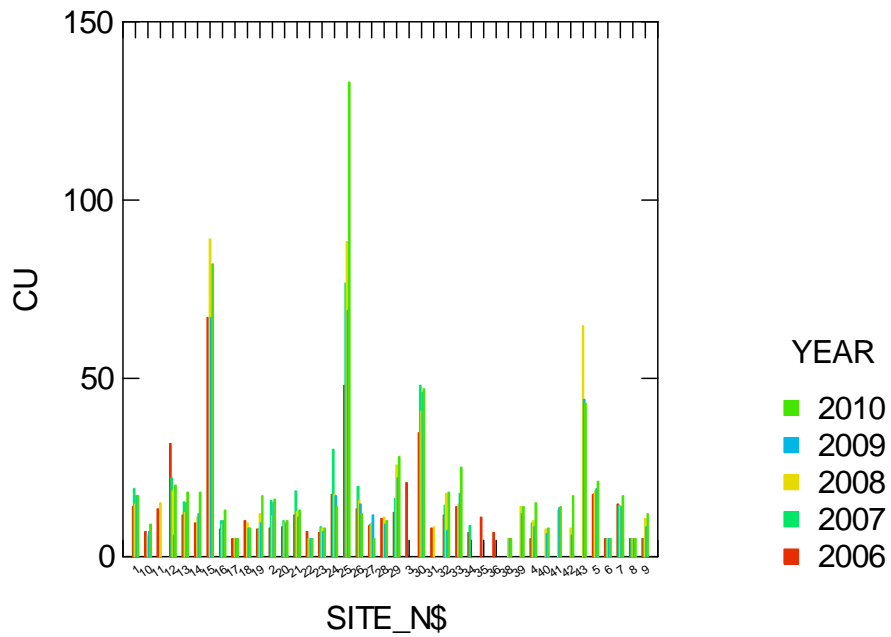


No statistically significant difference between years was found.

Dep Var: **Copper** N: 412 Multiple R: 0.116 Squared multiple R: 0.013

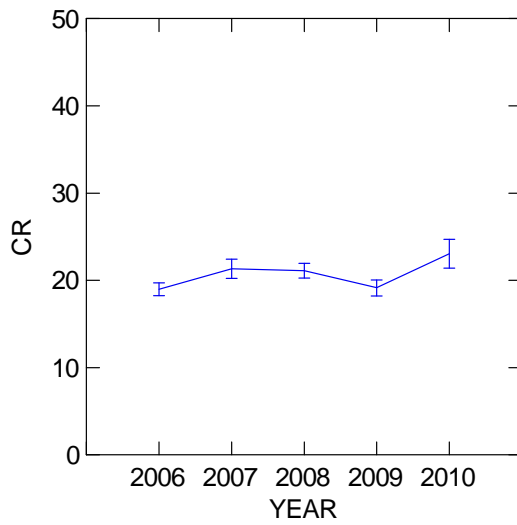
Source	Sum-of-Squares	df	Mean-Square	F-ratio	p
YEAR	1922.057	4	480.514	1.376	0.241
Error	142101.593	407	349.144		

Duplicates included P=0.115



Graph showing copper concentration at each site. Note BL15, BL25, BL30 and BL43 had consistently higher copper levels than other sites.

## 2.8 Chromium

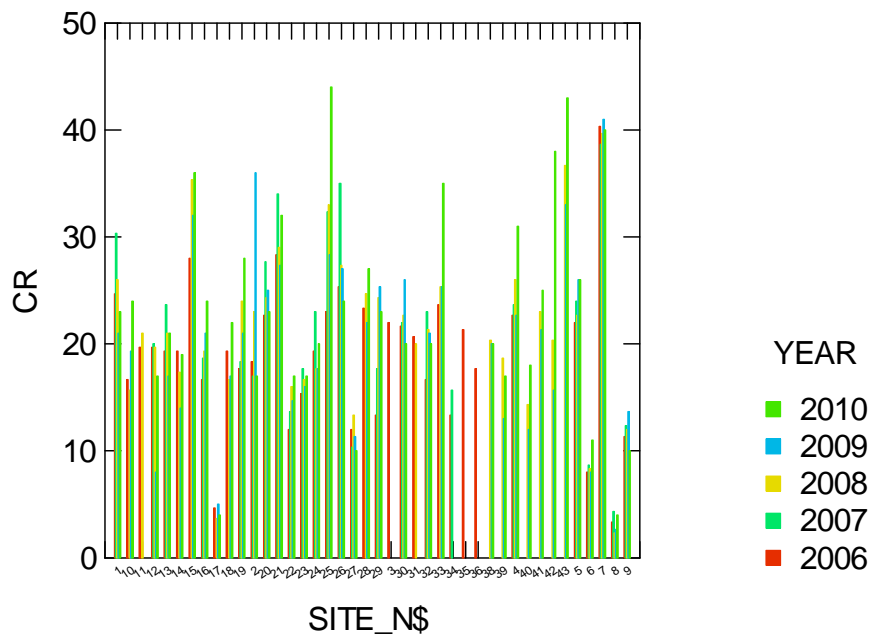


No statistically significant differences in chromium concentrations were found between years.

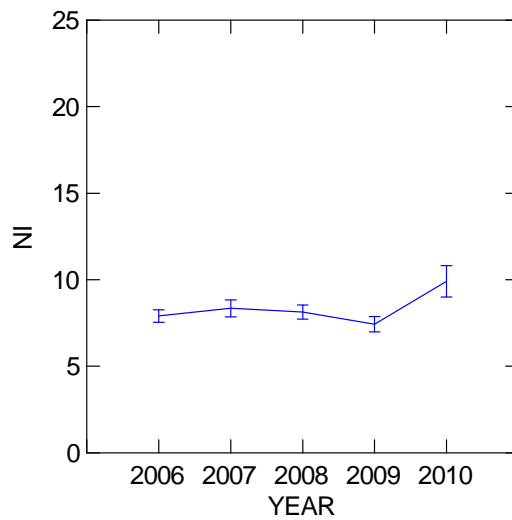
Dep Var: **Chromium** N: 412 Multiple R: 0.152 Squared multiple R: 0.3

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	720.153	4	180.038	2.412	0.049
Error	30374.029	407	74.629		

Duplicates included P=0.056



## 2.9 Nickel

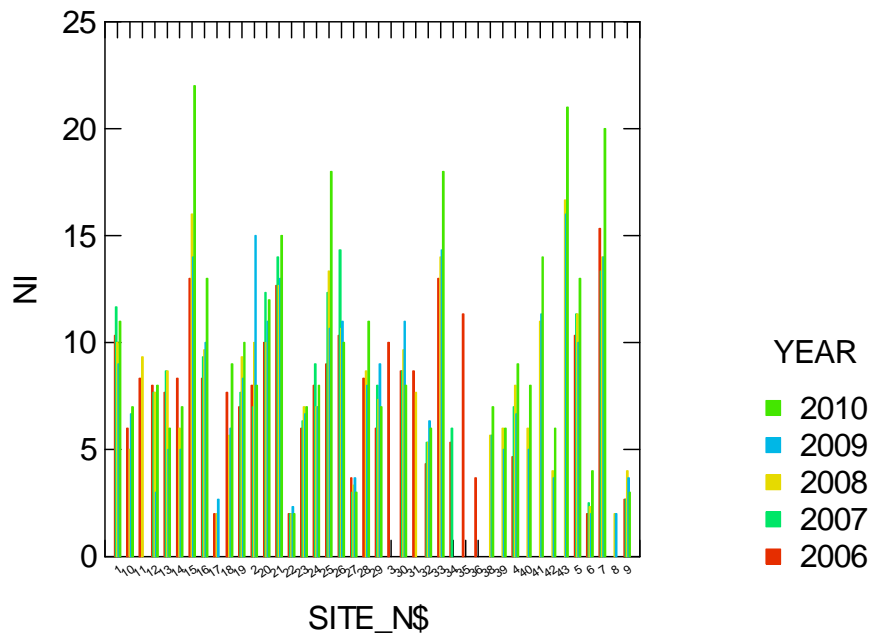


No statistically significant differences in chromium concentrations were found between years.

Dep Var: **Nickel** N: 400 Multiple R: 0.151 Squared multiple R: 0.023

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
YEAR	157.106	4	39.276	2.317	0.057
Error	6696.372	395	16.953		

Duplicates included P=0.081



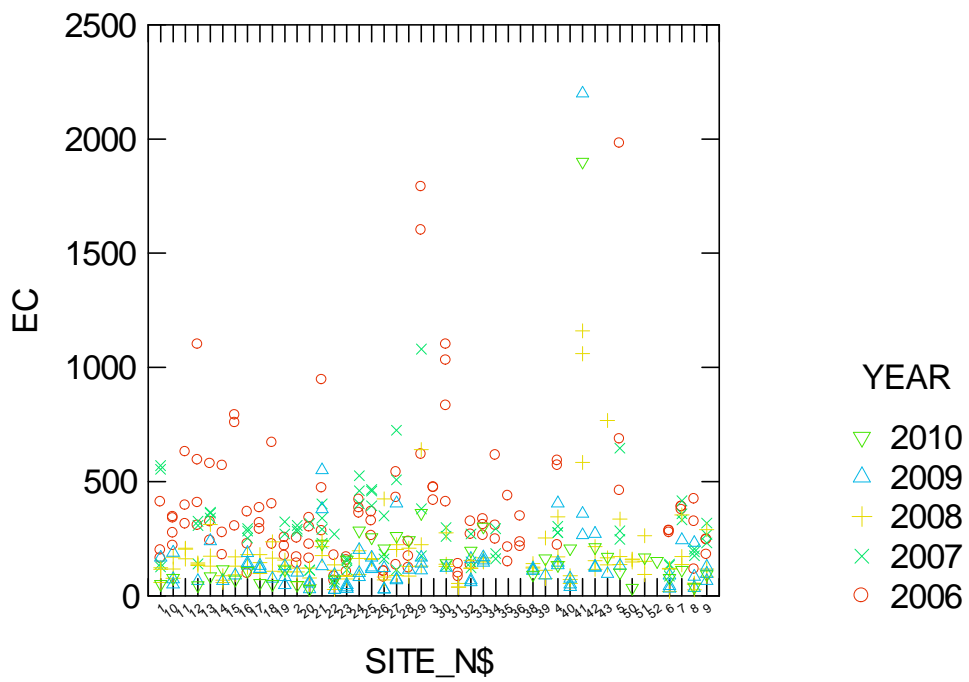
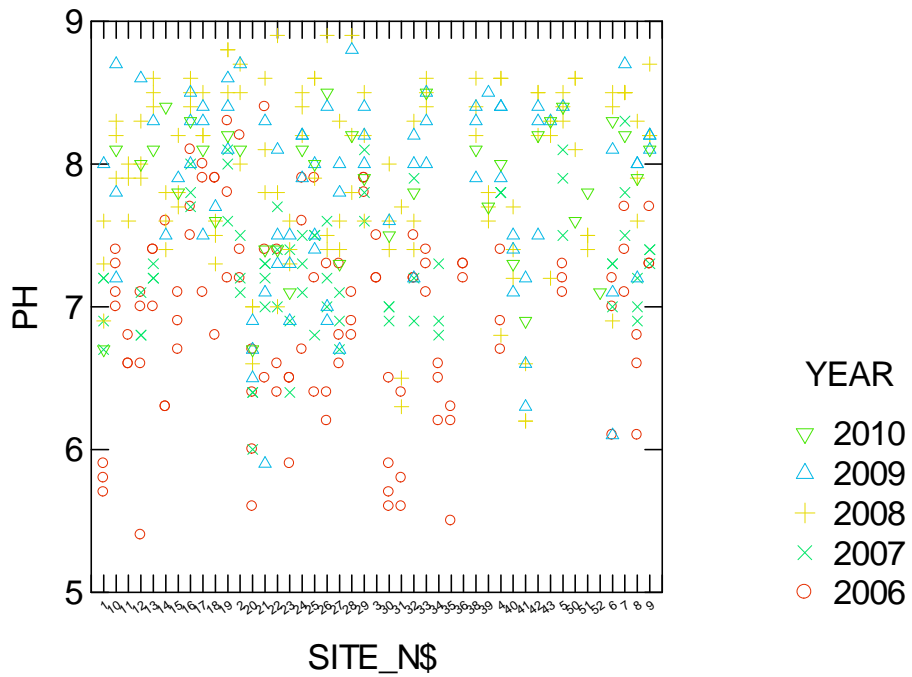
**Appendix A: Process 2010 Regional Rainwater Tank Data**

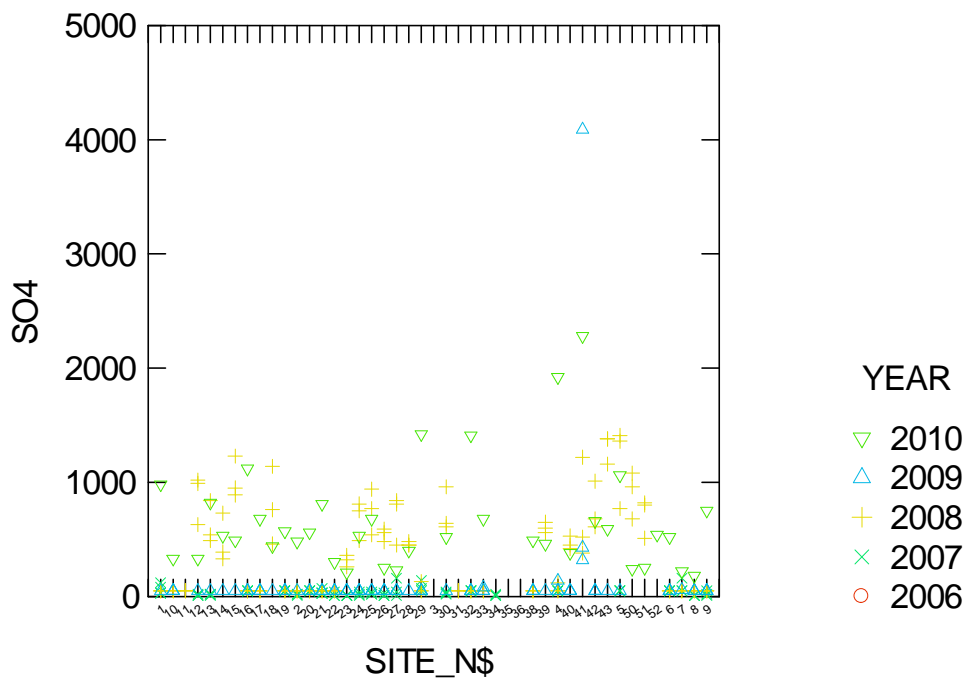
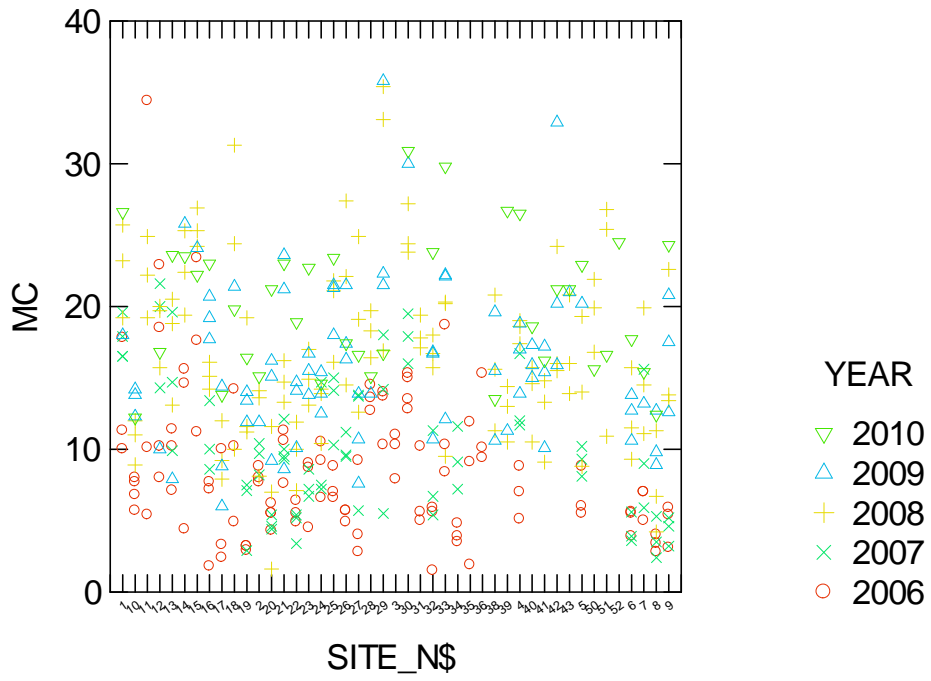
Site	1	2	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	32	33	38	39	40	41	42	43		
pH	6.7	8.1	8	8.4	8.3	8.2	7.9	8.1	8.1	8	8.1	8.4	7.8	8.3	8.1	7.6	8.2	6.7	7.4	7.4	7.1	8.1	8	8.5	7.3	8.2	7.9	7.5	7.8	8.5	8.1	7.7	7.3	6.9	8.2	8.3		
EC	51	47	134	102	78	113	37	93	78	45	85	116	70	109	56	51	115	29	228	70	157	285	255	206	262	244	362	142	197	302	92	163	207	1900	212	171		
MC	26.6	15.1	26.5	22.9	17.7	15.4	12.4	24.3	12.2	16.8	23.6	23.5	22.2	23	13.8	19.8	16.4	21.2	23	18.9	22.7	14.6	23.4	17.4	16.6	15.1	16.7	30.9	23.8	29.8	13.5	26.7	18.6	16.2	21.2	21.2		
As	<5	7	83	21	11	26	<5	6	6	5	20	<5	7	21	<5	11	13	6	5	34	<5	12	<5	<5	<5	7	23	14	12	11	27	9	<5	<5	35	8		
Cd	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Cr	23	17	31	26	11	40	4	10	24	17	21	19	36	24	4	22	28	23	32	17	17	20	44	24	10	27	23	20	20	35	20	17	18	25	38	43		
Cu	17	16	15	21	<5	17	<5	12	9	20	18	18	82	13	<5	8	17	10	13	<5	8	14	133	12	5	10	28	47	18	25	<5	14	8	14	17	43		
Fe	14800	11700	18200	14000	7350	25900	2610	6080	18000	10800	8120	12200	25600	16400	3010	17100	11800	12900	25600	15600	13600	19100	54200	17600	6840	20300	13000	14200	16100	27200	13600	12200	14600	20500	21300	32400		
Pb	14	18	11	34	6	27	6	6	10	18	17	30	62	22	<5	10	8	10	12	<5	9	10	13	9	10	48	108	22	22	17	13	80	10	12	23	63		
Mn																																						
Ni	11	8	9	13	4	20	<2	3	7	8	6	7	22	13	<2	9	10	12	15	2	7	8	18	10	3	11	7	8	6	18	7	6	8	14	6	21		
Se	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	
Ag	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Zn	66	56	73	148	156	44	19	123	22	98	63	83	105	53	36	38	25	67	48	14	19	45	63	25	68	56	121	73	99	139	27	41	34	27	129	90		
SO4	980	480	1920	1060	520	220	180	750	330	330	820	530	490	1120	680	440	570	560	810	300	210	530	680	250	230	400	1420	520	1410	680	490	460	380	2280	660	590		
NOx	2.3	1.7	0.8	0.8	<0.5	3.5	<0.5	6	2.2	2.8	<0.5	<0.5	3.4	1.7	2.2	4	3.6	<0.5	13.6	4.5	<0.5	6.3	13.2	2.8	<0.5	15.3	<0.5	7.5	5.6	7.1	1	2.8	33.2	7.8	13.1	9.4		
TKN	4380	2630	10600	7070	3270	870	1040	4890	1820	2430	6880	3610	3990	4260	4990	3730	3190	3890	8730	1880	3150	3600	4500	3140	3500	5260	12200	9040	6290	8520	2970	10100	4270	4220	8090	7770		
TN	4380	2630	10600	7070	3270	870	1040	4900	1820	2430	6880	3610	3990	4260	4990	3730	3190	3890	8740	1880	3150	3610	4510	3140	3500	5280	12200	9050	6300	8530	2970	10100	4300	4230	8100	7780		
TP	1010	271	1900	640	350	196	158	810	1410	432	706	999	657	584	862	786	365	2490	666	284	262	404	847	357	285	445	1220	1240	1750	1040	348	533	487	1360	936	578		

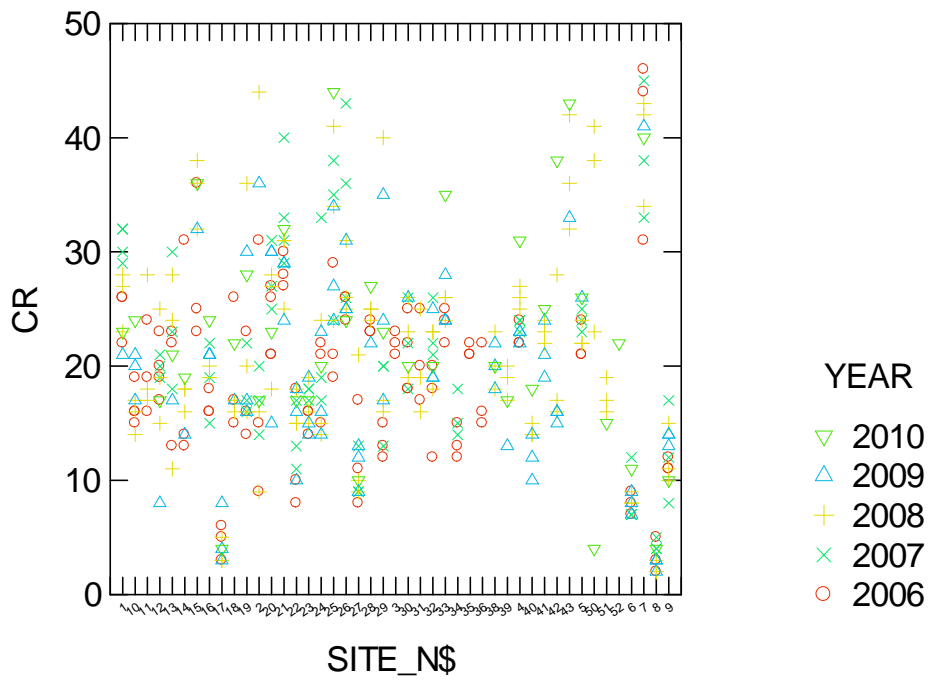
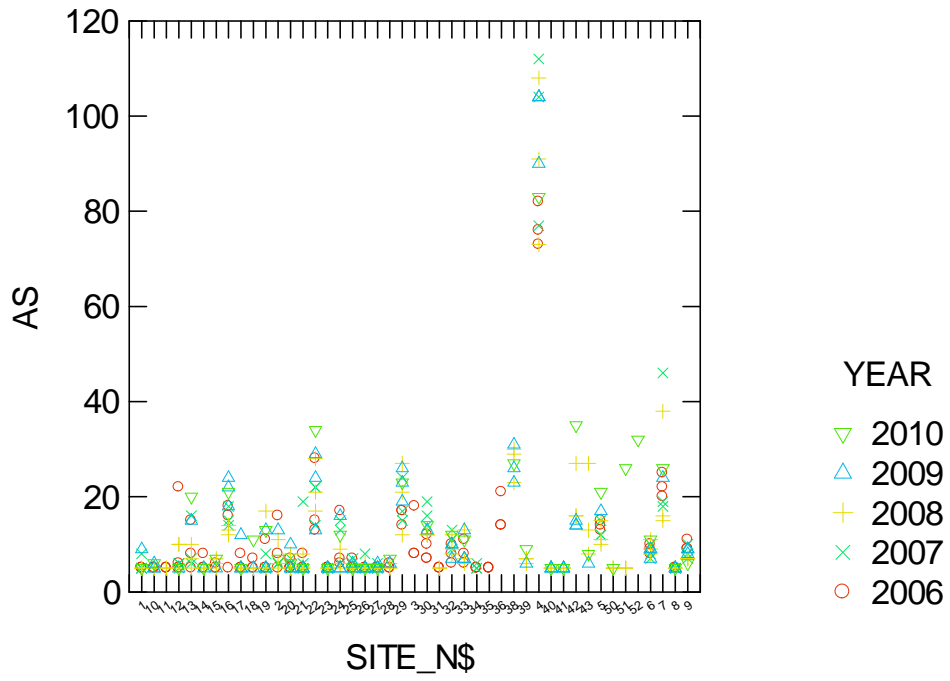
\* Units in mg/kg or as shown, MC= % Moisture Content (dried @ 103°C), EC=  $\mu\text{S}/\text{cm}$  Electrical Conductivity @ 25°C, SO4= Sulphate as SO4 2-, NOx= Nitrite + Nitrate as N (Sol.), TKN= Total Kjeldahl Nitrogen as N, TN= Total Nitrogen as N, TP= Total Phosphorus as P Schedule 2 -Water quality criteria EPA - SA Potable, Std Dev = Standard Deviation, CoV = Coefficient of variation. EC=Electrical Conductivity, TDS= Total Dissolved Solids @180°C @ 25°C. NOx= Nitrite + Nitrate, TKN= Total Kjeldahl Nitrogen, TN=Total Nitrogen, TP= Total Phosphorus.

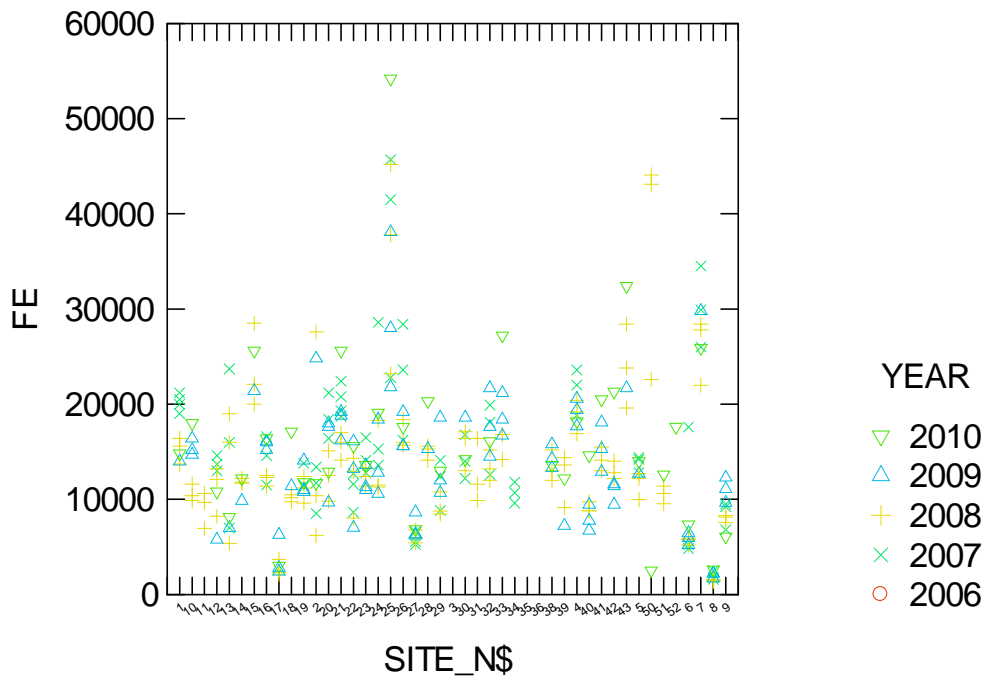
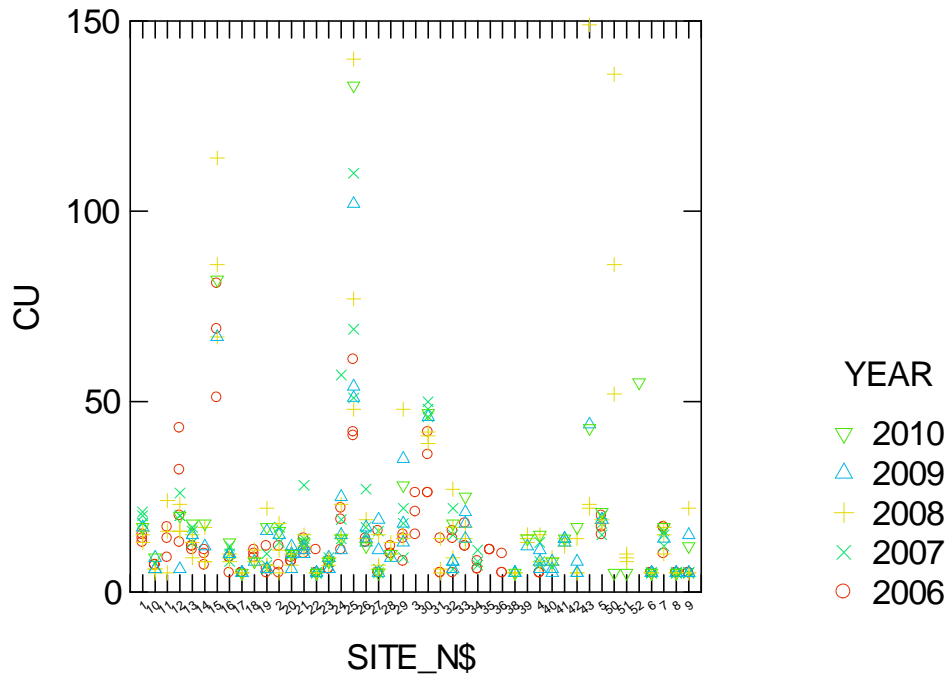
## Appendix B: Raw Data Plots

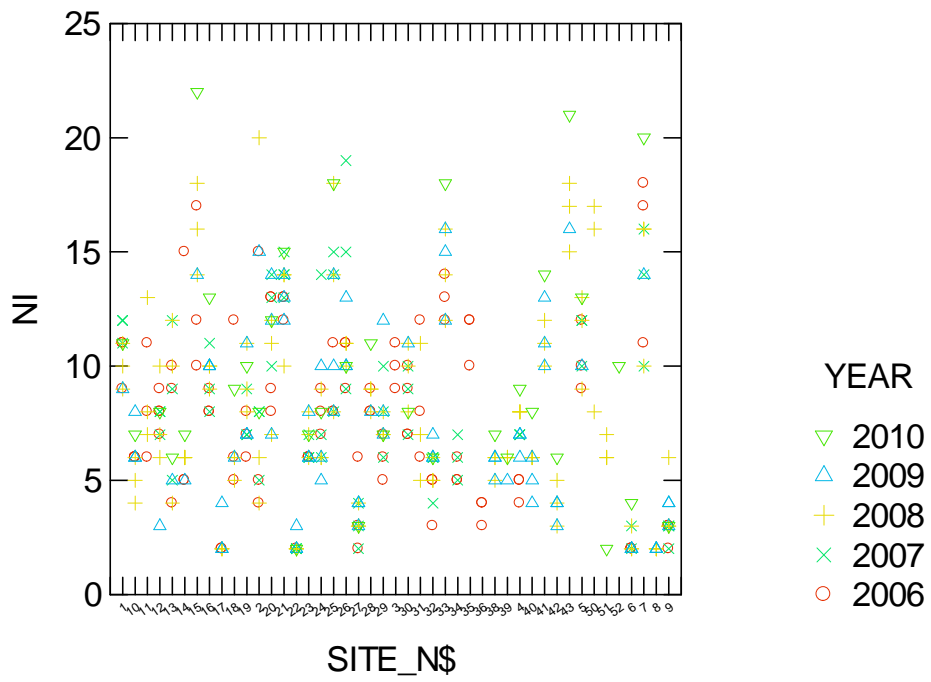
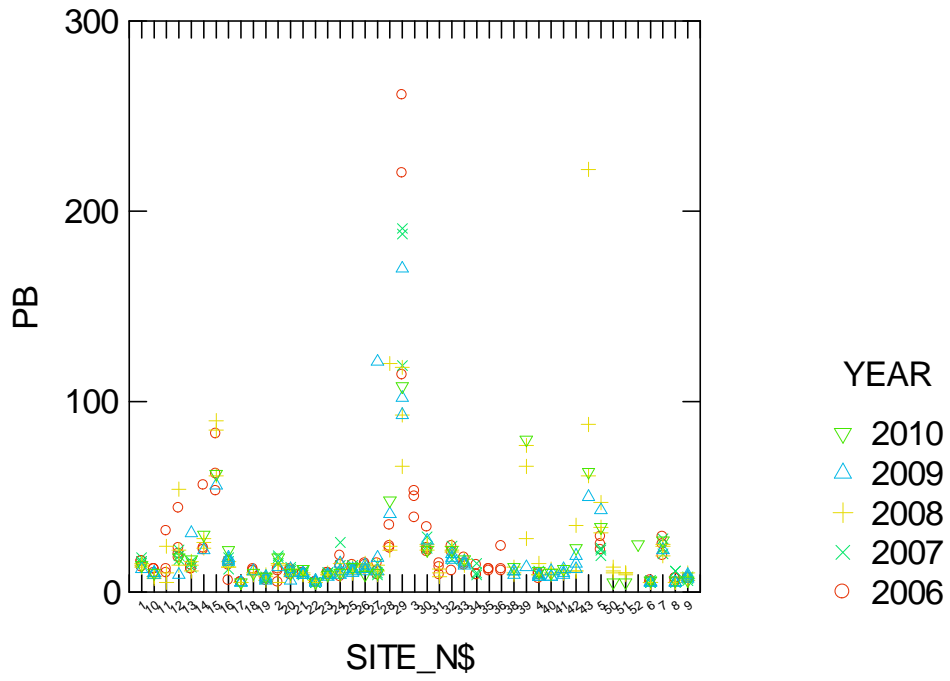
The raw data plots show the spread of results sorted by year for each site.

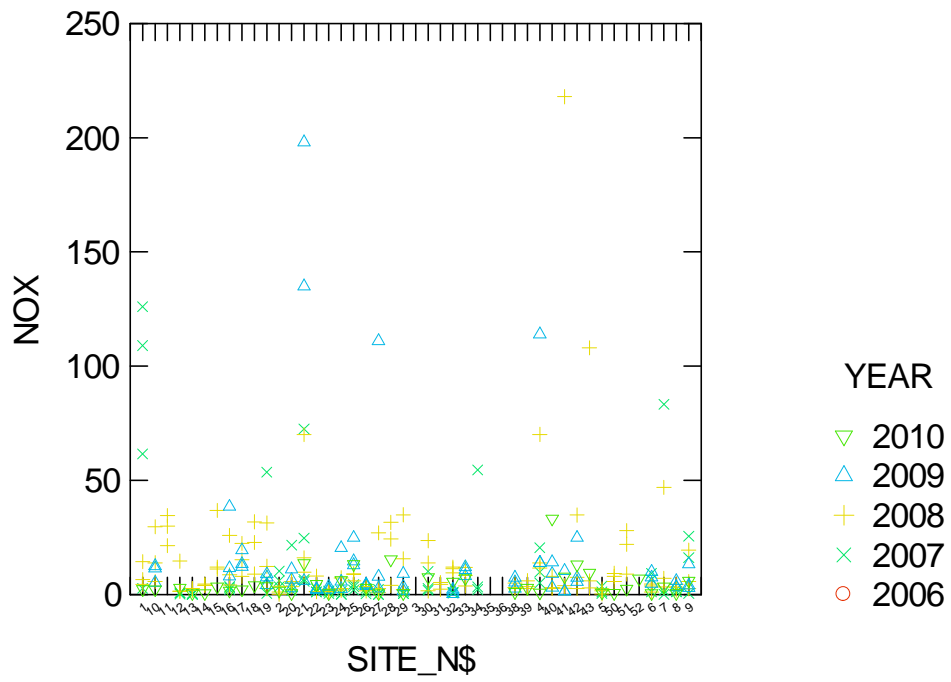
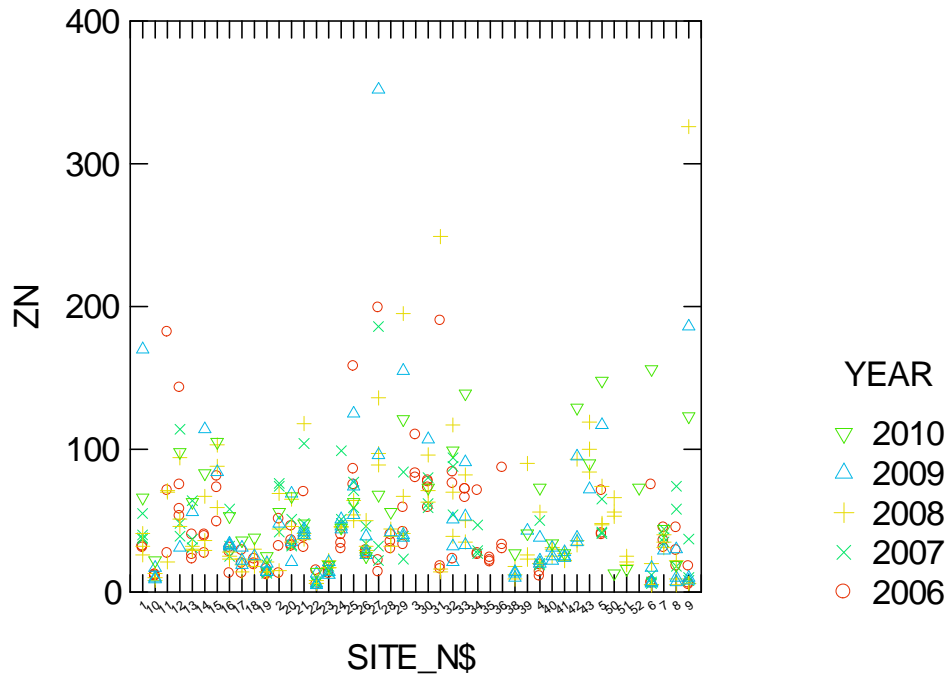


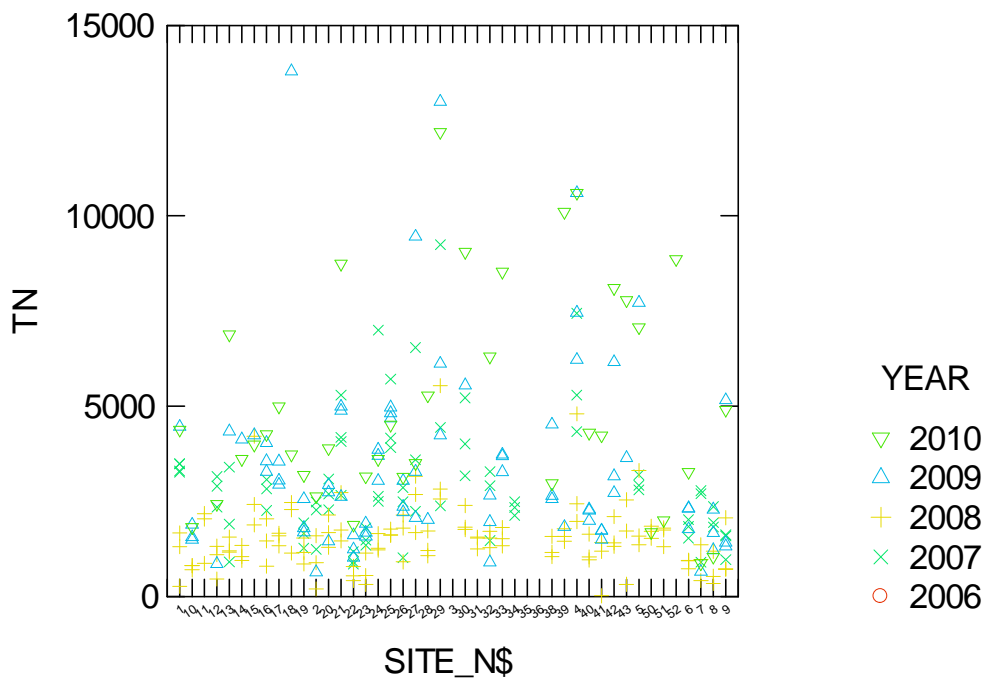
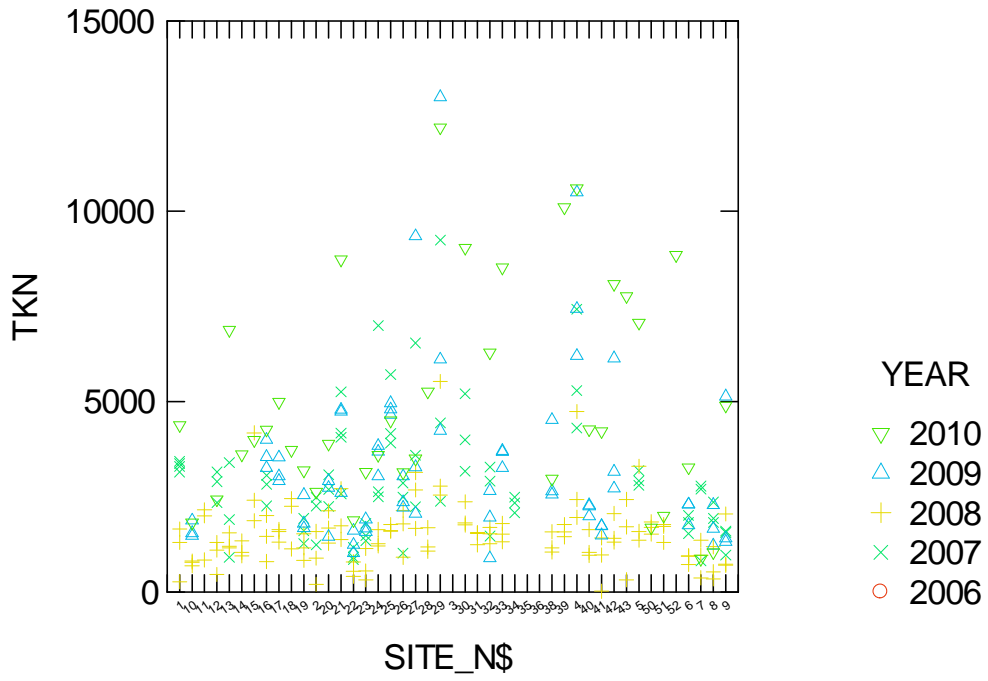


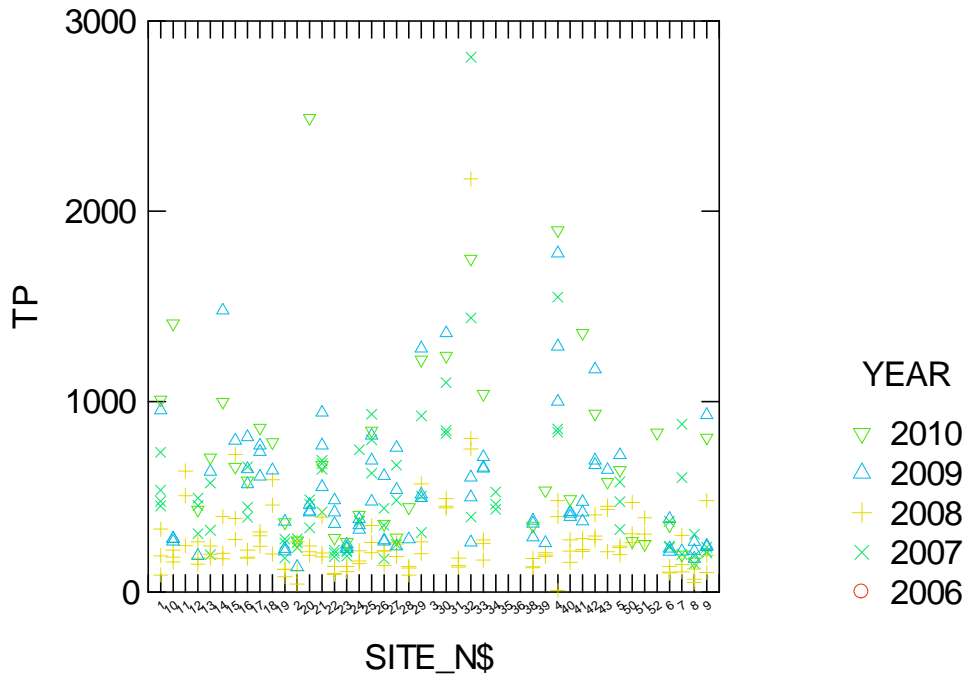












### Appendix C: Regional Annual Totals

The following graphs show the regional annual totals with standard error bars.

